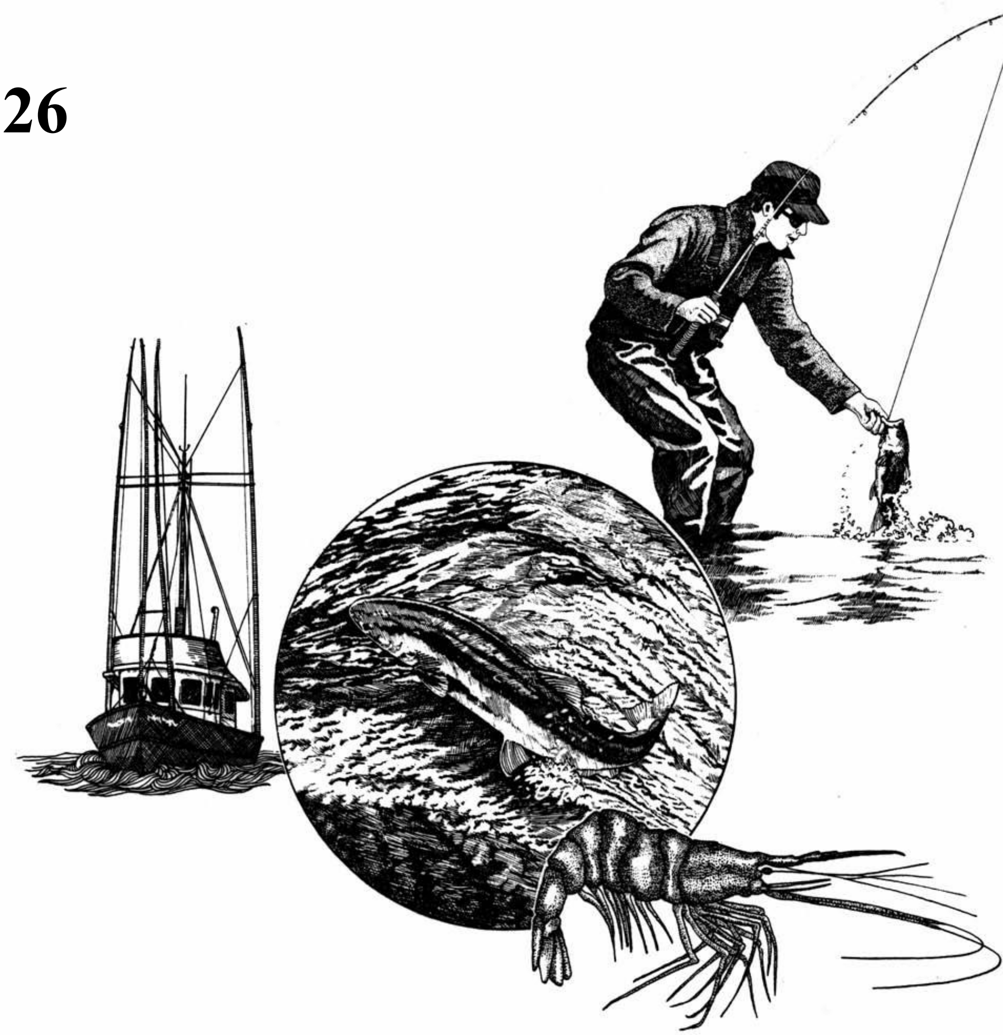
ODFW PROGRESS REPORT Series

2026



Oregon Department of Fish and Wildlife

2025 - Monitoring Report for the Clackamas Focused Investment Partnership.

Progress Report No. OPSW-ODFW-2026-7

PROGRESS REPORT FISH RESEARCH PROJECT OREGON

PROJECT TITLE: 2025 Monitoring Report for the Clackamas Focused Investment Partnership

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EXECUTIVE SUMMARY

In 2025, the Oregon Department of Fish and Wildlife's (ODFW) Aquatic Inventories Program (AQI) and Unoccupied Aircraft 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 physical 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 within sites associated with the Clackamas Partnership Strategic Restoration Action Plan (2018).

ODFW surveyed one pre-restoration site: Beebe Island. Multi-year post-restoration monitoring continued at Kingfisher, Eagle Creek, Riverbend, Barton Natural Area, and Johnson "J" Creek, and one-year post-restoration monitoring occurred at Austin Hot Springs. Ongoing monitoring was conducted at three control sites downstream of North Fork Dam: Upper, Middle, and Lower Control, and one control site upstream of North Fork Dam, USFS Control. 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. We used temperature loggers to monitor 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.

We used paired t-tests to describe changes associated with treatment/control one-year pre/post restoration, Before-After-Control-Impact (BACI) analysis to compare the mean differences between pre-treatment and post-treatment periods, and the HabRate model to assess habitat quality across salmonid life stages. Across habitat metrics, the control channels behaved similarly over time, but differences were observed between both the Upper and Middle Control channels when compared to the Lower Control. Austin Hot Springs was the only post-one-year site and results were similar to previous FIP one-year post-restoration site analyses; wood volume (m^3), the number of key pieces (≥12 meters in length and 60 cm in diameter), and secondary channel area increased, while fine sediments (silt and sand) and bedrock decreased. BACI results indicated that control and impact sites behaved similarly for the majority of habitat metrics, with some notable exceptions; both Riverbend and Eagle Creek showed a significant increase (p-value > 0.05) in large wood volume (m^3) following restoration treatment, while the percentage of pool habitat in Kingfisher and Johnson "J" Creek decreased significantly after intervention.

The HabRate model indicated that spawning habitat for Chinook increased from poor to good in Austin Hot Springs and the USFS Control site. Steelhead spawning habitat also increased in Austin Hot Springs and decreased from good to poor in the Eagle Creek Complex. Otherwise, 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, and salmonids were counted in five sites. No salmonids were observed during snorkel surveys downstream of the Middle Control site in 2025. Temperature results were similar to 2024 and 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).

2025 marked the sixth 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) and the Clackamas Partnership Strategic Restoration Action Plan (2018) 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 (Bailey et al. 2025). 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 were made in 2024 to document the results one year after the enhancements were 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.

In 2025, ODFW surveyed eleven sites, including one pre-restoration location – Beebe Island – and six post-restoration treatment sites: Austin Hot Springs, Kingfisher, Eagle Creek Complex, Barton Natural Area, Riverbend (Sieben), and Johnson "J" Creek. We continued monitoring four control site locations: Upper, Middle, and Lower Controls downstream of River Mill Dam, and USFS Control upstream of North Fork Reservoir. In addition, year-round temperature monitoring continued 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 Complex, Lower Control, Lower Clackamas River, and Riverbend. We deployed one additional temperature logger at a seasonally isolated scour pool within a secondary channel at Eagle Creek Complex.

Comparisons of pre- and post-restoration conditions will be made in this report to document the results one year after the enhancements were implemented along with the mean differences between pre-treatment and post-treatment periods. Restoration activities took place during the summer of 2025 at Beebe Island, with pre- and post-restoration comparisons to be made in the 2026 report to document the results one year after the enhancements.

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 2025, one site, Beebe Island, was surveyed before restoration efforts occurred. Six sites were surveyed following restoration—Austin Hot Springs, Kingfisher, Eagle Creek, Riverbend, Johnson "J" Creek, and Barton Natural Area—and four control sites —Upper, Middle, Lower, and USFS Control channels —were surveyed (Figure 1).

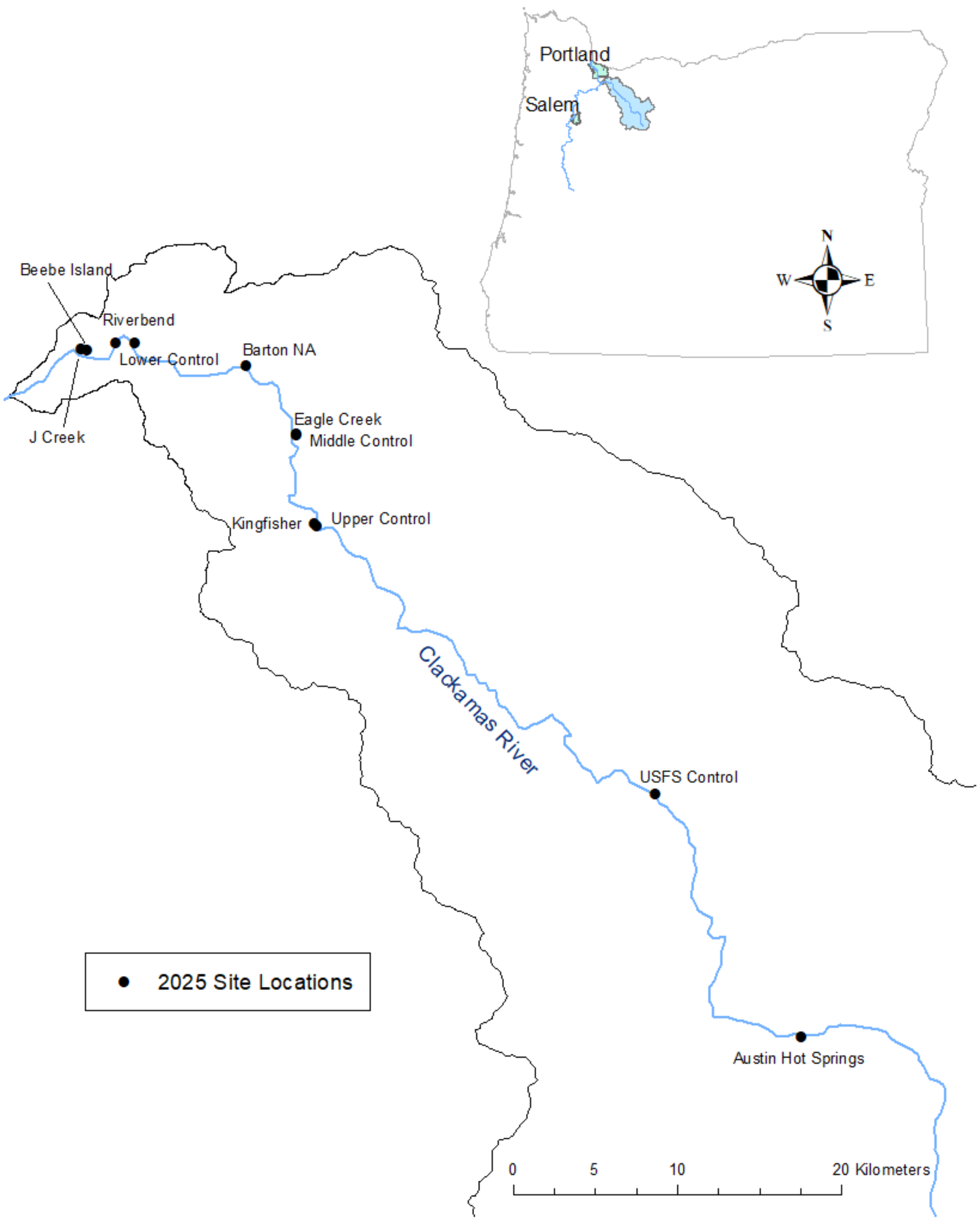

Figure 1. 2025 Clackamas FIP site locations.

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 approximately 45 meters between the hillslopes. Figure 2 illustrates the Austin Hot Springs site in 2025 during the winter and summer after restoration. Due to the size of the river within the site boundaries, the main channel was surveyed from upstream to downstream using inflatable kayaks, while the side channel habitats were surveyed on foot, moving upstream. For analysis, Austin Hot Springs is paired with USFS Control.

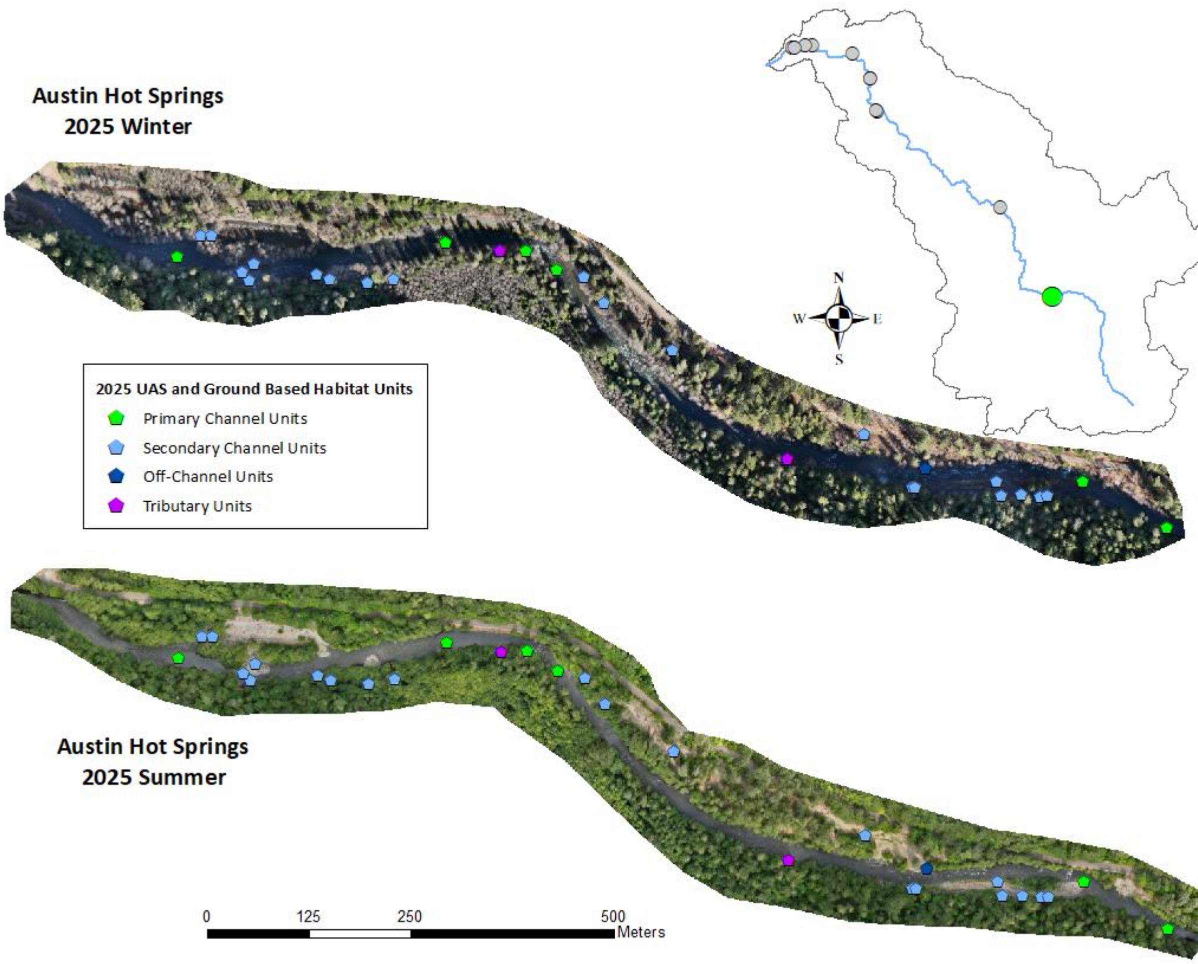

Figure 2. Austin Hot Springs winter and summer 2025 UAS imagery and ground-based survey points.

Barton Natural Area (NA)

The Barton Natural Area is located on the east side of the main channel of the Clackamas River and spans 95 acres, including nearly 32 acres of aquatic habitat. The area is located approximately 0.18 kilometers downstream from Barton Bridge and flows northwest for 864 meters.

In the summer of 2023, the Barton Natural Area underwent restoration enhancements to improve floodplain connectivity, alcove habitat, side channel habitat, and strategically place large woody debris. Figure 3 depicts the Barton Natural Area during the winter and summer of 2025. 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. For analysis, Barton Natural Area is paired with the Middle Control channel.

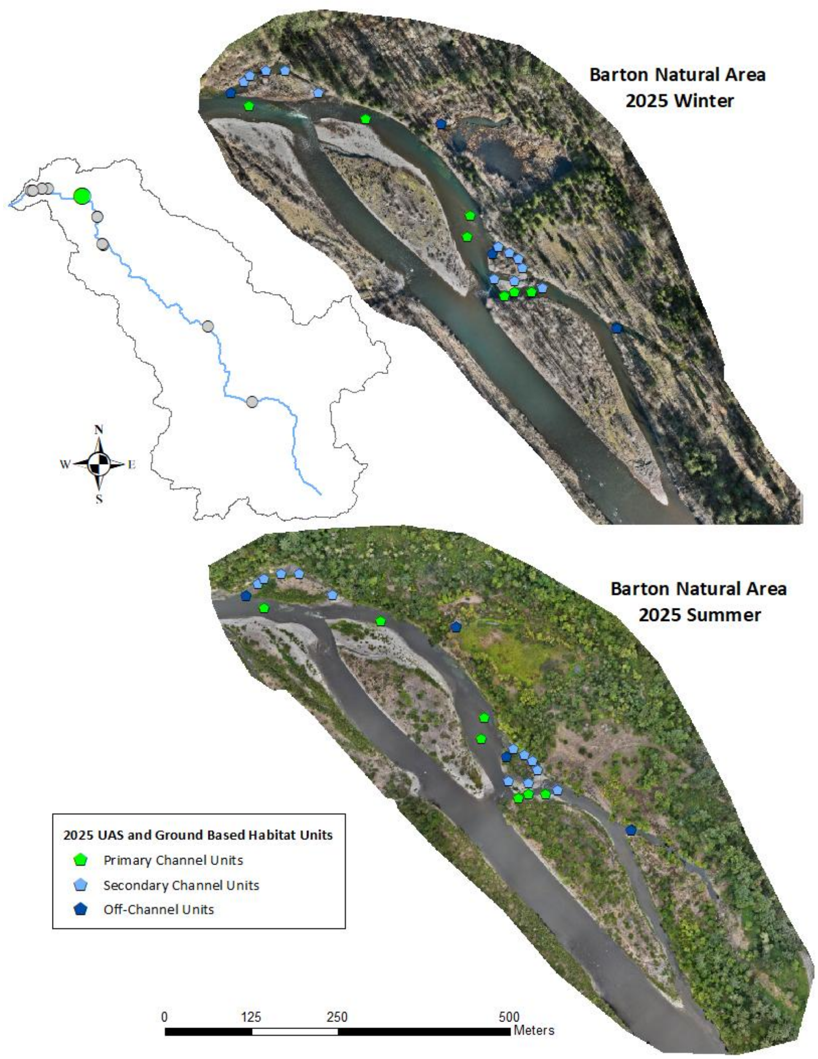

Figure 3. Barton Natural Area winter and summer 2025 UAS imagery and ground-based survey points.

Beebe Island

The Beebe Island side channel is situated on the north side of the Clackamas River's main channel and is located directly adjacent to Johnson "J" Creek. It sits approximately 1.5 kilometers upstream from Riverside Park and flows northwest for 792 meters. Beebe Island is constrained by terraces. While the Valley Width Index (VWI) indicates that the active channel is within a wide valley, the channel has limited ability for lateral movement due to the Clackamas River channel to the south and an industrial area to the north.

Restoration enhancements consisting of large wood placement were implemented in the summer of 2025. Figure 4 visually represents Beebe Island during the winter and summer of 2025. The UAS imagery depicts the area prior to restoration activity. During future pre-post analysis, Beebe Island will be paired with the Lower Control channel.

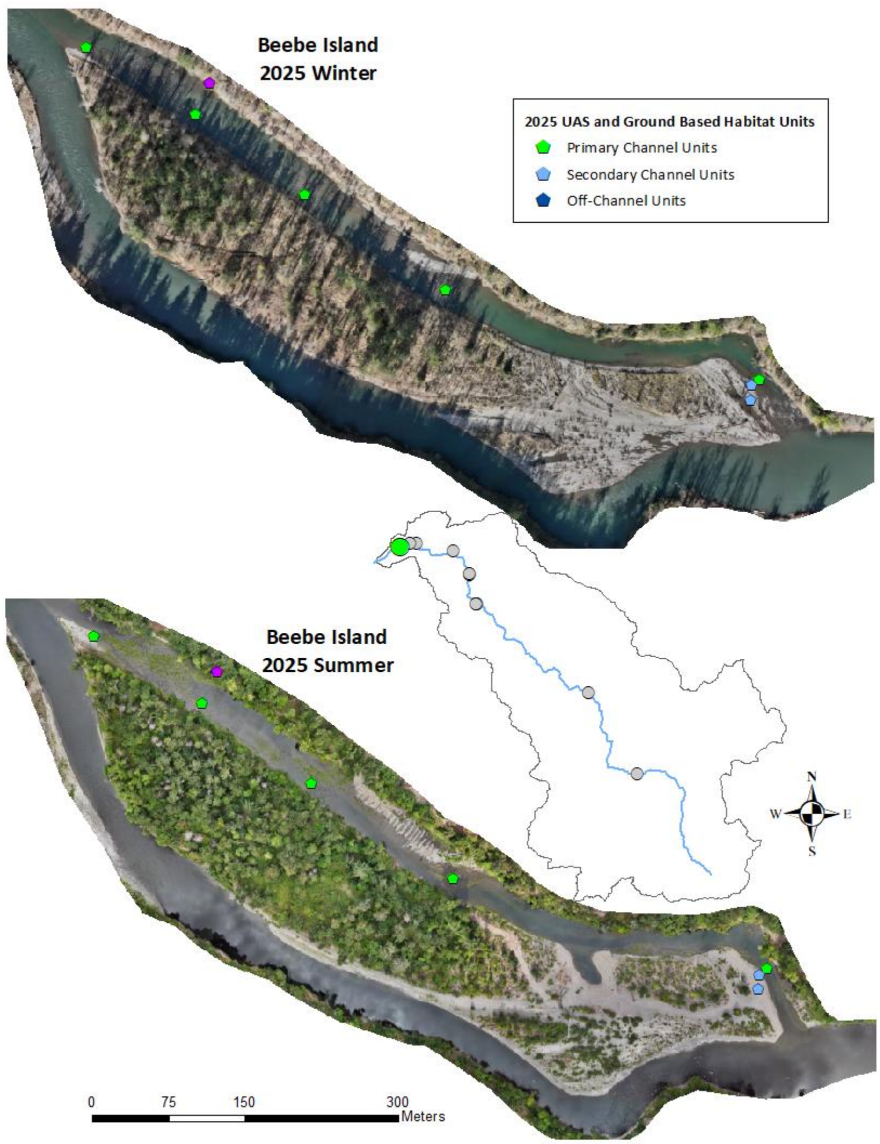

Figure 4. Beebe Island winter and summer 2025 UAS imagery and ground-based survey points.

Eagle Creek Complex

The Eagle Creek Complex began at the confluence with the Clackamas River and extended approximately 520 meters upstream to a point just west of the SE Dowty Road bridge. 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 330 meters across the valley floor.

Restoration efforts occurred at the Eagle Creek Complex during the summer of 2020. Figure 5 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. For analysis, the Eagle Creek Complex is paired with the Middle Control channel.

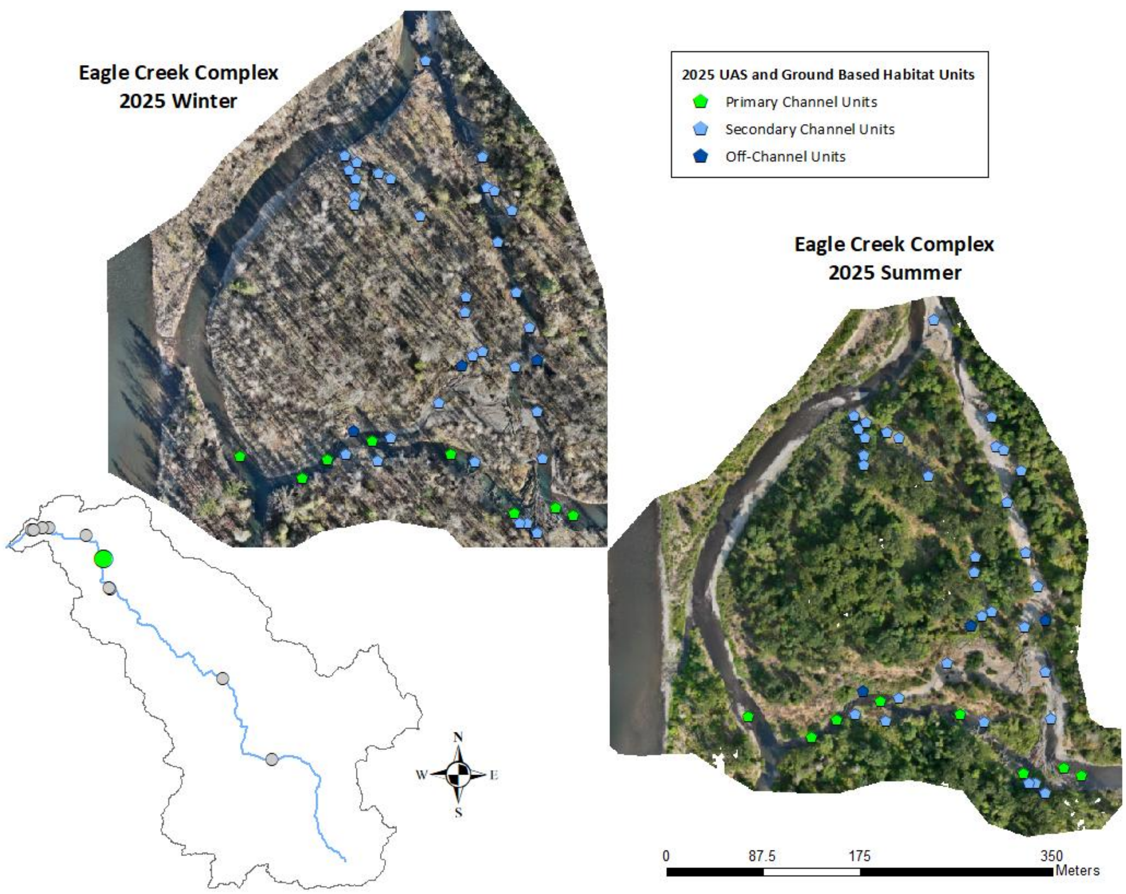

Figure 5. Eagle Creek Complex winter and summer 2025 UAS imagery and ground-based survey points.

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 Beebe Island on the Clackamas River, extends for 527 meters and maintains a perennial connection. The creek is constrained by high terraces, and the Valley Width Index (VWI) indicates that the channel has the potential to shift up to 150 meters between the hillslope features.

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 2025, showing Johnson "J" Creek one year after restoration, as illustrated in Figure 6. For analysis, J Creek is paired with the Lower Control Channel.

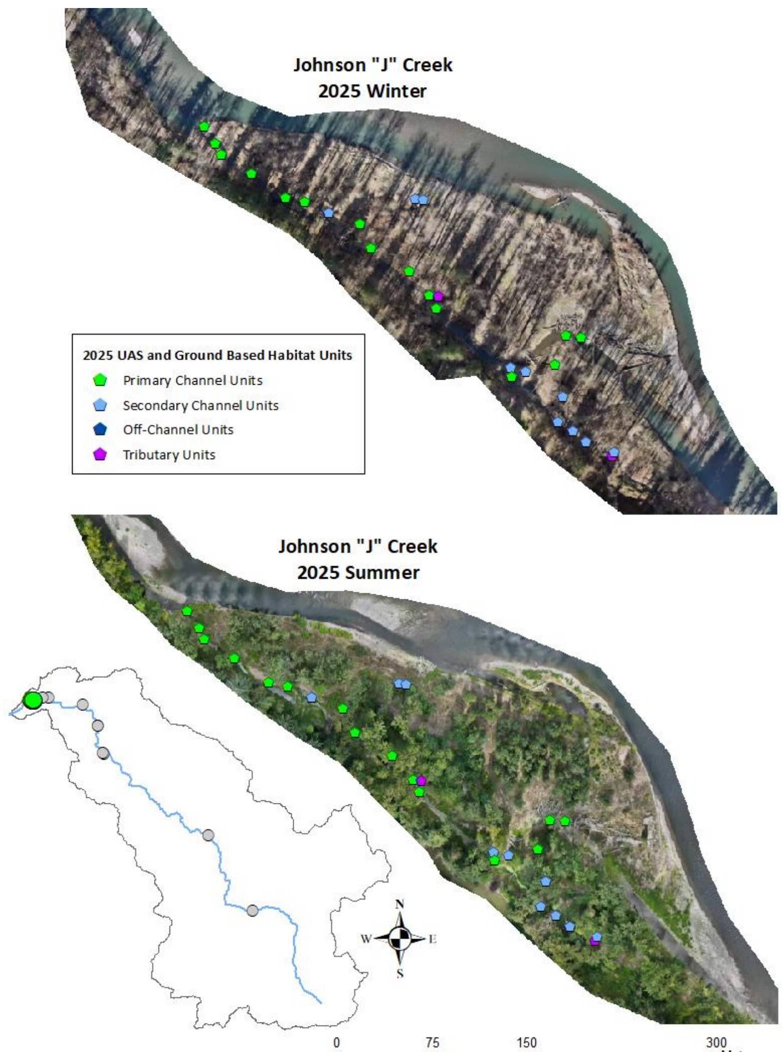

Figure 6. Johnson "J" Creek winter and summer 2025 UAS imagery and ground-based survey points.

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. The Valley Width Index (VWI) indicates that the channel has the potential to shift up to 150 meters between the hillslope and mainstem of the Clackamas River.

Restoration efforts occurred on the Kingfisher Side Channel during late summer 2021. Figure 7 illustrates the Kingfisher Side Channel four years after restoration. The site flows northward for 460 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 with year-round connection and flow. For analysis, Kingfisher Side Channel is paired with the Upper Control channel.

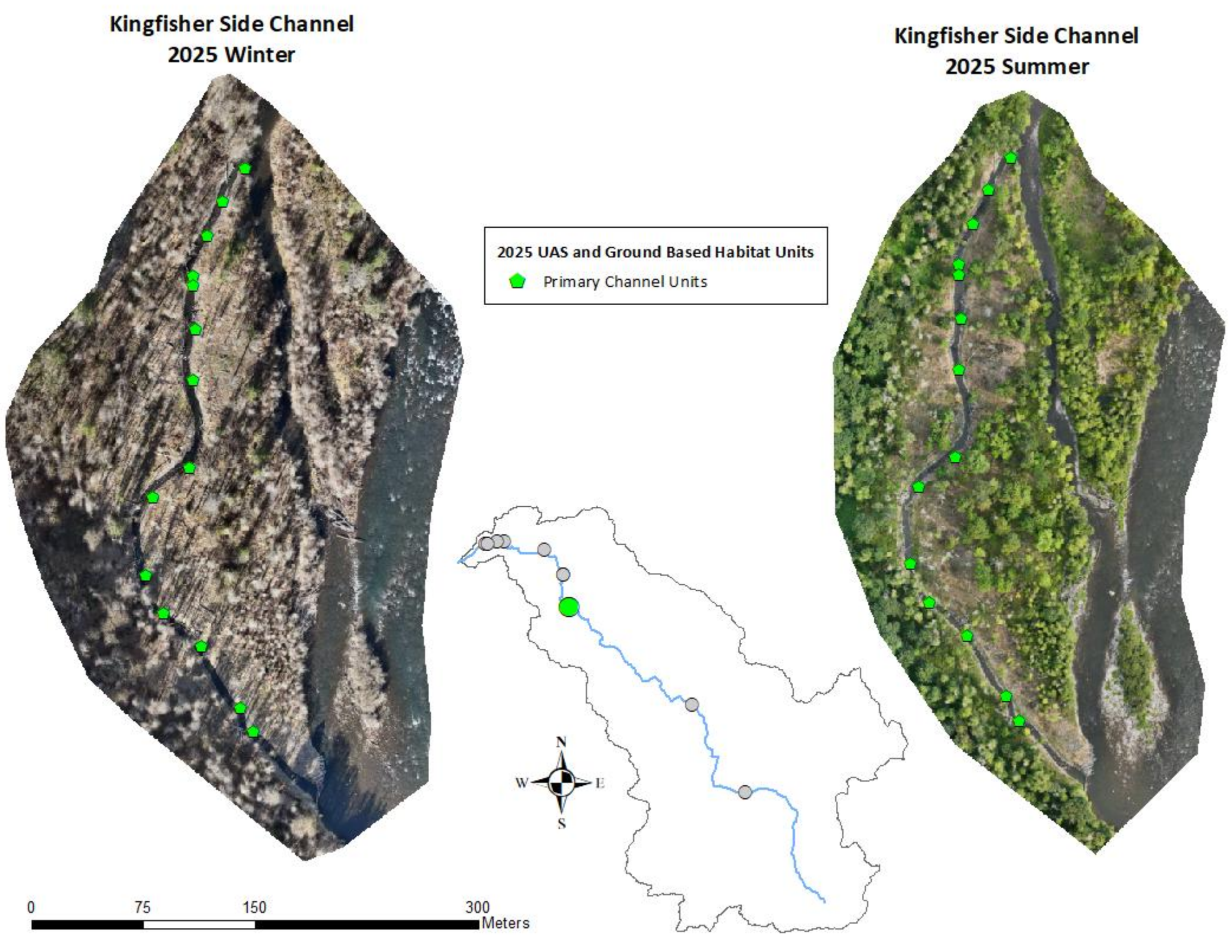

Figure 7. Kingfisher Side Channel winter and summer 2025 UAS imagery and ground-based survey points.

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 8 illustrates the Lower Control Channel during the winter and summer of 2025. 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.

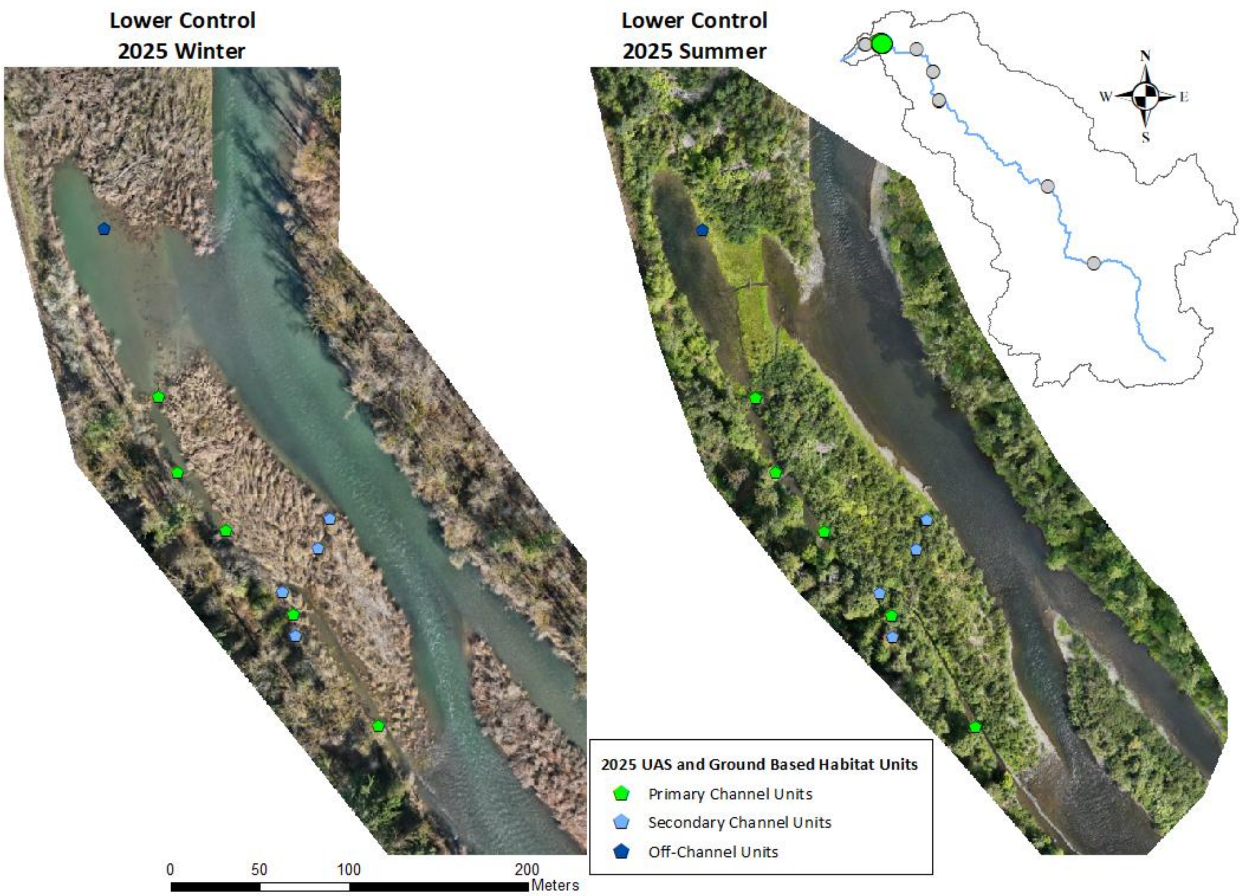

Figure 8. Lower Control winter and summer 2025 UAS imagery and ground-based survey points.

Middle Control Channel

The Middle Control Channel, located on the east side of the Clackamas River's primary channel, flows northward for approximately 350 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 9 visually represents the Middle Control Channel in the winter and summer of 2025. 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.

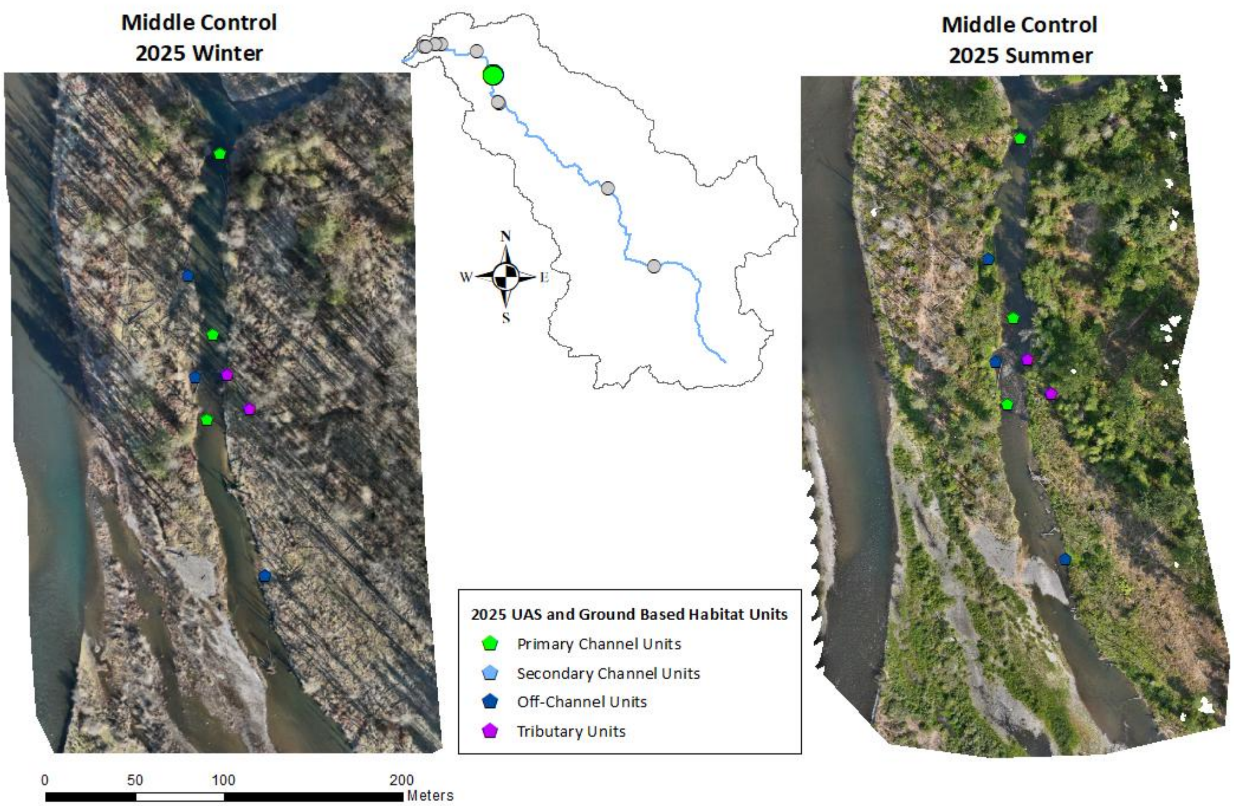

Figure 9. Middle Control winter and summer 2025 UAS imagery and ground-based survey points.

Riverbend (Sieben)

The Riverbend side-channel also includes a tributary, Sieben Creek. The site 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 approximately 730 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 move approximately 200 meters laterally between the Clackamas River and the west-side hillslope. 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 10 depicts the Riverbend side channel three 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 Sieben Creek are dry during summer low-flow conditions. For analysis, Riverbend is paired with the Lower Control channel.

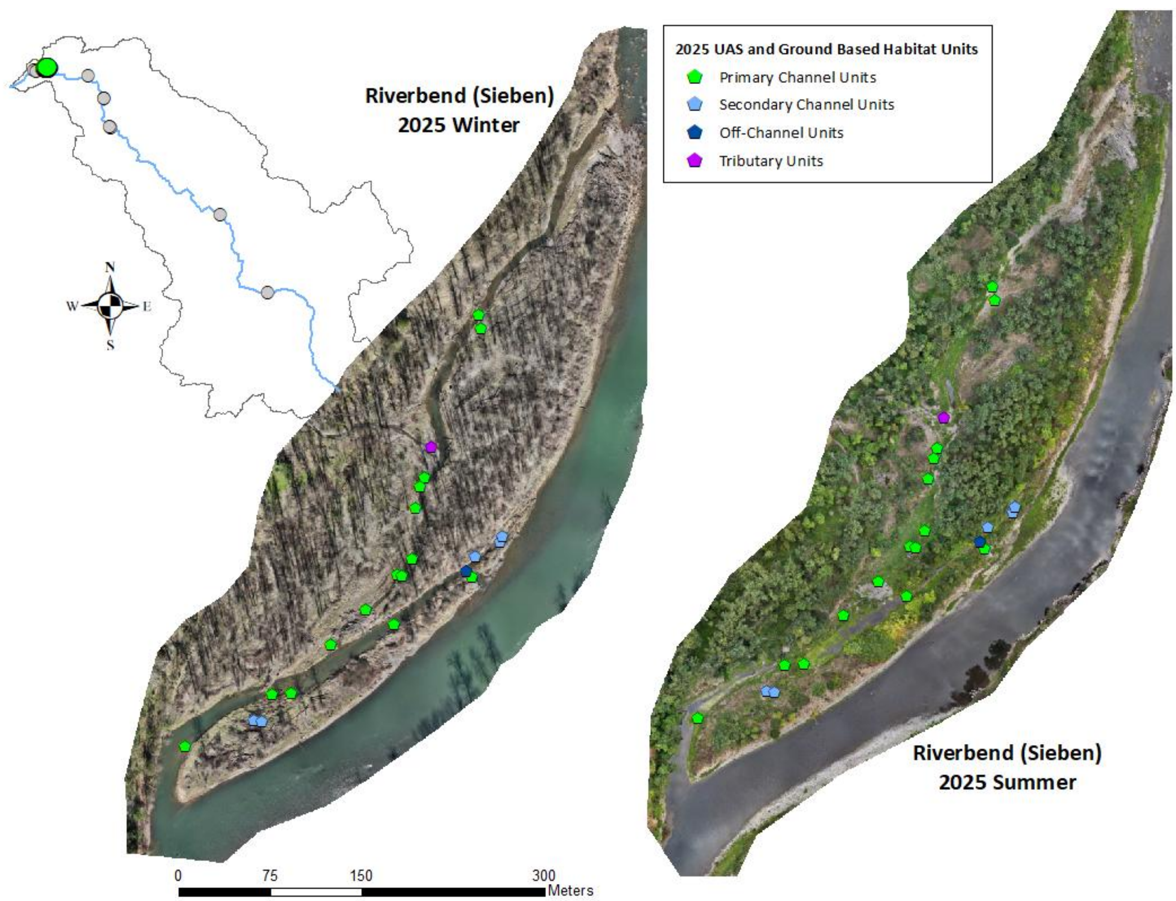

Figure 10. Riverbend (Sieben) winter and summer 2025 UAS imagery and ground-based survey points.

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 187 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 11 visually illustrates the Upper Control Channel during the winter and summer of 2025.

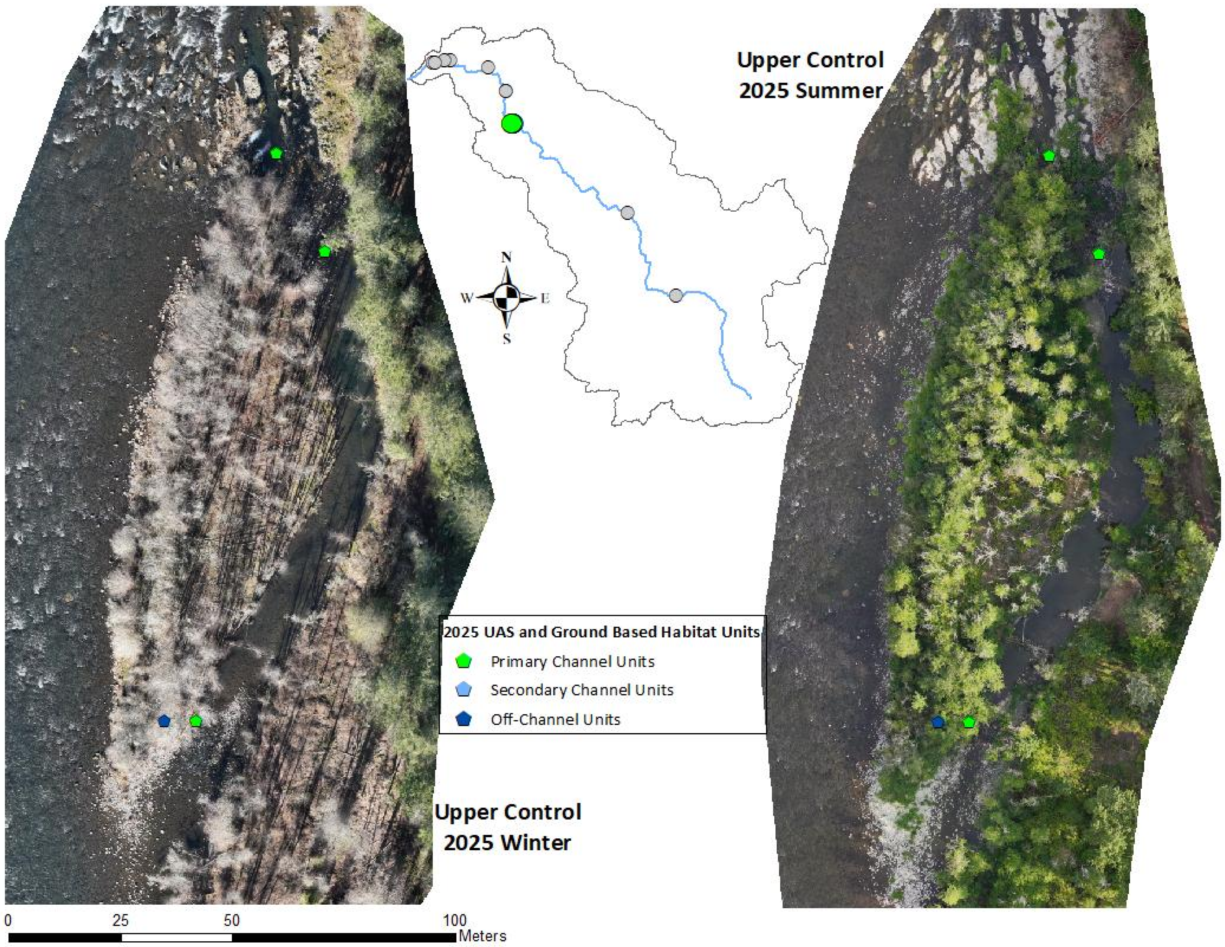

Figure 11. Upper Control winter and summer 2025 UAS imagery and ground-based survey points.

USFS Control

The USFS Control is located approximately 22 kilometers upstream of the North Fork Clackamas River Reservoir. Figure 12 depicts the USFS Control during the winter and summer of 2025. The reach is approximately 1.9 kilometers in length and extends from the downstream end of Sunstrip Campground to the Hole in the Wall boat access site. The Control Reach was surveyed downstream via boat 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 intermittent tributaries. A secondary channel at the Hole in the Wall boat access site provides velocity refuge for juvenile salmonids. The potential movement of the USFS Control is limited to the current location due to the surrounding hillslopes and Highway 224.

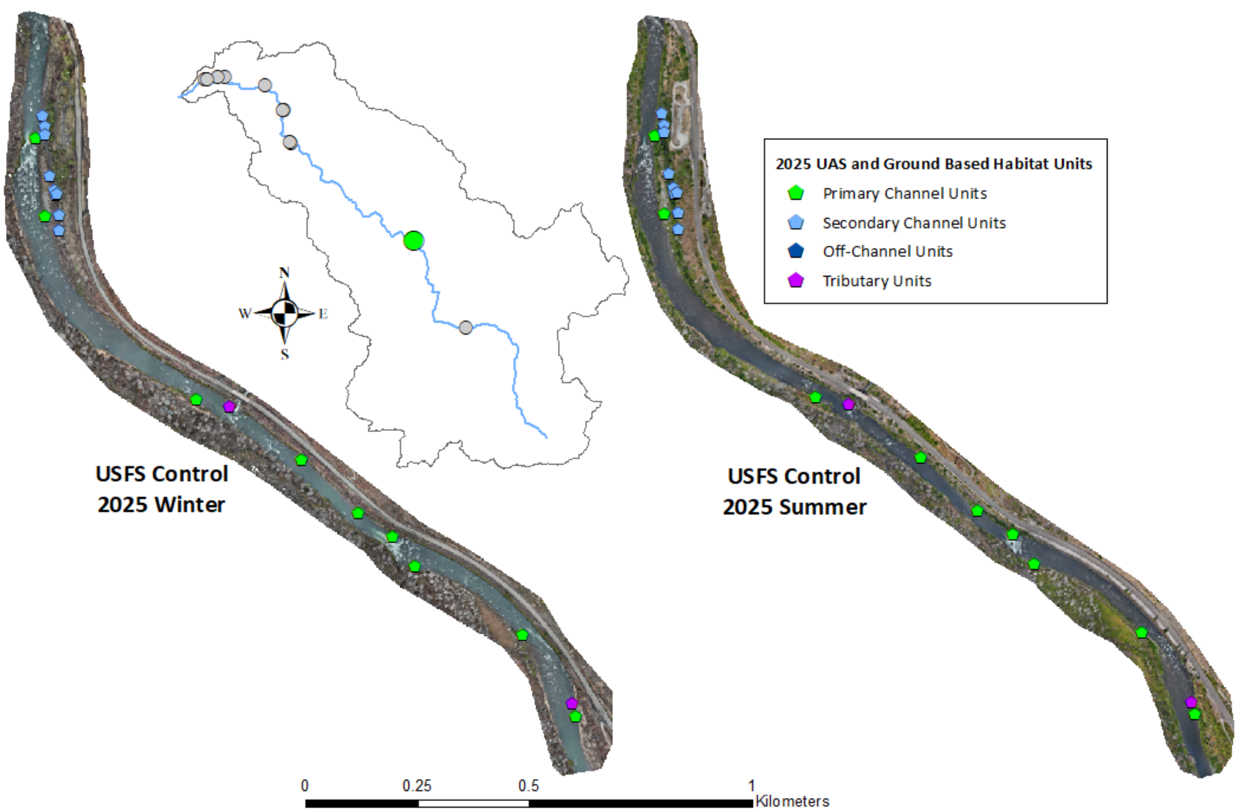

Figure 12. USFS Control winter and summer 2025 UAS imagery and ground-based survey points.

Ground Survey – Physical Habitat

Due to the nature and size of the channels and habitat characteristics, physical habitat ground surveys adhered to methods for wadeable streams (Moore et al. 2007). Surveys were summarized at the reach level to describe channel morphology and the physical structure of stream channel habitat, substrate compositions, and instream wood (including key wood pieces measuring ≥ 12 m in length and ≥ 60 cm diameter) (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 (m) Primary Channel Area (m^2) Secondary Channel Length (m) Secondary Channel Area (m^2) Pool Habitat (%) Off-Channel Pool Habitat (%) Residual Pool Depth (m) Riffle Depth (m)
Substrate Composition	% Fine Sediment (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)
In-stream Wood	Number of Large Wood Pieces Number of Key Large Wood Pieces Volume of Large Wood (m^3)

Snorkel Survey

We evaluated fish presence within pool habitats with a surface area ≥6m^2 and a depth ≥20cm. Juvenile steelhead and cutthroat trout ≥90mm were individually counted as well as all juvenile coho and Chinook salmon. All other visually observed species were noted as present. Snorkel surveys adhered to the methods described in Constable and Suring (2024).

Unoccupied Aircraft System (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 twelve locations across the Clackamas River basin. One logger was installed at each long-term restoration monitoring site (Kingfisher, Eagle Creek, Riverbend, and Austin Hot Springs) and their corresponding control sites (Upper Control, Middle Control, Lower Control, and USFS Control). Temperature loggers were also placed on the mainstem of the Clackamas River directly adjacent to each restoration and control site to capture mainstem river conditions. An additional logger was deployed in September of 2025 at the Eagle Creek Complex in a scour pool that maintains water through hyporheic flow within an intermittent side channel. All other loggers were deployed in April 2024 and operated continuously, recording water temperature every 30 minutes. In 2025, these data were downloaded during site visits in February, May, and September. In addition, we downloaded temperature data from the United States Geological Survey (USGS) Clackamas River monitoring stations at Carter Bridge, Estacada, and Oregon City. USGS data were paired with restoration, mainstem, and control site data as they corresponded to locations in the Clackamas River basin to serve as a baseline reference.

HabRate Model

We used the HabRate model to evaluate habitat quality with respect to production potential of coho and Chinook salmon, steelhead, and cutthroat trout (Burke et al. 2010). HabRate is designed to evaluate salmonid habitat quality based on critical habitat values defined in the literature (see Anlauf and Jones 2007 for summary). Habitat ratings of high, medium, and low are created for each habitat variable and for each stream life stage for coho, Chinook, steelhead, and cutthroat trout. The model output ranks habitat quality from 1 to 3: poor, fair, and good, respectively. Results of the model were evaluated within each surveyed site. Habitat requirements for discrete life history stages (i.e., spawning, egg survival, emergence, summer rearing, and winter rearing) were summarized and used to rate the quality of reaches as poor, fair, or good, based on attributes relating to stream substrate, habitat unit type, cover, and structure (i.e., large wood, undercut banks), and gradient.

Restoration Comparison

Paired t-tests evaluated differences across all habitat metrics for Austin Hot Springs pre- and post-restoration treatments (2024 pre, 2025 post). 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 impact sites (Kingfisher, Eagle Creek Complex, Barton Natural Area, Riverbend, and Johnson “J” Creek) and the control sites (Upper, Middle, and Lower Controls). Comparing the conditions before (Pre) and after (Post) the restoration period (2020-2025). 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).

Methods Comparison

Available habitat area (m^2), wood volume (m^3), and the number of key pieces of large wood were evaluated using both ground-based surveys and UAS imagery. Wetted surface area of discrete habitat units and Individual wood pieces were measured at all sites where both a ground survey and UAS imagery were captured. We then compared results from the ground surveys and UAS imagery using a simple linear regression analysis to assess whether discrepancies existed between the two approaches, and Pearson correlation coefficients were calculated. Method agreement was further evaluated using a Bland-Altman analysis to estimate mean bias and limits of agreement (±1.96 SD). In addition, root mean square error (RMSE) was calculated to quantify the overall deviation between methods (R Development Core Team, 2006).

RESULTS

Results of 2025 Physical Habitat, Snorkel, and UAS Surveys

Austin Hot Springs

UAS and a physical habitat ground survey captured one-year post-restoration stream habitat during average winter flow conditions on March 6, 2025. The total wetted winter surface area of Austin Hot Springs was 29,319.9 m^2. The total wetted summer surface area was 27,928.5 m^2. Austin Hot Springs contained 22,836.0 m^2 of primary channel habitat, 6,483.9 m^2 of secondary channel habitat, and 51.7 m^2 of off-channel pool habitat (Table 2).

Table 2. 2025 channel measurements from UAS and ground-based surveys in Austin Hot Springs.

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)
29,319.9	27,928.5	1,265.0	1,238.4	22,836.0	6,483.9	51.7

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised approximately 8% of the available habitat. The total large wood volume throughout the channel was 351.05 m^3, which is equivalent to 27.75 m^3 per 100 meters of primary channel length. Five key pieces of wood were measured, resulting in 0.40 pieces per 100 meters of primary channel length (Table 3).

Table 3. 2025 physical habitat summary from ground-based surveys in Austin Hot Springs.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
7.87	0.64	0.39	27.75	0.40

*Total/100m of primary channel.

The primary substrate types observed in Austin Hot Springs included boulders (37%), gravel (26%), and cobbles (25%) (Table 4).

Table 4. 2025 summary of streambed substrate in Austin Hot Springs.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
11.16	26.05	25.06	36.91	0.83

*Silt and Sand.

On September 2, 2025, a UAS and snorkel survey were conducted. We snorkeled 100% of the available pool area during the survey. Coho and Chinook salmon, juvenile steelhead, cutthroat trout, and trout fry were observed. In addition, we observed whitefish and counted 43 adult Spring Chinook, and 2 jacks (Table 5).

Table 5. 2025 results of summer snorkel surveys conducted within pool habitats in Austin Hot Springs.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
3,006.35	3,006.35	2,262	26	21	38	43 adult ChS, 2 jacks

Barton Natural Area

UAS and a physical habitat ground survey captured two-year post-restoration stream habitat during average winter flow conditions on February 12, 2025. The total wetted winter surface area of the Barton Natural Area was 37,297.6 m². The total wetted summer surface area of the Barton Natural Area was 18,181.0 m². The Barton Natural Area contained 23,882 m² of primary channel habitat, 13,415.6 m² of secondary channel habitat, and 11,634.0 m² of off-channel pool habitat (Table 6).

Table 6. 2025 channel measurements from UAS and ground-based surveys in the Barton Natural Area.

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)
37,297.6	18,181.0	864	630	23,882.0	13,415.6	11,634.0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 86% of the available habitat. The total large wood volume throughout the channel was 78.53 m³, which is equivalent to 9.09 m³ per 100 meters of primary channel length. Two key pieces of wood were measured, resulting in 0.23 pieces per 100 meters of primary channel length (Table 7).

Table 7. 2025 physical habitat summary from ground-based surveys in the Barton Natural Area.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
86.81	0.87	0.16	9.09	0.23

*Total/100m of primary channel.

The primary substrate types observed in the Barton Natural Area included fine sediments (silt and sand) (34%), cobbles (32%), and gravel (19%) (Table 8).

Table 8. 2025 summary of streambed substrate in the Barton Natural Area.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
34.26	19.09	32.19	9.70	4.75

*Silt and Sand.

On August 28, 2025, a UAS and snorkel survey were conducted. We snorkeled 10 pools, which comprised 95% of the available pool area during the survey. Coho salmon, dace, Redside shiner, Northern Pikeminnow, Largescale sucker, sculpin, sunfish, and mosquitofish were observed (Table 9).

Table 9. 2025 results of summer snorkel surveys conducted within pool habitats in the Barton Natural Area.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
14,377.98	13,706.75	25	0	0	0	dace, shiner, *NPM, Largescale sucker, sculpin, mosquitofish, sunfish

*Northern Pikeminnow.

Beebe Island

UAS and a physical habitat ground survey captured pre-restoration stream habitat conditions during average winter flow conditions on March 5, 2025. The total wetted winter surface area of the Beebe Island side channel was 27,864.0 m². The total wetted summer surface area of Beebe Island was 24,683.7 m². The Beebe Island side channel contained 27,423 m² of primary channel habitat and 441 m² of secondary channel habitat. Beebe Island did not have any off-channel pool habitat (Table 10).

Table 10. 2025 channel measurements from UAS and ground-based surveys in Beebe Island.

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)
27,864.0	24,683.7	792.0	70.0	27,423.0	441.0	0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 37% of the available habitat. The total large wood volume throughout the channel was 32.29 m³, which is equivalent to 4.08 m³ per 100 meters of primary channel length. Two key pieces of wood were measured, resulting in 0.25 pieces per 100 meters of primary channel length (Table 11).

Table 11. 2025 physical habitat summary from ground-based surveys in Beebe Island.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
37.58	0.83	0.47	4.08	0.25

*Total/100m of primary channel.

The primary substrate types observed in the Barton Natural Area included gravel (40%), cobbles (26%), and boulders (23%) (Table 12).

Table 12. 2025 summary of streambed substrate in Beebe Island.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
10.42	40.17	26.47	22.94	0

*Silt and Sand.

On August 28, 2025, a UAS and snorkel survey were conducted. We snorkeled two pools, which comprised 100% of the available pool area during the survey. Dace, Northern Pikeminnow, Largescale suckers, and sculpin were observed native species, while non-natives included mosquitofish, Largemouth bass, and sunfish (Table 13).

Table 13. 2025 results of summer snorkel surveys conducted within pool habitats in Beebe Island.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
8,976.53	8,976.53	0	0	0	0	dace, *NPM, Largescale sucker, sculpin, mosquitofish, Largemouth bass, sunfish

*Northern Pikeminnow.

Eagle Creek Complex

UAS and a physical habitat ground survey captured five-year post-restoration stream habitat conditions during average winter flow conditions on February 11, 2025. The total wetted winter surface area of the Eagle Creek Complex was 20,209.8 m^2. The total wetted summer surface area of Eagle Creek was 9,946.0 m^2. The Eagle Creek Complex contained 10,025 m^2 of primary channel habitat, 10,185 m^2 of secondary channel habitat, and 70.7 m^2 of off-channel pool habitat (Table 14).

Table 14. 2025 channel measurements from UAS and ground-based surveys in the Eagle Creek Complex.

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)
20,209.8	9,946.0	516.0	1,132.2	10,025.0	10,184.8	70.7

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 25% of the available habitat. The total large wood volume throughout the channel was 641.14 m^3, which is equivalent to 124.25 m^3 per 100 meters of primary channel length. Twenty-eight key pieces of wood were measured, resulting in 5.43 pieces per 100 meters of primary channel length (Table 15).

Table 15. 2025 physical habitat summary from ground-based surveys in the Eagle Creek Complex.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
25.91	0.79	0.25	124.25	5.43

*Total/100m of primary channel.

The primary substrate types observed in the Eagle Creek Complex were cobbles (42%) and gravel (33%) (Table 16).

Table 16. 2025 summary of streambed substrate in the Eagle Creek Complex.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
14.80	32.90	42.29	9.39	0.62

*Silt and Sand.

On August 26, 2025, a UAS and snorkel survey were conducted. We snorkeled 100% of the available pool area during the survey. Juvenile coho and Chinook salmon, and cutthroat trout were observed and counted. Trout fry, dace, Northern Pikeminnow, Largescale suckers, and sculpin were observed native species, while non-natives included mosquitofish and Largemouth bass. Additionally, we observed an adipose fin-clipped adult coho salmon (Table 17).

Table 17. 2025 results of summer snorkel surveys conducted within pool habitats in the Eagle Creek Complex.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
6,828.24	6,828.24	414	38	0	22	dace, shiner, *NPM, Largescale sucker, sculpin, mosquitofish, Largemouth bass, 1 adult hatchery coho

*Northern Pikeminnow.

Johnson "J" Creek

UAS and a physical habitat ground survey captured two-year post-restoration stream habitat conditions during average winter flow conditions on March 5, 2025. The total wetted winter surface area of J Creek was 4,552.6 m². The total wetted summer surface area of J Creek was

1,955.6 m². J Creek contained 3,829.5 m² of primary channel habitat and 723.1 m² of secondary channel habitat. J Creek did not have any off-channel pool habitat (Table 18).

Table 18. 2025 channel measurements from UAS and ground-based surveys in Johnson "J" Creek.

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)
4,552.6	1,955.6	526.5	362.0	3,829.5	723.1	0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 70% of the available habitat. The total large wood volume throughout the channel was 218.78 m³, which is equivalent to 41.55 m³ per 100 meters of primary channel length. Eleven key pieces of wood were measured, resulting in 2.09 pieces per 100 meters of primary channel length (Table 19).

Table 19. 2025 physical habitat summary from ground-based surveys in Johnson "J" Creek.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
70.47	0.56	0.31	41.55	2.09

*Total/100m of primary channel.

The primary substrate types observed in J Creek were gravel (33%), cobbles (24%), and fine sediments (23%) (Table 20).

Table 20. 2025 summary of streambed substrate in Johnson "J" Creek.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
23.35	32.94	23.99	9.64	10.08

*Silt and Sand.

On August 27, 2025, a UAS and snorkel survey were conducted. We snorkeled five pools, which comprised 84% of the available pool area during the survey. Juvenile coho were observed and counted. Other native species included dace, shiners, and sculpin, while mosquitofish were the only non-native species observed. Additionally, we observed an adipose fin-clipped adult coho salmon (Table 21).

Table 21. 2025 results of summer snorkel surveys conducted within pool habitats in Johnson “J” Creek.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
1,933.1	1,633.2	85	0	0	0	dace, shiner, sculpin, mosquitofish

Kingfisher Side Channel

UAS and a physical habitat ground survey captured four-year post-restoration stream habitat conditions during average winter flow conditions on February 20, 2025. The total wetted winter surface area of the Kingfisher Side Channel was 3,118.4 m². The total wetted summer surface area of Kingfisher was 2,767.0 m². Kingfisher contained 3,118.4 m² of primary channel habitat, but Kingfisher did not have secondary channel or off-channel pool habitat (Table 22).

Table 62. 2025 channel measurements from UAS and ground-based surveys in the Kingfisher Side Channel.

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)
3,118.4	2,767.0	461.7	0	3,118.4	0	0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 55% of the available habitat. The total large wood volume throughout the channel was 151.20 m³, which is equivalent to 32.75 m³ per 100 meters of primary channel length. Seven key pieces of wood were measured, resulting in 1.52 pieces per 100 meters of primary channel length (Table 23).

Table 23. 2025 physical habitat summary from ground-based surveys in the Kingfisher Side Channel.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
55.34	0.64	0.56	32.75	1.52

*Total/100m of primary channel.

The primary substrate types observed in the Kingfisher Side Channel were boulders (41%), cobbles (28%), and gravel (20%) (Table 24).

Table 24. 2025 summary of streambed substrate in the Kingfisher Side Channel.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
11.35	19.71	27.82	40.90	0.22

*Silt and Sand.

On August 25, 2025, a UAS and snorkel survey were conducted. We snorkeled eight pools, which comprised 100% of the available pool area during the survey. Juvenile Chinook were observed and counted. Other native species included dace, Northern Pikeminnow, Largescale suckers, and sculpin. Mosquitofish were the only non-native species observed (Table 25).

Table 25. 2025 results of summer snorkel surveys conducted within pool habitats in the Kingfisher Side Channel.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
1,445.6	1,445.6	0	0	0	64	dace, sculpin, *NPM, Largescale sucker, mosquitofish

*Northern Pikeminnow.

Lower Control

UAS and a physical habitat ground survey captured stream habitat conditions during average winter flow conditions on March 5, 2025. The total wetted winter surface area of the Lower Control was 10,443.1 m^2. The total wetted summer surface area of the Lower Control was 5,192.9 m^2. The Lower Control contained 2,697.5 m^2 of primary channel habitat and 7,745.6 m^2 of secondary channel habitat. But most of the secondary channel area is comprised of a single alcove that creates 7,191.0 m^2 of off-channel pool habitat (Table 26).

Table 26. 2025 channel measurements from UAS and ground-based surveys in the Lower Control.

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)
10,443.1	5,192.9	251.0	226.0	2,697.5	7,745.6	7,191.0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 75% of the available habitat. The total large wood volume throughout the channel was 16.1 m^3, which is equivalent to 6.41 m^3 per 100 meters of primary channel length. One key piece of wood was measured, resulting in 0.40 pieces per 100 meters of primary channel length (Table 27).

Table 27. 2025 physical habitat summary from ground-based surveys in the Lower Control.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
75.53	0.16	0.23	6.41	0.40

*Total/100m of primary channel.

The primary substrate types observed in the Lower Control were cobbles (32%), gravel (28%), fine sediments (22%), and boulders (19%) (Table 28).

Table 28. 2025 summary of streambed substrate in the Lower Control.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
21.68	27.73	31.98	18.61	0

*Silt and Sand.

On August 27, 2025, a UAS and snorkel survey were conducted. We snorkeled three pools, which comprised 100% of the available pool area during the survey. Native species included dace, Northern Pikeminnow, Largescale suckers, and sculpin. Mosquitofish, Largemouth bass, and Pumpkinseed sunfish were the non-native species observed (Table 29).

Table 29. 2025 results of summer snorkel surveys conducted within pool habitats in the Lower Control.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
4,003.4	4,003.4	0	0	0	0	dace, sculpin, *NPM, Largescale sucker, mosquitofish, Largemouth bass, Pumpkinseed

*Northern Pikeminnow.

Middle Control

UAS and a physical habitat ground survey captured stream habitat conditions during average winter flow conditions on February 11, 2025. The total wetted winter surface area of the Middle Control was 6,109.9 m^2. The total wetted summer surface area of the Middle Control was 4,488.4 m^2. The Middle Control contained 5,888.0 m^2 of primary channel habitat, 221.9 m^2 of secondary channel habitat, and 184.1 m^2 of off-channel pool habitat (Table 30).

Table 30. 2025 channel measurements from UAS and ground-based surveys in Middle Control.

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)
6,109.9	4,488.4	349.0	104.0	5,888.0	221.9	184.1

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 87% of the available habitat. The total large wood volume throughout the channel was 44.64 m^3, which is equivalent to 12.79 m^3 per 100 meters of primary channel length. Middle Control did not have any key pieces of wood (Table 31).

Table 71. 2025 physical habitat summary from ground-based surveys in the Middle Control.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
87.78	0.42	0.25	12.79	0

*Total/100m of primary channel.

The primary substrate types observed in the Middle Control were cobbles (34%), gravel (32%), and fine sediments (28%) (Table 32).

Table 32. 2025 summary of streambed substrate in the Middle Control.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
27.89	32.16	34.54	5.42	0

*Silt and Sand.

On August 26, 2025, a UAS and snorkel survey were conducted. We snorkeled three pools, which comprised 100% of the available pool area during the survey. Native species included dace, Northern Pikeminnow, and sculpin. Largemouth bass and Smallmouth bass were the non-native species observed (Table 33).

Table 33. 2025 results of summer snorkel surveys conducted within pool habitats in the Middle Control.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
3,898.9	3,898.9	0	0	0	1	dace, sculpin, *NPM, Largemouth bass, Smallmouth bass

*Northern Pikeminnow.

Riverbend (Sieben)

UAS and a physical habitat ground survey captured three-year post-restoration stream habitat conditions during average winter flow conditions on March 5, 2025. The total wetted winter surface area of Riverbend was 7,516.7 m². The total wetted summer surface area of Riverbend was 1,876.9 m². Riverbend contained 6,091.0 m² of primary channel habitat, 1,425.7 m² of secondary channel habitat, and 110.0 m² of off-channel pool habitat (Table 34).

Table 34. 2025 channel measurements from UAS and ground-based surveys in Riverbend (Sieben).

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)
7,516.7	1,876.9	734.2	224.8	6,091.0	1,425.7	110.0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 70% of the available habitat. The total large wood volume throughout the channel was 139.13 m³, which is equivalent to 18.95 m³ per 100 meters of primary channel length. Five key pieces of wood were measured, resulting in 0.68 pieces per 100 meters of primary channel length (Table 35).

Table 85. 2025 physical habitat summary from ground-based surveys in Riverbend (Sieben).

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m³)	*Key Wood Pieces
72.52	0.63	0.21	18.95	0.68

*Total/100m of primary channel.

The primary substrate types observed in Riverbend were gravel (38%), fine sediments (29%), and cobbles (20%) (Table 36).

Table 36. 2025 summary of streambed substrate in Riverbend (Sieben).

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
28.73	38.15	20.02	11.54	1.56

*Silt and Sand.

On August 27, 2025, a UAS and snorkel survey were conducted. We snorkeled two pools, which comprised 88% of the available pool area during the survey. We only observed native minnow and cottid species within the Riverbend restoration site: dace, Northern Pikeminnow, and sculpin (Table 37).

Table 37. 2025 results of summer snorkel surveys conducted within pool habitats in Riverbend (Sieben).

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
1550.0	1,370.0	0	0	0	0	dace, sculpin, *NPM

*Northern Pikeminnow.

Upper Control

UAS and a physical habitat ground survey captured stream habitat conditions during average winter flow conditions on February 20, 2025. The total wetted winter surface area of the Upper Control was 2,616.9 m^2. The total wetted summer surface area of the Upper Control was 2,026.8 m^2. The Upper Control contained 2,567.5 m^2 of primary channel habitat. The entire Upper Control secondary channel area consisted of a single alcove that created 49.4 m^2 of off-channel pool habitat (Table 38).

Table 38. 2025 channel measurements from UAS and ground-based surveys in the Upper Control.

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)
2,616.9	2,026.8	187.0	13.0	2,567.5	49.4	49.4

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised over 55% of the available habitat. The Upper Control did not have any large wood pieces within the bounds of the active channel (Table 39).

Table 99. 2025 physical habitat summary from ground-based surveys in the Upper Control.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
55.54	1.25	0.50	0	0

*Total/100m of primary channel.

The primary substrate types observed in the Upper Control were boulders (32%), cobbles (30%), and gravel (18%) (Table 40).

Table 100. 2025 summary of streambed substrate in the Upper Control.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
11.52	18.34	30.00	31.57	8.56

*Silt and Sand.

On August 25, 2025, a UAS and snorkel survey were conducted. We snorkeled one pool, which comprised 100% of the available pool area during the survey. Native species included dace and cutthroat trout. Mosquitofish were the only non-native species observed (Table 41).

Table 41. 2025 results of summer snorkel surveys conducted within pool habitats in the Upper Control.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
1,690.0	1,690.0	0	3	0	0	dace, mosquitofish

USFS Control

UAS and a physical habitat ground survey captured stream habitat conditions during average winter flow conditions on March 10, 2025. The total wetted winter surface area of the USFS Control was 92,645.4 m^2. The total wetted summer surface area of the USFS Control was 78,196.3 m^2. The USFS Control contained 91,151.0 m^2 of primary channel habitat and 1,494.4 m^2 of secondary habitat. There was no off-channel pool habitat in the USFS Control (Table 42).

Table 411. 2025 channel measurements from UAS and ground-based surveys in the USFS Control.

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)
92,645.4	78,196.3	1;889.0	361.5	91,151.0	1,494.4	0

*Measurement captured via UAS. **Alcoves, Backwaters, Isolated pools.

Pool habitat comprised approximately 18% of the available habitat. The total large wood volume throughout the USFS Control was 81.48 m^3, which is equivalent to 4.31 m^3 per 100 meters of primary channel length. Five key pieces of wood were measured, resulting in 0.26 pieces per 100 meters of primary channel length (Table 43).

Table 412. 2025 physical habitat summary from ground-based surveys in the USFS Control.

Pool Habitat (%)	Residual Pool Depth (m)	Riffle Depth (m)	*Wood Volume (m^3)	*Key Wood Pieces
18.47	2.19	0.74	4.31	0.26

*Total/100m of primary channel.

The primary substrate types observed in the USFS Control were cobbles (43%) and boulders (36%) (Table 44).

Table 134. 2025 summary of streambed substrate in the USFS Control.

% *Fines	% Gravel	% Cobble	% Boulder	% Bedrock
4.01	14.74	43.44	36.21	1.60

*Silt and Sand.

On September 3, 2025, a UAS and snorkel survey were conducted. We snorkeled five pools, which comprised 99% of the available pool area during the survey. We only observed native species in the USFS Control: juvenile coho, Chinook, and steelhead, trout fry, whitefish, and Largescale suckers. Additionally, we counted one jack and 34 adult Spring Chinook (Table 45).

Table 414. 2025 results of summer snorkel surveys conducted within pool habitats in the USFS Control.

Pool Area (m^2)	Snorkel Area (m^2)	Sum of Coho	Sum of Cutthroat	Sum of Steelhead	Sum of Chinook	Other fish observed
9,008.8	8,900.8	180	0	66	2	trout fry, whitefish, Largescale sucker, 34 adult ChS, 1 jack

Results of 2025 Temperature Monitoring

Austin Hot Springs and USFS Control

Water temperature data were collected within the Austin Hot Springs restoration site and USFS Control site (primary channel and secondary channel locations) using HOBO TidbiT temperature loggers and downloaded between January and September of 2025. In addition, 2025 temperature data were downloaded from the USGS Carter Bridge monitoring location to serve as a baseline reference between January 1st and September 30th. The USFS Control mainstem logger has data gap for the month of February due to a settings issue. The logger was mistakenly set to record every minute (rather than every 30 minutes), and the storage was filled prior to download (Figure 13).

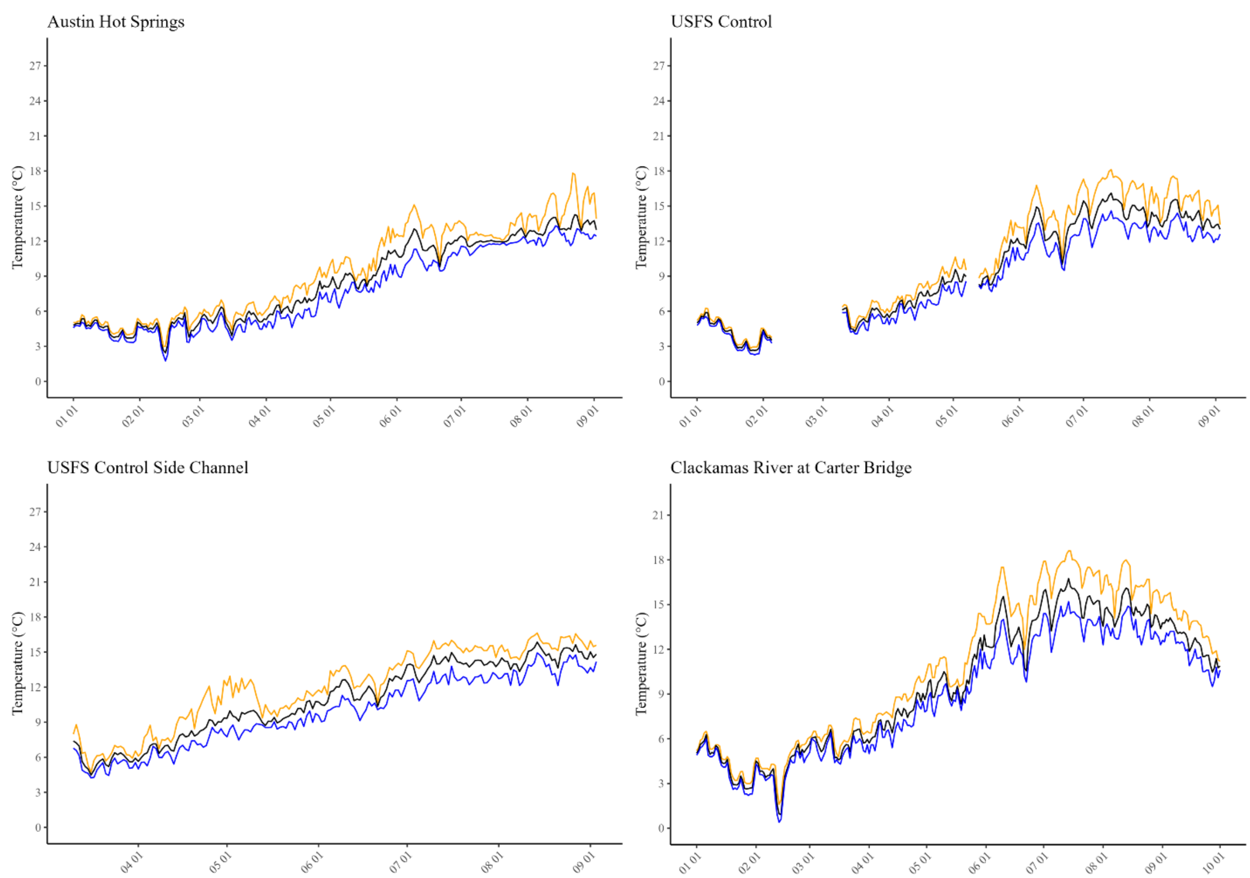

Figure 13. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends for Austin Hot Springs, USFS Control mainstem, USFS Control side channel, and the USGS monitoring station at Carter Bridge.

Eagle Creek Complex and Middle Control

Water temperature data were collected within the Eagle Creek restoration site, Middle Control channel, and mainstem Clackamas River (Middle Clackamas River) using HOBO TidbiT temperature loggers and downloaded between January and September of 2025. The Middle Clackamas River logger is located immediately upstream of Eagle Creek and Middle Control. In addition, 2025 temperature data were downloaded from the USGS Estacada monitoring location to serve as a baseline reference between January 1st and September 30th. Eagle Creek, Middle Clackamas, and Middle Control loggers have a data gap from February 8th through May 13th due to a settings issue. The loggers were mistakenly set to record every minute (rather than every 30 minutes), and the storage was filled prior to download (Figure 14).

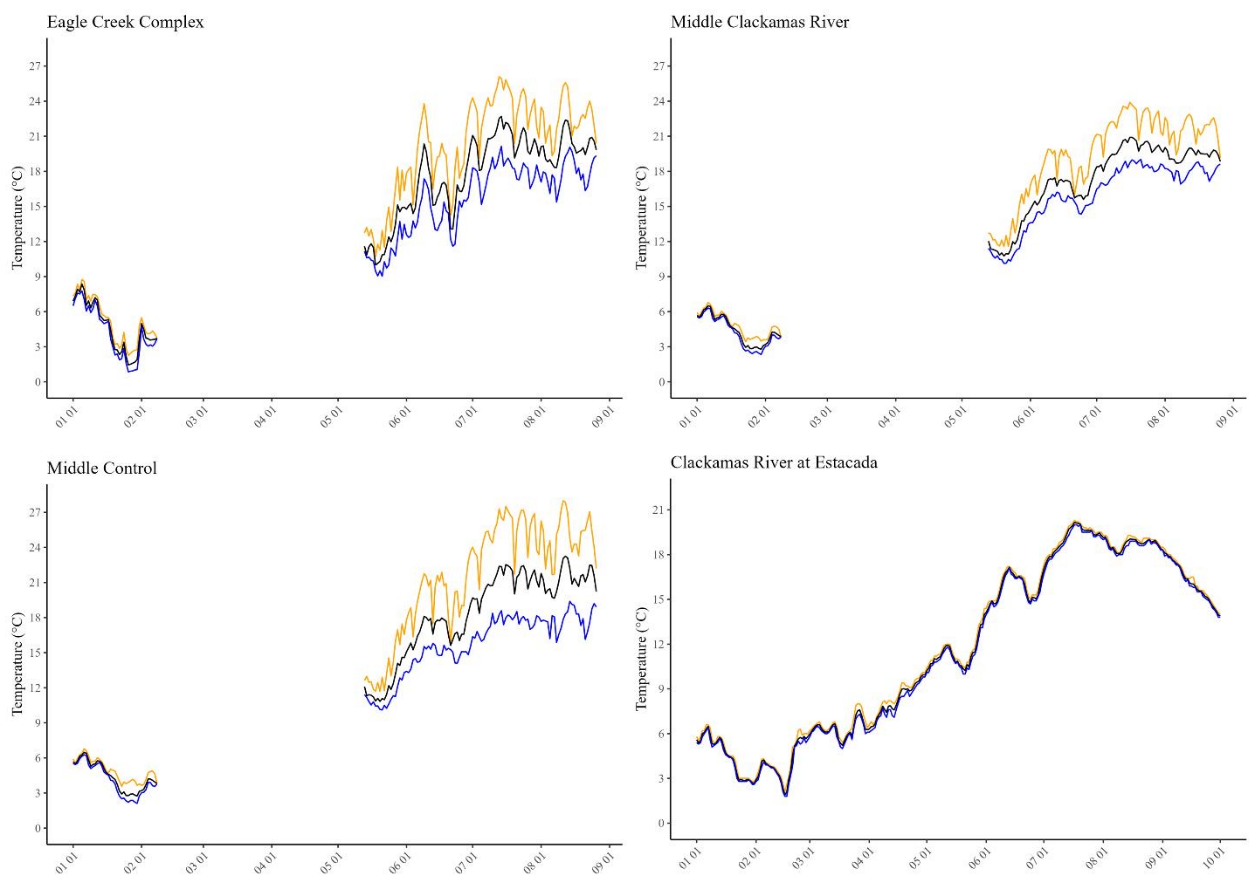

Figure 14. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends for Eagle Creek Complex, Middle Clackamas River, Middle Control channel, and the USGS monitoring station at Estacada.

Kingfisher Side Channel and Upper Control

Water temperature data were collected within the Kingfisher Side Channel, Upper Control channel, and mainstem Clackamas River (Upper Clackamas River) using HOBO TidbiT temperature loggers and downloaded between January and September of 2025. The Upper Clackamas River logger is located immediately adjacent to Kingfisher and Upper Control. In addition, 2025 temperature data were downloaded from the USGS Estacada monitoring location to serve as a baseline reference between January 1st and September 30th. Kingfisher, Upper Clackamas, and Upper Control loggers have a data gap from February 7th through May 13th due to a settings issue. The loggers were mistakenly set to record every minute (rather than every 30 minutes), and the storage was filled prior to download (Figure 15).

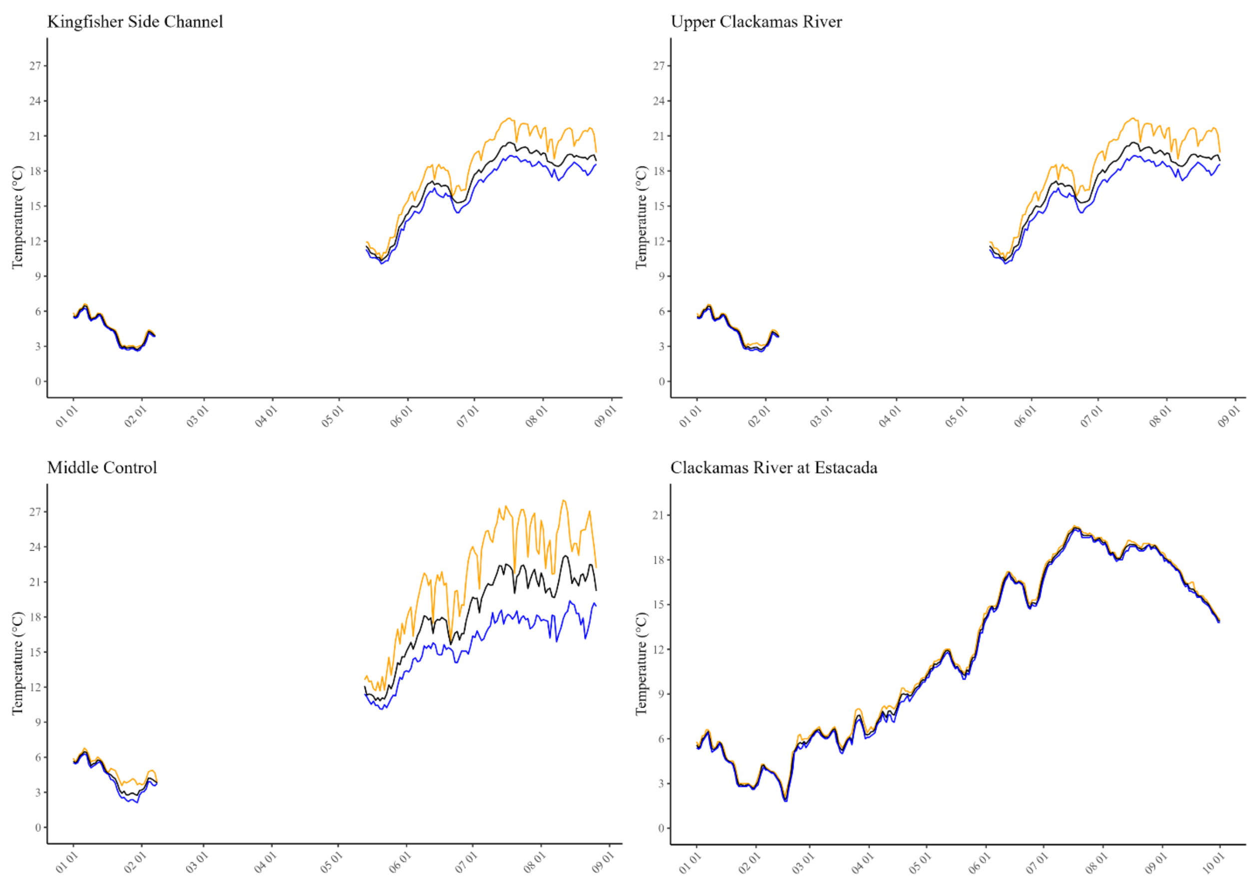

Figure 15. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends for Kingfisher Side Channel, Upper Clackamas River, Upper Control channel, and the USGS monitoring station at Estacada.

Riverbend (Sieben) and Lower Control

Water temperature data were collected within the Riverbend restoration site, Lower Control channel, and mainstem Clackamas River (Lower Clackamas River) using HOBO TidbiT temperature loggers and downloaded between January and September of 2025. The Lower Clackamas River logger is located on the west side of the river directly between Riverbend and Lower Control. In addition, 2025 temperature data were downloaded from the USGS Clackamas River at Oregon City monitoring location to serve as a baseline reference between January 1st and September 30th. Riverbend, Lower Clackamas, and Lower Control loggers experienced data gaps in 2025 due to a settings issue. The loggers were mistakenly set to record every minute (rather than every 30 minutes), and the storage was filled prior to download. Riverbend and Loer Clackamas River both have missing data from February 8th through May 15th, and the Lower Control has data gaps from February 8th through March 5th and again from May 11th to May 13th (Figure 16).

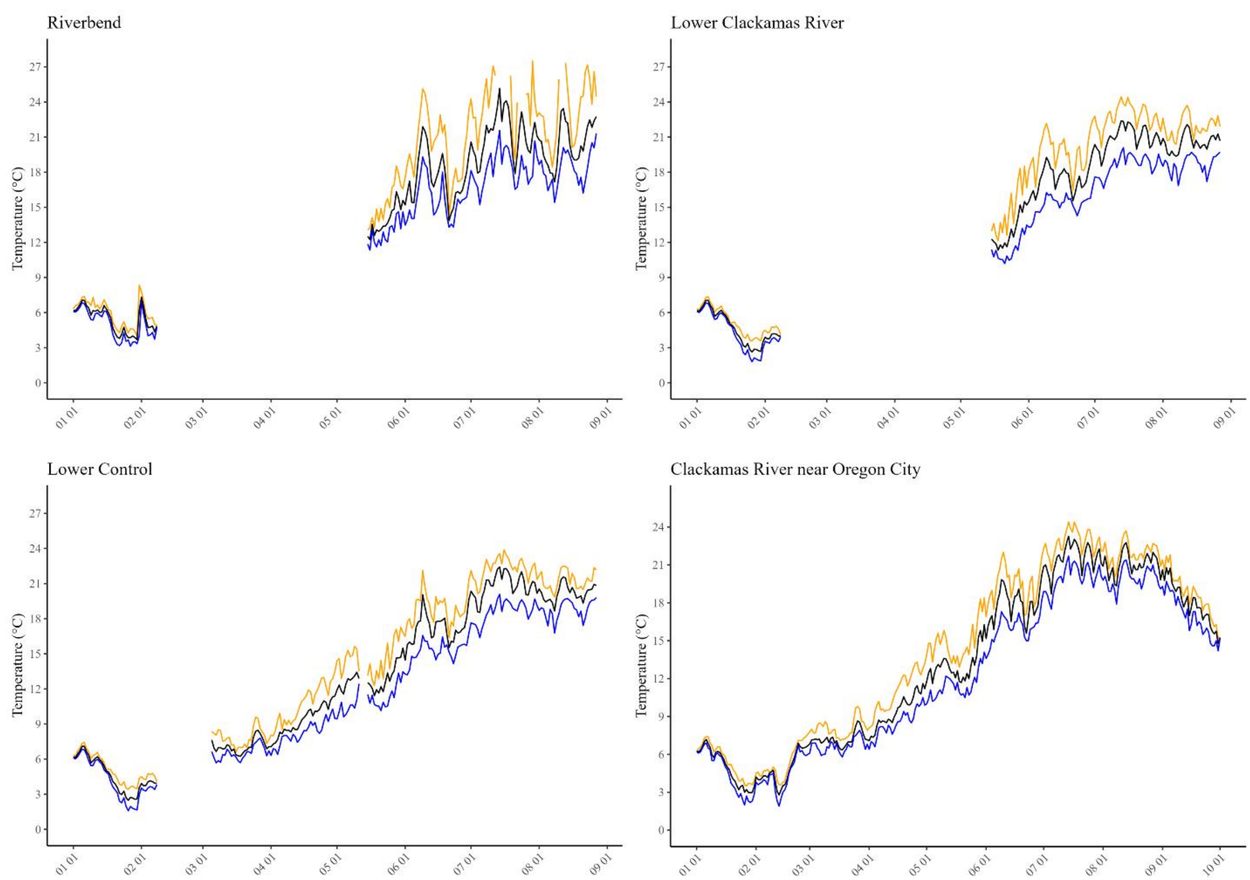

Figure 16. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends for Riverbend (Sieben), Lower Clackamas River, Lower Control channel, and the USGS Clackamas River monitoring station at Oregon City.

Results of HabRate Model

Austin Hot Springs

Prior to restoration activities, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within Austin Hot Springs was poor to fair across salmonid life history types. Species-specific averages for these life history types ranged from 1.3 (coho) to 2.2 (steelhead). Following the restoration efforts, the overall habitat rating improved for Chinook salmon, steelhead, and cutthroat trout while it remained unchanged for coho salmon (Table 45).

Table 45. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Austin Hot Springs.

Steelhead Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2024	1	2	3	2	3	2.2
2025	3	2	3	2	3	2.6

Cutthroat Trout Habitat					
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2024	1	2	2	2	1.8
2025	3	2	2	2	2.3

Chinook Salmon Habitat				
Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2024	1	2	2	1.6
2025	3	2	2	2.3

Coho Habitat				
Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2024	2	1	1	1.3
2025	2	1	1	1.3

Barton Natural Area

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 overall habitat rating improved for Chinook salmon, steelhead, and cutthroat trout while it remained unchanged for coho salmon (Table 46).

Table 415. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Barton NA.

Steelhead Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2023	1	2	2	2	1	1.4
2025	2	2	2	2	3	2.4
Cutthroat Trout Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer		Cutthroat Avg
2023	1	2	2	2		1.75
2025	2	2	2	2		2.0
Chinook Salmon Habitat						
Year	Spawning to Emergence	0+ Summer		0+ Winter		Chinook Avg
2023	1	2		2		1.6
2025	2	2		2		2.0
Coho Habitat						
Year	Spawning to Emergence	0+ Summer		0+ Winter		Coho Avg
2023	1	2		3		2.0
2025	2	2		2		2.0

Beebe Island

Pre-restoration treatment results from the HabRate model (Burke et al. 2010) suggest stream habitat quality within the Beebe Island channel was poor to fair across salmonid life history types. Species-specific averages for these life history types ranged from 1.3 (coho) to 2.3 (Chinook) (Table 47).

Table 47. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Beebe Island.

Steelhead Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2025	3	2	2	2	2	2.2
Cutthroat Trout Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer		Cutthroat Avg
2025	2	1	1	2		1.5
Chinook Salmon Habitat						
Year	Spawning to Emergence	0+ Summer		0+ Winter		Chinook Avg
2025	3	2		2		2.3
Coho Habitat						
Year	Spawning to Emergence	0+ Summer		0+ Winter		Coho Avg
2025	2	1		1		1.3

Eagle Creek Complex

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 2.3 (cutthroat and Chinook) to 2.7 (coho salmon). In 2025, five years post-restoration, the habitat rating in the Eagle Creek complex remained relatively unchanged for all species-specific averages across life history types, ranging from 2.0 (Chinook) to 2.4 (steelhead) (Table 48).

Table 48. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Eagle Creek Complex.

Steelhead Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2020	1	3	3	2	3	2.4
2025	1	3	3	2	3	2.4

Cutthroat Trout Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2020	2	3	2	2	2.3
2025	2	3	2	2	2.3

Chinook Salmon Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2020	1	3	3	2.3
2025	1	2	3	2.0

Coho Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2020	2	3	3	2.7
2025	2	3	2	2.3

Johnson "J" Creek

Prior to restoration activities, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within Johnson "J" Creek were mostly poor across salmonid life history types. Species-specific averages for these life history types ranged from 1.0 for steelhead to 1.7 for Chinook salmon and coho salmon. In 2025, two years post-restoration treatment, the habitat rating improved for steelhead and cutthroat trout but remained unchanged for coho salmon and Chinook salmon (Table 49).

Table 49. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Johnson "J" Creek.

Steelhead Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2023	1	1	1	1	1	1.0
2025	1	2	2	2	2	1.8

Cutthroat Trout Habitat					
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2023	1	2	1	2	1.5
2025	2	2	2	2	2.0

Chinook Salmon Habitat				
Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2023	1	2	2	1.7
2025	1	2	2	1.7

Coho Habitat				
Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2023	1	2	2	1.7
2025	1	2	2	1.7

Kingfisher Side Channel

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 1.8 (cutthroat trout). Following restoration efforts, the habitat rating improved for all species. 2025 species-specific averages for life history types ranged from 2.0 (coho) to 3.0 (steelhead and Chinook) (Table 50).

Table 50. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Kingfisher Side Channel.

Steelhead Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2021	1	2	1	1	1	1.2
2025	3	3	3	3	3	3.0

Cutthroat Trout Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2021	1	2	2	2	1.8
2025	3	2	3	2	2.5

Chinook Salmon Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2021	1	2	2	1.7
2025	3	3	3	3.0

Coho Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2021	1	1	2	1.3
2025	2	3	1	2.0

Lower Control Channel

Results of the HabRate model (Burke et al. 2010) in 2020 suggested habitat quality within the Lower Control ranged from poor-fair to fair-good. The species-specific averages ranged from 1.7 (coho) to 2.6 (steelhead). In 2025, habitat quality ranged from fair to fair-good, and species-specific averages for life history types ranged from 2.0 (Chinook and cutthroat) to 2.6 (steelhead) (Table 51).

Table 51. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Lower Control.

Steelhead Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2020	2	2	3	2	3	2.6
2025	2	2	3	2	3	2.6

Cutthroat Trout Habitat					
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2020	2	3	2	2	2.3
2025	2	2	2	2	2.0

Chinook Salmon Habitat				
Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2020	2	2	2	2.0
2025	2	2	2	2.0

Coho Habitat				
Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2020	2	1	2	1.7
2025	2	2	3	2.3

Middle Control Channel

Results of the HabRate model (Burke et al. 2010) in 2020 suggested habitat quality within the Middle Control ranged from poor-fair to fair. The species-specific averages ranged from 1.7 (Chinook and coho) to 2.0 (cutthroat). In 2025, habitat quality ranged from poor-fair to fair, and species-specific averages for life history types ranged from 1.3 (coho) to 2.0 (cutthroat) (Table 52).

Table 52. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Lower Control.

Steelhead Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2020	1	2	2	2	2	1.8
2025	1	2	2	2	2	1.8

Cutthroat Trout Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2020	2	2	2	2	2.0
2025	2	2	2	2	2.0

Chinook Salmon Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2020	1	2	2	1.7
2025	1	2	2	1.7

Coho Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2020	1	2	2	1.7
2025	1	2	1	1.3

Riverbend (Sieben)

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), 1.7 (Chinook), and 1.8 (steelhead) (Table 53).

Table 53. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Riverbend.

Steelhead Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2021	1	2	2	2	2	1.8
2025	1	2	2	2	2	1.8

Cutthroat Trout Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2021	2	2	2	2	2.0
2025	2	2	2	2	2.0

Chinook Salmon Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2021	1	2	2	1.7
2025	1	2	2	1.7

Coho Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2021	1	2	1	1.3
2025	1	2	1	1.3

Upper Control Channel

Results of the HabRate model (Burke et al. 2010) in 2020 suggested habitat quality within Upper Control ranged from poor-fair to fair-good. The species-specific averages ranged from 1.3 (cutthroat) to 2.3 (Chinook). In 2025, habitat quality had increased across all species except coho, which remained unchanged. Habitat quality ranged from poor-fair to good, and species-specific averages for life history types ranged from 1.7 (coho) to 3.0 (steelhead and Chinook) (Table 54).

Table 54. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for Upper Control.

Steelhead Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2020	1	3	2	2	2	2.0
2025	3	3	3	3	3	3.0
Cutthroat Trout Habitat						
Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer		Cutthroat Avg
2020	1	1	1	2		1.3
2025	2	2	2	2		2.0
Chinook Salmon Habitat						
Year	Spawning to Emergence	0+ Summer		0+ Winter		Chinook Avg
2020	2	2		3		2.3
2025	3	3		3		3.0
Coho Habitat						
Year	Spawning to Emergence	0+ Summer		0+ Winter		Coho Avg
2020	1	3		1		1.7
2025	2	2		1		1.7

USFS Control

Results of the HabRate model (Burke et al. 2010) in 2020 suggested habitat quality within USFS Control ranged from poor-fair to fair-good. The species-specific averages ranged from 1.3 (coho) to 2.2 (steelhead). In 2025, habitat quality increased across all species. Habitat quality ranged from fair to fair-good, and species-specific averages for life history types ranged from 2.0 (cutthroat and coho) to 2.4 (steelhead) (Table 55).

Table 55. 2025 HabRate (Burke et al. 2010) provides pre- and post-restoration life history ratings for steelhead, cutthroat trout, Chinook salmon, and coho habitat for USFS Control.

Steelhead Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	1+ Winter	Steelhead Avg
2024	1	2	3	2	3	2.2
2025	2	2	3	2	3	2.4

Cutthroat Trout Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	1+ Summer	Cutthroat Avg
2024	1	2	2	2	1.8
2025	2	2	2	2	2.0

Chinook Salmon Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Chinook Avg
2024	1	2	2	1.7
2025	3	2	2	2.3

Coho Habitat

Year	Spawning to Emergence	0+ Summer	0+ Winter	Coho Avg
2024	2	1	1	1.3
2025	3	2	1	2.0

Results of Restoration Comparison

Austin Hot Springs and USFS Control

Following the restoration treatment of Austin Hot Springs between 2024 and 2025, changes in channel form and morphology were observed. The primary channel area decreased from 33,033.0 m^2 to 22,836.0 m^2, while the secondary channel area increased from 1,956.9 m^2 to 6,483.9 m^2 despite lower stream flows during the post-restoration sampling effort. The percentage of pool habitat, residual pool depth, and riffle depth remained similar from 2024 to 2025.

The USFS Control channel form and morphology remained similar from 2024 to 2025 for channel area and percentage of pool habitat. However, both residual pool depth and riffle depth increased (Table 56).

Table 56. Channel form and morphology differences between pre- and post-restoration treatments in USFS Control and Austin Hot Springs (2024-2025) based on winter physical habitat ground surveys.

Habitat Metric	USFS Control 2024	USFS Control 2025	Austin HS 2024	Austin HS 2025
*River Level (CFS)	2,750	1,850	2,750	2,160
Primary Channel Area (m^2)	90,364.0	91,151.0	33,033.0	22,836.0
Secondary Channel Area (m^2)	1,992.0	1,494.0	1,956.9	6,483.9
Off-Channel Area (m^2)	0	0	319.4	51.7
% Pool Habitat	16.9	18.5	7.5	7.9
Residual Pool Depth (m)	1.18	2.19	0.62	0.64
Riffle Depth (m)	0.25	0.74	0.30	0.39

*Clackamas River above Three Lynx Creek gauge station.

Channel form and channel morphology attribute slope differences between pre-restoration and post-restoration periods were similar between the control (USFS Control) and the impact site (Austin Hot Springs) for percentage of pool habitat and riffle depth (Figure 17). Primary channel area slopes differed slightly between Austin Hot Springs and USFS control, while noticeable differences were observed in secondary channel area, off-channel area, and residual pool depth.

There was no statistical significance ($p\text{-value} > 0.05$) across channel form and channel morphology attributes between pre-restoration and post-restoration periods. Although, there should be caution in interpreting the significance because confidence intervals are very wide, indicating high levels of uncertainty due to the limited sample size (Table 57).

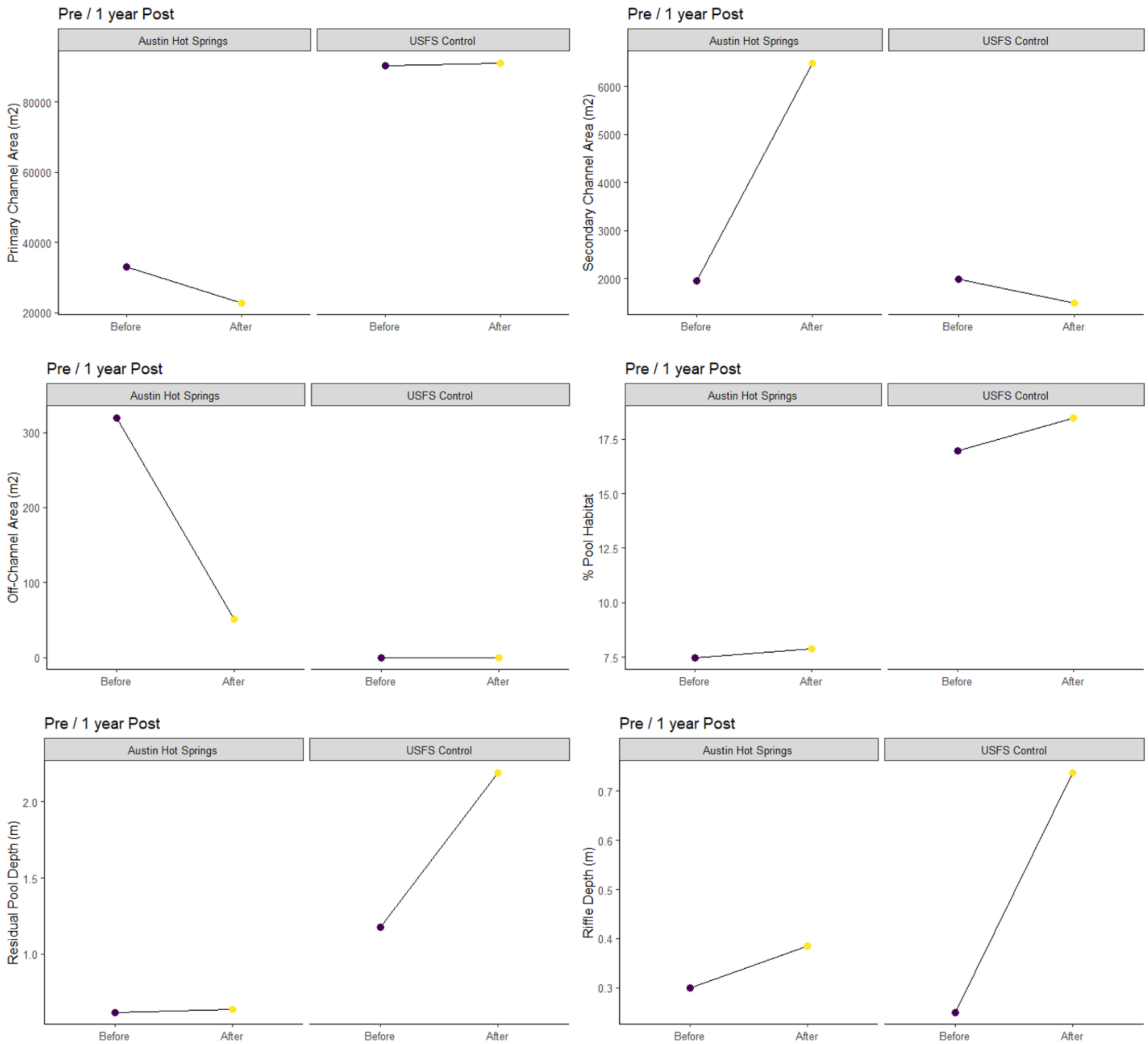

Figure 17. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for Austin Hot Springs and USFS Control.

Table 57. Channel form and channel morphology Welch two-sample t-test results assessing differences among instream habitat attributes before and after restoration across USFS Control and Austin Hot Springs. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	Mean Difference	t	p-value	95% CI
Primary Channel Area (m^2)	-4,705.0	0.8567	0.549	-65077.48, 74487.48
Secondary Channel Area (m^2)	2,014.5	-0.8018	0.5698	-33939.04, 29910.01
Off-Channel Area (m^2)	-133.85	1	0.50	-1566.88, 1834.58
% Pool Habitat	0.9612	-1.683	0.3413	-8.22, 6.30
Residual Pool Depth (m)	0.515381	-1.039	0.4878	-6.82, 5.79
Riffle Depth (m)	0.28625	-1.4224	0.3901	-2.84, 2.27

Following the restoration treatment of Austin Hot Springs between 2024 and 2025, minor changes in substrate were observed. The percentage of silt and sand, cobble, and bedrock decreased, and the percentage of gravel and boulders increased. However, USFS Control channel had reductions in the percentage of silt and sand and gravel, and the percentage of cobble, boulder, and bedrock increased (Table 58).

Table 58. Substrate composition differences between pre- and post-restoration treatments in USFS Control and Austin Hot Springs (2024-2025) based on winter physical habitat ground surveys.

Habitat Metric	USFS Control 2024	USFS Control 2025	Austin HS 2024	Austin HS 2025
% Fines (silt and sand)	14.75	4.01	20.81	11.16
% Gravel	20.95	14.74	25.44	26.05
% Cobble	39.31	43.44	35.04	25.06
% Boulder	24.26	36.21	16.87	36.91
% Bedrock	0.72	1.60	1.84	0.83

The slope in substrate attribute mean differences between Austin Hot Springs and USFS Control were similar across pre-restoration and post-restoration periods for fine sediments and boulders, and there were differences for gravel, cobble, and bedrock (Figure 18). Overall, impact attributes behaved similarly to the control attributes and the percentage of fine sediment (silt and sand) was the only substrate attribute to differ significantly across restoration periods. There should be caution in interpreting the significance because confidence intervals are very wide, indicating high levels of uncertainty due to the limited sample size (Table 59).

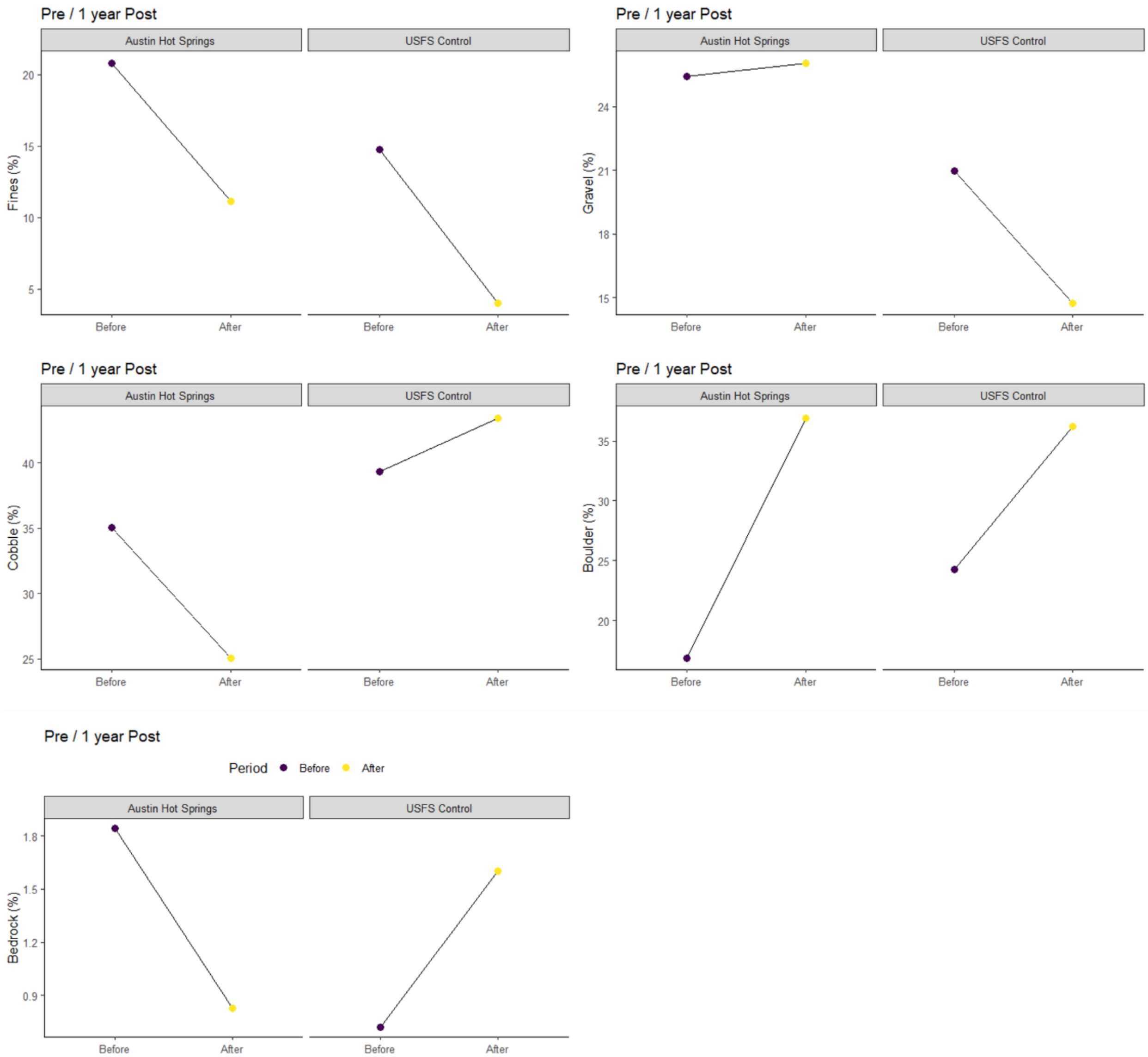

Figure 18. Pre-restoration and post-restoration substrate composition linear mixed model plots for Austin Hot Springs and USFS Control.

Table 59. Substrate composition Welch two-sample t-test results assessing differences among instream habitat attributes before and after restoration across USFS Control and Austin Hot Springs. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	Mean Difference	t	p-value	95% CI
% Fines (silt and sand)	-10.20	18.885	0.03368	3.336671, 17.059847
% Gravel	-2.803	0.82067	0.5625	-40.59836, 46.20485
% Cobble	-2.930	0.41519	0.7495	-86.71374, 92.57205
% Boulder	15.99	-3.9526	0.1578	-67.41504, 35.42439
% Bedrock	-0.0647	0.06824	0.9566	-11.97535, 12.10468

Following the restoration treatment of Austin Hot Springs between 2024 and 2025, changes in wood metrics were observed. The volume (m^3) increased from 7.70 to 27.75, and the number of key pieces of wood increased from three to five. The number of key pieces of wood also increased in the USFS Control, but wood volume (m^3) decreased slightly by 1.89 (Table 60).

Table 60. In-stream wood differences between pre- and post-restoration treatments in USFS Control and Austin Hot Springs (2024-2025) based on winter physical habitat ground surveys.

Habitat Metric	USFS Control 2024	USFS Control 2025	Austin HS 2024	Austin HS 2025
Wood Volume per 100m (m^3)	6.20	4.31	7.70	27.75
# Of Key Wood Pieces	4	5	3	5

The slope of in-stream wood attribute mean differences between pre-restoration and post-restoration periods were similar between the control (USFS Control) and the impact site (Austin Hot Springs) for the number of key pieces and differed for wood volume (Figure 19). In addition, the differences that were observed were not significant, although there should be caution in interpreting the significance because confidence intervals are very wide, indicating high levels of uncertainty due to the limited sample size (Table 61).

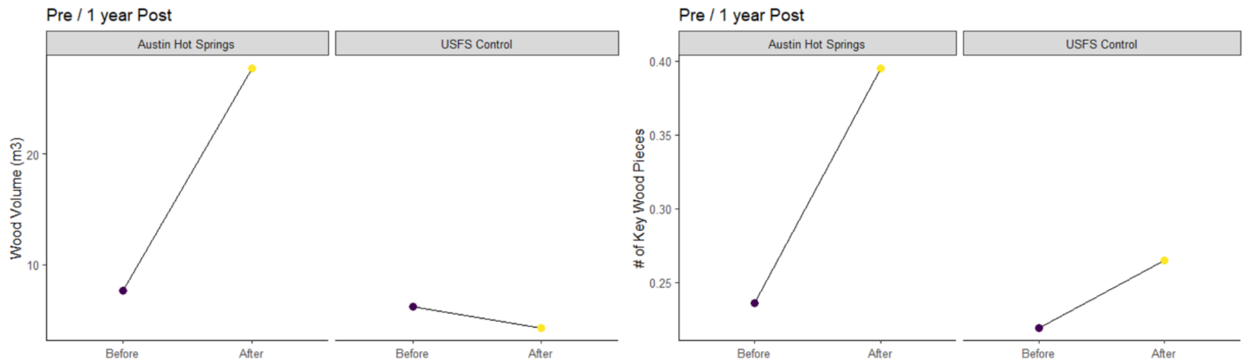

Figure 19. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Austin Hot Springs and USFS Control.

Table 61. In-stream wood Welch two-sample t-test results assessing differences among attributes before and after restoration across USFS Control and Austin Hot Springs. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	Mean Difference	t	p-value	95% CI
Wood Volume per 100m (m^3)	9.08	-0.82801	0.5597	-148.4654, 130.2996
Key Wood Pieces per 100m	0.1022	-1.7988	0.323	-0.824209, 0.61978

Barton Natural Area and Middle Control

Following the restoration treatment of Barton Natural Area between 2023 and 2025, changes in channel form and morphology were observed which coincided with considerably lower stream flows (cfs) during the post-restoration sampling effort. The primary channel area decreased from 44,616.0 m^2 to 23,882.0 m^2, and the secondary channel area decreased from 18,166.1 m^2 to 13,415.6 m^2. The percentage of pool habitat increased from 46% to 86.8%. However, there were reductions in the residual pool depth and riffle depth (Table 62).

Table 62. Channel form and morphology differences between pre- and post-restoration treatments in Middle Control and Barton NA (2023-2025) based on winter physical habitat ground surveys.

Habitat Metric	Middle Control 2023	Middle Control 2025	Barton NA 2023	Barton NA 2025
*River Level (CFS)	5,560	1,470	2,340	1,380
Primary Channel Area (m^2)	6,372.3	5,888.0	44,616.0	23,882.0
Secondary Channel Area (m^2)	265.2	221.9	18,166.1	13,415.6
Off-Channel Area (m^2)	249.2	184.1	15,249.0	11,634.0
% Pool Habitat	47.6	87.8	45.9	86.8
Residual Pool Depth (m)	1.18	0.42	1.23	0.87
Riffle Depth (m)	0.65	0.25	0.70	0.16

*Estacada gauge station.

The slope of channel form and channel morphology attribute mean differences between pre-restoration and post-restoration periods were similar between the control (Middle Control) and the impact site (Barton Natural Area) (Figure 20). In addition, impact attributes behaved similarly to the control attributes and no significant differences were observed (Table 63).

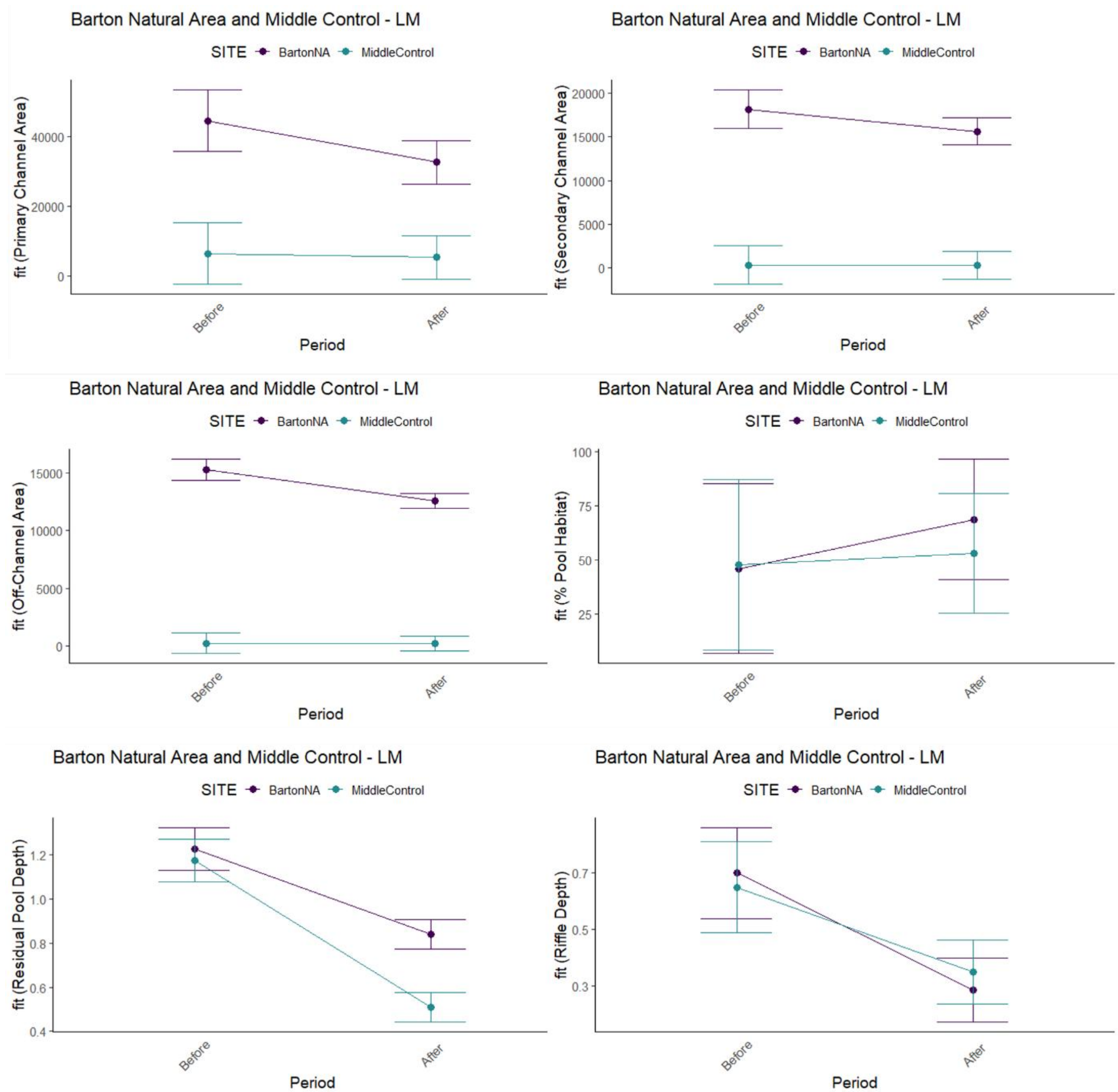

Figure 20. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for Barton NA and Middle Control.

Table 63. Channel form and channel morphology linear mixed-effect regression model results assessing differences among instream habitat attributes across Middle Control and Barton NA. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Primary Channel Area (m^2)	-10895	15400	-0.709	0.4786
Secondary Channel Area (m^2)	-2500	3820	-0.654	0.5132
Off-Channel Area (m^2)	-2656	1550	-1.716	0.0861
% Pool Habitat	17.5	28.9	0.605	0.6297
Residual Pool Depth (m)	0.281	0.167	1.680	0.1065
Riffle Depth (m)	-0.116	0.279	-0.416	0.7176

Following the restoration treatment of Barton Natural Area between 2023 and 2025, minor changes in substrate were observed. The percentage of silt and sand, gravel, and bedrock increased, and the percentage of cobbles and boulders decreased. However, Middle Control channel had reductions in the percentage of silt and sand, boulder, and bedrock, and the percentage of gravel and cobble increased (Table 64).

Table 64. Substrate composition differences between pre- and post-restoration treatments in Middle Control and Barton NA (2023-2025) based on winter physical habitat ground surveys.

Habitat Metric	Middle Control 2023	Middle Control 2025	Barton NA 2023	Barton NA 2025
% Fines (silt and sand)	41.88	27.89	30.5	34.26
% Gravel	29.01	32.16	17.4	19.09
% Cobble	17.53	34.54	34.6	32.19
% Boulder	9.07	5.42	14.1	9.70
% Bedrock	2.51	0	3.1	4.75

The slope in substrate attribute mean differences between pre-restoration and post-restoration periods were similar for gravel, boulder, and bedrock between the control (Middle Control) and the impact site (Barton Natural Area), and there were differences for fine substrate (silt and sand) and cobble (Figure 21). Overall, impact attributes behaved similarly to the control attributes and no significant differences were observed (Table 65).

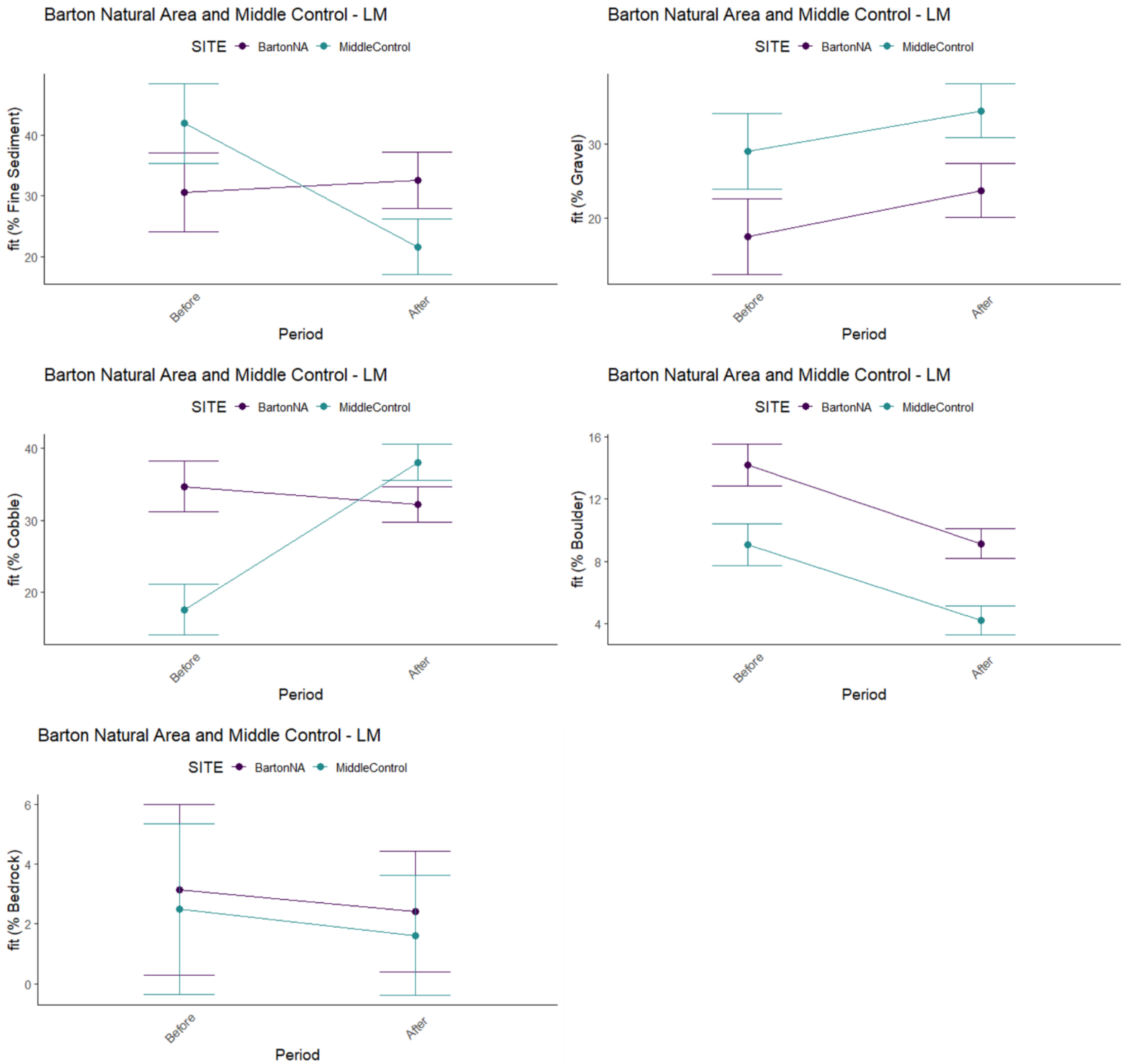

Figure 21. Pre-restoration and post-restoration substrate composition linear mixed model plots for Barton NA and Middle Control.

Table 65. Substrate composition linear mixed-effect regression model results assessing differences among instream habitat attributes across Middle Control and Barton NA. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
% Fines (silt and sand)	22.3	7.9	2.819	0.1213
% Gravel	0.756	3.95	0.191	0.8490
% Cobble	-23.0	6.09	-3.777	0.0589
% Boulder	-0.163	1.11	-0.146	0.8839
% Bedrock	0.156	4.94	0.032	0.9775

Following the restoration treatment of Barton Natural Area between 2023 and 2025, changes in wood metrics were observed. The volume (m^3) increased from 4.45 to 9.09, and the number of key pieces of wood increased from one to two. The increase in wood volume was similar to that in the Middle Control channel, although no key pieces of wood have been counted in the Middle Control (Table 66).

Table 66. In-stream wood differences between pre- and post-restoration treatments in Middle Control and Barton NA (2023-2025) based on winter physical habitat ground surveys.

Habitat Metric	Middle Control 2023	Middle Control 2025	Barton NA 2023	Barton NA 2025
Wood Volume per 100m (m^3)	5.25	12.79	4.45	9.09
# Of Key Wood Pieces	0	0	1	2

The slope of in-stream wood attribute mean differences between pre-restoration and post-restoration periods were similar between the control (Middle Control) and the impact site (Barton Natural Area) (Figure 22). In addition, impact attributes behaved similarly to the control attributes, and no significant differences were observed (Table 67).

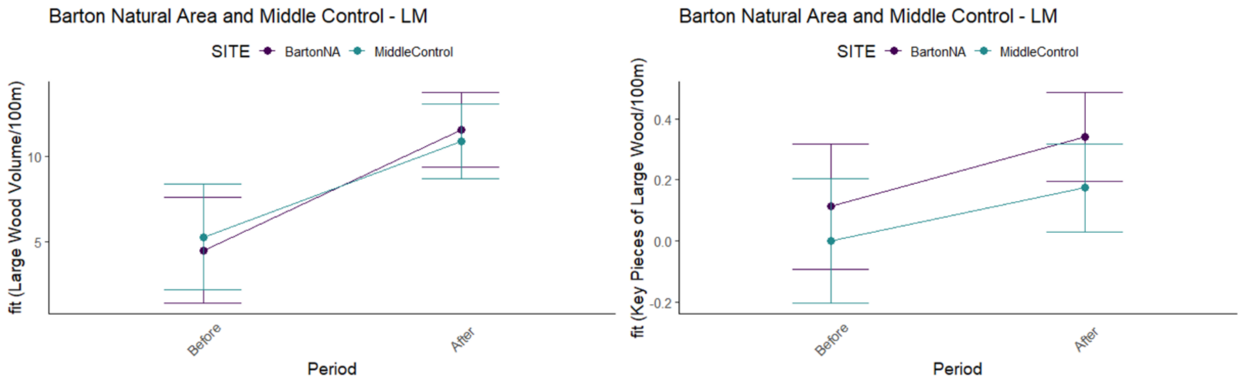

Figure 22. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Barton NA and Middle Control.

Table 67. In-stream wood linear mixed-effect regression model results assessing differences among instream habitat attributes across Middle Control and Barton NA. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Wood Volume per 100m (m^3)	1.48	5.42	0.273	0.8102
Key Wood Pieces per 100m	0.0544	0.112	0.487	0.6337

Eagle Creek Complex and Middle Control

Following the restoration treatment of the Eagle Creek Complex between 2020 and 2025, changes in channel form and morphology were observed. The primary channel area decreased from 11,749.8 m^2 to 10,025.0 m^2, and the secondary channel area increased from 7,350.8 m^2 to 10,184.8 m^2. The percentage of pool habitat decreased from 48% to 26%. However, the residual pool depth increased by 22 cm. Additionally, stream flow (cfs) was considerably lower during the post-restoration sampling effort. Within the Middle Control channel, secondary channel area and off-channel pool area behaved similarly to Eagle Creek. Primary channel area and percentage of pool habitat increased across years in the control channel, while residual pool depth and riffle depths decreased (Table 68).

Table 68. Channel form and morphology differences between pre- and post-restoration treatments in Middle Control and Eagle Creek Complex (2020-2025) based on winter physical habitat ground surveys.

Habitat Metric	Middle Control 2020	Middle Control 2025	Eagle Creek 2020	Eagle Creek 2025
*River Level (CFS)	2,370	1,470	2,330	1,470
Primary Channel Area (m^2)	4,668.0	5,888.0	11,749.8	10,025.0
Secondary Channel Area (m^2)	0	221.9	7,350.8	10,184.8
Off-Channel Area (m^2)	443.1	184.1	108.0	70.74
% Pool Habitat	71.30	87.87	48.16	25.91
Residual Pool Depth (m)	1.16	0.42	0.57	0.79
Riffle Depth (m)	0.45	0.25	0.23	0.25

*Estacada gauge station.

The slope of channel form and channel morphology attribute mean differences between pre-restoration and post-restoration periods were generally similar between the control (Middle Control) and the impact site (Eagle Creek Complex) (Figure 23). Minor differences in slopes were observed in residual pool and riffle depths. In addition, impact attributes behaved similarly to the control attributes and no significant differences were observed (Table 69).

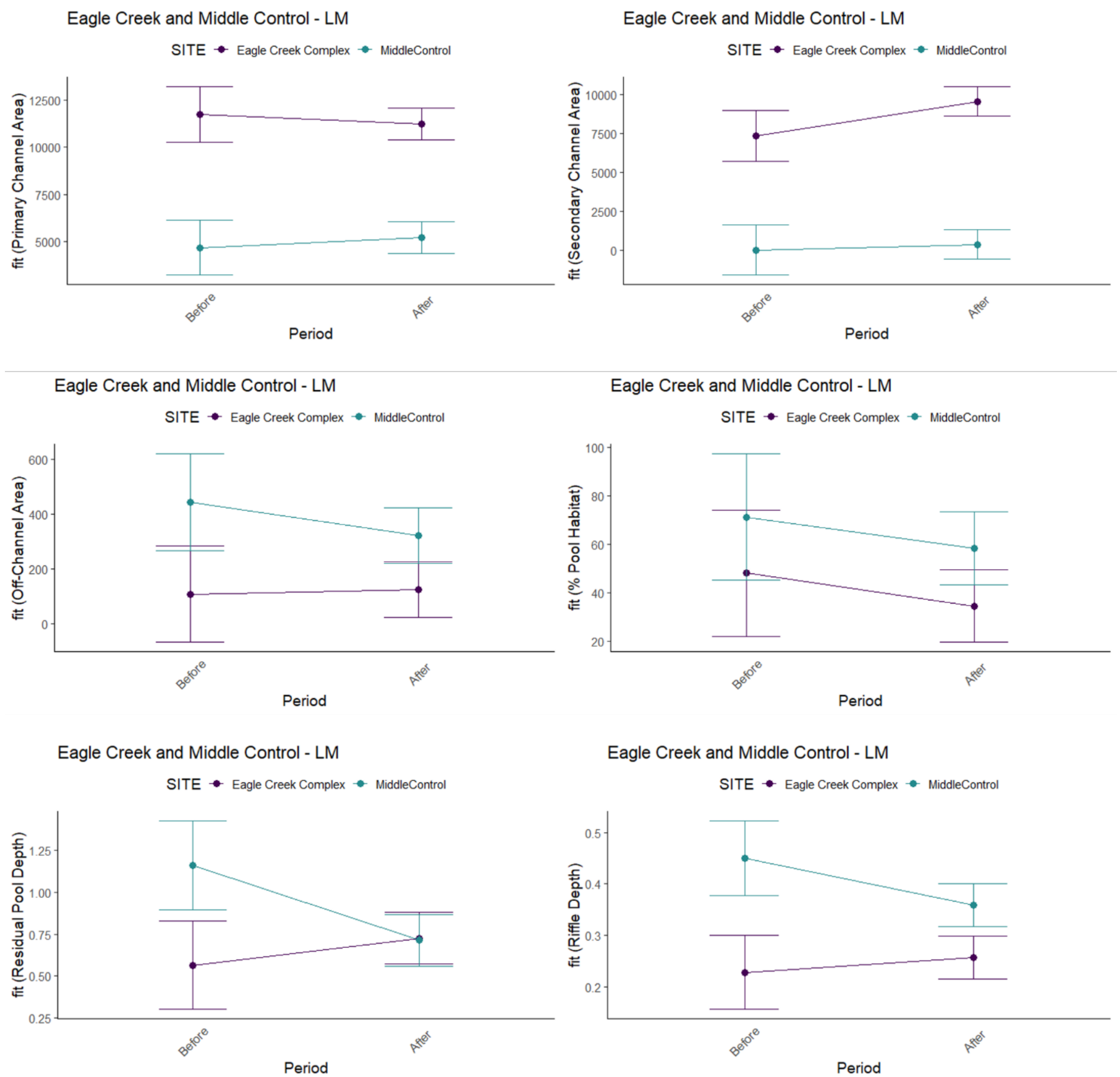

Figure 23. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for the Eagle Creek Complex and Middle Control.

Table 69. Channel form and channel morphology linear mixed-effect regression model results assessing differences among instream habitat attributes across Middle Control and Eagle Creek Complex. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Primary Channel Area (m^2)	-1052	2390	-0.441	0.6595
Secondary Channel Area (m^2)	1862	2660	0.699	0.4846
Off-Channel Area (m^2)	138	116	1.188	0.2412
% Pool Habitat	-0.499	42.5	-0.012	0.9909
Residual Pool Depth (m)	0.607	0.431	1.407	0.2159
Riffle Depth (m)	0.12	0.115	1.049	0.3004

Following the restoration treatment of the Eagle Creek Complex between 2020 and 2025, minor changes in substrate were observed. The percentage of silt and sand, gravel, and cobbles decreased, and the percentage of boulders and bedrock increased. The Middle Control channel substrate composition changes were similar to Eagle Creek. However, the percentage of gravel increased (Table 70).

Table 160. Substrate composition differences between pre- and post-restoration treatments in Middle Control and Eagle Creek Complex (2020-2025) based on winter physical habitat ground surveys.

Habitat Metric	Middle Control 2020	Middle Control 2025	Eagle Creek 2020	Eagle Creek 2025
% Fines (silt and sand)	29.15	27.89	16.42	14.80
% Gravel	26.37	32.16	37.19	32.90
% Cobble	41.91	34.54	43.53	42.29
% Boulder	2.56	5.42	2.86	9.39
% Bedrock	0	0	0	0.62

The slope in substrate attribute mean differences between pre-restoration and post-restoration periods were similar between the control (Middle Control) and the impact site (Eagle Creek Complex). Minor slope differences were observed with the percentage of gravel (Figure 24). Overall, impact attributes behaved similarly to the control attributes and no significant differences were observed (Table 71).

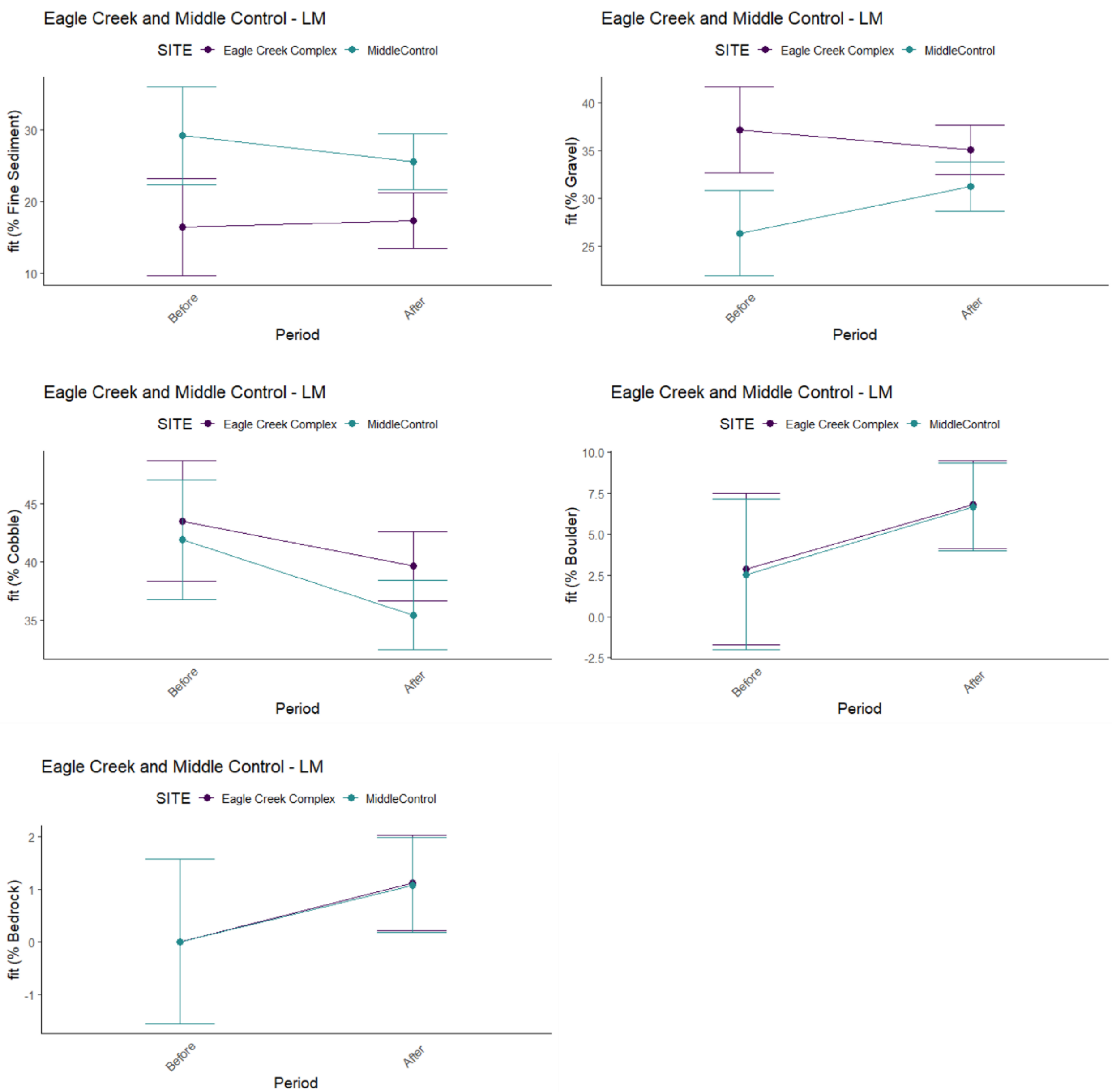

Figure 24. Pre-restoration and post-restoration substrate composition linear mixed model plots for Eagle Creek Complex and Middle Control.

Table 71. Substrate composition linear mixed-effect regression model results assessing differences among instream habitat attributes across Middle Control and Eagle Creek Complex. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
% Fines (silt and sand)	4.53	10.2	0.445	0.6571
% Gravel	-7.02	6.90	-1.016	0.3353
% Cobble	2.61	4.18	0.625	0.5726
% Boulder	-0.161	3.84	-0.042	0.9695
% Bedrock	0.0394	0.834	0.047	0.9662

Following the restoration treatment of the Eagle Creek Complex between 2020 and 2025, changes in wood metrics were observed. The volume (m^3) increased from 88.73 to 124.25, and the number of key pieces of wood remained unchanged (Table 72).

Table 172. In-stream wood differences between pre- and post-restoration treatments in Middle Control and Eagle Creek Complex (2020-2025) based on winter physical habitat ground surveys.

Habitat Metric	Middle Control 2020	Middle Control 2025	Eagle Creek 2020	Eagle Creek 2025
Wood Volume per 100m (m^3)	12.31	12.79	88.73	124.25
# Of Key Wood Pieces	0	0	28	28

The slope of in-stream wood attribute mean differences between pre-restoration and post-restoration periods differed slightly between the control (Middle Control) and the impact site (Eagle Creek Complex) (Figure 25). In addition, wood volume at the impact increased significantly compared to the control. No significant differences were observed for key pieces of wood (Table 73).

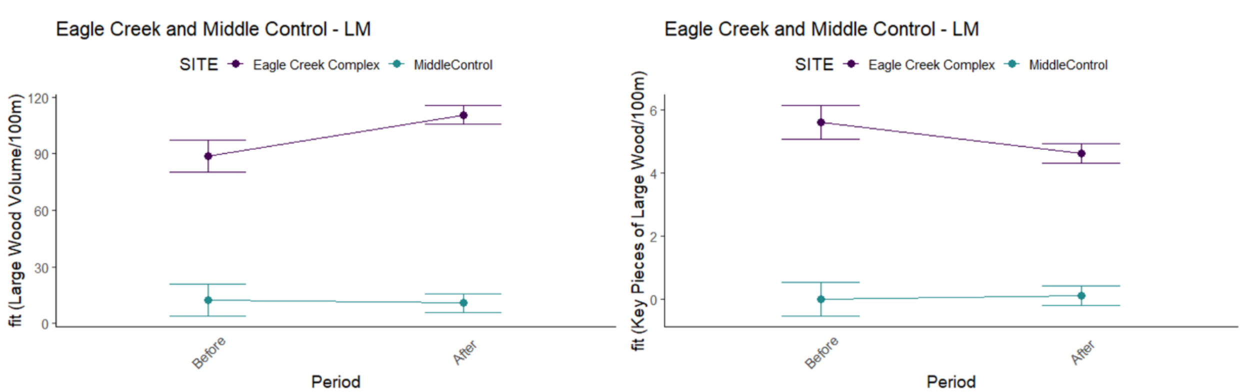

Figure 25. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Eagle Creek Complex and Middle Control.

Table 73. In-stream wood linear mixed-effect regression model results assessing differences among instream habitat attributes across Middle Control and Eagle Creek Complex. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Wood Volume per 100m (m^3)	23.2	11.8	1.970	0.0489
Key Wood Pieces per 100m	-1.11	0.874	-1.266	0.2054

Johnson "J" Creek and Lower Control

Following the restoration treatment of J Creek between 2023 and 2025, changes in channel form and morphology were observed. The primary channel area increased from 2,205.4 m^2 to 3,829.5 m^2, and the secondary channel area increased from 147.2 m^2 to 723.1 m^2. The area of off-channel habitat decreased from 1,691 m^2 in 2023 to zero, as no alcoves, beaver ponds, or backwater pools were recorded in 2025. The percentage of pool habitat decreased by 15%, however, residual pool and riffle depths increased. Within the Lower Control channel, secondary channel area, off-channel pool area, and the percentage of pool habitat increased, while primary channel area, residual pool depth, and riffle depth decreased. Attributes associated with channel form and morphology generally followed the increase in stream flow (cfs) experienced in the post-restoration sampling effort (Table 74).

Table 184. Channel form and morphology differences between pre- and post-restoration treatments in Lower Control and Johnson "J" Creek (2023-2025) based on winter physical habitat ground surveys.

Habitat Metric	Lower Control 2023	Lower Control 2025	J Creek 2023	J Creek 2025
*River Level (CFS)	2,060	2,960	2,060	2,960
Primary Channel Area (m^2)	3,338.0	2,697.5	2,205.4	3,829.5
Secondary Channel Area (m^2)	4,030.0	7,745.6	147.2	723.1
Off-Channel Area (m^2)	3,892.0	7,191.0	1,691.0	0
% Pool Habitat	63.02	75.53	86.38	70.47
Residual Pool Depth (m)	0.21	0.16	0.47	0.56
Riffle Depth (m)	0.30	0.23	0.21	0.31

*Estacada gauge station.

The slope of channel form and channel morphology attribute mean differences between pre-restoration and post-restoration periods behaved differently between the control (Lower Control) and the impact site (Johnson "J" Creek) for primary channel area, off-channel area, percent pool habitat, residual pool depth, and riffle depth (Figure 26). The impact and control secondary channel area slopes were similar between pre- and post-restoration sampling periods. In addition, primary channel area, percent pool habitat, and residual pool depth within Johnson “J” Creek differed significantly compared to the Lower Control channel. No significant differences were observed across sampling periods for secondary channel area, off-channel pool area, or riffle depth (Table 75).

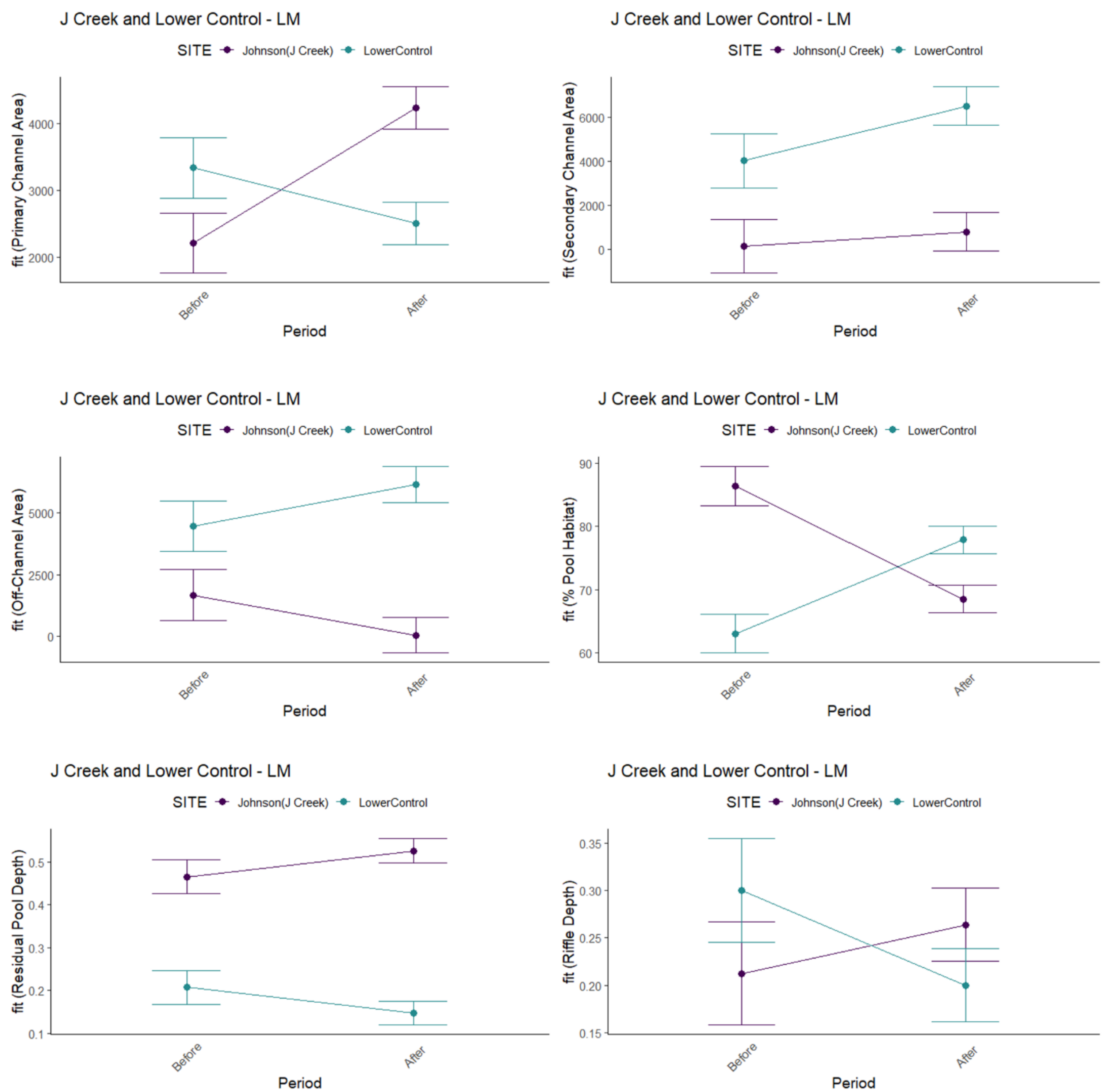

Figure 26. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for Johnson “J” Creek and Lower Control.

Table 75. Channel form and channel morphology linear mixed-effect regression model results assessing differences among instream habitat attributes across Lower Control and Johnson “J” Creek. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Primary Channel Area (m^2)	2863	781	3.668	0.0293
Secondary Channel Area (m^2)	-1829	2120	-0.861	0.3896
Off-Channel Area (m^2)	-3314	1790	-1.855	0.0664
% Pool Habitat	-32.8	5.36	-6.120	0.0247
Residual Pool Depth (m)	0.121	0.0421	2.863	0.0047
Riffle Depth (m)	0.151	0.0949	1.594	0.2520

Following the restoration treatment of Johnson “J” Creek between 2023 and 2025, changes in substrate composition were observed. The percentage of silt and sand decreased, while the percentage of gravel, cobbles, boulder, and bedrock increased. The Lower Control channel substrate composition changes were similar to J Creek. However, the percentage of cobbles decreased, and bedrock was not observed in either 2023 or 2025 (Table 76).

Table 196. Substrate composition differences between pre- and post-restoration treatments in Lower Control and Johnson “J” Creek (2023-2025) based on winter physical habitat ground surveys.

Habitat Metric	Lower Control 2023	Lower Control 2025	J Creek 2023	J Creek 2025
% Fines (silt and sand)	34.71	21.68	75.82	23.35
% Gravel	18.89	27.73	23.06	32.94
% Cobble	42.85	31.98	1.12	23.99
% Boulder	3.55	18.61	0	9.64
% Bedrock	0	0	0	10.08

The slope in substrate attribute mean differences between pre-restoration and post-restoration periods were similar with the percentage of gravel, boulders, and bedrock between the control (Lower Control) and the impact site (Johnson “J” Creek). Differences in slope were observed with the percentage of silt and sand, cobbles, and bedrock (Figure 27). Generally, impact attributes behaved similarly to the control attributes and significant differences were not observed. However, the percentage of cobbles within Johnson “J” Creek differed significantly compared to the Lower Control channel (Table 77).

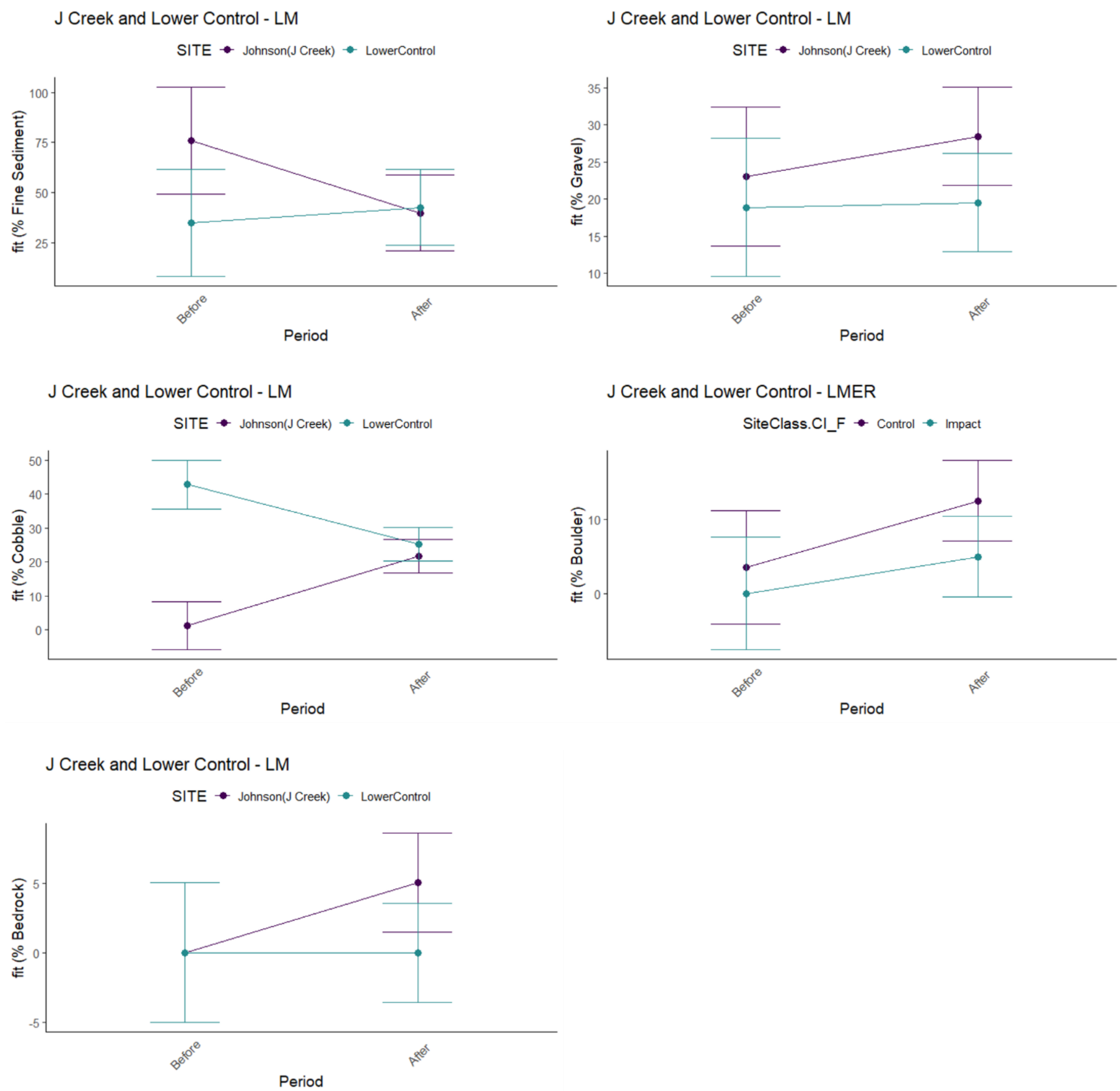

Figure 27. Pre-restoration and post-restoration substrate composition linear mixed model plots for Johnson "J" Creek and Lower Control.

Table 77. Substrate composition linear mixed-effect regression model results assessing differences among instream habitat attributes across Lower Control and Johnson “J” Creek. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
% Fines (silt and sand)	-43.9	7.81	-5.628	0.1038
% Gravel	4.77	6.46	0.739	0.4719
% Cobble	38.2	7.63	5.003	0.0210
% Boulder	-4.03	2.41	-1.677	0.2717
% Bedrock	5.04	8.73	0.577	0.5941

Following the restoration treatment of Johnson “J” Creek between 2023 and 2025, changes in wood metrics were observed. The volume (m^3) increased from 14.60 to 41.55, and the number of key pieces of wood increased from four to eleven. However, wood volume in the Lower Control channel decreased from 2023 (20.22 m^3) to 2025 (6.41 m^3). The number of key pieces of wood decreased from three to one (Table 78).

Table 208. In-stream wood differences between pre- and post-restoration treatments in Lower Control and Johnson “J” Creek (2023-2025) based on winter physical habitat ground surveys.

Habitat Metric	Lower Control 2023	Lower Control 2025	J Creek 2023	J Creek 2025
Wood Volume per 100m (m^3)	20.22	6.41	14.60	41.55
# Of Key Wood Pieces	3	1	4	11

The slope of in-stream wood attribute mean differences between pre-restoration and post-restoration periods differed slightly between the control (Lower Control) and the impact site (Johnson “J” Creek) (Figure 28). No significant differences were observed for wood volume or the number of key pieces (Table 79).

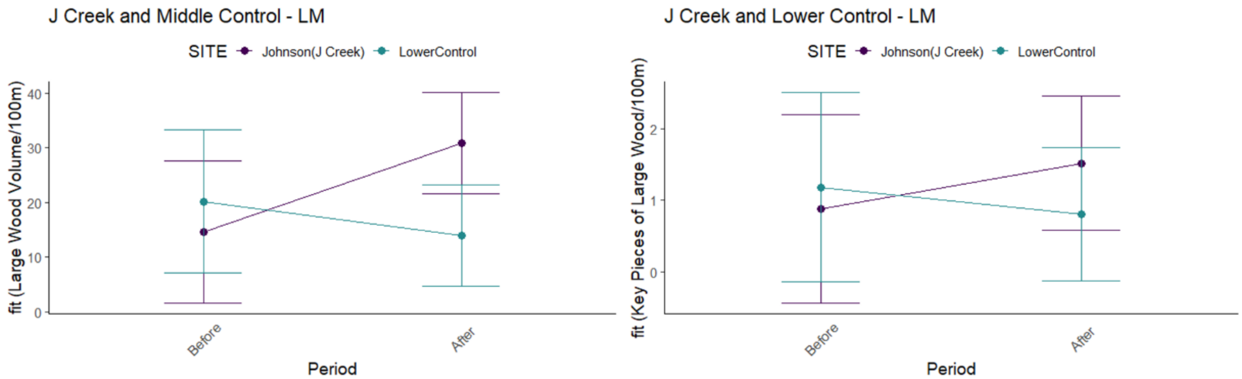

Figure 28. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Johnson "J" Creek and Lower Control.

Table 79. In-stream wood linear mixed-effect regression model results assessing differences among instream habitat attributes across Lower Control and Johnson "J" Creek. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Wood Volume per 100m (m^3)	22.6	22.6	0.997	0.3900
Key Wood Pieces per 100m	0.848	1.68	0.505	0.6590

Kingfisher Side Channel and Upper Control

Following restoration treatment of the Kingfisher Side Channel between 2021 and 2025, changes in channel form and morphology were observed. The primary channel area decreased by 165.1 m^2, pool habitat decreased from 82% to 55%, and no off-channel pool habitat was measured in 2025 compared to 264.5 m^2 in 2021. Riffle depth increased from 18 cm to 56 cm while residual pool depth remained similar across the sampling period. Within the Upper Control channel, all channel form and channel morphology attributes increased accordingly with the increase in stream flow (cfs) experienced during the post-restoration sampling effort, except for pool habitat, which decreased from 61% in 2021 to 55% in 2025 (Table 80).

Table 80. Channel form and morphology differences between pre- and post-restoration treatments in Upper Control and Kingfisher (2021-2025) based on winter physical habitat ground surveys.

Habitat Metric	Upper Control 2021	Upper Control 2025	Kingfisher 2021	Kingfisher 2025
*River Level (CFS)	2,030	4,200	2,030	4,200
Primary Channel Area (m^2)	1,688.0	2,567.5	3,283.5	3,118.4
Secondary Channel Area (m^2)	0	49.4	0	0
Off-Channel Area (m^2)	0	49.4	264.5	0
% Pool Habitat	61.02	55.55	82.03	55.34
Residual Pool Depth (m)	1.12	1.25	0.65	0.64
Riffle Depth (m)	0.30	0.50	0.18	0.56

*Estacada gauge station.

The slope of channel form and channel morphology mean differences between pre-restoration and post-restoration periods behaved differently between the control (Upper Control) and the impact site (Kingfisher Side Channel) for primary channel area, off-channel area, and residual pool depth (Figure 29). The impact and control secondary channel area, percent pool habitat, and riffle depth slopes were similar between pre- and post-restoration sampling periods. In addition, primary channel area, off-channel pool habitat area, and percent pool habitat changed significantly between pre- and post-restoration sampling periods within Kingfisher compared to the Upper Control channel. No significant differences were observed across sampling periods for secondary channel area, residual pool depth, or riffle depth (Table 81).

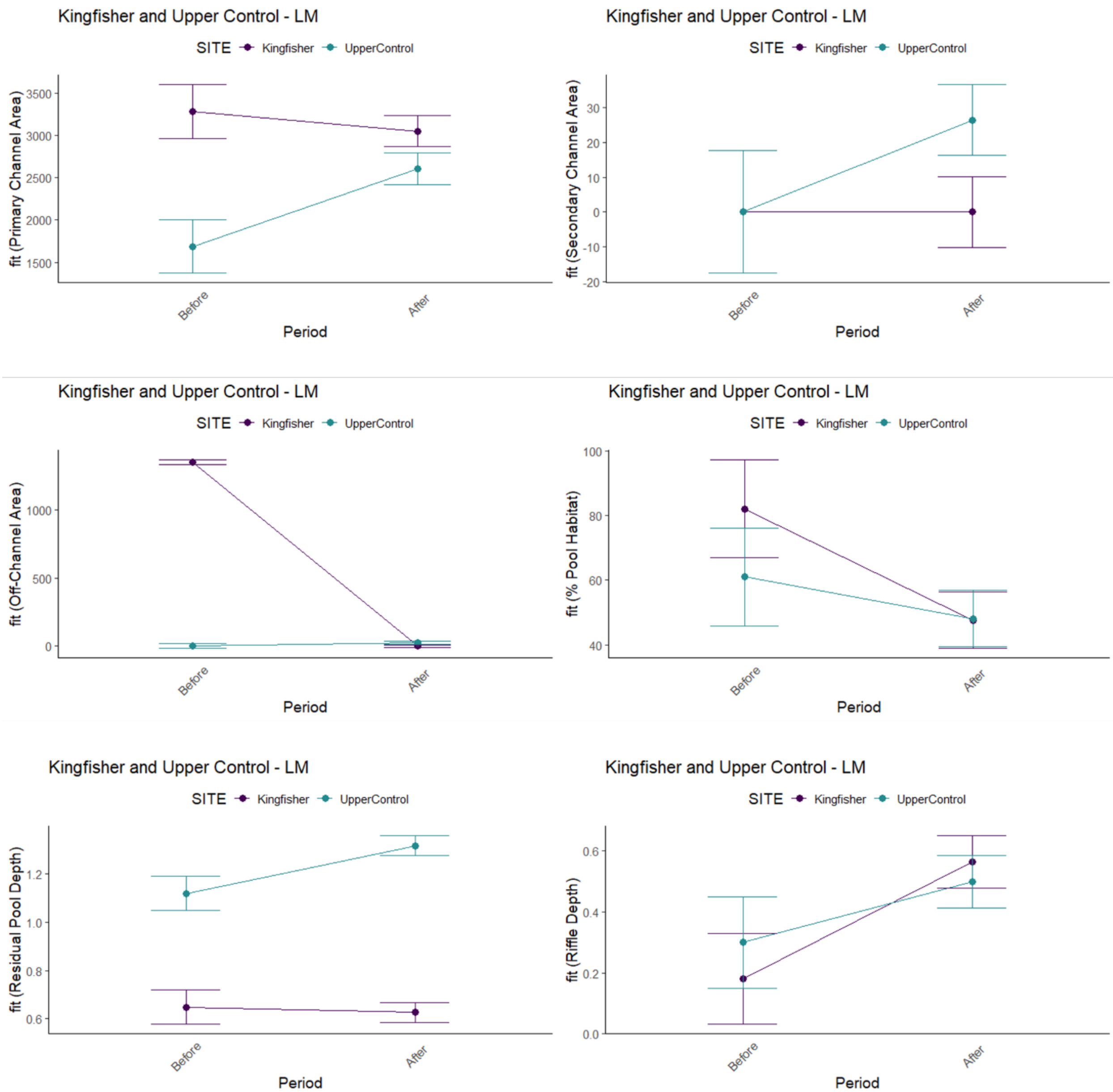

Figure 29. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for Kingfisher Side Channel and Upper Control.

Table 81. Channel form and channel morphology linear mixed-effect regression model results assessing differences among instream habitat attributes across Upper Control and Kingfisher Side Channel. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Primary Channel Area (m^2)	-1150	164	-7.013	0.0049
Secondary Channel Area (m^2)	-26.5	28.7	-0.921	0.3723
Off-Channel Area (m^2)	-1375	28.7	6.59	< 0.001
% Pool Habitat	-21.5	3.55	-6.059	0.0242
Residual Pool Depth (m)	-0.219	0.117	-1.868	0.0618
Riffle Depth (m)	0.184	0.243	0.755	0.4922

Following the restoration treatment of Kingfisher between 2021 and 2025, changes in substrate composition were observed. The percentage of fine sediments (silt and sand) decreased, while the percentage of gravel, cobbles, and boulders increased. The percentage of bedrock remained <1% across sampling periods. Within the Upper Control channel, the percentage of cobbles decreased, while the percentage of boulders increased. Minor changes occurred with the percentage of fine sediments, gravels, and bedrock (Table 82).

Table 82. Substrate composition differences between pre- and post-restoration treatments in Upper Control and Kingfisher Side Channel (2021-2025) based on winter physical habitat ground surveys.

Habitat Metric	Upper Control 2021	Upper Control 2025	Kingfisher 2021	Kingfisher 2025
% Fines (silt and sand)	9.15	11.52	47.88	11.35
% Gravel	19.38	18.34	14.11	19.71
% Cobble	43.19	30.00	23.36	27.82
% Boulder	19.12	31.57	14.66	40.90
% Bedrock	9.15	8.56	0	0.22

The slope in substrate attribute mean differences between pre-restoration and post-restoration periods were similar with the percentage of gravel, boulders, and bedrock between the control (Upper Control) and the impact site (Kingfisher Side Channel). Differences in slope were observed with the percentage of fine sediments and cobbles (Figure 30). The percentage of fine sediments (silt and sand) changed significantly between pre- and post-restoration sampling periods within Kingfisher compared to the Upper Control channel. No significant differences were observed across sampling periods for gravel, cobble, boulder, or bedrock (Table 83).

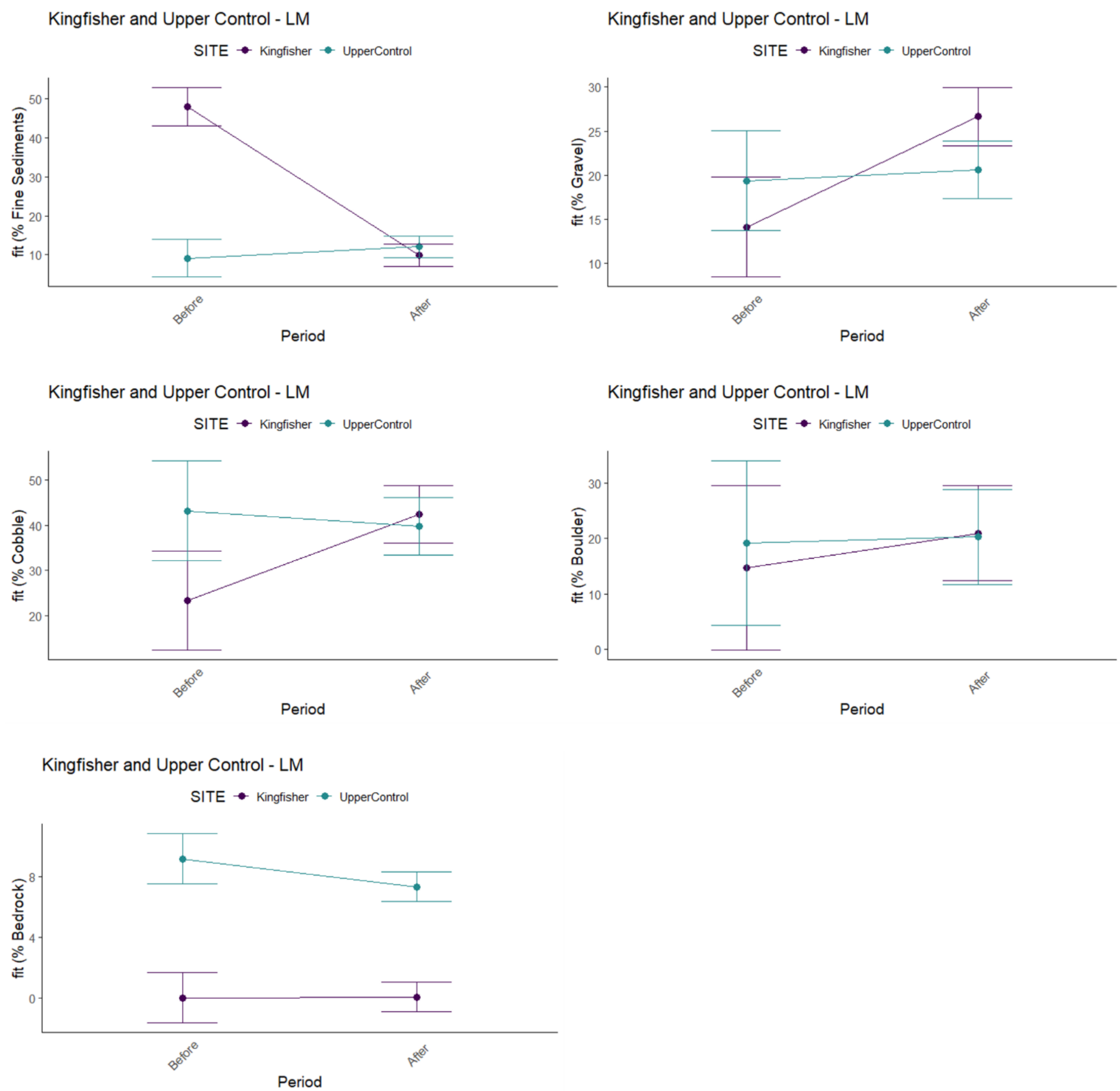

Figure 30. Pre-restoration and post-restoration substrate composition linear mixed model plots for Kingfisher and Upper Control.

Table 83. Substrate composition linear mixed-effect regression model results assessing differences among instream habitat attributes across Upper Control and Kingfisher Side Channel. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
% Fines (silt and sand)	-40.9	7.98	-5.128	0.0027
% Gravel	11.3	4.66	2.423	0.1073
% Cobble	22.6	6.88	3.285	0.0649
% Boulder	5.12	9.22	0.555	0.6276
% Bedrock	1.9	2.65	0.720	0.4717

Following the restoration treatment of Kingfisher Side Channel between 2021 and 2025, changes in wood metrics were observed. The volume (m^3) increased from 6.56 to 32.75, and the number of key pieces of wood increased from one to seven. However, wood volume in the Upper Control channel decreased from 2021 (0.30 m^3) to 2025 (0 m^3). No key pieces of wood have been counted within the Upper Control channel (Table 84).

Table 84. In-stream wood differences between pre- and post-restoration treatments in Upper Control and Kingfisher Side Channel (2021-2025) based on winter physical habitat ground surveys.

Habitat Metric	Upper Control 2021	Upper Control 2025	Kingfisher 2021	Kingfisher 2025
Wood Volume per 100m (m^3)	0.30	0	6.56	32.75
# Of Key Wood Pieces	0	0	1	7

The slope of in-stream wood attribute mean differences between pre-restoration and post-restoration periods differed between the control (Upper Control) and the impact site (Kingfisher Side Channel) (Figure 31). The percentage of wood volume (m^3 per 100m) changed significantly between pre- and post-restoration sampling periods within Kingfisher compared to the Upper Control channel. No significant differences were observed across sampling periods for the number of key pieces of wood (Table 85).

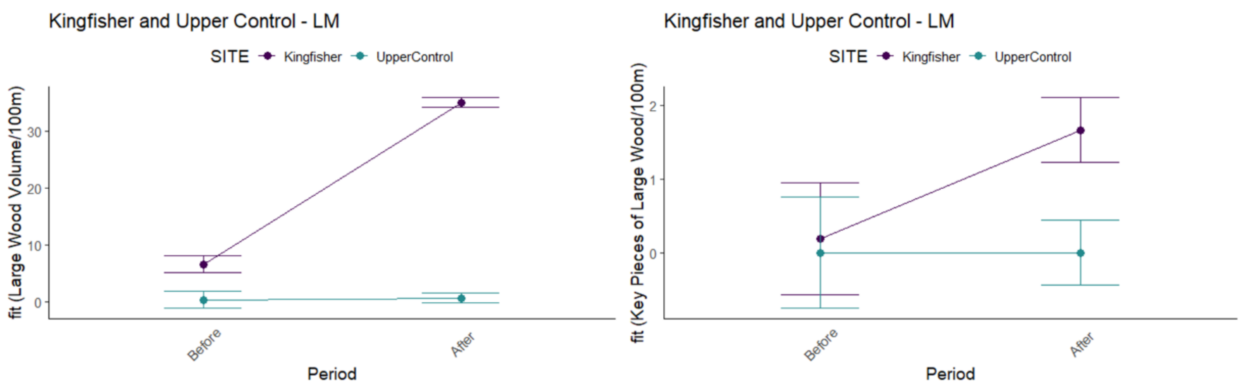

Figure 31. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Kingfisher Side Channel and Upper Control.

Table 85. In-stream wood linear mixed-effect regression model results assessing differences among instream habitat attributes across Upper Control and Kingfisher Side Channel. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Wood Volume per 100m (m^3)	28.1	1.63	17.212	< 0.001
Key Wood Pieces per 100m	1.48	1.24	1.193	0.2610

Riverbend (Sieben) and Lower Control

Following restoration treatment of Riverbend (Sieben) between 2021 and 2025, changes in channel form and morphology were observed. Attributes associated with channel form and morphology generally followed the increase in stream flow (cfs) experienced in the post-restoration sampling effort. The primary channel area increased from 3,549.3 m^2 in 2021 to 6,091.0 m^2 in 2025, secondary channel area (m^2) increased from 156.0 in 2021 to 1,425.7 in 2025, and off-channel pool habitat area increased from 0 m^2 in 2025 to 110 m^2 in 2025. While the percentage of pool habitat decreased from 83% to 73%, the residual pool depth increased from 43 cm in 2021 to 63 cm in 2025. Riffle depth increased from nine cm to 21 cm. Within the Lower Control channel, most channel form and channel morphology attributes decreased slightly independently of the higher stream flows (cfs) experienced during the post-restoration sampling effort, except for riffle depth which increased by three cm (Table 86).

Table 86. Channel form and morphology differences between pre- and post-restoration treatments in Lower Control and Riverbend (2021-2025) based on winter physical habitat ground surveys.

Habitat Metric	Lower Control 2021	Lower Control 2025	Riverbend 2021	Riverbend 2025
*River Level (CFS)	1,990	2,960	1,990	2,960
Primary Channel Area (m^2)	3,097.2	2,697.5	3,549.3	6,091.0
Secondary Channel Area (m^2)	8,382.0	7,745.6	156.0	1,425.7
Off-Channel Area (m^2)	8,262.0	7,191.0	0	110.0
% Pool Habitat	76.38	75.53	82.81	72.52
Residual Pool Depth (m)	0.40	0.16	0.43	0.63
Riffle Depth (m)	0.20	0.23	0.09	0.21

*Estacada gauge station.

The slope of channel form and channel morphology mean differences between pre-restoration and post-restoration periods behaved differently between the control (Lower Control) and the impact site (Riverbend) for primary channel area, secondary channel area, off-channel area, and residual pool depth (Figure 32). The impact and control percent pool habitat and riffle depth slopes were similar between pre- and post-restoration sampling periods. In addition, residual pool depth changed significantly between pre- and post-restoration sampling periods within Riverbend (Sieben) compared to the Lower Control channel. No significant differences were observed across sampling periods for primary channel area, secondary channel area, off-channel pool area, percentage of pool habitat, or riffle depth (Table 87).

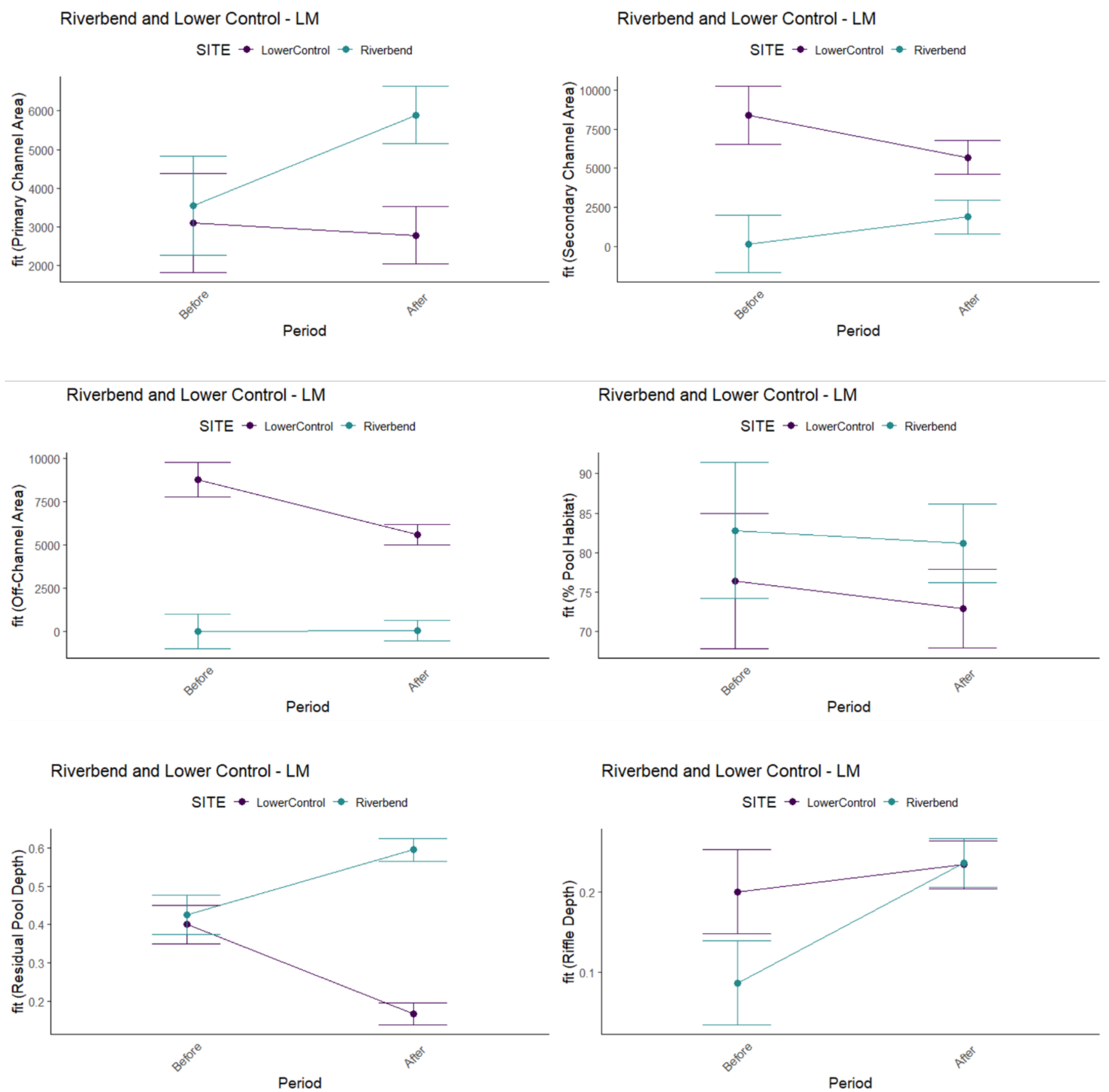

Figure 32. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for Riverbend (Sieben) and Lower Control.

Table 87. Channel form and channel morphology linear mixed-effect regression model results assessing differences among instream habitat attributes across Lower Control and Riverbend (Sieben). Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Primary Channel Area (m^2)	2656	1440	1.849	0.0788
Secondary Channel Area (m^2)	4419	2840	1.556	0.1267
Off-Channel Area (m^2)	3223	1580	2.046	0.0412
% Pool Habitat	1.84	14	0.131	0.8986
Residual Pool Depth (m)	0.402	0.0824	4.885	< 0.001
Riffle Depth (m)	0.116	0.0853	1.355	0.2468

Following the restoration treatment of Riverbend (Sieben) between 2021 and 2025, changes in substrate composition were observed. The percentage of fine sediments (silt and sand) decreased, while the percentage of gravel, cobbles, boulders, and bedrock increased. Within the Upper Control channel, the percentage of fine sediments (silt and sand) decreased, while the percentage of gravel, cobble, and boulders increased. Bedrock was not observed within the Lower Control channel across sampling periods (Table 88).

Table 88. Substrate composition differences between pre- and post-restoration treatments in Lower Control and Riverbend (Sieben) (2021-2025) based on winter physical habitat ground surveys.

Habitat Metric	Lower Control 2021	Lower Control 2025	Riverbend 2021	Riverbend 2025
% Fines (silt and sand)	59.57	21.68	54.47	28.73
% Gravel	16.64	27.73	24.12	38.15
% Cobble	20.46	31.98	19.27	20.02
% Boulder	3.34	18.61	2.14	11.54
% Bedrock	0	0	0	1.56

The slope in substrate attribute mean differences between pre-restoration and post-restoration periods were similar across all substrate types between the control (Upper Control) and the impact site (Kingfisher Side Channel) (Figure 33). No significant differences were observed across sampling periods for any of the substrate types (Table 89).

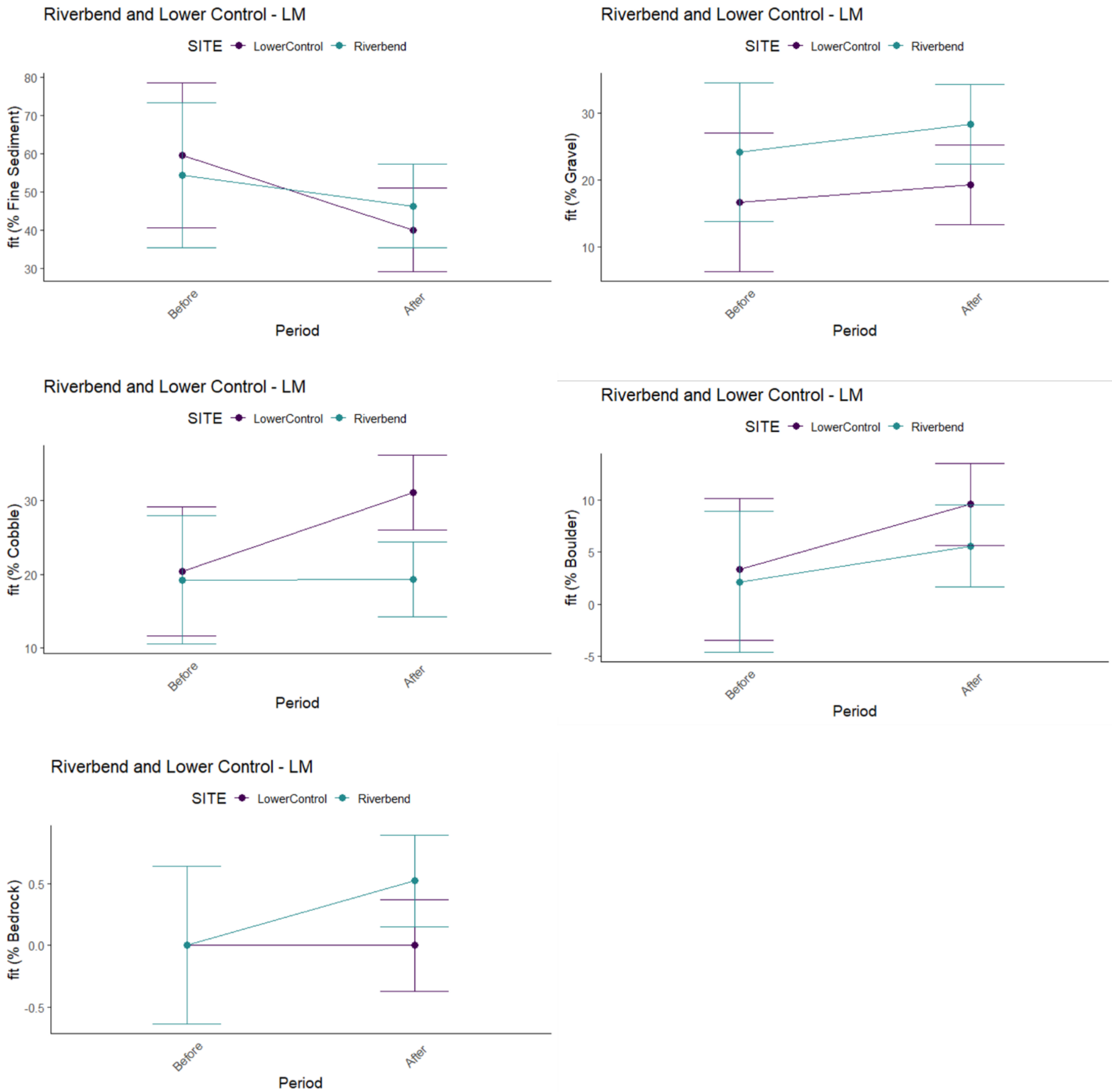

Figure 33. Pre-restoration and post-restoration substrate composition linear mixed model plots for Riverbend (Sieben) and Lower Control.

Table 89. Substrate composition linear mixed-effect regression model results assessing differences among instream habitat attributes across Lower Control and Riverbend (Sieben). Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
% Fines (silt and sand)	11.4	10.6	1.073	0.3806
% Gravel	1.52	5.68	0.267	0.7928
% Cobble	-10.6	14.3	-0.744	0.4738
% Boulder	-2.78	3.11	-0.893	0.4378
% Bedrock	0.522	1.04	0.500	0.6322

Following the restoration treatment of Riverbend (Sieben) between 2021 and 2025, changes in wood metrics were observed. The volume (m^3) increased from 11.14 to 18.95, and the number of key pieces of wood increased from two to five. However, wood volume in the Lower Control channel decreased from 2021 (21.04 m^3) to 2025 (6.41 m^3). In addition, the number of key pieces decreased from two in 2021 to one in 2025 (Table 90).

Table 90. In-stream wood differences between pre- and post-restoration treatments in Lower Control and Riverbend (Sieben) (2021-2025) based on winter physical habitat ground surveys.

Habitat Metric	Upper Control 2021	Upper Control 2025	Kingfisher 2021	Kingfisher 2025
Wood Volume per 100m (m^3)	21.04	6.41	11.14	18.95
# Of Key Wood Pieces	2	1	2	5

The slope of in-stream wood attribute mean differences between pre-restoration and post-restoration periods differed between the control (Lower Control) and the impact site (Riverbend) (Figure 34). The percentage of wood volume (m^3 per 100m) changed significantly between pre- and post-restoration sampling periods within Riverbend compared to the Lower Control channel. No significant differences were observed across sampling periods for the number of key pieces of wood (Table 91).

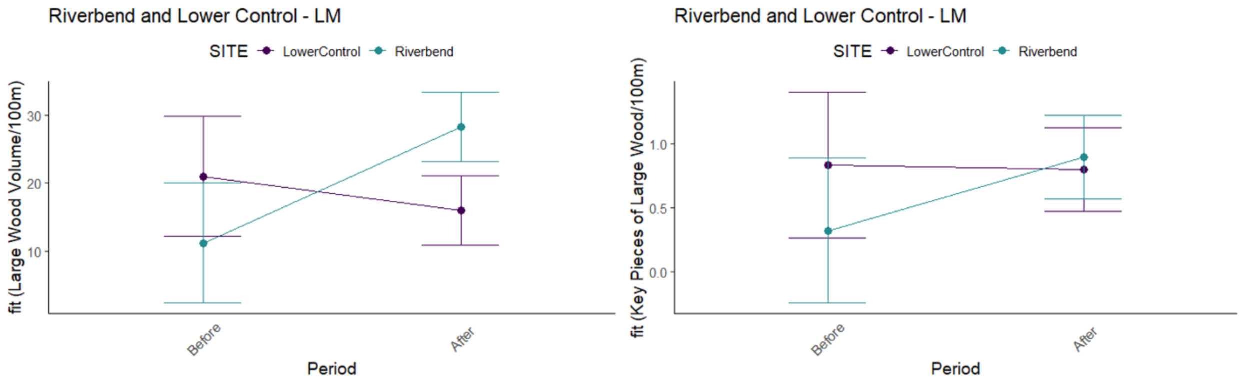

Figure 34. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Riverbend (Sieben) and Lower Control.

Table 91. In-stream wood linear mixed-effect regression model results assessing differences among instream habitat attributes across Lower Control and Riverbend (Sieben). Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Wood Volume per 100m (m^3)	22.2	4.79	4.628	0.0296
Key Wood Pieces per 100m	0.606	0.585	1.037	0.3753

Upper Control, Middle Control, and Lower Control

The slope of channel form and channel morphology mean differences between sampling periods behaved similarly across control channels for primary channel area, percentage of pool habitat, and riffle depth (Figure 35). Control channel secondary channel area, off-channel pool area, and riffle depth slopes behaved differently between sampling periods. In addition, secondary channel area and off-channel pool area changed significantly between sampling periods and varied across control channels. No significant differences were observed across the sampling period, and no variance was observed between control channels for primary channel area, percentage of pool habitat, residual pool depth, or riffle depth (Table 92).

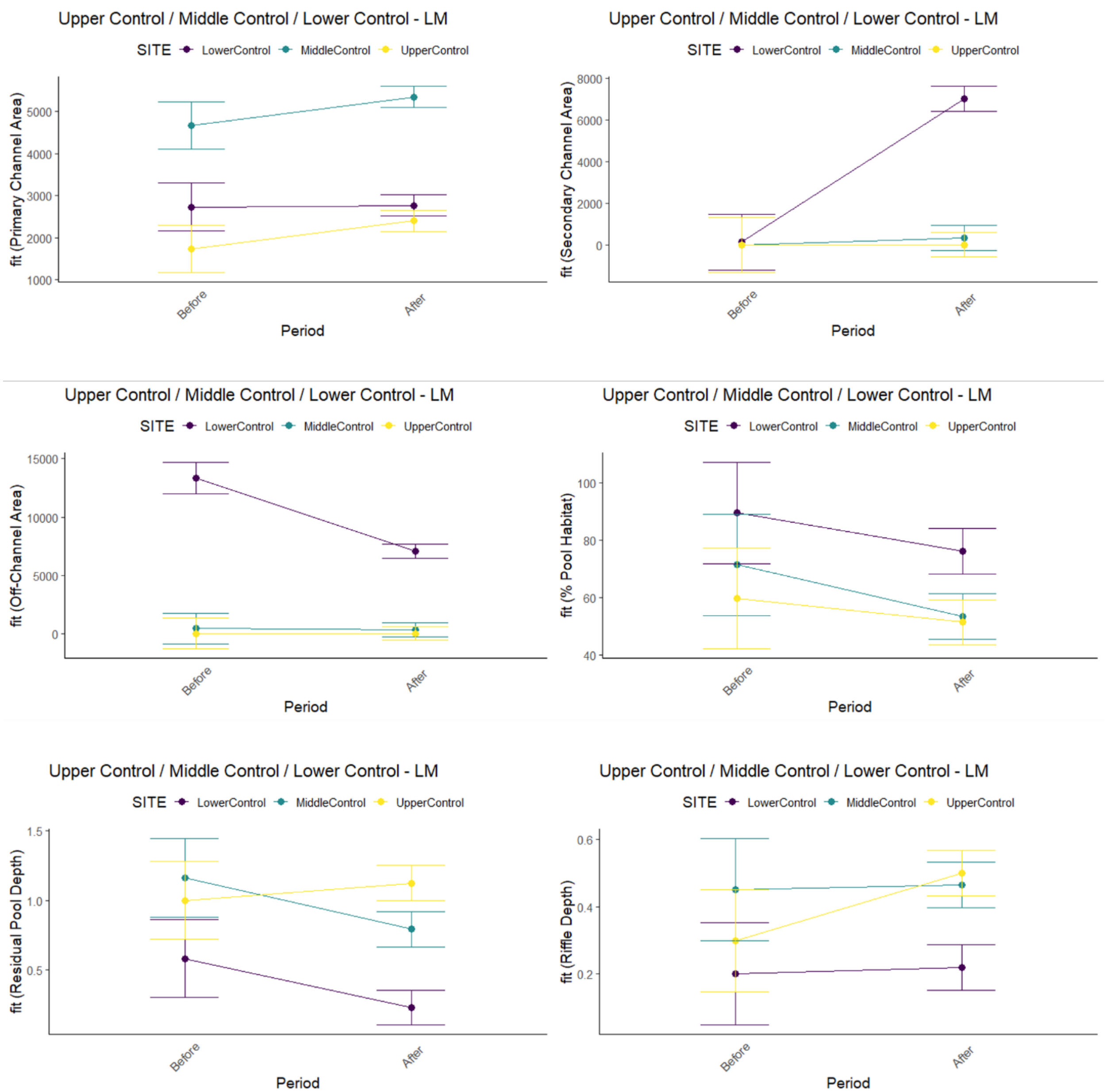

Figure 35. Pre-restoration and post-restoration channel form and channel morphology linear mixed model plots for Upper Control, Middle Control, and Lower Control.

Table 92. Channel form and channel morphology linear mixed-effect regression model results assessing differences among instream habitat attributes across Upper Control, Middle Control, and Lower Control. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Primary Channel Area (m^2)	35.34	623.22	0.057	0.9557
Secondary Channel Area (m^2)	6892.6	1467.9	4.696	< 0.001
Off-Channel Area (m^2)	-6273	1452	-4.322	< 0.001
% Pool Habitat	-13.28	19.29	-0.689	0.5041
Residual Pool Depth (m)	-0.3523	0.3078	-1.145	0.2750
Riffle Depth (m)	0.0200	0.1662	0.120	0.9060

The slope in substrate attribute mean differences between sampling periods were similar for the percentage of fine sediment (silt and sand), gravel, cobble, and boulder substrate types between the control channels. The slope for the percentage of bedrock was slightly different between control channels across the sampling period (Figure 36). In addition, the percentage of cobbles changed significantly between sampling periods across control channels. No significant differences were observed across the sampling period, and no variance was observed between control channels for percentage of fine sediments (silt and sand), gravel, boulder, or bedrock substrate types (Table 93).

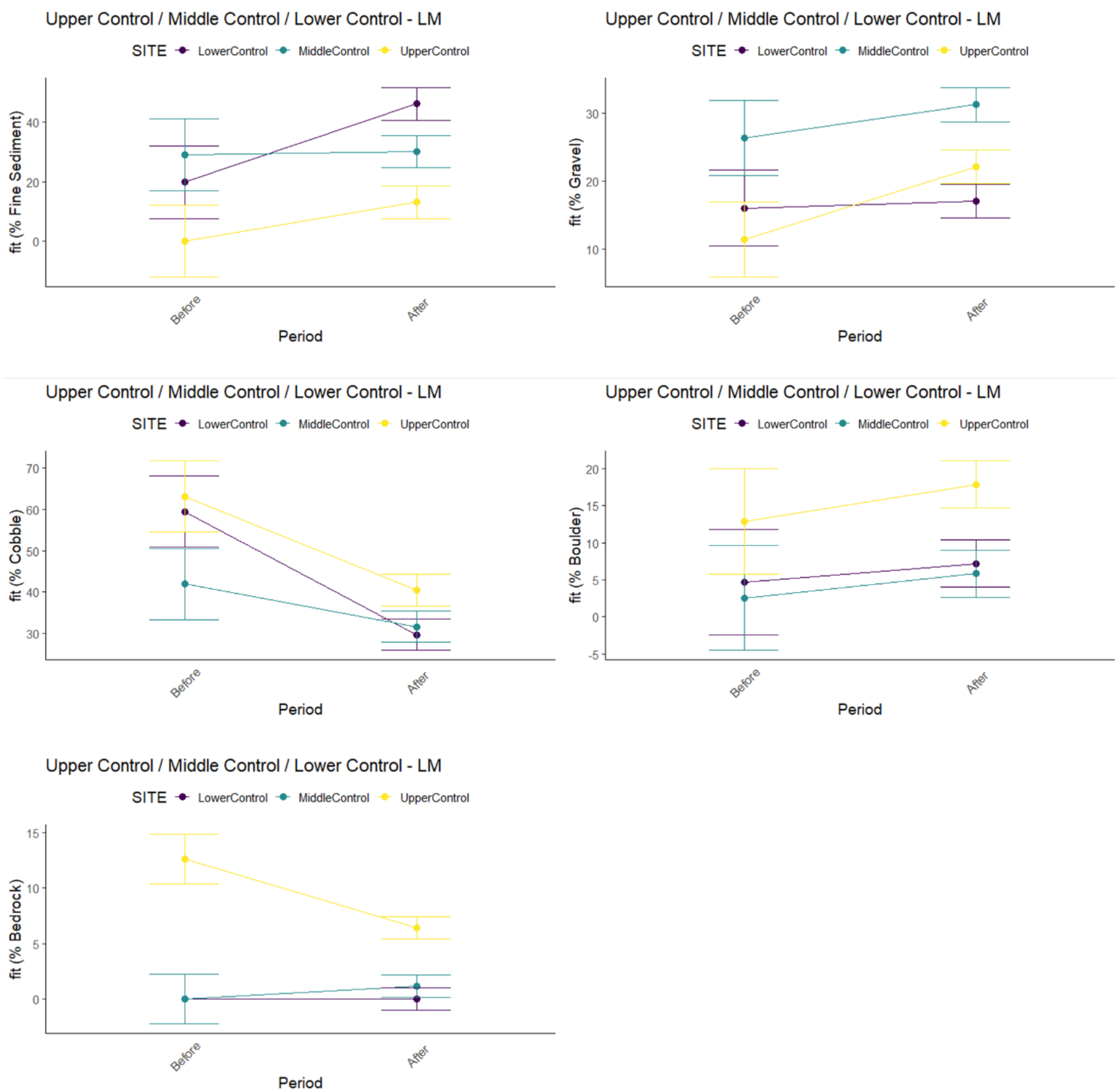

Figure 36. Pre-restoration and post-restoration substrate composition linear mixed model plots for Upper Control, Middle Control, and Lower Control.

Table 93. Substrate composition linear mixed-effect regression model results assessing differences among instream habitat attributes across Upper Control, Middle Control, and Lower Control. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
% Fines (silt and sand)	26.33	13.31	1.979	0.0713
% Gravel	0.9861	6.12	0.161	0.8750
% Cobble	-29.87	9.41	-3.175	0.0080
% Boulder	2.558	7.79	0.328	0.7480
% Bedrock	-0.001	0.244	0.000	1.0000

The slope of wood volume (m^3 per 100m) across sampling periods differed slightly between control channels, but the slope for the number of key pieces was similar across control channels between sampling periods (Figure 37). No significant differences were observed across the sampling period, and no variance was observed between control channels for in-stream wood attributes (Table 94).

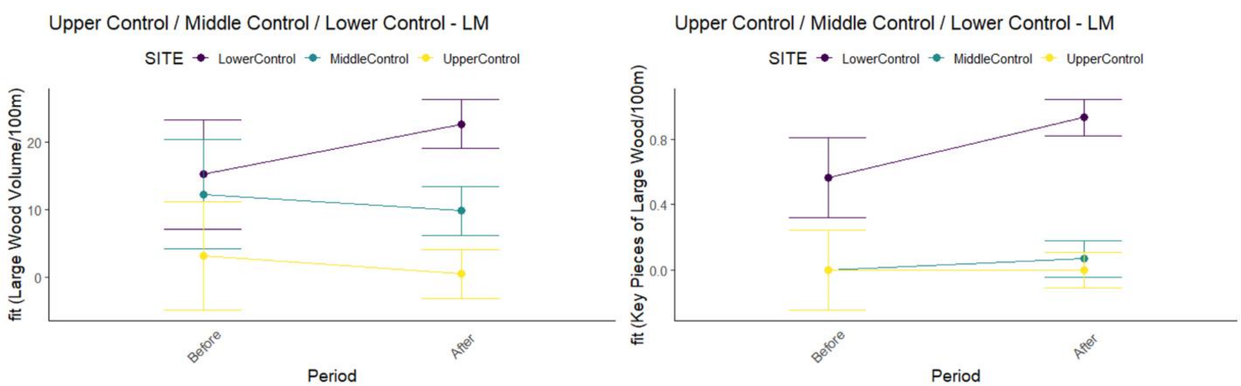

Figure 37. Pre-restoration and post-restoration in-stream wood linear mixed model plots for Upper Control, Middle Control, and Lower Control

Table 94. In-stream wood linear mixed-effect regression model results assessing differences among instream habitat attributes across Upper Control, Middle Control, and Lower Control. Random effect = Year and Site, Alpha = 0.05.

Habitat Metric	contrast estimate	SE	t-ratio	p-value
Wood Volume per 100m (m^3)	7.47	8.85	0.844	0.4153
Key Wood Pieces per 100m	0.366	2.269	1.362	0.1983

Results of Methods Comparison

We compared our UAS and ground methods used to describe habitat surface area (m^2), wood volume (m^3/100m), and number of key pieces of large wood (>10m in length and >60cm diameter), both within discrete habitat units and summarized them within individual survey sites. We used simple linear regression to assess the association between methods, and we evaluated the overall deviation using a Bland-Altman analysis. Unit surface area, site surface area, wood volume per 100m, and key pieces of wood per 100m showed a strong relationship with a high association between methods. Wood volume within discrete habitat units had a moderate relationship and methods were in moderate-strong agreement. The number of key pieces within discrete habitat units showed a weak correlation and relationship between methods (Table 95). On average, UAS methods described more surface area than ground surveys both within habitat units (+16.65 m^2) and across individual sites (+430.32 m^2). But ground surveys detected more wood volume than UAS methods both within habitat units (+2.98 m^3) and across sites (+56.56 m^3). Additionally, ground surveys measured more key pieces of wood than UAS methods within habitat units (0.134 more pieces) and across sites (+2.55 more pieces).

Table 95. Results of ground surveys and UAS survey comparisons for habitat surface area (m^2), wood volume (m^3), and the number of key pieces of wood within sites and discrete habitat units where both methods were utilized.

Habitat Metric	Pearson's Correlation	RMSE	df	Adjusted R^2	p-value
Unit Surface Area (m^2)	0.9717	715.83	207	0.944	< 0.001
Site Surface Area (m^2)	0.9932	3030.04	9	0.985	< 0.001
*Wood Volume (m^3)	0.6951	11.21	207	0.481	< 0.001
Wood Volume per 100m (m^3)	0.9842	99.76	9	0.965	< 0.001
*Key Wood Pieces	0.2155	0.880	207	0.042	0.002
Key Wood Pieces per 100m	0.8971	5.134	9	0.783	< 0.001

*Within discrete habitat units.

DISCUSSION

Austin Hot Springs

Following restoration efforts within the Austin Hot Springs section of the Clackamas River between 2024 and 2025, we found increased quantity and quality of stream habitat. Restoration efforts focused on increasing complexity and floodplain connectivity by adding large wood and secondary channels. Following restoration treatment, we observed increased wood volume (m^3/100m) and secondary channel area (m^2). Although Welch two-sample t-test results did not suggest significance for these attributes (p-value > 0.05), the analysis was based on a very small sample size (n=2), limiting statistical power and reliability of inference. The linear mixed model slopes showed a substantial increase from pre-treatment to post-treatment for both secondary channel area and wood volume. HabRate model results describing habitat quality for species specific life-history types were like results across the same sampling period in the USFS Control. The secondary channel area increase was substantial considering the post-restoration sampling effort coincided with reduced stream discharge (cfs) compared to the pre-restoration effort. This would suggest restoration efforts were primarily responsible for influencing in-stream habitat attributes associated with key objectives.

Barton Natural Area

Following restoration efforts within the Barton Natural Area between 2023 and 2025, we found increased quantity and quality of stream habitat. Restoration efforts focused on increasing complexity and floodplain connectivity by adding large wood and increasing side channel habitat. Decreases in secondary channel and off-channel pool habitat area (m^2) were a direct reflection of decreased stream flow (cfs) experienced during the post-restoration sampling effort. Mixed-effect regression model results did not suggest significant difference across sampling periods between the Barton Natural Area and the Middle Control channel for these attributes (p-value > 0.05), the linear mixed model slopes showed a substantial increase from pre-treatment to post-treatment for both percent pool habitat and wood volume. HabRate results showed a substantial increase in habitat quality for most species-specific life-history types when compared to the Middle Control channel. While BACI results suggest that restoration efforts were not exclusively responsible for influencing individual in-stream habitat attributes, increases in pool habitat (%), volume of large wood (m^3/100m), and HabRate model results suggested these efforts had a greater effect on habitat quantity and quality.

Beebe Island

We collected baseline pre-restoration treatment data in 2025. Restoration treatment occurred during the summer of 2025 following our sampling efforts and focused on improving habitat complexity by adding large wood and increasing connectivity to the Clackamas River mainstem. We will collect post-treatment data in 2026, and results will be paired with results from the Lower Control channel across the same sampling period.

Eagle Creek Complex

Following restoration efforts for the Eagle Creek Complex within Bonnie Lure State Park between 2020 and 2025, we found increased quantity and similar quality of stream habitat.

Restoration efforts focused on increasing complexity and floodplain connectivity by adding large wood and increasing side channel habitat. Following restoration treatment, we observed increased wood volume (m^3/100m) and secondary channel area (m^2). Mixed-effect regression model results did not suggest a significant difference across sampling periods between the Eagle Creek Complex and the Middle Control channel for secondary channel area (p-value > 0.05), but differences were significant for wood volume (p-value = 0.04). Linear mixed model slopes showed a substantial increase from pre-treatment to post-treatment for both secondary channel area and wood volume. BACI results evaluating all other habitat attribute differences across channel form and channel morphology, substrate composition, and in-stream wood between Eagle Creek and the Middle Control were not significant. Results of the HabRate model describing habitat quality for species specific life-history types were like results across the same sampling period for the Middle Control channel. Secondary channel area and residual pool depth increased following restoration efforts despite substantially reduced stream flows (cfs) encountered during the post-restoration sampling effort. This would suggest that restoration efforts were primarily responsible for influencing in-stream habitat attributes associated with key objectives.

Initially, changes in flow routing and summer drying led to lower habitat ratings for Chinook, steelhead, and coho salmon. By 2025, the ratings improved, indicating that restoration efforts 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.

Johnson "J" Creek

Following restoration efforts within the Johnson "J" Creek channel between 2023 and 2025, we found increased quantity and quality of stream habitat. Channel form and morphology attributes generally followed the increase in stream flow (cfs) encountered during the post-restoration sampling effort. Restoration efforts focused on increasing complexity and floodplain connectivity by adding large wood and increasing side channel habitat. Following restoration treatment, we observed increased wood volume (m^3/100m) and secondary channel area (m^2). The mixed-effect regression model assessing before-after-control-impact results did not suggest significant differences across sampling periods between Johnson "J" and the Lower Control channel for secondary channel area or wood volume (p-value > 0.05), but differences were significant for primary channel area, pool habitat (%), residual pool depth (m), and percent cobble substrate. Linear mixed model slopes showed a substantial increase from pre-treatment to post-treatment for both secondary channel area and wood volume. This would suggest that restoration efforts have been successful but were likely not exclusively responsible for influencing in-stream habitat attributes.

Kingfisher Side Channel

Following restoration efforts for the Kingfisher Side Channel within Milo McIver State Park between 2020 and 2025, we found increased quantity and quality of stream habitat. Restoration efforts focused on increasing complexity and floodplain connectivity by adding large wood and increasing side channel habitat. Following restoration treatment, we observed increased wood volume (m^3/100m) and no change in the secondary channel area (m^2). Mixed-effect regression model results did not suggest a significant difference across sampling periods between the Kingfisher Side Channel and the Upper Control channel for secondary channel area (p-value > 0.05), but differences were significant for wood volume (p-value < 0.001). Other significant BACI results were a decrease in primary channel area (m2), off-channel pool area (m2), and pool habitat (%). These channel form and morphology attributes decreased despite a substantial increase in stream flow (cfs) encountered during the post-restoration sampling effort. Additionally, the percentage of fine sediments (silt and sand) decreased across the sampling period. Although not significant, mixed linear model plots showed an increase in all other substrate types. Results of the HabRate model described an increase in habitat quality across species specific life-history types. These were similar to results across the same sampling period for the Upper Control channel.

The restoration of the Kingfisher Side Channel that occurred in 2021 resulted in positive 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 wood pieces. Following restoration, we did not see an increase in secondary channel habitat, but that was not the intent of the treatment. The increase in riffle depth from 18 cm prior to restoration to 56 cm in 2025 directly indicates increased flow and habitat connectivity across seasons. 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.

Riverbend (Sieben)

Following restoration efforts for Riverbend (Sieben) between 2021 and 2025, we found increased quantity and consistent quality of stream habitat. Channel form and morphology attributes generally increased across the sampling period and reflected the increased stream flow (cfs) encountered during the post-restoration sampling effort. Restoration efforts focused on increasing complexity and floodplain connectivity by adding large wood and increasing side channel habitat. Following restoration treatment, we observed increased wood volume (m^3/100m), number of key pieces (length ≥10m and diameter ≥60cm), and secondary channel area (m^2). Mixed-effect regression model results did not suggest a significant difference across sampling periods between Riverbend and the Lower Control channel for secondary channel area (p-value > 0.05), but differences were significant for wood volume (p-value < 0.02). Other significant BACI results were an increase in off-channel pool area (m2) and residual pool depth (m). Although not significant, mixed linear model plots for Riverbend presented an increasing slope for secondary channel area. In addition, a decreasing slope was observed for the percentage of fine sediment (silt and sand), and the percentage of gravel had an increasing slope. These results would suggest an increase in the quality of spawning and rearing habitat, but results of the HabRate model did not describe any differences within species specific life-history types across the same sampling period for Riverbend. HabRate results for the Lower Control channel across the same sampling period described a decrease in cutthroat trout habitat quality and increase in a coho habitat quality. Modeled results and habitat attribute increases associated with increased flow would suggest that restoration efforts were not exclusively responsible for influencing in-stream habitat attributes.

Control Channels

The analysis of control sites (Upper, Middle, and Lower control channels) over the years (2020–2025) reveals minimal changes in habitat metrics over time but significant differences between sites. Results of the linear mixed-effect regression model indicate significant site-specific differences in secondary channel area (m^2), off-channel pool habitat (m^2), and the percentage of cobbles. The Upper Control and Middle Control sites generally behaved similarly, although the Upper Control channel exhibited an increase in residual pool and riffle depths. These were likely influenced by river discharge (cfs) events increasing the channel entrance and bedload scour. Linear mixed model slopes indicate the Lower Control site demonstrated the greatest variability, particularly in the secondary channel area and wood volume, which were likely driven by more extreme stream flow events resulting in shifting wood accumulation. These 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.

Temperature Monitoring

Across all monitored sites, temperature data revealed consistent seasonal trends, with peak values in summer and cooling through fall. Within the Austin Hot Springs, Eagle Creek Complex, and Kingfisher Side Channel restoration sites, temperatures were slightly lower than the corresponding control sites, suggesting localized cooling benefits potentially from restoration efforts. Within the Clackamas River basin, our furthest downstream temperature site, Riverbend (Sieben), exhibited the highest temperatures and greatest daily variation. 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 Austin Hot Springs restoration 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.

Methods Comparison

Results of the simple linear regression suggest UAS imagery does not describe variation ($R^2 < 0.7$) in wood volume or the number of key wood pieces to warrant confidence in that method within discrete habitat types when compared to ground survey methods. Although, we have confidence ($R^2 > 0.7$) in using UAS methods to describe the variation in surface area measurements, wood volume per 100m, and key pieces of wood per 100m when compared to ground survey methods. We found that using UAS imagery to describe wood volume can be hindered by factors such as canopy closure, channel margins, varying wood volume levels, and complexity related to the size and orientation of wood structures. But UAS can serve as an appropriate tool for describing wood volume, channel margins, varying wood volume levels, and the complexity related to the size and orientation of wood structures when summarized across an entire site.

Our findings highlight both the potential and the limitations of using UAS imagery to describe wood volume in complex riparian environments. Variations in canopy closure, wood orientation, and unit complexity can reduce the accuracy of UAS results at the habitat unit level. Bland-Altman analysis results indicated that ground surveys detect more individual wood pieces and greater volume (m^3), while the UAS imagery described more surface area. These suggest that weighting attributes based on methods used to collect data may be appropriately used to reduce sampling biases associated with hindering factors.

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.

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