U.S. Army Corps of Engineers
Omaha District

# 2025 Report

# Evaluation of 2024 Summer Releases at Cherry Creek Reservoir to Improve Water Quality

## May 2025

**Prepared By:**
Brent Dinkel, Limnologist
Kathryn Seefus, Hydraulic Engineer
Laura Knapp Leiferman, Water Control Water Quality Section Chief

*U.S. Army Corps of Engineers, Northwest Division, Omaha District, Engineering Division, Hydrologic Engineering Branch, Water Control and Water Quality Section*

# WATER QUALITY SUMMARY REPORT

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## 1. BACKGROUND

### 1.1. HISTORICAL WATER QUALITY CONDITIONS

Cherry Creek Dam and Reservoir are located in Denver, Colorado, on Cherry Creek, a tributary to the South Platte River. The dam was completed in June 1950 for the authorized purpose of flood control, and later was authorized for recreation and fish and wildlife.

Cherry Creek Reservoir is currently listed on the State of Colorado's 303(d) list of impaired waters for not supporting the aquatic life use due to high chlorophyll-a levels and low dissolved oxygen conditions. During the summer, the reservoir can become thermally stratified and the volume of water below the thermocline (the hypolimnion) fails to mix with the surface water (the epilimnion). While thermal stratification at the reservoir has historically been limited, there has been enough inhibition of mixing to allow hypoxic to anoxic conditions to regularly develop near the reservoir bottom. These low oxygen conditions at the sediment water interface result in sediment release of phosphate and ammonia, which accumulate in the hypolimnion until the reservoir mixes and then become available for algal growth (increase in reservoir chlorophyll-a). Come winter, the resulting algal growth dies off and sinks, the decomposition of this additional organic matter adds to the sediment oxygen demand further fueling anoxic conditions in future years.

### 1.2. SUMMER 2024 WATER QUALITY RELEASES

Concentrations of nutrients, in particular phosphorus, in the hypolimnion of Cherry Creek Reservoir tend to peak in July. In 2024, the Omaha District of the U.S. Army Corps of Engineers (USACE) implemented a release strategy to potentially improve water quality in the reservoir via a controlled hypolimnetic withdrawal. This strategy involved storing water in about 1% of the flood control zone, if water was available, in January through March. The maximum storage that would be allowed was in the first foot of the flood control zone (5550 to 5551 feet, Project Datum) also known as the transition zone (Figure 1). This zone has 881 ac-ft or about 1% of flood control zone storage. Water stored in the transition zone would then be released via the reservoir's low-level gate in July, with the intent to release nutrient rich water from the

hypolimnion to preempt it fueling algal growth later in the season. The water control manual allows this first foot of flood storage to be used for “maintenance of the multipurpose zone,” which includes water quality.

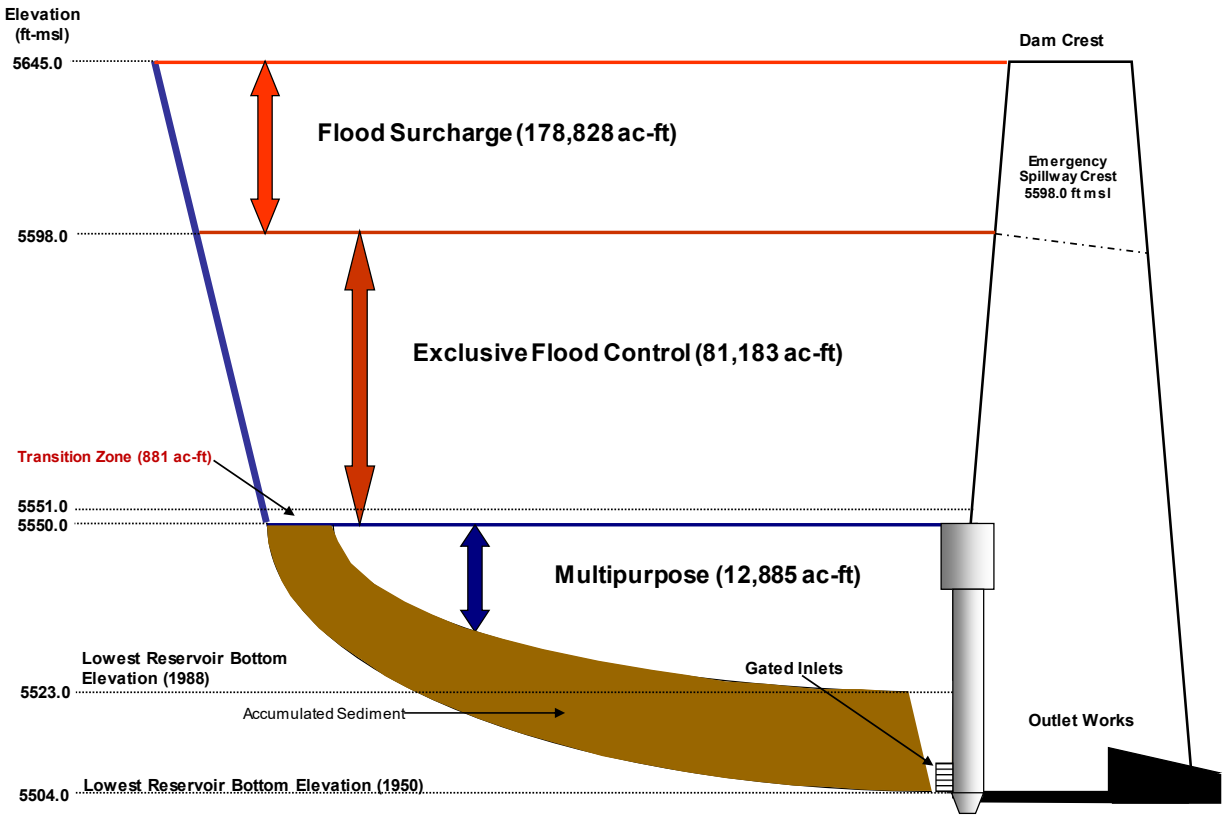


**Figure 1.** Current storage zones of Cherry Creek Reservoir based on the 2007 survey data showing flood control transition zone used for water quality releases.

## 2. WATER QUALITY MONITORING

Water quality sampling was conducted by USACE in 2024 at four different sampling sites: an upper-lake site (CCRLKUP1), mid-lake site (CCRLKML1), near-dam site (CCRLKND1), and an outflow site (CCRRL1) (Figure 2). Sampling was conducted monthly from May through September (end of growing season).

Profile measurements were taken at all three lake sites at half meter increments, measuring water temperature, pH, conductivity, dissolved oxygen (mg/l and % saturation), oxidation-reduction potential (ORP), turbidity, and chlorophyll-a. A grab sample measurement was collected at the outflow for the same parameters.

Nutrient samples were collected at the near-dam and outflow sites. Two samples were collected at the near-dam site: a near-surface sample at half of the measured Secchi depth and a near-bottom sample at half of a meter above the reservoir bottom. A grab sample was also collected from the reservoir outflow. All collected samples were analyzed for ammonia,

nitrate/nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, and dissolved phosphorus. Chlorophyll-a samples were also collected at the near-dam near-surface site for trend analysis pending long term evaluation of the July water quality releases.

In addition to samples collected by USACE, analysis of the July water quality release includes samples collected by the Cherry Creek Basin Water Quality Authority (CCBWQA) at their comparable near-dam site (CCR2), outflow site (CC-Out), and inflow site (CC-10).

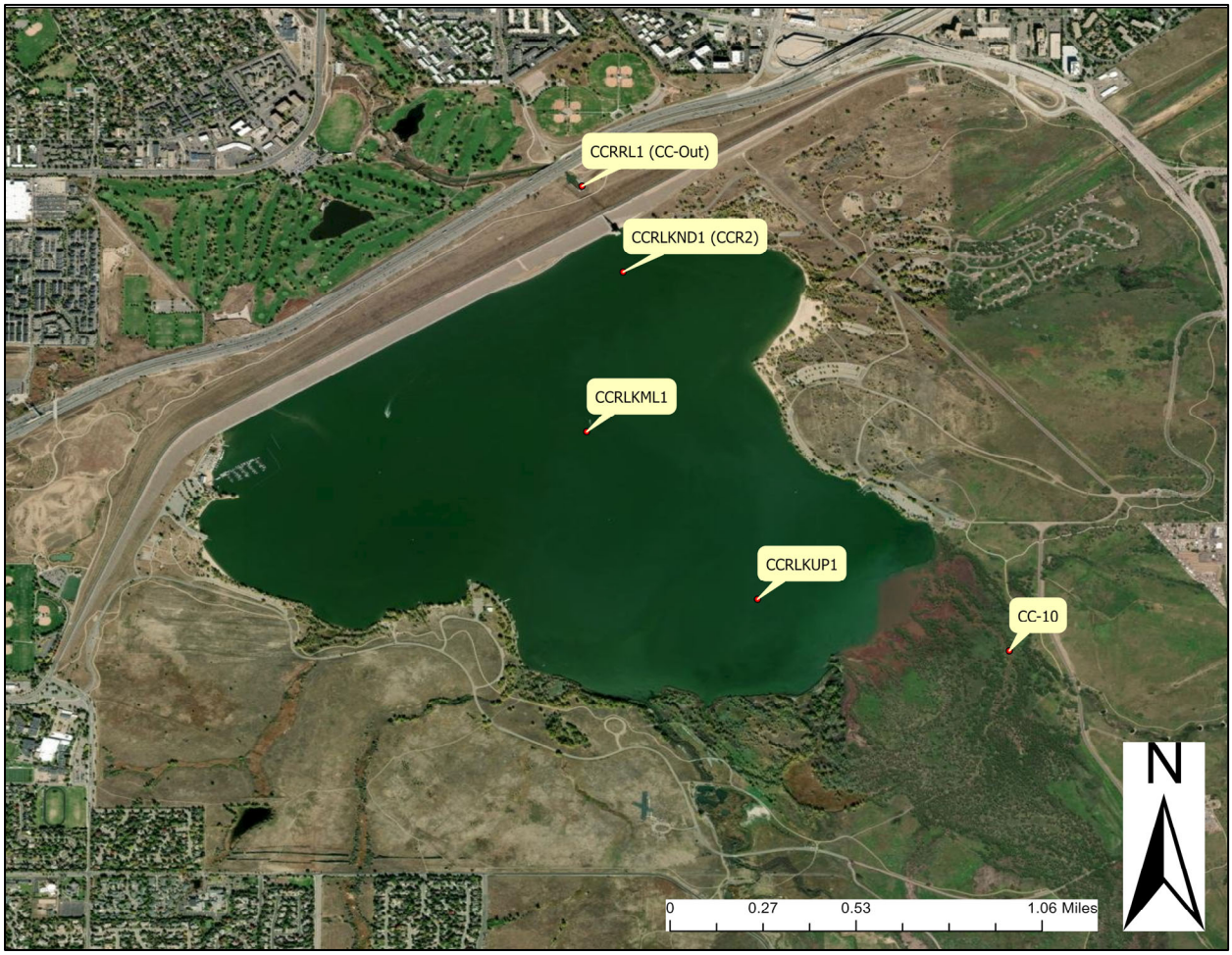


**Figure 2.** Location of applicable sites where water quality monitoring was conducted by USACE and CCBWQA at Cherry Creek Reservoir in 2024.

## 3. 2024 WATER QUALITY RELEASE RESULTS

### 3.1. RELEASE MODIFICATIONS

Figure 3 shows the 2024 releases from Cherry Creek Dam compared to past operational strategies. Modifications were necessary to store a sufficient water volume to be released in July. In January, the outflow was reduced in order to fill the transition zone. Once the transition zone was filled, the outflow matched a normal operational year until July. July outflows were increased by approximately fifteen cfs beginning July 3 and ending August 1 compared to past operational strategies. Post-July releases were identical regardless of operational strategy.


**Figure 3.** Cherry Creek Dam outflow modifications to achieve July water quality releases.

### 3.2. RESERVOIR STRATIFICATION

Existing thermal stratification of Cherry Creek Reservoir measured during the summer of 2024 is depicted by longitudinal temperature contour plots constructed along the length of the reservoir. Figure 4 provides longitudinal temperature contour plots based on depth-profile temperature measurements taken from May through September at sites CCRLKND1, CCRLKML1, and CCRLKUP1 in 2024. The contours indicate that Cherry Creek Reservoir exhibited minimal thermal stratification. Since Cherry Creek Reservoir ices over in the winter and exhibits frequent or continuous circulation during the summer, it fits the definition of a discontinuous cold polymictic lake.

Dissolved oxygen contour plots were also constructed along the length of Cherry Creek Reservoir based on depth-profile measurements. Figure 5 provides longitudinal dissolved oxygen contour plots based on depth-profile measurements taken from May through September in 2024. Hypoxic to anoxic conditions were monitored near the reservoir bottom from July into September. Although Cherry Creek Reservoir appears to be polymictic based on thermal stratification there was enough inhibition of mixing to allow hypoxic to anoxic conditions to develop near the reservoir bottom.

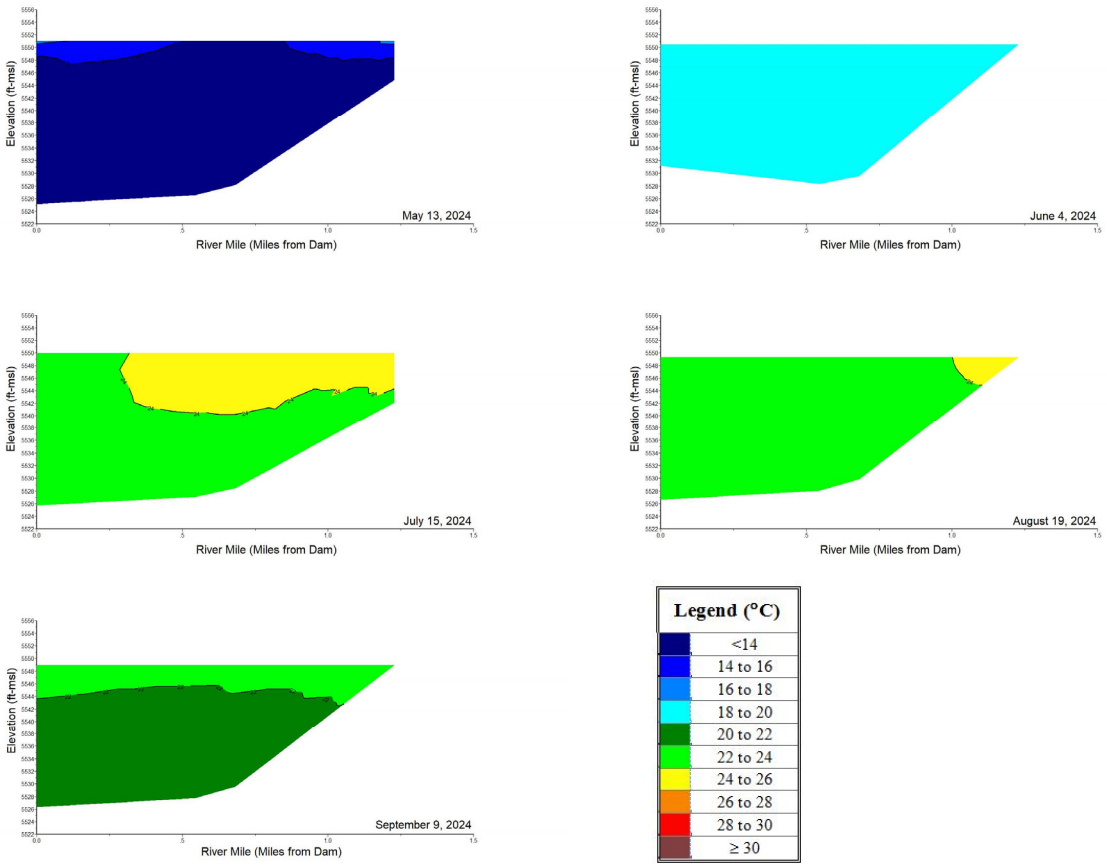


**Figure 4.** Longitudinal temperature contour plots of Cherry Creek Reservoir based on depth-profile temperature measurements (ºC) measured at sites CCRLKND1, CCRLKML1, and CCRLKUP1 in 2024.

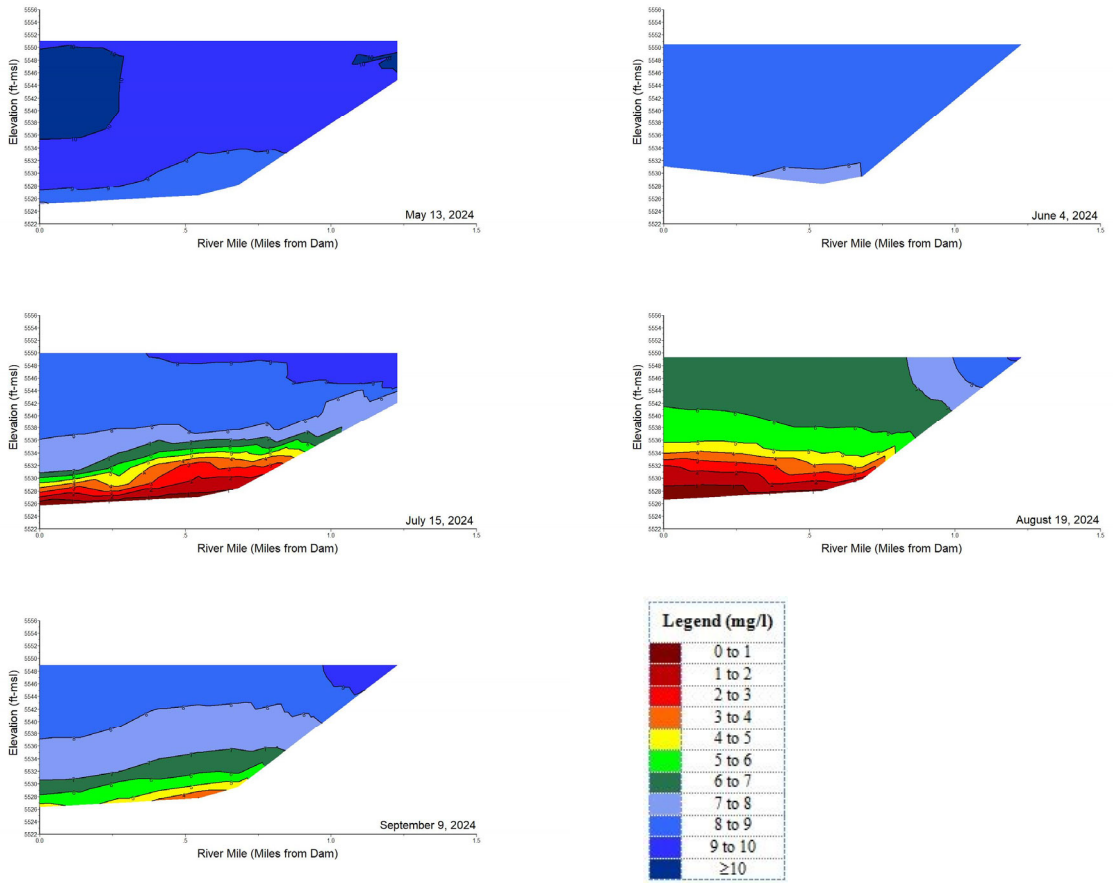


**Figure 5.** Longitudinal dissolved oxygen contour plots of Cherry Creek Reservoir based on depth-profile dissolved oxygen measurements (mg/l) measured at sites CCRLKND1, CCRLKML1, and CCRLKUP1 in 2024.

### 3.3. TOTAL PHOSPHORUS RESULTS

Total phosphorus samples were collected from Cherry Creek Reservoir at sampling site CCRLKND1 along with the outflow site CCRRL1. At CCRLKND1, samples were collected at the surface and the bottom of the reservoir. Surface samples were collected at half the measured Secchi depth. Bottom samples were collected at half a meter from the reservoir bottom. Figure 6 summarizes sampling results for total phosphorus collected in 2024. Hypoxic to anoxic conditions observed at the bottom of the reservoir were strong enough to lead to sediment phosphorus release. This phosphorus was then moved out of the reservoir through the intake structure.

Total phosphorus results showed concentrations were higher in the outflow than were measured near the bottom of the reservoir. This indicates the intake is pulling water from deeper in the water column than the depth at which the reservoir bottom samples were collected. Project drawings and pictures confirm that the intake is about thirty feet lower than the bottom sample due to the accumulated sediment within the reservoir. As a result, total phosphorus measurements collected from the outflow, at the water quality monitoring site CCRRL1, were used to calculate the amount of phosphorus being removed from Cherry Creek Reservoir. This data also verifies that water is being pulled from an appropriate reservoir depth for hypolimnetic withdrawal and not from higher in the water column where phosphorus concentrations would be lower.

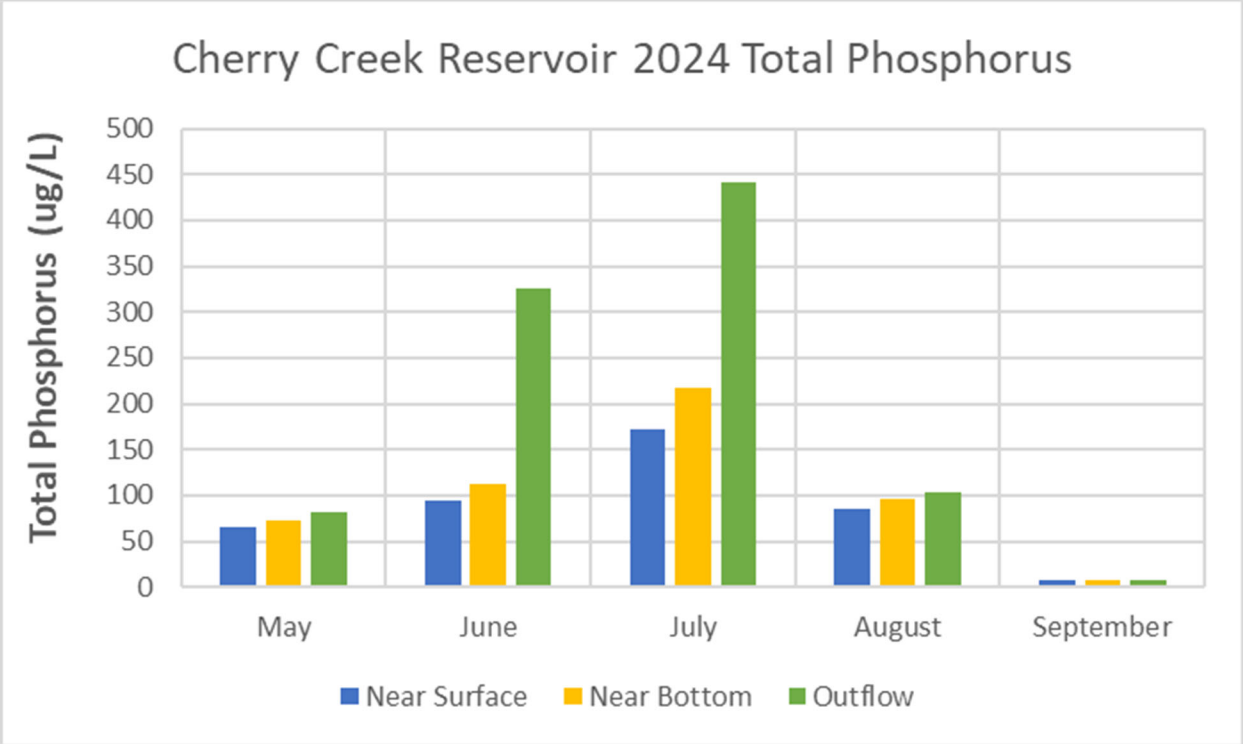


**Figure 6.** Total phosphorus sampling results from Cherry Creek Reservoir. Near-surface and near-bottom samples represent in-reservoir samples (CCRLKND1). Outflow represents samples collected in dam releases (CCRRL1).

Table 1 summarizes the estimated amount of phosphorus that was removed from Cherry Creek Reservoir during the July water quality release strategy versus what would have been

released otherwise. January and July are the only two months that releases varied between the operational strategies, with January being when the transition zone was filled and July when waters stored in the transition zone were released. Storing water in January resulted in less phosphorus being removed from the reservoir when compared to past strategies, while July releases resulted in more phosphorus being removed. The overall effect of all operational changes related to the transition zone (January storage and July releases) was removal of an estimated additional 253 kg of phosphorus from the reservoir.

While the amount of phosphorus removed from Cherry Creek Reservoir was increased, it is also worth noting the amount of phosphorus entering the reservoir. These data are displayed in Table 1 and represents the estimated average amount of phosphorus entering the reservoir as computed based on data collected at the CCBWQA's CC-10 (see Figure 2) inflow sampling site from 2015 through 2023. In summary, while more phosphorus was removed via the modified releases, there is still a net gain in the amount of phosphorus in Cherry Creek Reservoir because inputs are significantly higher than outputs, even with the water quality releases.

**Table 1.** Total phosphorus removed from and entering Cherry Creek Reservoir using different operational strategies.

| Time Period | Total Phosphorus Removed Using Past Release Strategy (kg) | Total Phosphorus Removed in 2024 Using Water Quality Releases (kg) | Net Change in Total Phosphorus Removed via Releases (kg) | Relative Percent Difference* | Phosphorus Input through CC-10 Inflow (kg; average 2015-2023) |
|---|---|---|---|---|---|
| **January** | 112.21 | 39.83 | -72.39 | -95% | 241.03 |
| **July** | 307.88 | 633.53 | 325.65 | 69% | 757.00 |
| **Combined January and July Only** | 420.09 | 673.35 | 253.26 | 46% | ----- |
| **January through September** | 2549.66 | 2802.92 | 253.26 | 9% | 7,018.67 |

*Relative Percent Difference computed as the difference in phosphorus removed (removal via water quality releases minus removal via past release strategy) divided by the mean average of phosphorus removed by the two scenarios and then multiplied by 100 to compute a percentage.

### 3.4. OUTFLOW IMPACTS TO WATER QUALITY STANDARDS

Reservoir outflow dissolved oxygen and ammonia conditions were monitored throughout the summer to ensure water sent downstream did not pose a risk to aquatic life. Figure 7 shows that the outflow structure at Cherry Creek Reservoir is sufficient to aerate water released downstream from the reservoir. Outflow ammonia samples also tested below chronic and acute criteria standards for the protection of aquatic life.

It should be noted that outflow was reduced to zero cfs for a brief period in January in order to fill the transition zone. No negative downstream impacts were reported from this reduced outflow.

## 4. DISCUSSION

Timing of the 2024 water quality storage and releases went as planned due to several enabling variables that may not occur every year:

- Reservoir inflows were high enough to allow filling of the Cherry Creek Reservoir transition zone during the month of January.
- Inflows were also sufficient in February to June such that the transition zone remained full until the planned July releases.
- Reservoir stratification, particularly when considering dissolved oxygen, also occurred as expected and the reservoir remained chemically stratified from July into September (see Figure 5).
- Observed hypoxic to anoxic conditions near the reservoir bottom led to the sediment releasing phosphorus into the water column.
- Total phosphorus concentrations peaked in July (see Figure 6), at which point a portion passed downstream through the increased water quality releases, making those releases optimally timed in terms of nutrient removal of the water stored in the transition zone.

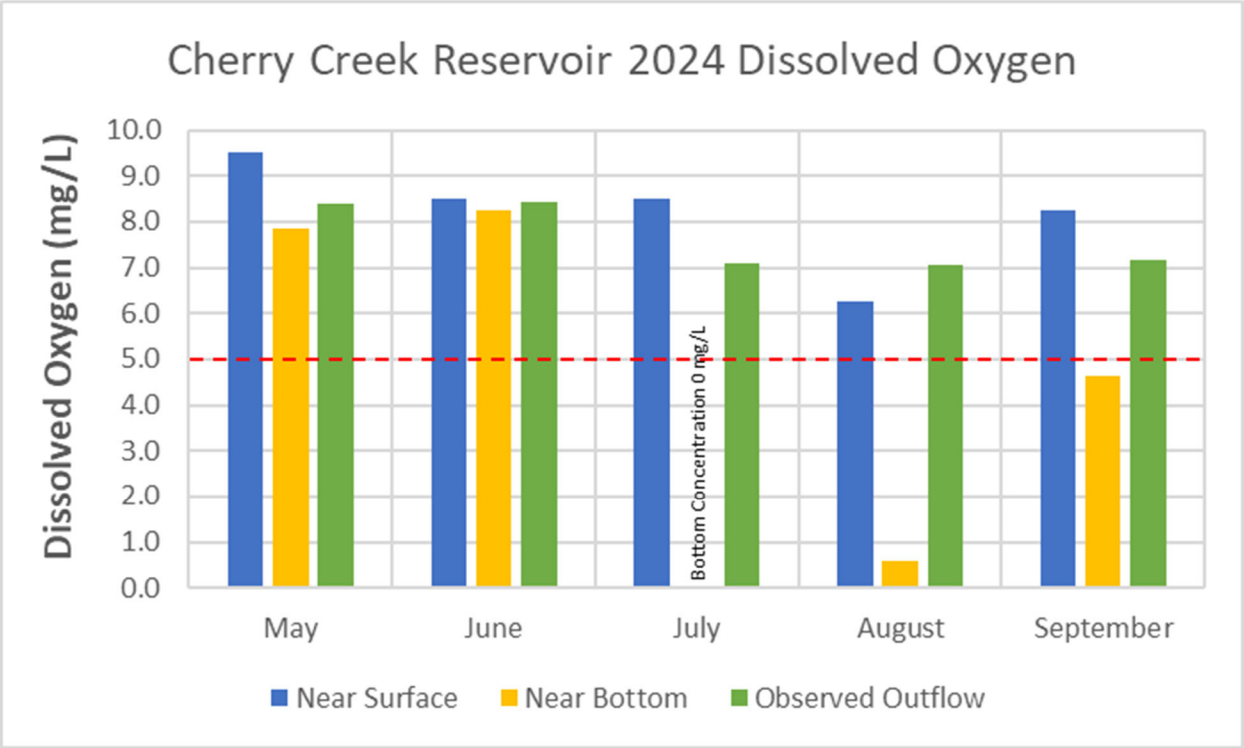


**Figure 7.** Dissolved oxygen sampling results from Cherry Creek Reservoir. Near-surface and near-bottom samples represent in-reservoir samples collected from CCRLKND1. Observed outflow represents samples collected in dam releases. Water quality criterion marked with red line.

Monitoring results, particularly measurements of total phosphorus, indicate that increased July releases pulled water from the bottom of the water column at Cherry Creek Reservoir, which was a positive finding for the water quality releases. Similar monitoring at other USACE reservoirs have shown that this is not always the case; Hypolimnetic withdrawals at

other reservoirs have shown that sedimentation, location of intake structure, and increased flow can all potentially cause water to be pulled from higher in the water column than expected, which did or would likely result in releasing water with lower concentrations of phosphorus. However, at Cherry Creek Reservoir, the outflow phosphorus concentrations were higher than those measured near the reservoir bottom. This indicates that the intake structure is deeper in the water column than the reservoir bottom samples collected.

A comparison in total phosphorus removed from Cherry Creek Reservoir through past operational strategies and through the 2024 water quality releases strategy was conducted. January and July were the only months when releases differed between the two strategies, with water stored in the transition zone during January and released during July. Analysis of total phosphorus showed less phosphorus was released in January in the water quality releases strategy than in past operation years due to the reduction in outflows; however, water quality releases removed more phosphorus than past operations in July and the July increase was more than the January decrease. Overall, it is estimated that an additional 253 kg of phosphorus were removed from Cherry Creek Reservoir using the water quality release strategy. It is important to note that the amount of phosphorus entering the reservoir is significantly more than what the water quality release strategy (or past operations) could remove, particularly when considering year-round inflows and outflows.

Downstream impacts from the water quality release strategy were minimal. The intake structure was able to sufficiently aerate water moving downstream and ammonia sampling results showed no exceedances of ammonia criteria for the protection of aquatic life. No negative impacts were reported from the reduced releases in January.

Overall, the results of this project were very well received by the Cherry Creek Reservoir stakeholders. Reducing phosphorus in the reservoir is a high priority for stakeholders. Multiple past, ongoing, and proposed projects to reduce reservoir nutrients and nutrient loading have been conducted at the reservoir through the years. In general, projects that aim to remove phosphorus from a reservoir or reduce the amount entering are expensive. This modified July water quality release is a very low-cost strategy that has the potential to remove a substantial amount of phosphorus when compared to other projects.

## 5. RECOMMENDATIONS

The modified water quality release strategy at Cherry Creek Reservoir in 2024 showed that additional phosphorus can be removed from the reservoir compared to past release strategies. While there is a benefit to any amount of in-pool phosphorus removal, observable changes in the reservoir's water quality may be limited, particularly when considering the relatively small amount of phosphorus removed compared to the amount entering the reservoir. It is worth noting however that the reservoir met its chlorophyll-a standard of 18 ug/l in 2024 for the first time since 2019. Cherry Creek Reservoir has only met its chlorophyll-a standard three times in the last fifteen years, including 2024. It is also important to note that the modified release strategy has provided other benefits. These include additional water moving downstream during a time of the year that is historically hotter and drier, along with providing more water in the reservoir later in the season for recreation. Overall, the results of this low-cost phosphorus removal project were very well received by Cherry Creek Reservoir stakeholders.

As long as the modified July water quality release continues to have stakeholder support, it is recommended that, if possible, the releases be continued to determine if phosphorus and chlorophyll-a concentrations show any change in trends over time. This

assumes that no negative effects or impacts are identified by the USACE or stakeholders. Identified negative impacts may outweigh any observable water quality improvements the releases provide. These water quality releases should be considered another “tool in the toolbox” for addressing water quality at Cherry Creek Reservoir and be used in conjunction with other management tools and resources.