



North Clackamas Watersheds 2025 Temperature Study



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Supported by:



Executive Summary

Purpose

In 2019-20 the North Clackamas Watersheds Council (the Council) completed a Watershed Bio-Assessment. The Bio-Assessment determined that the absence of temperature data has made it difficult to prioritize projects that protect cold water refugia, or to track long term watershed conditions over time. Thanks to funding from the PGE Habitat Support Program and Oak Lodge Water Services, the North Clackamas Watersheds Council has begun to fill some of these stream temperature data gaps, with 2025 being the fourth year of data collection. Robust temperature monitoring information is critical to the management and restoration of our watersheds in four ways:

1. Determining the location of cold-water sources that create refugia for fish
2. Tracking on-going watershed trends
3. Informing decision-making by multiple agencies in project prioritization, land management, policy, and resource allocation
4. Educating landowners and land managers about watershed health

The methodology for this monitoring study was developed in cooperation with the Oregon Department of Environmental Quality (DEQ) Volunteer Monitoring Program. Temperature probes were launched in mid-May and were collected mid-October. The months of July and August were identified as the time period where temperatures were most critical for cold water species. We placed loggers at the confluences of the creeks in our service area to see how they function as potential cold water refugia (CWR) for fish migrating through the Lower Willamette.

Findings

There are several key findings that we can surmise from this year's temperature monitoring data.

1. *Several Willamette River confluences are potential cold water refugia*
Boardman Creek was identified as CWR. Both Kellogg Creek and River Forest Creek were warmer than the Lower Willamette River. However, loggers placed above Kellogg and River Forest lakes showed that those impoundments significantly increased water temperatures. If Kellogg Dam and its associated impoundment could be removed then the mouth of Kellogg Creek would function as CWR habitat. And if River Forest Lake could be hydraulically disconnected from River Forest Creek, that confluence could also function as CWR habitat. Rinearson Creek may be functioning as CWR, however there is uncertainty about how much the beaver pond is warming in the summer months. Water entering into the beaver pond is much cooler and meets the temperature criteria for rearing, but water leaving the pond is quite warm. This may be related to the warm water being skimmed off the top of the pond as it pours over the beaver dam.
2. *Kellogg Creek, Dean Creek, and Phillips Creek continue to provide cold water, cold water found in Rinearson Creek*
We were able to identify several cold-water areas in the North Clackamas watersheds. The water flowing from Dean Creek and Kellogg Creek upstream of its confluence with Mt. Scott Creek was significantly cooler than Mt. Scott Creek. Phillips Creek was also

slightly cooler than Mt. Scott Creek. The coldest water found was at Minthorn Springs, however, this water warmed significantly to become the warmest water studied as it travelled through Minthorn Springs Wetland. This year, stream temperatures in Rinearson Creek were significantly cooler than those documented in previous years, however this water seems to be warming considerably as it moves through the beaver pond.

3. *Thermal imaging of in-line stream impoundments is a tool that can be used in understanding complex temperature dynamics at sites with beaver activity.*

The thermal drone imagery has proven to be helpful in analyzing complex temperature dynamics in beaver ponds in our watersheds. This year we used drone imagery of Parmenter Ponds and the Rinearson mitigation site to better understand how in-line impoundments are impacting stream temperatures. At Parmenter Pond, water temperatures appeared to stay relatively cool throughout the pond, with gradual warming in the wider, downstream end of the pond. At Rinearson, thermal imaging showed warming in the wider sections of the impoundment, but overall appeared cooler than expected based on recorded temperatures. Data from the thermal imaging drone will help to inform future temperature monitoring at both sites.

4. *Less warming through in-line impoundments than in previous years*

This year we documented lower than usual temperature changes in several in-line impoundments in our watersheds, including the Kellogg Impoundment and in Mt. Scott Creek at the water control structure, despite similar average summer temperatures across years. Ongoing monitoring at these sites will help to determine if these are temporary fluctuations or ongoing trends at these sites. This highlights the importance of multi-year temperature studies that capture annual variations.

Implications for Restoration, Protection, and Management

The Council is utilizing these results to prioritize their restoration, protection, and management efforts in the watersheds in our service area.

1. *Fix heat-loading effects at impoundments*

Water temperatures increased significantly through water impoundments. Potential treatments vary at each site:

- When Kellogg Dam is removed, the associated impoundment will be dewatered and the channel will be restored to a sinuous flowing creek.
- River Forest Lake could potentially be disconnected hydraulically from River Forest Creek, while maintaining the lake for its surrounding residents. Further study should be conducted to determine the feasibility of accomplishing this.
- Minthorn Springs Wetland heats up considerably in the summer and restoration of that wetland should focus on controlling summer temperatures.
- As Clackamas WES implements restoration of their 3-Creeks property, consideration should be given to the pool downstream of the water diversion structure to determine how best to mitigate the temperature impacts at that site.
- The pond in the Rinearson Natural Area was maintained in the mitigation project at the request of adjacent landowners who wanted to be able to see the open water. However, the heat loading that occurs in this pond during the summer is problematic. Consideration should be given to restoring this area to a beaver-managed wetland complex that would allow the creek to access the floodplain.

2. *Target cold water areas for protection and fish access*

The cold-water areas (Boardman/Willamette Confluence, Dean Creek, Upper Kellogg Creek below Parmenter Ponds, North Fork Boardman Creek) should be prioritized for protection and fish access. These areas will provide thermal refuge for fish in the summer, and the Council will focus on removing any barriers to fish accessing these reaches, especially during summer low flows. There are two large passage barriers upstream of the Boardman Creek confluence at Walta Vista and River Roads that currently block passage of anadromous fish past that point.

3. *Identify restoration projects that can trap spawning gravels for coho and Pacific Lamprey in the Kellogg-Mt. Scott Watershed, in preparation for removal of Kellogg Dam.*

Restoring spawning gravel beds involves replenishing and trapping quality gravel in rivers and streams to provide suitable habitat for fish to lay their eggs. Adding habitat complexity through additions of large wood slows down the water and traps these gravels for fish. Sometimes additional gravels are placed behind wood structures to speed up the process. The stability of added gravels is dependent on gravel size and on the hydrology of the reach. One potential site for these large wood additions is Mt. Scott Creek through Mt. Talbert Nature Park. NCWC is discussing the potential for a large wood project at this location with Metro.

Further Study

As with any research project, this work has generated several more questions that need study. Future monitoring years should study the following in more depth:

- Repeat temperature monitoring in the upper reaches of Mt. Scott Creek to verify potential cold-water sources and determine why it heats up so much as water flows down to Mt. Talbert.
- Continue long-term trend monitoring to track changes in watershed temperature impacts from climate change, development, and restoration actions.
- Compare the results of this study with the Council's fish passage barrier and eDNA studies to better understand fish utilization.
- Study harmful algae blooms (HAB's) in the impoundment behind Kellogg dam and potentially other sites with warming stagnant water. As temperatures increase, and the impoundment continues to fill in with sediment, we are seeing increased growth in algae. There is a desire to better understand that growth and the potential impact to the surrounding community.
- Utilize drone technology mounted with an infrared camera to look at temperature dynamics such as point-sources for heating and cooling, and the management of these impacts in restoration sites.

Despite the association between warm summer water temperatures and reduced salmonid survivorship, there is often little consistent long-term temperature data collected year after year in smaller streams. The Council plans on continuing our temperature monitoring program annually. Funding for repeated annual monitoring programs can be difficult to secure, and it is our hope that granting agencies recognize the importance of utilizing empirical data to inform our protection and restoration efforts. We currently have funding to complete five years of temperature monitoring.

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Introduction

In 2019-20 the North Clackamas Watersheds Council (the Council) completed a Watershed Bio-Assessment and developed a list of high-priority restoration projects for ecological uplift of the Clackamas fish population (NCWC, 2020). The Bio-Assessment found there is little to no continuous temperature monitoring underway in these watersheds, the exceptions being one project on Lower Rinearson Creek and 3 stations maintained by the Clackamas Water Environment Services (WES) to calibrate flow meters. The absence of this fundamental information has made it difficult to prioritize projects that protect cold water refugia, or to track long term watershed conditions over time as we monitor impacts from restoration, climate change, and urbanization.

Water temperature affects the distribution, health, and survival of native salmonids and other aquatic organisms by influencing their physiology and behavior. Water that is too warm can cause direct mortality of fish. But while lethal high temperatures can be locally problematic, temperatures in the range that cause sublethal effects are much more widespread and may have the greatest effect on the overall wellbeing of our native fish populations. These sublethal effects resulting from abnormally high temperatures include impaired feeding, reduced growth, diminished resistance to disease, inability to compete, and poor predator avoidance (EPA, 2001). Evidence suggests that small increases in temperatures (2-3 °C) above biologically optimal ranges can begin to reduce salmonid fitness. Temperature related impacts to lamprey are more difficult to describe as there are few studies in nature to describe such impacts. Researchers investigating lamprey through laboratory experiments, field observations, and telemetry work concluded that water temperature in the Willamette Basin ≥ 20 °C is correlated with developmental abnormalities in larvae, expedited sexual maturation, pre-spawning mortality, slowed or stopped upstream migration by adults, and gonadal tissue damage (Ben Clemens, ODFW Statewide Lamprey Coordinator, personal communication with Todd Alsbury, November 2020).

Water temperatures are influenced by solar radiation, stream shade, ambient air temperatures, channel morphology, groundwater inflows, and stream velocity, volume, and flow. Surface water temperatures may also be warmed by anthropogenic activities such as discharged heated water, changed stream width or depth, lowered stream complexity that decreases hyporheic exchange, reduced stream shading, and water withdrawals.

The Kellogg-Mt. Scott, Rinearson, River Forest, and Boardman watersheds provide rearing habitat and some spawning habitat to threatened and endangered salmonids and other priority species including winter steelhead, coho salmon, Pacific lamprey, cutthroat trout (resident, fluvial, and anadromous), and fall and spring Chinook salmon (Clackamas Partnership, 2018). Furthermore, they provide both potential off-channel cold-water refugia in a stretch of the Willamette River where geological features largely prevent alcoves and significant side channel refugia in the Willamette mainstem (USGS, 2018 and DEQ, 2020). This makes the availability of cold water refugia critical in lower Willamette tributaries and tributary junctions. However, the lack of information on cold-water refugia in these tributary systems of the Willamette floodplain is a key knowledge gap that has hindered strategic restoration.

NCWC has begun to fill some of these stream temperature data gaps, and this year is the fourth year of monitoring. The previous years of data collection were completed in 2022, 2023, and 2024 (NCWC, 2023; NCWC, 2024; NCWC, 2025), and that data informed this year's study sites and priorities. Funding has been secured through OWEB to continue the research for a total of five years, and the hope is that this monitoring program will run in perpetuity. This effort is being undertaken in cooperation with multiple jurisdictions and partners including the Oregon Department of Environmental Quality (DEQ), Oregon Department of Fish and Wildlife (ODFW), Oak Lodge Water Services (OLWS), Clackamas Water Environment Services (WES), City of Gladstone, City of Milwaukie, City of Happy Valley, Metro, and North Clackamas Parks & Recreation District.

Project Goals

Robust temperature monitoring information will be critical to the management and restoration of these watersheds in four ways:

1. *Determine the location of cold-water sources that create refugia for fish:* This study helps address knowledge gaps regarding cold-water refuges in tributaries of the lower Willamette and North Clackamas watersheds. By closing information gaps on temperature, the Council will ensure that future projects are located to protect and maximize cold water refugia, and remove barriers that potentially prevent access to cold water refugia. The thermograph monitoring effort will also be supplemented by flying some sites with a drone carrying a thermal infrared camera, thanks to a grant from ODFW. This will allow in-channel restoration projects to be designed in a way to capture and maximize cold water for fish.
2. *Track ongoing watershed trends:* Ongoing continuous temperature monitoring is fundamental to a long-term understanding of watershed function and how it changes over time with impacts from climate change, urbanization, and ongoing restoration efforts. We will maintain these temperature stations in the same locations (if funded), creating a long-term trend analysis that will guide the Council's restoration and advocacy.
3. *Inform decision-making by multiple agencies:* The information gathered in this study will be shared with local and state jurisdictions, allowing them to utilize it to engage in informed planning when projects may impact these watersheds. It will also help to monitor the impact natural areas have on stream temperatures as local jurisdictions advocate to create, protect and manage natural areas, parks and public lands and take other steps to improve water quality and climate resilience in their jurisdictions. Finally, the data will provide baseline information to better understand how man-made impacts such as development and point-source discharges affect stream temperatures.
4. *Use for landowner education:* Projects such as these provide vital opportunities to engage the public in watershed science. Discussions with landowners and residents during the Bio-Assessment revealed a lack of understanding by well-meaning landowners of the role of large wood, side channels, wetlands, in-channel complexity,

and temperature as a limiting factor for aquatic health. This field work has opened the door to many of these conversations, and this temperature monitoring information will be incorporated into on-going landowner education efforts.

Methods

The Council developed the temperature monitoring methodology in cooperation with the Oregon Department of Environmental Quality (DEQ) Volunteer Monitoring Program. The Council developed a Sampling and Analysis Plan (SAP) which was approved by DEQ in 2022. We are collecting Level A quality data, as defined by DEQ in the Quality Assurance Project Plan (QAPP): Volunteer Water Quality Monitoring, July 2021. Level A data can be used to assess compliance with water quality standards, permitting requirements, or other regulatory activities; however, the Council is not a regulatory agency and will not be using the data in this way. Level A data requires that the accuracy of every thermograph is checked with a NIST thermometer within an accuracy $\pm 0.5^{\circ}\text{C}$ and a precision of $\pm 0.5^{\circ}\text{C}$. This NIST thermometer is borrowed from DEQ through their Volunteer Monitoring Program, and every year they calibrate it for accuracy. All temperature data was collected using Onset HOBO MX2203 Tidbit Data Loggers in Celsius. The Tidbits are durable and designed for data collection up to 400-foot depths. They are waterproof with a precision sensor with $\pm 0.2^{\circ}\text{C}$ accuracy, 0.01C resolution, and ranges between -20°C and 50°C (-4 to 122°F) in water. The accuracy of the thermographs were tested against a NIST certified temperature probe before and after field deployment to ensure that they operated within their designed range of accuracy ($\pm 0.5^{\circ}\text{C}$), which they all did. These pre- and post-season logger calibrations are then submitted to DEQ with the data every year. The monitoring was intended to capture high summer water temperatures, which predominantly occur from June through September.

Temperature monitoring occurred in Kellogg-Mt. Scott, Rinearson, River Forest, and Boardman watersheds and their confluences with the Willamette River. The Council selected some sites as reference sites to reflect baseline conditions within a specific stream year after year. Other sites were chosen as study sites to answer specific questions about how water temperatures are impacted by water impoundments, nature areas, or instream temperatures, and those research questions change year to year. Temperatures were monitored May to October in order to capture high summer water temperatures.

Figure 1 - Locations of temperature monitoring stations in 2025.



Table 1 - Station descriptions and research questions being asked at each location. Table arranged by geographic proximity.

Site ID#	Logger#	Station Description	Research Question
1	21723348	Kellogg Dam fish ladder	Temperatures at the downstream end of the Kellogg Dam impoundment?
42	21333038	Behind Milwaukie Presbyterian Church	Temperatures in a back channel to the impoundment?
49	21333016	Kellogg Creek upstream of the impoundment (at Oatfield Road)	Does Site 2 accurately reflect temperatures flowing into Kellogg Dam impoundment?
2	21727635	Kellogg Creek upstream of impoundment (on private land)	Temperatures flowing into the Kellogg Dam impoundment?
28	21333042	Kellogg Creek at Rusk Road culvert	Temperature profile of Kellogg Creek?

Site ID#	Logger#	Station Description	Research Question
44	21333040	In Parmenter Pond near WES facility	Temperatures of water going in Parmenter Ponds?
29	21333036	Kellogg Creek at SE Clackamas Road culvert	Temperature profile of Kellogg Creek?
5	21333029	Clackamas Park	Temperature profile of Kellogg Creek?
6	22106059	Mt. Scott Creek at downstream end of 3-Creeks Natural Area	Temperatures leaving 3 Creeks?
7	22106058	Mt. Scott Creek upstream of water control structure	Temperatures going into the pond downstream of the water control structure at 3 Creeks?
8	21727636	3 Creeks downstream of Phillips confluence	Temperatures in 3 Creeks after tributary influence?
11	22106057	Mouth of Dean Creek behind PCC	Temperatures in Dean Creek before entering Mt. Scott?
51	21333037	Dean Creek at end of 84 th Ave	Temperature profile of Dean Creek?
12	21723339	Mt. Scott at SE 84 th	Temperatures of Mt. Scott before being influenced by Dean & Phillips Creeks?
13	21727634	Phillips on WES 84 th property north of Sunnybrook	Temperatures in Phillips Creek?
15	22106061	Mt. Scott downstream of Mt. Talbert east of 97 th	Temperatures flowing out of Mt. Talbert Nature Park?
34	21727637	Mt. Scott in Mt. Talbert downstream of unnamed tributary confluence	Temperatures of Mt. Scott Creek after the confluence with the unnamed tributary?
52	22106060	Mt. Scott at bridge crossing across from SE Spring Mountain Drive	Temperature profile of Mt. Scott Creek?
16	21723338	Mt. Scott end of anadromy	Temperatures of Mt. Scott Creek at the uppermost limit of anadromy (as defined by ODFW)?
18	21333035	Spring entering Minthorn Wetlands	Temperature of the spring feeding Minthorn Wetlands?

Site ID#	Logger#	Station Description	Research Question
17	21726928	Leaving Minthorn Wetlands	Temperatures flowing out of Minthorn Wetlands compared to the springs?
19	21726927	River Forest downstream of lake below culvert	How does the lake impact River Forest temps before it drains into the Willamette?
20	21723336	River Forest upstream of lake at SE Fair Oaks	Temperatures of River Forest Creek before it enters River Forest Lake?
22	21333033	Boardman at OLWS lift station	Boardman's temperatures before draining into the Willamette?
24	21333026	Boardman at Stringfield Park	Temperatures of the south fork before it joins with the north fork?
53	21333032	Boardman at SE Boardman Ave	Temperatures after passing through the HW99 corridor?
40	21333025	Outlet of Boardman Wetlands at Boardman Rd.	Temperatures exiting Boardman Wetlands and just before passing through the HW99 corridor?
26	21333023	Rinearson downstream of River Road	Temperatures of creek after flow through Hwy99?
27	21333028	Rinearson at Olson wetlands (end of Risley Ave)	How does the influence of Olson Wetlands affect stream temps?
45	21333019	Downstream of pond at Meldrum Bar	Temperatures leaving pond?
46	21333039	Upstream of pond at Meldrum Bar	Temperatures going into pond?

At all sites except Site 1, a three-foot piece of rebar was driven into the streambed and was used to secure each thermograph. This rebar was driven to a depth below the surface of the water level, keeping the installation relatively hidden. At locations that were accessible to the public, the rebar was topped with a plastic cap to prevent people from injuring themselves on it. The probes were housed in a 2" ABS pipe that had 15-20 ¼ inch holes drilled out to allow water to through on a constant basis while preventing potential sediment accumulation around the probe (see Figure 2). Stainless steel cable and clamps then attached the ABS pipe to the rebar to ensure probes were not lost during the sampling period. Once the rebar and pipe were installed, the probe was not noticeable from above the water to prevent tampering. For this reason, photos were taken at every installation location and the sample sites were geo-located utilizing the ArcGIS Field Maps phone app to ensure that the rebar could be found when collecting the probes at the end of the sample season. All site data was also recorded on Field Maps. The installation at Site 1 was slightly different. This logger was installed at the mouth of Kellogg Creek in the fish ladder located at the dam by putting the

thermograph in the ABS pipe, affixing that to a 10-pound weight, and then sinking into the fish ladder.

Figure 2 - All temperature loggers are protected in 2" ABS pipes that had 15-20 ¼ inch holes drilled out to allow water to through on a constant basis while preventing potential sediment accumulation around the probe.



At the end of the sampling season, the thermographs were recovered and downloaded. The data was summarized based on a 7-day average maximum (7dAM), which is calculated by averaging the daily maximum instream water temperatures for 7 consecutive days. Because the criteria apply to every 7-day period, it is often referred to as the rolling 7dAM. For example, one 7-day period is July 1-7, and the next is July 2-8. The 7dAM value for each 7-day period is reported on 7th day of the period. All raw and analyzed data has been backed up in NCWC's Google Drive cloud storage.

Unfortunately, at several sites loggers with either lost/stolen or the logger became corrupted and the data was not recoverable. This occurred at the following locations:

- Site 42 - Back channel in Kellogg Impoundment (Logger not recovered)
- Site 28 - Kellogg at Rusk Road (Logger not recovered)
- Site 29 - Kellogg at Clackamas Road (unknowingly removed by contractor)
- Site 40 - Outlet of Boardman Wetlands (Logger not recovered)
- Site 7 - Upstream of water control structure in 3 Creeks (Unit didn't log data)

This year we added additional thermal imaging to some of our project sites. The drone selected for this work was the DJI Mavic 3T, thanks to a grant provided by ODFW. This drone is portable enough for field work and has two cameras, a Zoom camera for the visible light spectrum and an infrared camera for the thermal spectrum. The Mavic 3T's zoom and

thermal cameras also support continuous side-by-side views on the controller for easy comparisons. The flight interface allows for pre-programming the flight paths and specifying image overlap, both of which is necessary for the creation of orthomosaic photos.

Figure 3 - Side by side viewfinder on remote controller of DJI Mavic 3T (images from DJI Enterprise)



A "Small UAS Certificate of Registration" was acquired from the Federal Aviation Administration (FAA) to register the drone. All flights were done by a licensed drone pilot to comply with FAA regulations. The project sites were flown twice, collecting images in both the infrared and visual light spectrums. A flight plan was created using the flight planning software on the drone remote. All flights were flown at 300 feet above ground level (AGL). Front and side overlap for flights was set to 85%. The drone speed was slowed down to approximately 60% of max speed to minimize blur in the photos.

The site photos were converted to .tiff files to be processed in Pix4D Mapper. The resulting orthomosaics were exported in .tiff format, allowing comparison of the visible light images with the infrared images.

Figure 4 – Drone pilots were all licensed by the FAA.



Temperature Standards

The Council is not a regulatory entity, and cannot use temperature data in a regulatory capacity. Temperature standards are simply a way that we can reflect on a waterbody's capacity to provide habitat for cold-water fish species. This data will predominately be used for the purpose of strategic watershed planning, with the goal of identifying and prioritizing cold-water areas for restoration and protection. The data will be provided to DEQ annually as per our Sampling and Analysis Plan (SAP) through DEQ's Volunteer Water Quality Monitoring Program.

Beneficial Uses

The objective of a water quality standard, as required by the Clean Water Act, is to protect the beneficial uses of the waters of the State. In the case of temperature, the most sensitive beneficial use is Oregon's native cold-water aquatic species such as salmon and trout. The DEQ established temperature standards for specific life history stages of salmon and steelhead (as seen below in Table 2). The standards are used in establishment for Total maximum Daily Load (TMDL) criteria for water quality limited streams in Oregon (DEQ, 2008), and are based on 7dAM.

Table 2 - List of designated beneficial uses and associated temperatures.

Beneficial use	7dAM
1. Salmon & steelhead spawning (during spawning use)	55.4 °F / 13 °C
2. Core coldwater habitat (year round)	60.8 °F / 16 °C
3. Salmon & trout rearing & migration (year round)	64.4 °F / 18 °C
4. Migration corridor for salmon & steelhead (year round)	68.0 °F / 20 °C

1. *Salmon & steelhead spawning* - Waters that are or could be used for salmon and steelhead spawning, egg incubation, and fry emergence
2. *Core coldwater habitat* - Waters that are expected to maintain temperatures within the range generally considered optimal for salmon and steelhead rearing
3. *Salmon & trout rearing & migration* - Waters that are thermally suitable rearing habitat for salmon, steelhead, rainbow trout, and cutthroat trout.
4. *Migration corridor for salmon & steelhead* - Waters that are predominantly used for salmon and steelhead migration during the summer and have little or no anadromous salmonid rearing in the months of July and August.

The creeks studied here are primarily limited to rearing habitat since very few spawners are able to access Kellogg Creek due to the existing dam, so the ideal 7dAM threshold would be 18°C. Once Kellogg Dam is removed, there is potential for the Kellogg-Mt. Scott watershed to be utilized by salmonids and Pacific lamprey for spawning in the future. For this reason, this year we targeted some areas with spawning gravels in Kellogg-Mt. Scott Creek for year-round monitoring to consider temperatures during potential spawning seasons (fall through spring), as well as the summer months when thermal loading is a problem.

Cold-Water Refugia

DEQ also establishes standards for identifying cold-water refuge (CWR) along the Lower Willamette. The CWR provision supplements the migration criterion in the Lower Willamette of 20°C to protect migrating populations of salmon and steelhead. The criterion states that these water bodies must have sufficiently distributed CWR that allow salmon and steelhead migration without significant adverse effects from 7dAM temperatures up to 20°C (DEQ, 2020). Candidates as cold-water refuge from tributaries was defined as having at least a 2°C colder temperature than the daily maximum temperature of the adjacent well-mixed flow of the water body. Therefore, at creek confluences with the Willamette we will be assessing the differences between average daily maximum temperatures during the months of July and August, which is slightly different than the 7-day rolling average temperatures (7dAM) that we will be assessing outside of the Lower Willamette confluence CWR analysis.

Wetlands

Oregon has no unique temperature criteria for wetlands at this time. However, wetlands with direct connections to creeks and rivers have the potential to impact water temperatures. For example, in this study the Minthorn Springs wetland acts as the headwaters of Minthorn Creek and directly impacts water temperatures flowing into that system.

Results: Lower Willamette Confluences as CWR

Evaluating creek confluences that flow into migration corridors as potential CWR is important, particularly in the Lower Willamette where side channels and backwater habitats are limited by the area's geology. Migration corridors are often channels that are too large to be cooled by shading vegetation and groundwater inflow. Because of the importance of CWR in the Lower Willamette, NCWC and its partners in the Clackamas Partnership have developed a confluence strategy to prioritize protecting and enhancing potential cold-water inputs into the Willamette River (see Figure 5). As part of that strategy, the need for confluence temperature monitoring was identified, and loggers were placed at the mouths of all confluences within NCWC's service area.

Any identified CWR habitat may be enhanced and protected by:

1. maintaining or enhancing vegetation for shade,
2. creating instream cover with large wood,
3. protecting cold tributaries from development in riparian areas,
4. protecting and creating channel features that create cold water flows through hyporheic exchange,
5. protecting sources of groundwater inflows,
6. reducing heat impacts from stormwater inputs through detention and treatment, and
7. removing physical and thermal barriers to fish accessing areas of cold water.

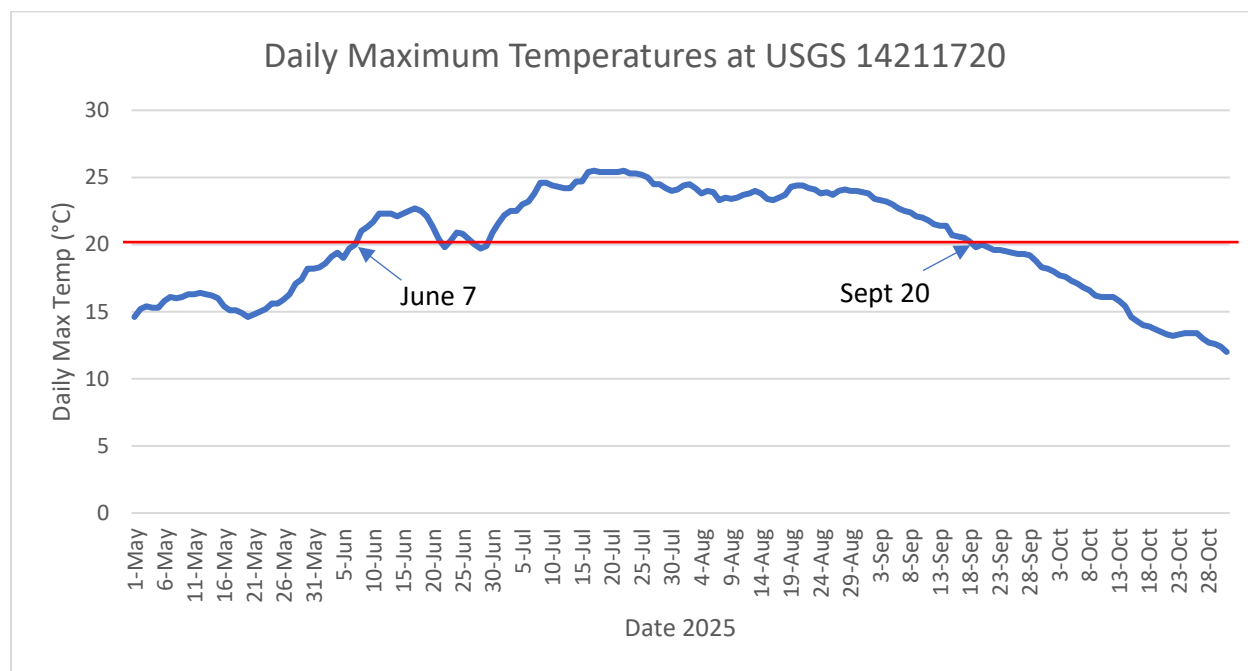
Figure 5 - Potential CWR along the lower Willamette River located in creek confluences.



The USGS gaging station for the Willamette River at Portland (USGS 14211720 at the Morrison Bridge) was used as the reference temperature for the mainstem Lower Willamette. This same gage station was also used in the 2023 and 2024 temperature studies, and during the DEQ 2020 study. Last year, an additional temperature logger was installed in the Willamette near the confluence of River Forest Creek which confirmed that the USGS gaging station adequately reflects temperatures throughout the Oswego reach of the lower Willamette River (NCWC 2024).

In 2025, the lower Willamette River exceeded the DEQ 20°C temperature standard for migration corridors from June 7, 2025 to September 20, 2025, as seen below in Figure 6. The 2012 EPA study identified July and August as the season of concern for quantifying CWR in the lower Willamette River. The 2022 temperature study (NCWC, 2023) concurred with that assessment. However, in 2023, 2024 and 2025 the season of concern extended much further into September. This longer season of high temperatures should be tracked over time to see how it impacts fish in context of climate change. For consistency, we will continue to focus on July and August as the limiting season, however, after five years of data collection we will do an analysis to look at trends over time. One of the variables that should be looked at closer is the persistence/longevity of the high summer temperatures.

Figure 6 - Summer daily maximum water temperatures in the lower Willamette River at USGS gage station 14211720.

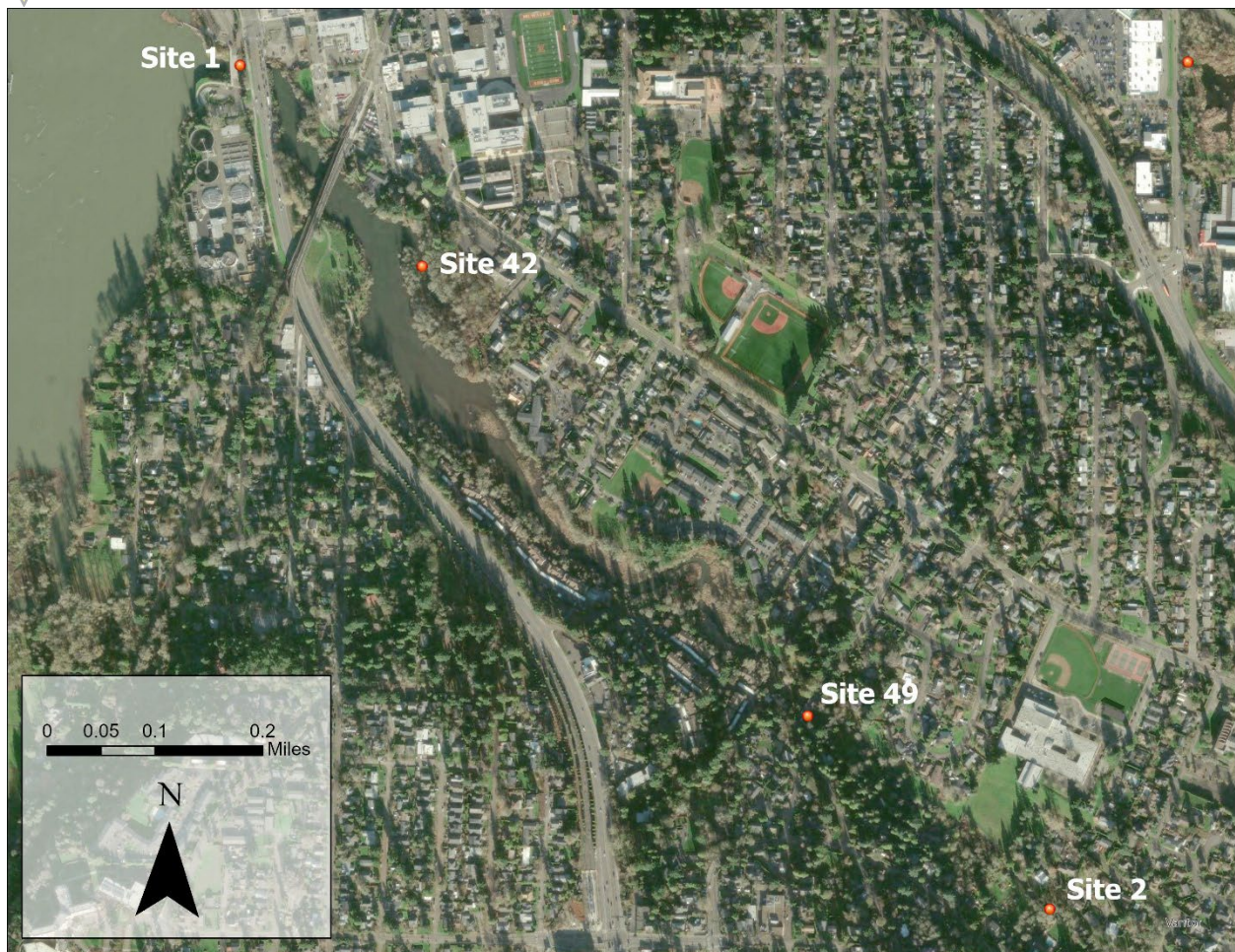


It is important to reiterate that by definition CWR is identified as having at least a 2°C colder temperature than the daily maximum temperature of the adjacent well-mixed flow of the water body. Therefore, for this analysis, we will be looking at the averages of daily maximum temperatures, NOT the 7dAM.

Kellogg Creek Confluence

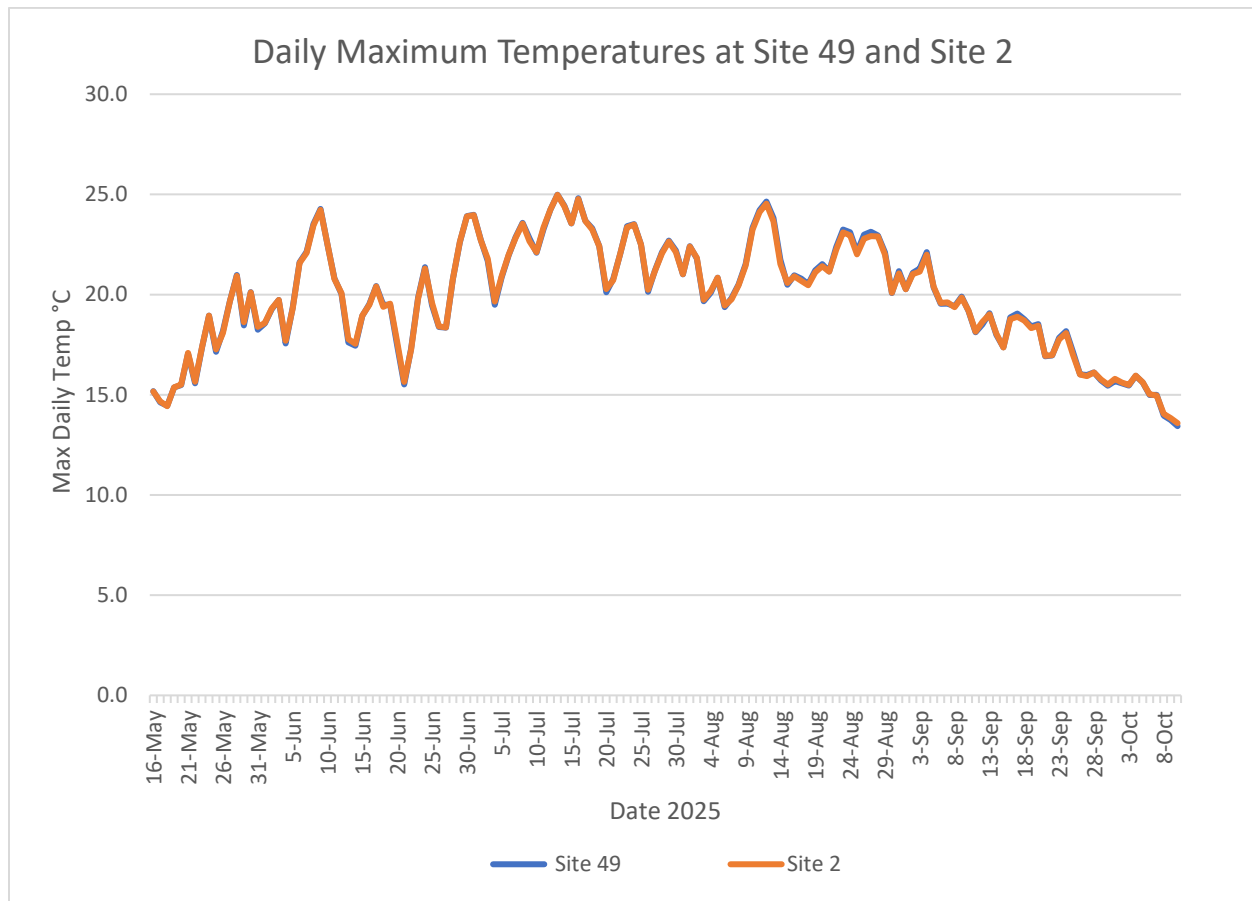
One temperature logger was installed at the mouth of Kellogg Creek in the fish ladder (Site 1). A second logger was installed on private property upstream of the impoundment behind Kellogg dam (Site 2) to determine how water temperatures were specifically affected by the widened, shallow impoundment formed behind the dam. This year a third logger was added within the Clackamas County right of way on Oatfield Road, upstream of the impoundment (Site 49) to confirm that Site 2 adequately reflected temperatures entering the impoundment. A fourth logger was installed in a back channel in the middle of the impoundment but was not recovered.

Figure 7 - Location of Kellogg Creek confluence temperature loggers



The daily maximum temperatures at Site 49 were on average within 0.01 C of those found at Site 2 as seen in Figure 8. This confirms that Site 2 data accurately reflects the temperatures entering the impoundment. Further analysis will rely on data from Site 2, to maintain consistency across years.

Figure 8 - Summer daily maximum water temperatures in Kellogg Creek upstream of the impoundment at Site 2 and Site 49.



During DEQ’s CWR study (DEQ, 2020) Kellogg Creek was identified as a cold-water refuge during the summer months. However, the temperature data collected at Kellogg’s mouth and upstream of the dam’s impoundment show that the potential of Kellogg’s confluence to provide CWR is not only impacted by the dam blocking fish access into the creek, but the impoundment behind the dam is significantly increasing water temperatures to levels similar to the Willamette mainstem.

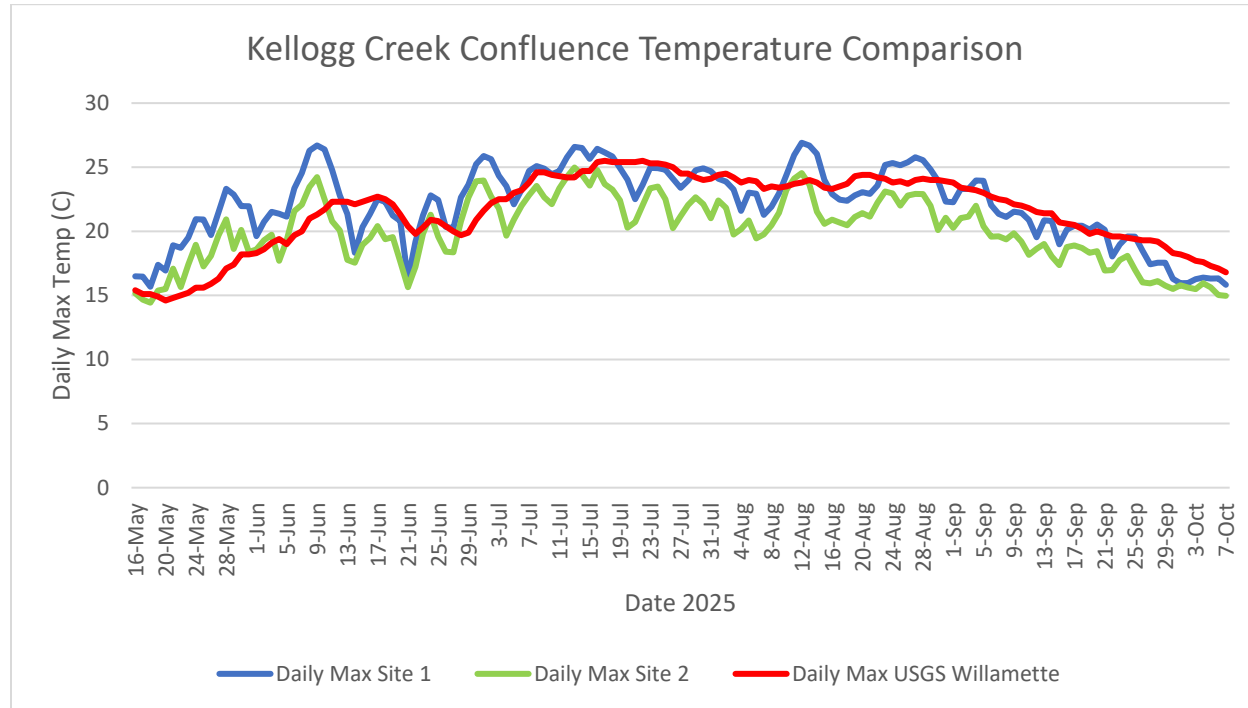
When comparing daily maximum temperatures in Kellogg Creek versus the Lower Willamette, we found that on average the daily maximums were slightly higher in the Kellogg fish ladder than in the Willamette mainstem for the months of July and August by 0.2 °C (see Table 3). However, we know that the dam’s impoundment is wide and shallow and affects the water temperature through that reach. In fact, the temperature logger upstream of the impoundment shows water temperatures 2.0 °C cooler than the Willamette, indicating that the water is heating up 2.2 °C (4.0 °F) as it flows through the impoundment and into the fish ladder. This is slightly less than the temperature increases we saw in the impoundment in previous years. In 2023 and 2024, temperatures increased by 2.7 °C between Site 2 and Site 1, and by 2.8 °C in 2022. In Kellogg Creek, the continual infill of the dam impoundment by

sediment may be causing the channel to become shallower and wider over the years, increasing the water's exposure to the warming effects of convection and radiation.

Table 3 - Average daily maximum temperatures of Kellogg Creek both upstream and downstream of the dam impoundment as compared with lower Willamette River temperatures.

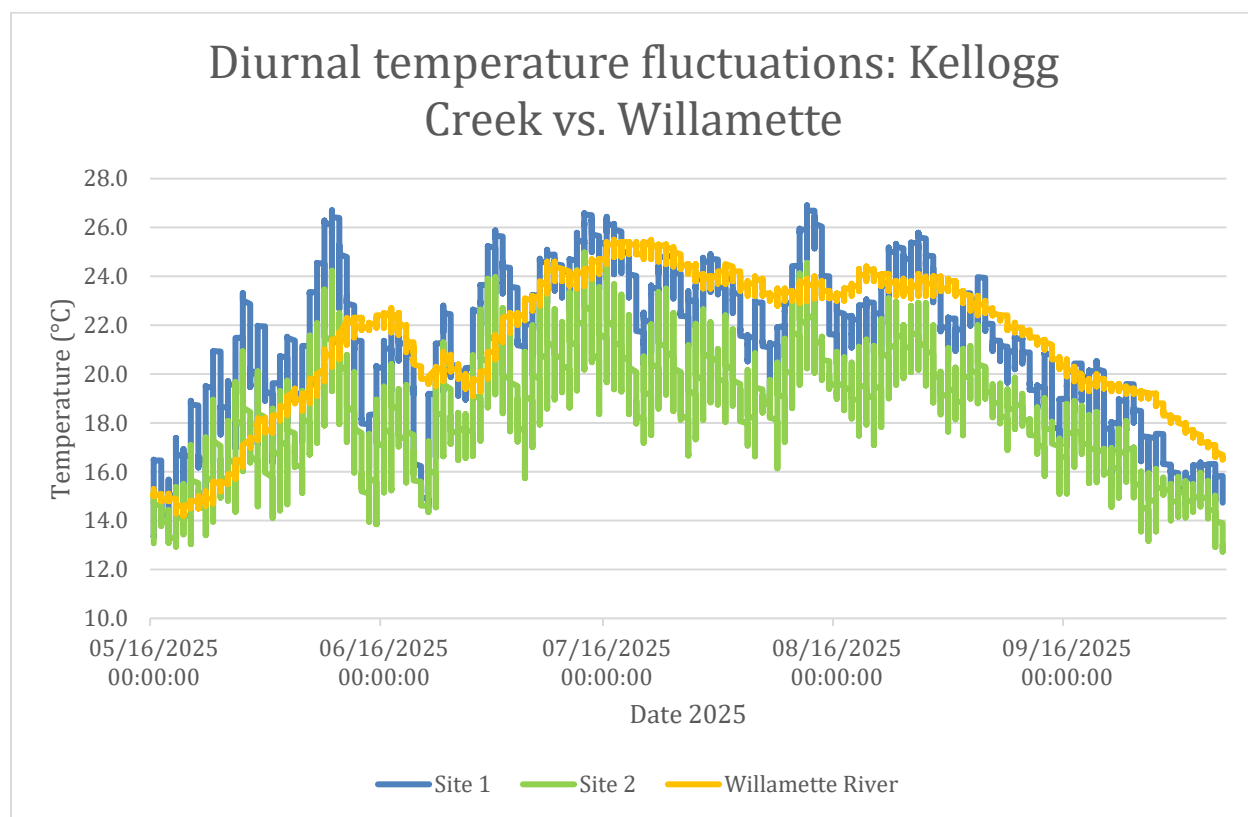
	July 2025 (°C)		August 2025 (°C)		July & August 2025 (°C)	
Location	July Mean Daily Max Temp	Change from Willamette	August Mean Daily Max Temp	Change from Willamette	Summer Mean Daily Max Temp	Change from Willamette
Willamette (USGS 14211720)	24.3	-	23.9	-	24.1	-
Mouth of Kellogg Creek (Site 1)	24.7	0.4	24.0	0.1	24.3	0.2
Upstream of Kellogg Impoundment (Site 2)	22.5	-1.8	21.7	-2.2	22.1	-2.0

Figure 9 - Average daily maximum temperatures of Kellogg Creek both upstream and downstream of the dam impoundment as compared with lower Willamette River temperatures.



One of the challenges of utilizing daily maximums when looking at CWR habitat is that maximums do not take into account daily temperature variations. The Lower Willamette is a large well-mixed water body. Larger, deeper water bodies are less influenced by daily fluctuations due to ambient air temperatures and solar radiation. Smaller, shallower creeks like Kellogg Creek are much more susceptible to these factors. When we plot daily temperature fluctuations at the three sites mentioned above, we see that diurnal flux is much larger in Kellogg Creek than the Willamette (Figure 10). These daily temperature fluctuations are a more accurate representation of the temperature variations facing a fish migrating through the Lower Willamette and potentially utilizing the mouth of Kellogg Creek as CWR.

Figure 10 - Diurnal temperature fluctuations at the Kellogg Creek confluence as compared with the Lower Willamette in 2024.



River Forest Creek Confluence

Two temperature loggers were installed associated with River Forest Creek this year:

- Site 19 - at the confluence downstream of River Forest Lake
- Site 20 - upstream of River Forest Lake

These study sites were chosen to determine if the water from River Forest Lake was significantly impacting water temperatures and the ability of the River Forest Creek confluence to act as CWR for the Lower Willamette.

Figure 11 - Location of River Forest Creek confluence temperature loggers.

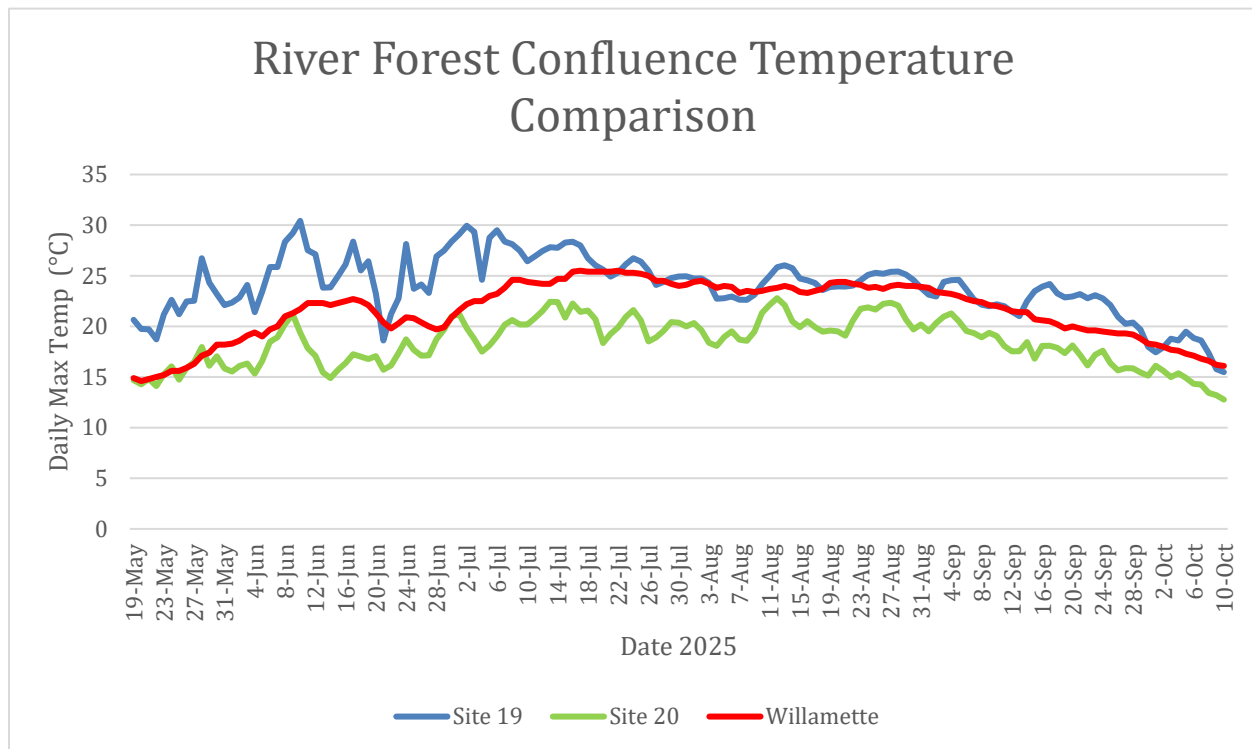


When comparing daily maximum temperatures in River Forest Creek versus the Lower Willamette, we found that on average the daily maximums were higher at the River Forest confluence than in the Willamette mainstem for the months of July and August by 1.5 °C (see Table 4). This is consistent with previous monitoring years, when summer water temperatures found at the mouth of River Forest Creek were higher than the Lower Willamette River as a result of the high temperature water flowing out of River Forest Lake. Water temperatures upstream of the lake at Site 20 continued to be cooler than the Willamette River, by an average of 3.8 °C, which is consistent with data from previous years.

Table 4 - Average daily maximum temperatures of River Forest Creek as compared with lower Willamette River temperatures.

	July 2025 (°C)		August 2025 (°C)		July & August 2025 (°C)	
Location	July Mean Daily Max Temp	Change from Willamette	August Mean Daily Max Temp	Change from Willamette	Summer Mean Daily Max Temp	Change from Willamette
Willamette (USGS 14211720)	24.3	-	23.9	-	24.1	-
Mouth of River Forest Creek (Site 19)	26.9	2.5	24.3	0.5	25.6	1.5
Upstream of River Forest Lake (Site 20)	20.3	-4.1	20.4	-3.5	20.3	-3.8

Figure 12 - Average daily maximum temperatures of River Forest Creek as compared with lower Willamette River temperatures.



This data continues to show that River Forest Creek has the potential to function as CWR habitat if the channel could be disconnected from River Forest Lake. This also supports the findings of the Council's 2022 Watershed Action Plan, which recommends the disconnection of the River Forest Creek channel from the River Forest Lake impoundment as a priority action. Because the lake is not an in-line impoundment, it's disconnection from the creek

may be possible, and further study should be conducted to determine its feasibility. NCWC also completed a habitat enhancement project at the confluence that went to construction Summer 2024. This project targeted winter and spring rearing habitat in the Willamette River as we know this reach of River Forest Creek below the culvert typically dries up in the summer.

Boardman Creek Confluence

There was one logger installed at the confluence of Boardman Creek with the Willamette River. Site 22 was at the Oak Lodge pump station and the site was selected because the temperatures there are not influenced by the backwater effects of the lower Willamette River.

Figure 13 - Location of Boardman Creek confluence temperature logger.

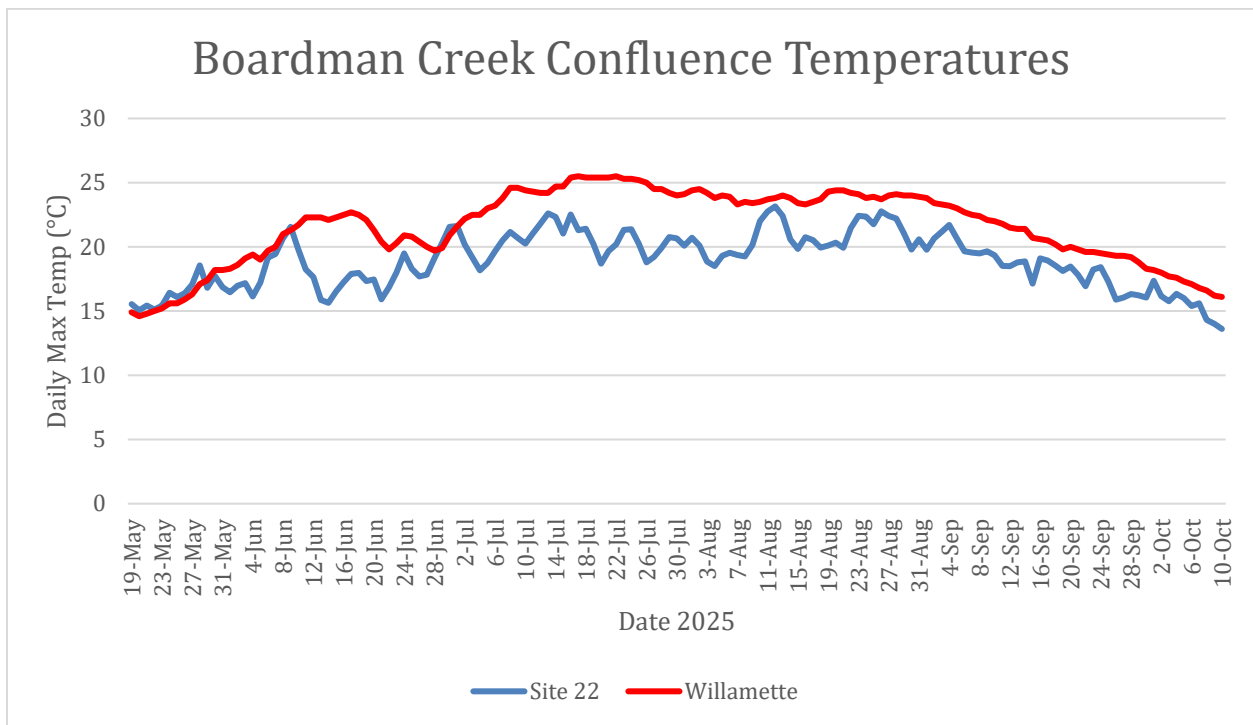


Summer water temperatures at the Boardman Creek confluence were cooler than the Willamette, and the average daily maximum temperature for the months of July and August was 3.6 °C lower than the Willamette USGS gage (see Table 5).

Table 5 - Average daily maximum temperatures of Boardman Creek as compared with lower Willamette River temperatures.

	July 2025 (°C)		August 2025 (°C)		July & August 2025 (°C)	
Location	July Mean Daily Max Temp	Change from Willamette	August Mean Daily Max Temp	Change from Willamette	Summer Mean Daily Max Temp	Change from Willamette
Willamette (USGS 14211720)	24.3	-	23.9	-	24.1	-
Mouth of Boardman Creek (Site 22)	20.5	-3.8	20.8	-3.1	20.6	-3.6

Figure 14 - Average daily maximum temperatures of Boardman Creek as compared with lower Willamette River temperatures.



The results from this year and previous years (NCWC, 2024; NCWC, 2023) show that Boardman Creek currently functions as CWR habitat in the Lower Willamette in the summer months. Although summer flows out of Boardman Creek are low, they are perennial, and the confluence provides thermal refuge for fish. The Council currently is designing a habitat restoration project to create pools and install large wood to provide instream cover at this site. Construction of the project will be dependent on securing landowner agreements and funding.

Rinearson Creek Confluence

This year, two temperature loggers were installed in the natural area near the mouth of Rinearson Creek. One was located at the downstream end of the beaver pond (Site 45) and one was located upstream of the beaver pond (Site 46).

Figure 15 - Average daily maximum temperatures of Rinearson Creek as compared with lower Willamette River temperatures

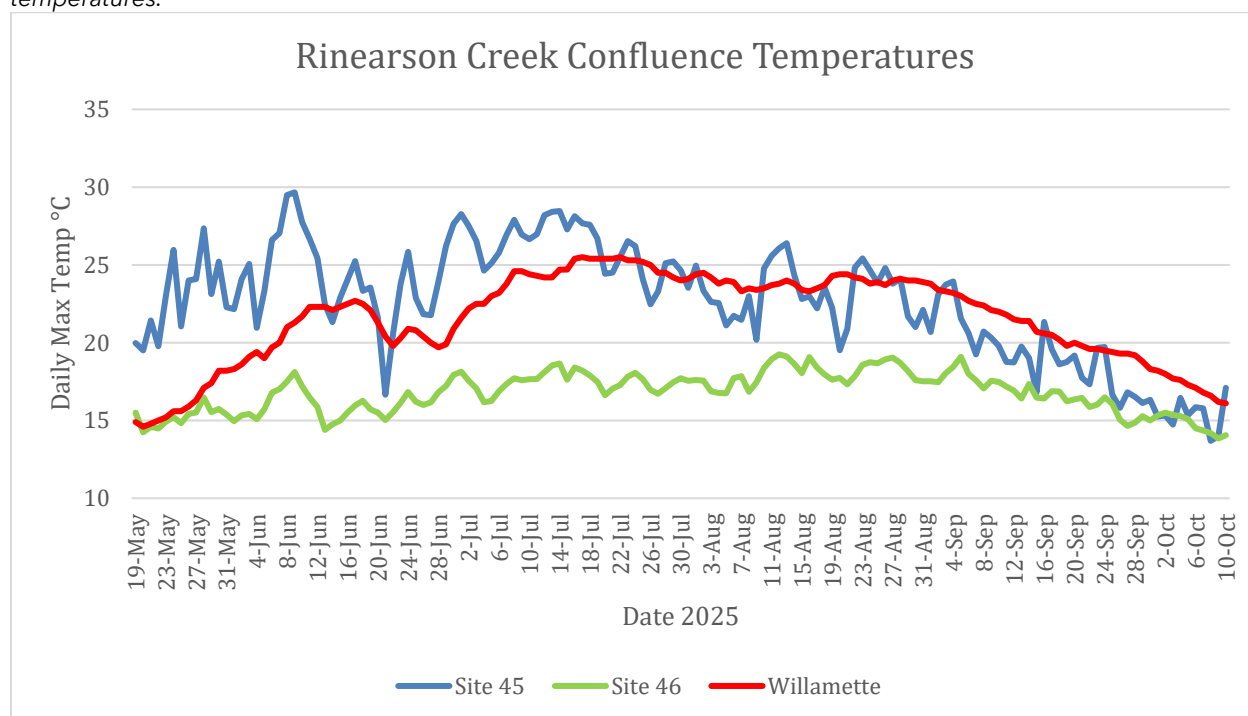


The warm temperatures coming out of the beaver pond may impact the ability of the confluence of Rinearson Creek to function as cold water refugia for fish in the summer months as seen in Table 6. Any woody vegetation around the pond gets significantly pruned by the beavers, preventing the pond from having much shade from direct sun. The pond is also wide and shallow, which makes it susceptible to warming. This year, summer mean daily maximum water temperatures increased by 7°C through the beaver pond. Temperatures downstream of the pond are consistent with previous years, however average mean temperatures upstream entering the pond at Site 46 were 2°C cooler than those seen in the previous year (NCWC, 2025). This highlights the importance of multi-year sampling to track trends and changes over time.

Table 6 - Average daily maximum temperatures of Rinearson Creek as compared with lower Willamette River temperatures.

	July 2025 (°C)		August 2025 (°C)		July & August 2025 (°C)	
Location	July Mean Daily Max Temp	Change from Willamette	August Mean Daily Max Temp	Change from Willamette	Summer Mean Daily Max Temp	Change from Willamette
Willamette (USGS 14211720)	24.4	-	23.9	-	24.1	-
Rinearson downstream of pond (Site 45)	26.1	+1.8	23.1	-0.7	24.7	+0.5
Rinearson upstream of pond (Site 46)	17.5	-6.8	18.1	-5.8	17.7	-6.3

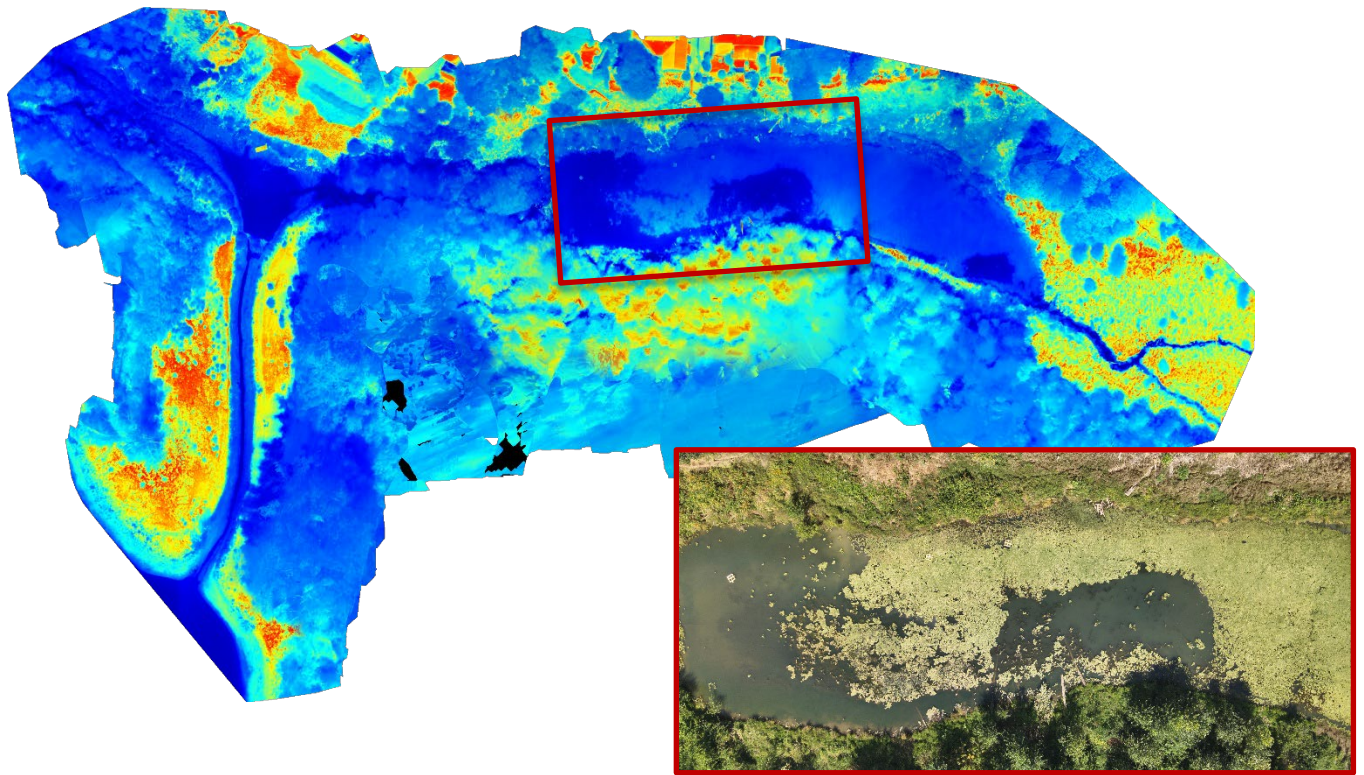
Figure 16 - Average daily maximum temperatures of Site 45 and 46 as compared with lower Willamette River temperatures.



In order to further investigate the significant warming associated with the beaver pond, this site was flown with the Council's thermal imaging drone in the afternoon of August 22, 2025. Thermal images were difficult to interpret because much of the water surface was covered with emergent vegetation (Figure 17), which alters our ability to determine surface water temperatures with the infrared drone. The current placement of the logger at this site is potentially recording higher temperature water flowing over the top of the beaver dam, as this particular dam is very old and impermeable. Consideration will be given to the

placement of this logger in the 2026 monitoring season to ensure that temperature data captures complex temperature dynamics within the pond.

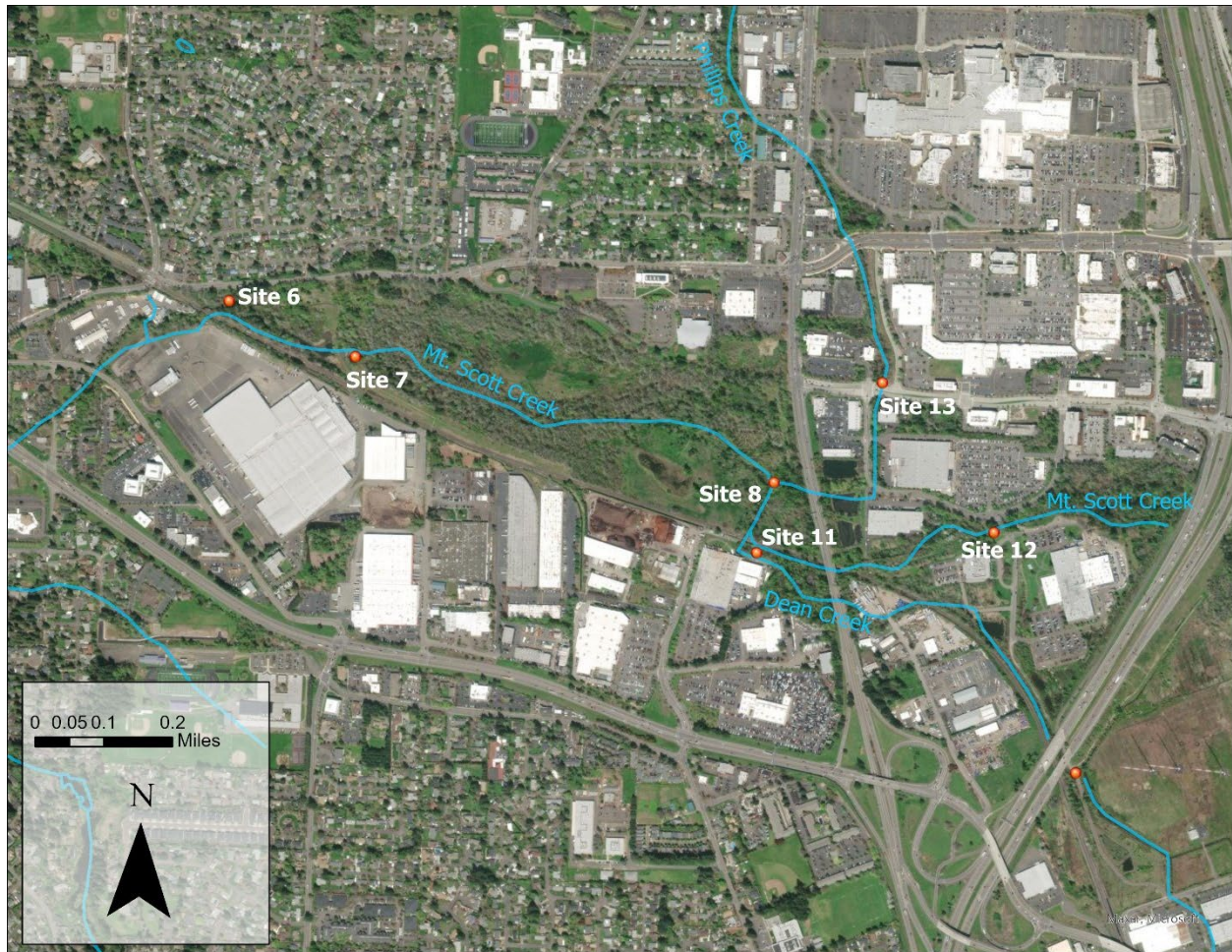
Figure 17 - Thermal aerial imagery of the beaver pond along Rinearson Creek.



Results: 3-Creeks Natural Area

The 3-Creeks Natural Area is approximately 89 acres of streams, wetlands, and upland habitat that encompasses Mt. Scott Creek and its confluences with Phillips and Dean Creeks. The site is wedged in between industrial and commercial properties, a set of active railroad tracks, and private homes. The site is also owned by Clackamas Water Environment Services (WES) and is home to a flood control facility which stores water during the heaviest rains to protect businesses and infrastructure. There were three thermographs installed in 3-Creeks Natural Area (Sites 6, 7, and 8) and one just upstream at Site 12. Additional loggers at Sites 11 and 13 monitor stream temperature inputs from Phillips and Dean Creek, respectively. Unfortunately, the logger installed at Site 7 malfunctioned and no data was recoverable from that site this year.

Figure 18 - Location of 3-Creeks Natural Area temperature loggers.



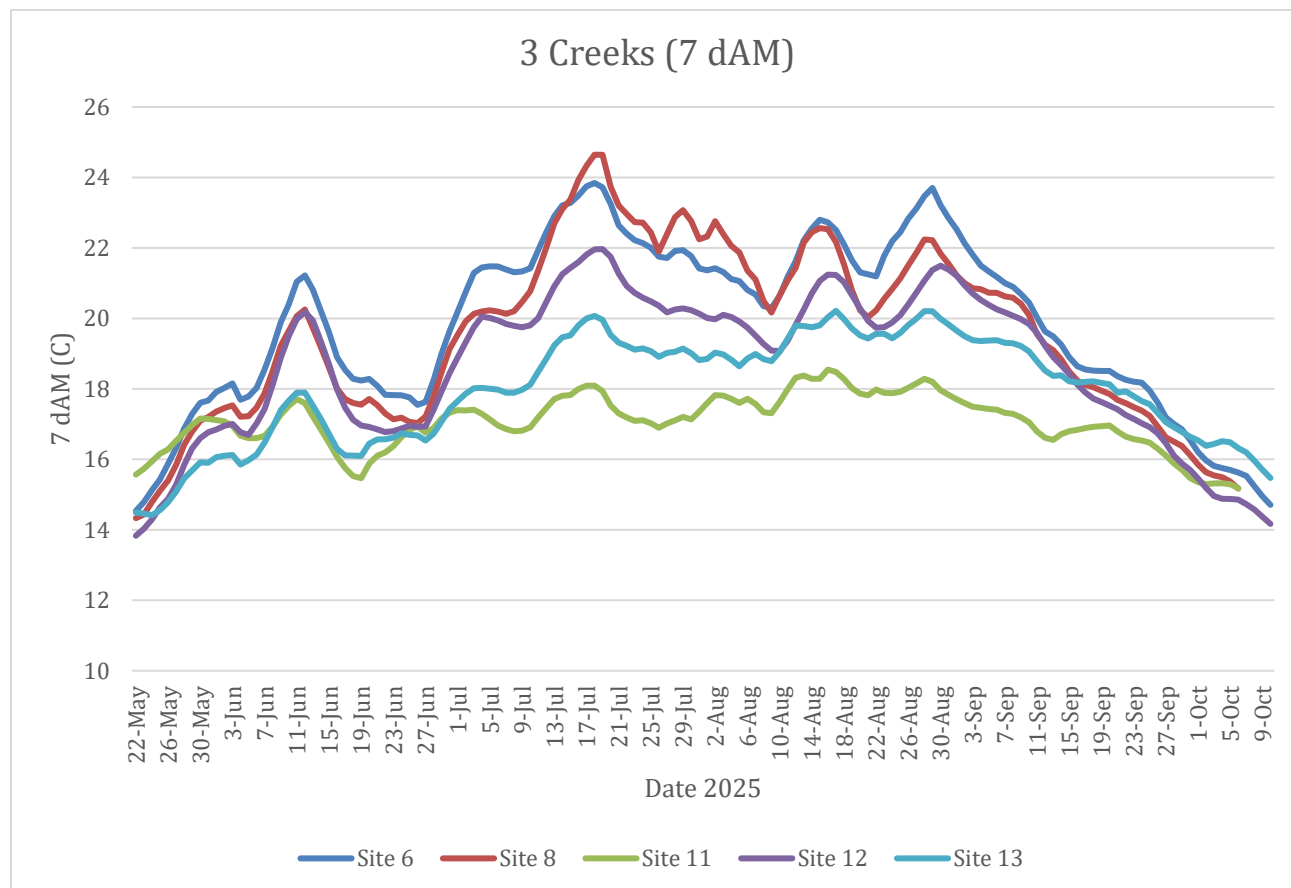
Previous years temperature studies showed very little change between Site 7 and Site 8, however this stretch of Mt. Scott Creek had a large instream restoration project go to construction in 2025 which will continue in summer 2026 and may impact stream temperatures by creating deep pools and increasing instream cover.

- Average 7dAM at Site 6 (July - August) = 22.0 °C
- Average 7dAM at Site 8 (July - August) = 21.8 °C
- Average 7dAM at Site 11 (July - August) = 17.6°C
- Average 7dAM at Site 12 (July - August) = 20.4 °C
- Average 7dAM at Site 13 (July - August) = 19.2 °C

Dean Creek (Site 11) continues to show the coolest water during the months of July - August at 17.6 °C, and continues to be one of the few places recording temperatures below the DEQ temperature standard of 18°C for rearing. This means that Dean Creek is most likely a temperature refugia for fish rearing in this watershed during the summer. Because of this, the Council will prioritize protection, restoration, and research efforts in Dean Creek. This year, additional temperature loggers were installed along Dean Creek to further evaluate

temperature dynamics in the creek prior to the its confluence with Mt. Scott Creek. Results from this analysis are discussed on page 37. During a 2023 fish passage barrier assessment (NCWC, 2023) a culvert was identified at the mouth of Dean Creek that functions as a partial barrier to fish. Phillips Creek (Site 13) has previously shown some lower temperatures in this part of the watershed, however this year stream temperatures exceeded the summer temperatures standards for rearing fish, with a 7dAM of 19.2°C.

Figure 19 - 7dAM temperatures in 3-Creeks Natural Area.



In previous monitoring years we have seen warming of 1.5 -2 °C between Sites 6 and 8, with the majority of warming occurring between Sites 6 and 7 (NCWC, 2025; NCWC, 2023). This year, 7dAM stream temperatures saw minimal increase (0.2°C) between Sites 6 and 8 in July and August. Future monitoring will help determine if this is the result of a temporary change in the system, or an ongoing trend. The downstream end of 3 Creeks between Site 7 and Site 6 may also be a good candidate for the thermal imaging drone to get more spatial data following restoration.

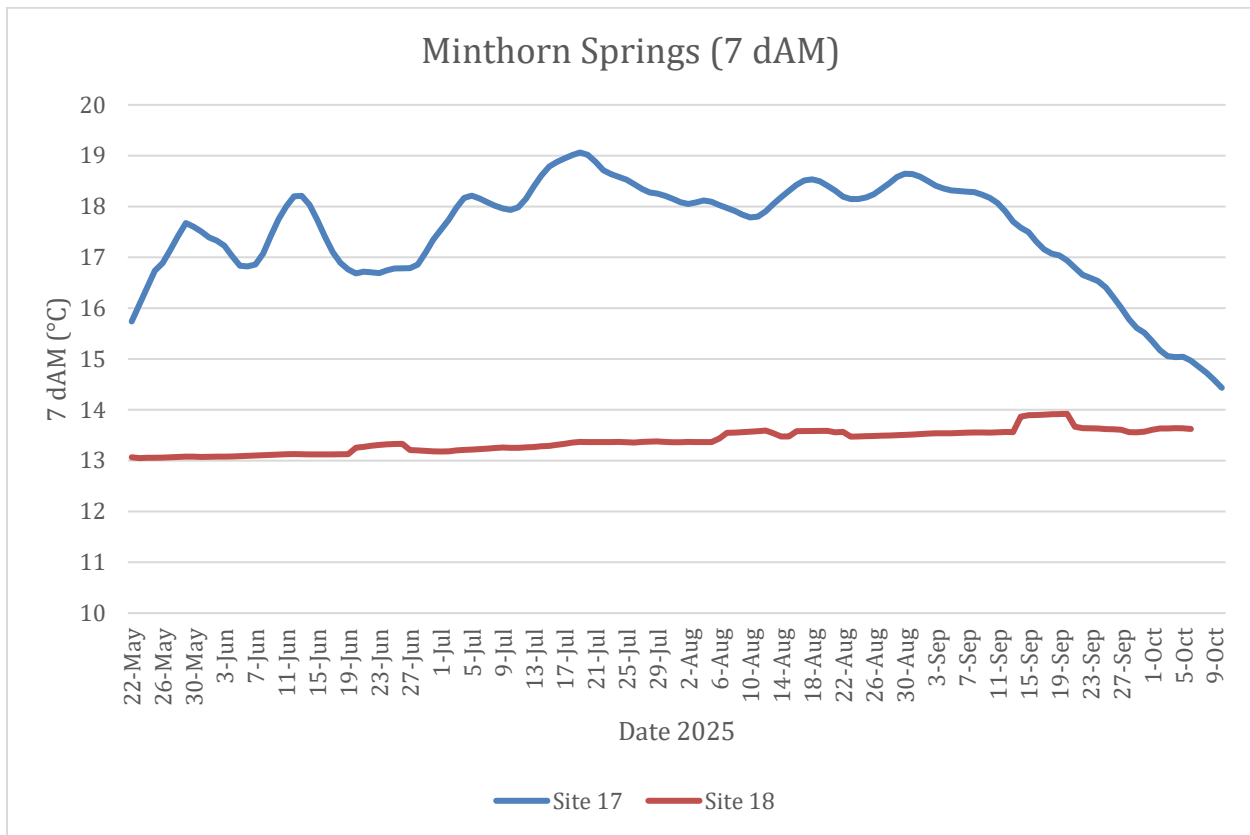
Results: Minthorn Springs Wetland

Minthorn Springs Preserve is a 6.5-acre nature preserve owned by The Wetlands Conservancy that was created as a nature and water sanctuary when nearby wetlands were filled for development. The Wetlands Conservancy Urban Wetlands State-of-the-Catchments Summary (Labbe and Scully-Engelmeyer, 2016) noted that the water quality in Minthorn Springs Wetland is considered poor. For this investigation, we assessed the difference between water temperatures coming directly out of the spring seep at the inlet of the wetland (Site 18), versus water temperatures exiting the wetlands into Minthorn Creek (Site 17). The location of these temperature loggers can be seen below.

Figure 20 - Location of Minthorn Springs temperature loggers.



Figure 21 - 7dAM temperatures at Minthorn Springs Wetland.



The spring-fed inlet to the wetlands maintained a consistent 13-14 °C all summer long, providing some of the coolest water seen during this study. Every year, the logger placed at the outlet of the wetlands has shown significant heating in the wetland. Because of the interesting temperature dynamics in Minthorn Wetlands, this site was selected to collect infrared drone imagery 2024. Thermal imaging analysis showed water heating in the center of the wetland where the water is shallow and the soils are saturated, making it difficult to establish woody vegetation for shade coverage. A warm water plume was also identified on the south side of the property, near Site 17, which may be influencing the high temperatures recorded at this site. Consideration will be given to moving the location of this temperature logger in successive monitoring years, perhaps to the outlet at the northeast outlet of the wetland.

Results: Longitudinal study of Mt. Scott Creek into Lower Kellogg

There were many loggers installed throughout the Kellogg-Mt. Scott watershed and we wanted to conduct a longitudinal study of water temperatures from Mt. Scott Creek down to confluence of Kellogg Creek with the Lower Willamette River. For this study we pulled data from the following locations:

- Site 1 - Kellogg Creek at the dam
- Site 2 - Kellogg Creek upstream of impoundment
- Site 5 - Mt. Scott Creek at SE Lake Road
- Site 6 - Mt. Scott Creek upstream of flood structure in 3-Creeks Natural Area
- Site 8 - Mt. Scott Creek downstream of Phillips Creek confluence
- Site 12 - Mt. Scott Creek at SE 84th Avenue
- Site 15 - Mt. Scott Creek at SE 97th Avenue
- Site 34 - Mt. Scott Creek at Mt. Talbert
- Site 52 - Mt. Scott Creek at Spring Mt. Drive
- Site 16 - Presumed end of anadromy at 129th Avenue bridge

These locations were selected because the other loggers either had corrupted datasets, were removed, or showed no temperature variations to nearby loggers.

Figure 22 - Location of Kellogg-Mt. Scott loggers used for longitudinal study (shown in yellow).

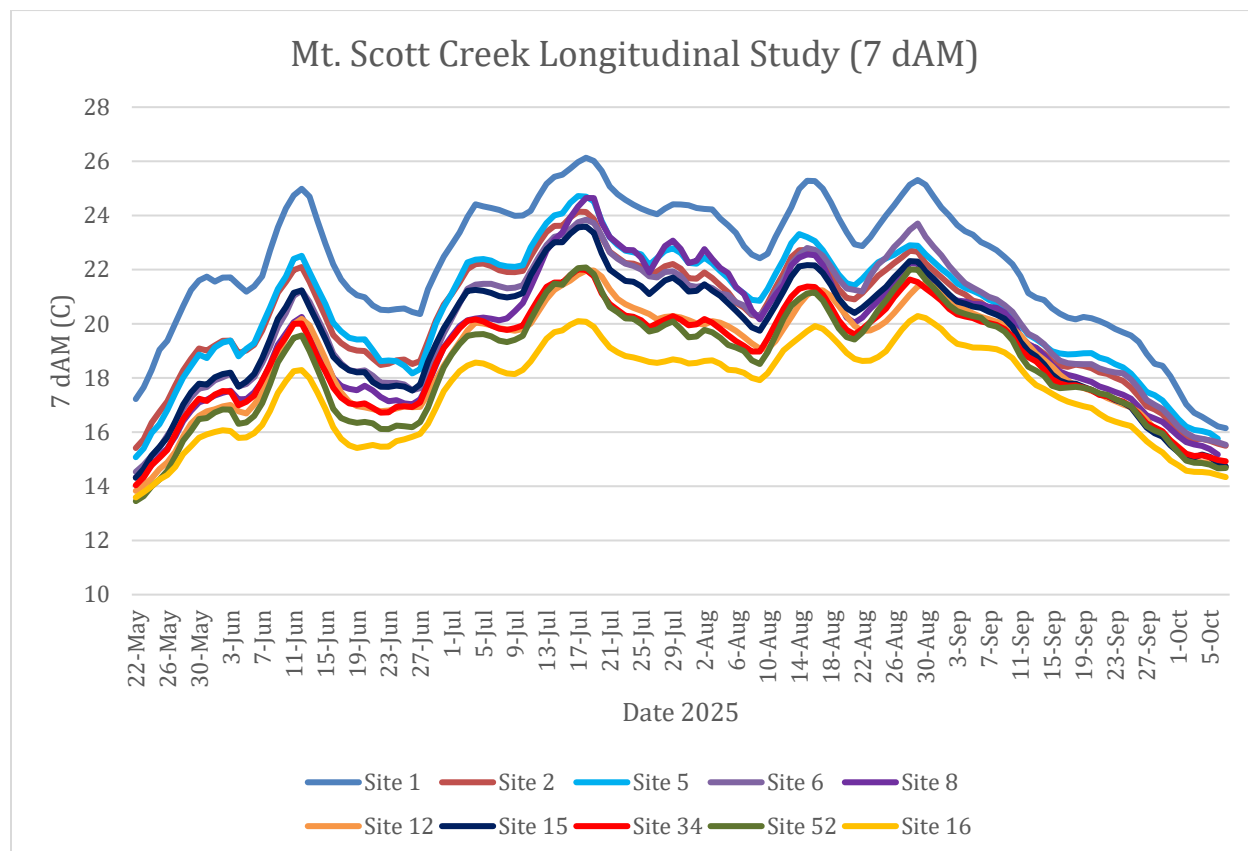


Looking at the mean summer 7dAM in July through August, we see a gradual warming of temperatures as we move from the upper parts of Mt. Scott Creek down to the outlet into the Willamette River.

- Average 7dAM at Site 1 = 24.3 °C
- Average 7dAM at Site 2 = 22.1 °C
- Average 7dAM at Site 5 = 22.5 °C
- Average 7dAM at Site 6 = 22.0 °C
- Average 7dAM at Site 8 = 21.8 °C
- Average 7dAM at Site 12 = 20.4 °C
- Average 7dAM at Site 15 = 21.5 °C
- Average 7dAM at Site 34 = 20.4 °C
- Average 7dAM at Site 52 = 20.2 °C
- Average 7dAM at Site 16 = 18.9 °C

We saw a similar increase in temperatures between Site 16 and Site 15 through the Sunnyside corridor that we saw in 2024 and 2022, with a 2.6 °C increase in average summer 7dAM in 2025. The monitoring sites in between Sites 15 and 16 show a gradual warming of water temperatures. Although this reach is well shaded, there are opportunities to increase habitat complexity and hyporheic exchange that could decrease water temperatures. NCWC is working with Metro in Mt. Talbert Nature Park, to install large wood jams to improve this habitat complexity.

Figure 23 - 7dAM for loggers included in Kellogg-Mt. Scott longitudinal study.



Unfortunately, most sites exceed DEQ's 18 °C temperature standard for rearing salmonids during the summer months. For this reason, protection of cold-water inputs into this watershed such as Kellogg Creek, Philips Creek and Dean Creek is even more important.

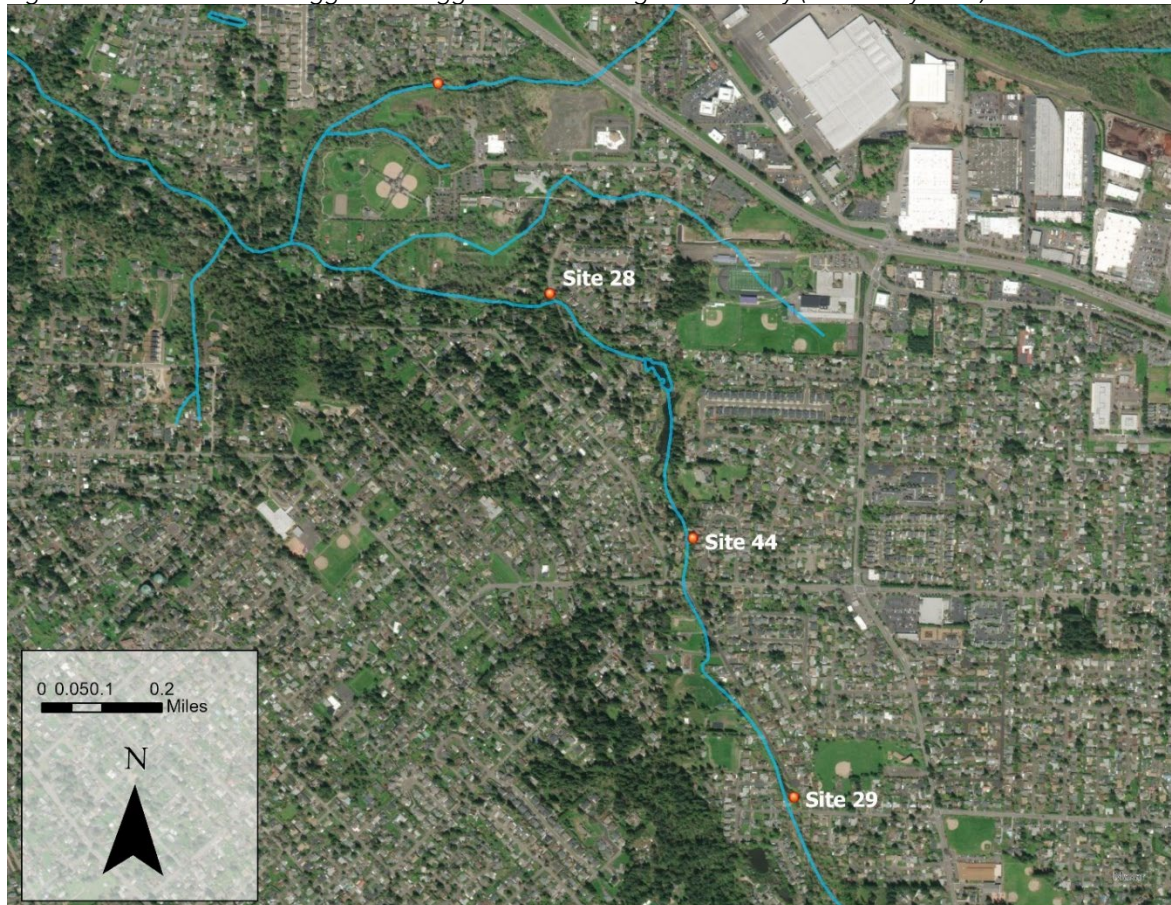
Results: Longitudinal study of Kellogg Creek upstream of confluence

Previous years temperature studies showed some cold water coming from Kellogg Creek at its confluence with Mt. Scott Creek, which appears to originate from Parmenter Wetland. This year, temperature monitoring in Kellogg Creek continued, building on previous efforts to further understand the temperature profile upstream of its confluence with Mt. Scott Creek. Three temperature loggers were deployed along its length:

- Site 28 - Kellogg Creek at SE Rusk Road
- Site 44 - In Parmenter Pond near WES facility.
- Site 29 - Kellogg Creek at SE Clackamas Road

Unfortunately, the logger at Site 28 was not recovered and the logger at Site 29 was removed by contractors during restoration work on Upper Kellogg Creek.

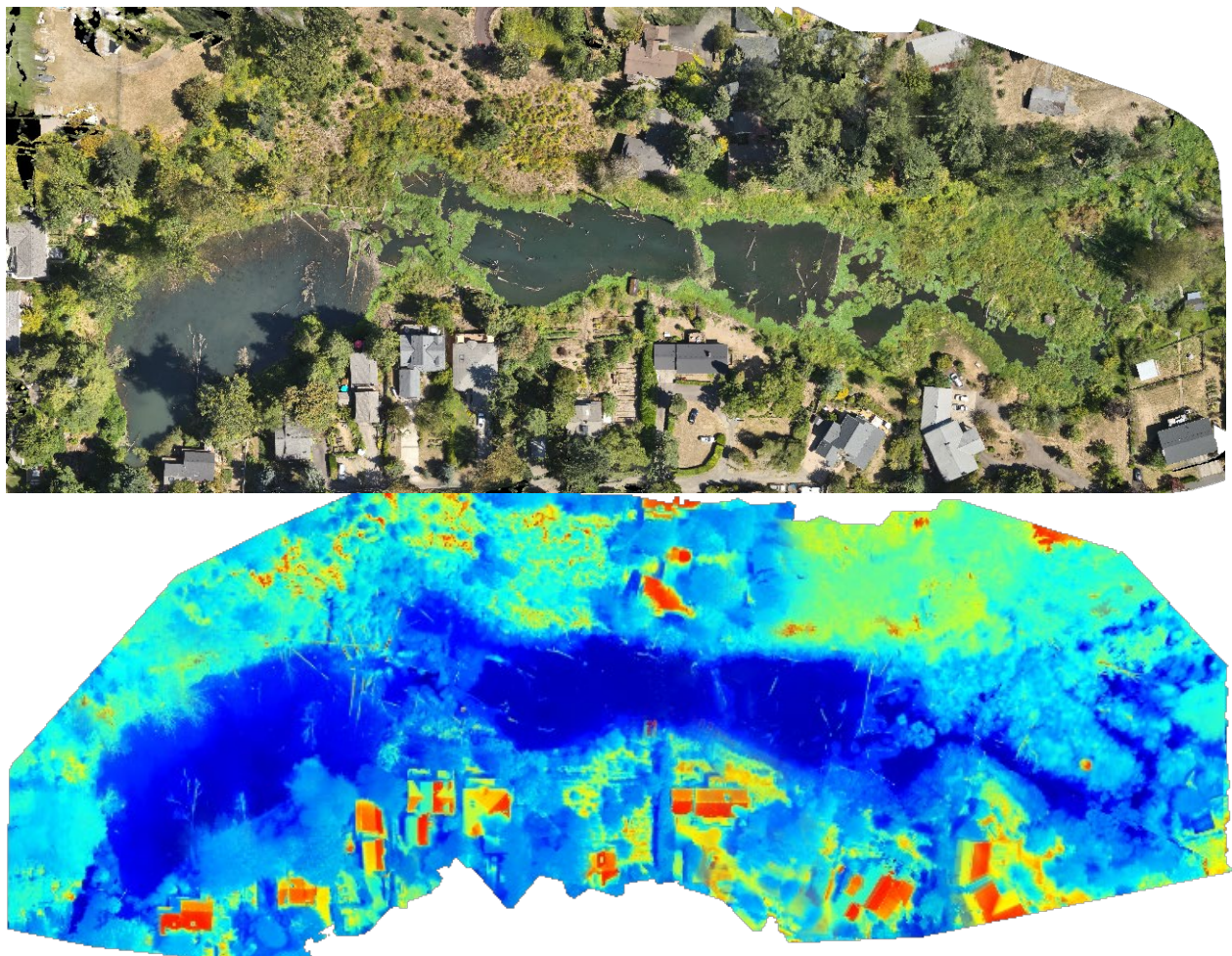
Figure 24 - Location of Kellogg Creek loggers used for longitudinal study (shown in yellow).



Mean summer 7dAM at Site 44 in Parmenter Pond exceeded Oregon DEQ standards for fish rearing, with an average temperature of 19.5°C in July and August. Temperatures this season directly upstream and downstream of the pond (Site 29 and Site 28) are unknown as both loggers were unrecovered. Site 29 is located approximately 0.5 miles upstream, along upper Kellogg Creek between SE Thiessen and SE Clackamas Road. During summer 2025, Clackamas Water Environment Services completed several culvert replacements, improved stormwater retention, and restored approximately 750 linear feet of stream channel within this section of the creek. Continued monitoring within this reach will help to evaluate temperature dynamics through Parmenter Pond and to assess potential long-term changes in stream temperature following these restoration efforts.

In order to further investigate the cool water seen in previous years between Site 44 and Site 28 (NCWC, 2024), Parmenter Ponds was flown with the Council's thermal imaging drone on August 22, 2025. Thermal imaging analysis shows cool water entering the pond, and only slightly warming as the water moves downstream (Figure 26).

Figure 25 - Visual and infrared aerial imagery of Parmenter Ponds.



Results: Longitudinal Study of Rinearson Creek

Temperature loggers were installed in Rinearson Creek in four locations. Sites 45 and 46 are located upstream and downstream of the pond at the Rinearson mitigation site. Site 26 was located on the west side of River Road and Site 27 was located upstream adjacent to Olsen Wetlands (see Figure 27).

Figure 26 - Location of Rinearson Creek temperature loggers.



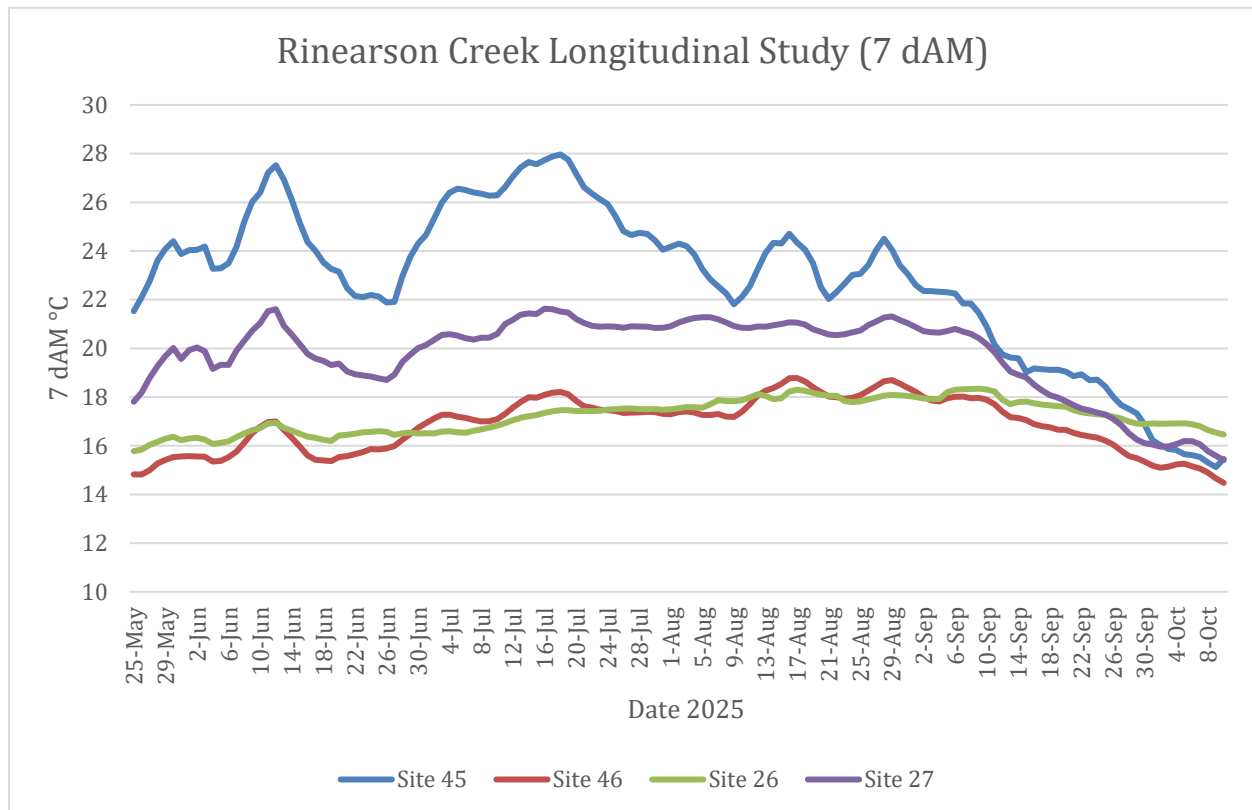
In 2022 we saw a significant temperature increase as water flowed from Site 27 to Site 26 (NCWC, 2023). We did not see that heating through the McLoughlin corridor this year or the previous. This year, the average summer 7dAM (July-August) decreased 3.9 °C between these sites. This drop in temperature may be because Rinearson Creek diverted into an underground pipe between these two monitoring locations. This shows the importance of collecting multiple years of data over successive years.

- Average 7dAM at Site 45 (July - August) = 24.8 °C
- Average 7dAM at Site 46 (July - August) = 17.1 °C
- Average 7dAM at Site 26 (July - August) = 17.1 °C
- Average 7dAM at Site 27 (July - August) = 21.0 °C

We also saw significant warming between Site 46 and Site 45, with an increase of average summer 7dAM (July-August) of 7.7 °C. This increase in temperature is probably due to the large beaver pond at this mitigation site. This result is also consistent with what was found in

the Rinearson Natural Area Restoration Year 5 (2023) Monitoring Draft Report (Waterways Consulting, Inc, 2023). That report showed that the pond temperatures increased significantly over those recorded just upstream in the emergent marsh. To further investigate temperature patterns through this reach, the site was surveyed using a thermal imaging drone on August 22, 2025. Results from the aerial imagery analysis are discussed in a previous section (see p. 22).

Figure 27 - 7dAM temperatures in Rinearson Creek.



Results: Longitudinal study of Boardman Creek

Four temperature loggers were installed in Boardman Creek, one of which (Site 40) we were unable to recover.

- Site 22 - Confluence of Boardman Creek with the Willamette River
- Site 24 - Boardman Creek at Stringfield Park
- Site 53 - SE Boardman Ave
- Site 40 - Boardman Creek at Boardman Avenue

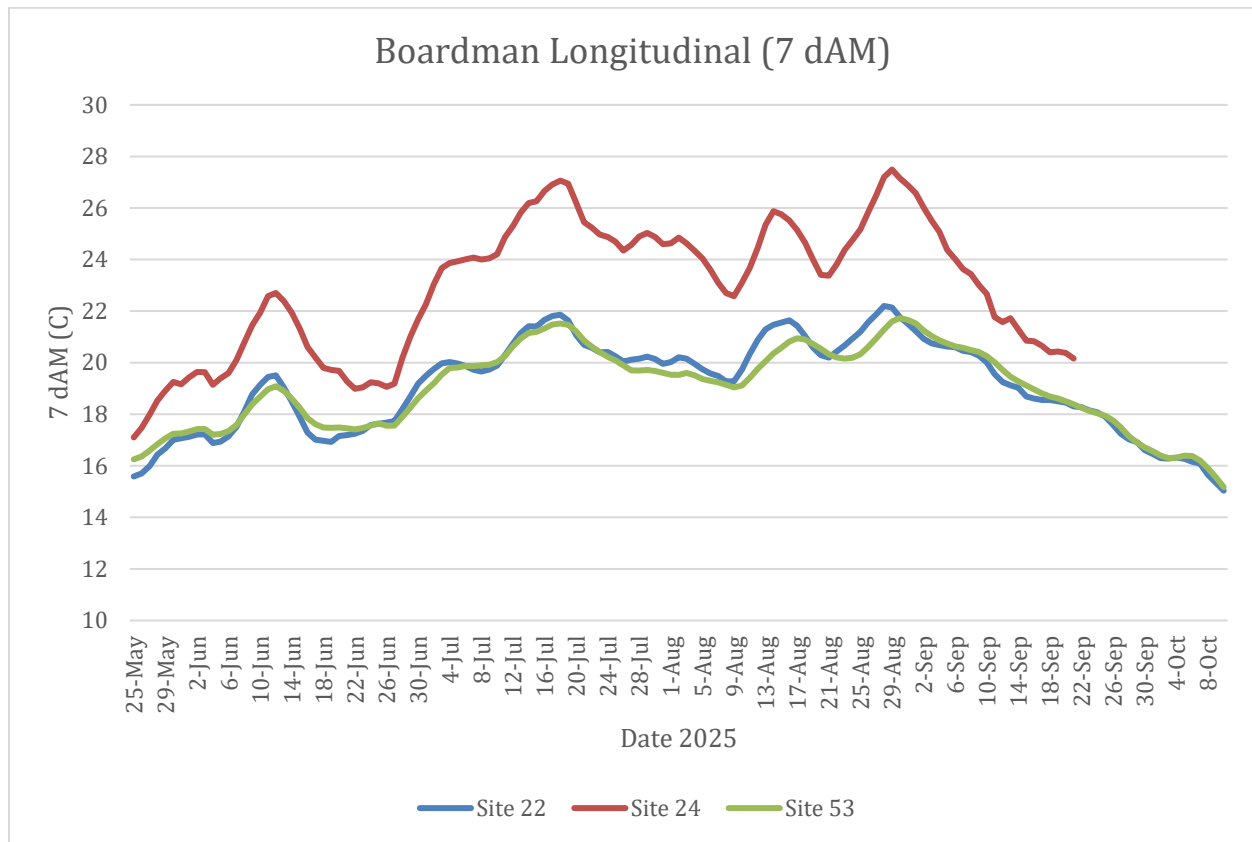
Figure 28 - Location of Boardman Creek temperature loggers.



Mean summer temperatures entering the Willamette from Boardman Creek were similar to those seen last year, and exceed the DEQ temperature standard of 18°C for rearing (NCWC, 2024). This year, temperatures increased by 4.6 °C between Site 53 and Site 24, which may be the result of beaver activity in Stringfield Park. The logger from Site 24 was not able to be retrieved in the previous two monitoring seasons due to flooding from beaver activity at this site. Future monitoring at these sites is needed to better understand the temperature dynamics through this reach and identify the source of heating. This site may also be a good candidate for imagery collection utilizing the infrared drone.

- Average 7dAM at Site 22 (July -August) = 20.5 °C
- Average 7dAM at Site 24 (July -August) = 24.8 °C
- Average 7dAM at Site 53 (July -August) = 20.2 °C

Figure 29 - 7dAM temperatures in Boardman Creek.



Results: Longitudinal study of Dean Creek

Previous years temperature studies showed some cold water coming from Dean Creek at its confluence with Mt. Scott Creek. This year, two temperature loggers were installed in Dean Creek, to better understand the temperature profile upstream of it's confluence with Mt. Scott Creek:

- Site 11 - Confluence of Dean Creek at Mt. Scott Creek
- Site 51 - Dean Creek at end of 84th Ave.

The mouth of Dean Creek (Site 11) has consistently shown the coolest water entering Mt. Scott Creek during the months of July - August at 17.6 °C, and continues to be one of the few places recording temperatures below the DEQ temperature standard of 18°C for rearing. At Site 54, located upstream of the confluence near I-205, temperatures are much warmer, with summer mean temperature of 23.4°C. Additional monitoring is needed to better understand the temperature dynamics through this reach. Another logger will be installed between Site 54 and Site 11 in 2026 to try to identify the source of cooling through this reach.

- Average 7dAM at Site 11 (July -August) = 17.6°C
- Average 7dAM at Site 51 (July -August) = 23.4°C

Figure 30 - Locations of Dean Creek temperature loggers.

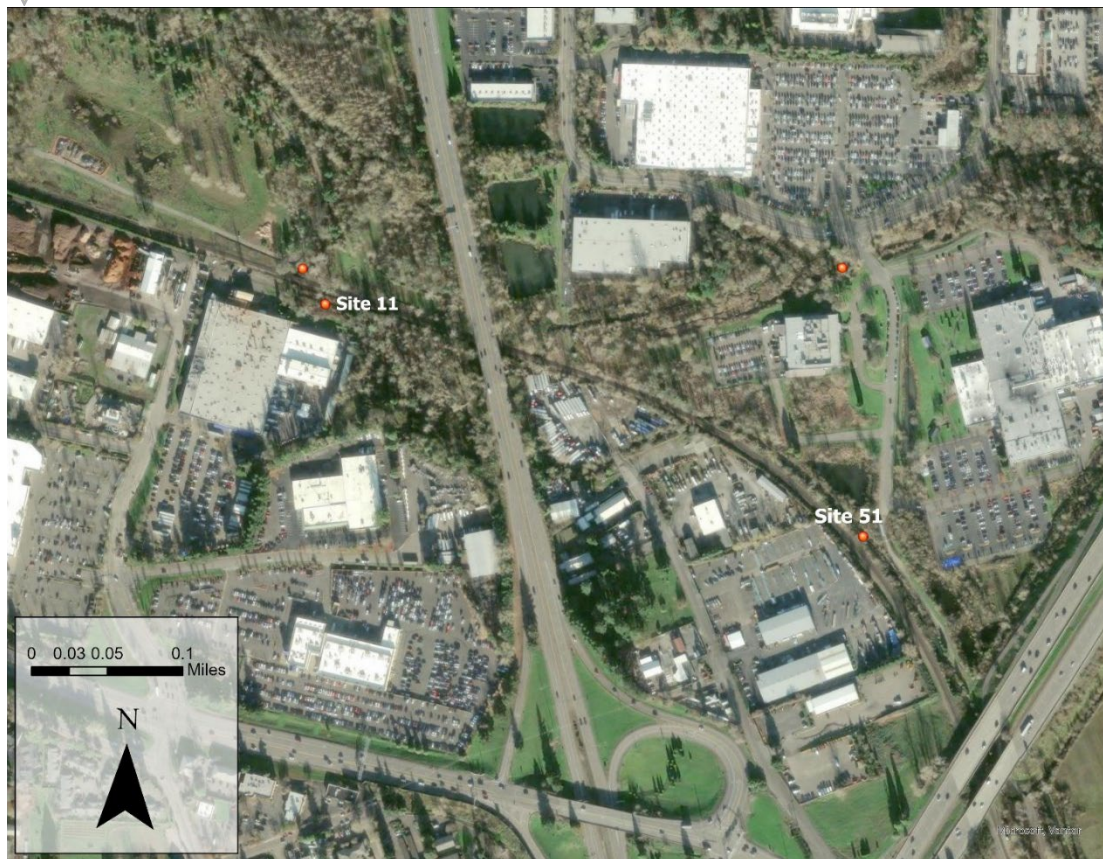
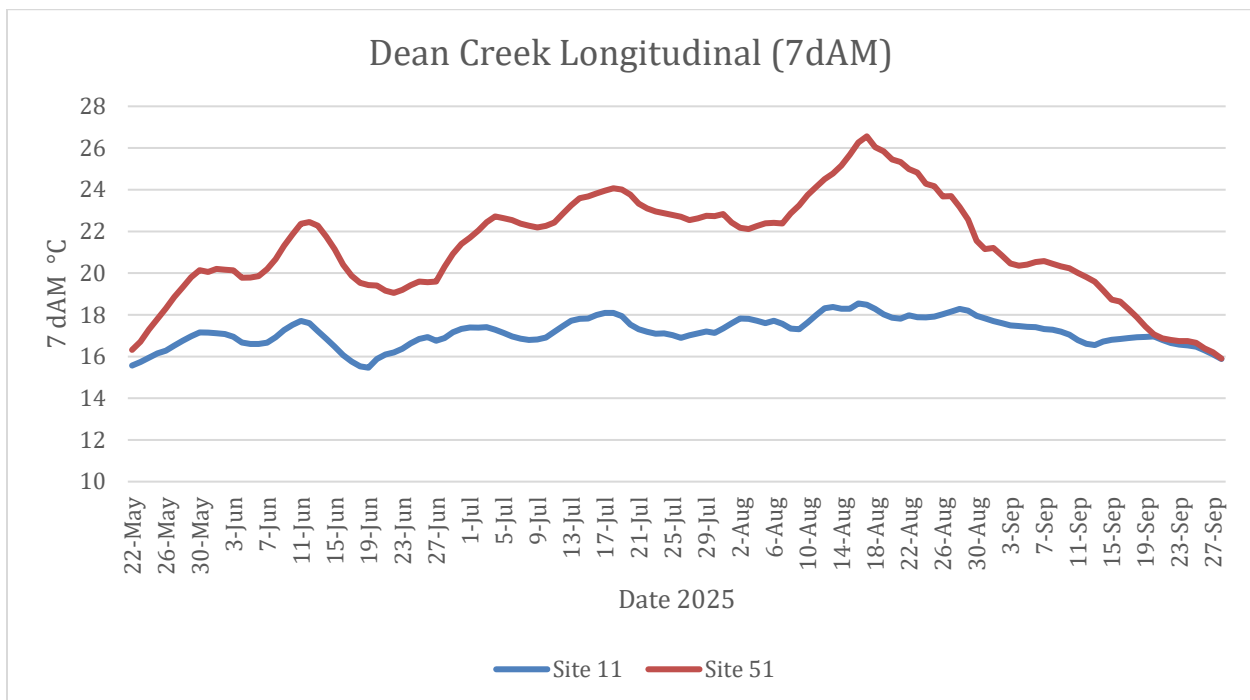


Figure 31 - 7dAM temperatures in Dean Creek.



Conclusions and Recommendations

Findings

There are several key findings that we can surmise from this year's temperature monitoring data.

5. *Several Willamette River confluences are potential cold water refugia*

Boardman Creek was identified as CWR. Both Kellogg Creek and River Forest Creek were warmer than the Lower Willamette River. However, loggers placed above Kellogg and River Forest lakes showed that those impoundments significantly increased water temperatures. If Kellogg Dam and its associated impoundment could be removed then the mouth of Kellogg Creek would function as CWR habitat. And if River Forest Lake could be hydraulically disconnected from River Forest Creek, that confluence could also function as CWR habitat. Rinearson Creek may be functioning as CWR, however there is uncertainty about how much the beaver pond is warming in the summer months. Water entering into the beaver pond is much cooler and meets the temperature criteria for rearing, but water leaving the pond is quite warm. This may be related to the warm water being skimmed off the top of the pond as it pours over the beaver dam.

6. *Kellogg Creek, Dean Creek, and Philips Creek continue to provide cold water, cold water found in Rinearson Creek*

We were able to identify several cold-water areas in the North Clackamas watersheds. The water flowing from Dean Creek and Kellogg Creek upstream of its confluence with Mt. Scott Creek was significantly cooler than Mt. Scott Creek. Phillips Creek was also slightly cooler than Mt. Scott Creek. The coldest water found was at Minthorn Springs, however, this water warmed significantly to become the warmest water studied as it travelled through Minthorn Springs Wetland. This year, stream temperatures in Rinearson Creek were significantly cooler than those documented in previous years, however this water seems to be warming considerably as it moves through the beaver pond.

7. *Thermal imaging of in-line stream impoundments is a tool that can be used in understanding complex temperature dynamics at sites with beaver activity.*

The thermal drone imagery has proven to be helpful in analyzing complex temperature dynamics in beaver ponds in our watersheds. This year we used drone imagery of Parmenter Ponds and the Rinearson mitigation site to better understand how in-line impoundments are impacting stream temperatures. At Parmenter Pond, water temperatures appeared to stay relatively cool throughout the pond, with gradual warming in the wider, downstream end of the pond. At Rinearson, thermal imaging showed warming in the wider sections of the impoundment, but overall appeared cooler than expected based on recorded temperatures. Data from the thermal imaging drone will help to inform future temperature monitoring at both sites.

8. *Less warming through in-line impoundments than in previous years*

This year we documented lower than usual temperature changes in several in-line impoundments in our watersheds, including the Kellogg Impoundment and in Mt. Scott Creek at the water control structure, despite similar average summer temperatures across years. Ongoing monitoring at these sites will help to determine if these are temporary

fluctuations or ongoing trends at these sites. This highlights the importance of multi-year temperature studies that capture annual variations.

Implications for Restoration, Protection, and Management

The Council is utilizing these results to prioritize their restoration, protection, and management efforts in the watersheds in our service area.

4. Fix heat-loading effects at impoundments

Water temperatures increased significantly through water impoundments. Potential treatments vary at each site:

- When Kellogg Dam is removed, the associated impoundment will be dewatered and the channel will be restored to a sinuous flowing creek.
- River Forest Lake could potentially be disconnected hydraulically from River Forest Creek, while maintaining the lake for its surrounding residents. Further study should be conducted to determine the feasibility of accomplishing this.
- Minthorn Springs Wetland heats up considerably in the summer and restoration of that wetland should focus on controlling summer temperatures.
- As Clackamas WES implements restoration of their 3-Creeks property, consideration should be given to the pool downstream of the water diversion structure to determine how best to mitigate the temperature impacts at that site.
- The pond in the Rinearson Natural Area was maintained in the mitigation project at the request of adjacent landowners who wanted to be able to see the open water. However, the heat loading that occurs in this pond during the summer is problematic. Consideration should be given to restoring this area to a beaver-managed wetland complex that would allow the creek to access the floodplain.

5. Target cold water areas for protection and fish access

The cold-water areas (Boardman/Willamette Confluence, Dean Creek, Upper Kellogg Creek below Parmenter Ponds, North Fork Boardman Creek) should be prioritized for protection and fish access. These areas will provide thermal refuge for fish in the summer, and the Council will focus on removing any barriers to fish accessing these reaches, especially during summer low flows. There are two large passage barriers upstream of the Boardman Creek confluence at Walta Vista and River Roads that currently block passage of anadromous fish past that point.

6. Identify restoration projects that can trap spawning gravels for coho and Pacific Lamprey in the Kellogg-Mt. Scott Watershed, in preparation for removal of Kellogg Dam.

Restoring spawning gravel beds involves replenishing and trapping quality gravel in rivers and streams to provide suitable habitat for fish to lay their eggs. Adding habitat complexity through additions of large wood slows down the water and traps these gravels for fish. Sometimes additional gravels are placed behind wood structures to speed up the process. The stability of added gravels is dependent on gravel size and on the hydrology of the reach. One potential site for these large wood additions is Mt. Scott Creek through Mt. Talbert Nature Park. NCWC is discussing the potential for a large wood project at this location with Metro.

Further Study

As with any research project, this work has generated several more questions that need study. Future monitoring years should study the following in more depth:

- Repeat temperature monitoring in the upper reaches of Mt. Scott Creek to verify potential cold-water sources and determine why it heats up so much as water flows down to Mt. Talbert.
- Continue long-term trend monitoring to track changes in watershed temperature impacts from climate change, development, and restoration actions.
- Compare the results of this study with the Council's fish passage barrier and eDNA studies to better understand fish utilization.
- Study harmful algae blooms (HAB's) in the impoundment behind Kellogg dam and potentially other sites with warming stagnant water. As temperatures increase, and the impoundment continues to fill in with sediment, we are seeing increased growth in algae. There is a desire to better understand that growth and the potential impact to the surrounding community.
- Utilize drone technology mounted with an infrared camera to look at temperature dynamics such as point-sources for heating and cooling, and the management of these impacts in restoration sites.

Despite the association between warm summer water temperatures and reduced salmonid survivorship, there is often little consistent long-term temperature data collected year after year in smaller streams. The Council plans on continuing our temperature monitoring program annually. Funding for repeated annual monitoring programs can be difficult to secure, and it is our hope that granting agencies recognize the importance of utilizing empirical data to inform our protection and restoration efforts. We currently have funding to complete five years of temperature monitoring.

References

Clackamas Partnership. 2018. Watershed Restoration for Native Fish Populations: Strategic Restoration Action Plan. July 2018.

Department of Environmental Quality. 2008. Temperature Water Quality Standard Implementation – A DEQ Internal Management Directive. Written by Debra Sturdevant, Water Quality Standards Coordinator. April 2008.

Department of Environmental Quality. 2020. Lower Willamette River Cold-Water Refuge Narrative Criterion Interpretation Study. Submitted to NOAA – March 2020.

Environmental Protection Agency. 2001. Issue Paper 1: Salmonid Behavior and Water Temperature. Prepared by Sally T. Sauter, John McMillan, and Jason Dunham. May 2001.

Environmental Protection Agency. 2012. Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes. Prepared by Christian Torgersen, Joseph Ebersole, and Druscilla Keenan. February 2012.

Leinenbach, P. 2017. Evaluation of the potential CWR by tributaries in the Willamette based on NorWeST modeling.

Labbe, Ted and Kaegan Scully-Engelmeyer. 2016. The Wetlands Conservancy Urban Wetlands State-of-the-Catchments Summary. August 22, 2016.

McCullough, D. A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5. Summary of technical literature examining the physiological effects of temperature on salmonids. EPA-910-D-01-005, prepared as part of U.S. EPA Region 10 Temperature Water Quality Criteria Guidance Development Project (2001).

North Clackamas Watersheds Council. 2023. North Clackamas Watersheds Temperature Study. Prepared by Amy van Riessen, Watershed Restoration Manager. January 2023,

North Clackamas Watersheds Council. 2022. North Clackamas Watersheds Action Plan 2022-2032. Prepared by Samara Group, LLC & GeoEngineers. July 2022.

North Clackamas Watersheds Council. 2020. Rapid Bio-Assessment Report: North Clackamas Watersheds. Prepared by Inter-fluve, Inc. May 2020.

Richter, Ann and Steven Kolmes. 2005. Maximum Temperature Limits for Chinook, Coho, and Chum Salmon, and Steelhead Trout in the Pacific Northwest. Reviews in Fisheries Science, 13:23-49.

U.S. Fish & Wildlife Service. 2019. Pacific Lamprey *Entosphenus tridentatus* Assessment from February 1, 2019. <https://www.pacificlamprey.org/wp-content/uploads/2022/02/Pacific-Lamprey-Entosphenus-tridentatus-Assessment---2018-Revision.pdf>

U.S. Geological Survey. 2018. Mangano, J.F., Piatt, D.R., Jones, K.L, and Rounds, S.A. Water temperature in tributaries, off-channel features, and main channel of the lower Willamette River, Northwestern Oregon, summers 2016 and 2017: U.S. Geological Survey Open-File Report 2018-1184, 33 p., <https://doi.org/10.3133/ofr20181184>.

Waterways Consulting, Inc. 2023. Rinearson Natural Area Restoration Year 5 (2023) Monitoring Draft Report. Prepared for Columbia Restoration Group, LLC. December, 2023.