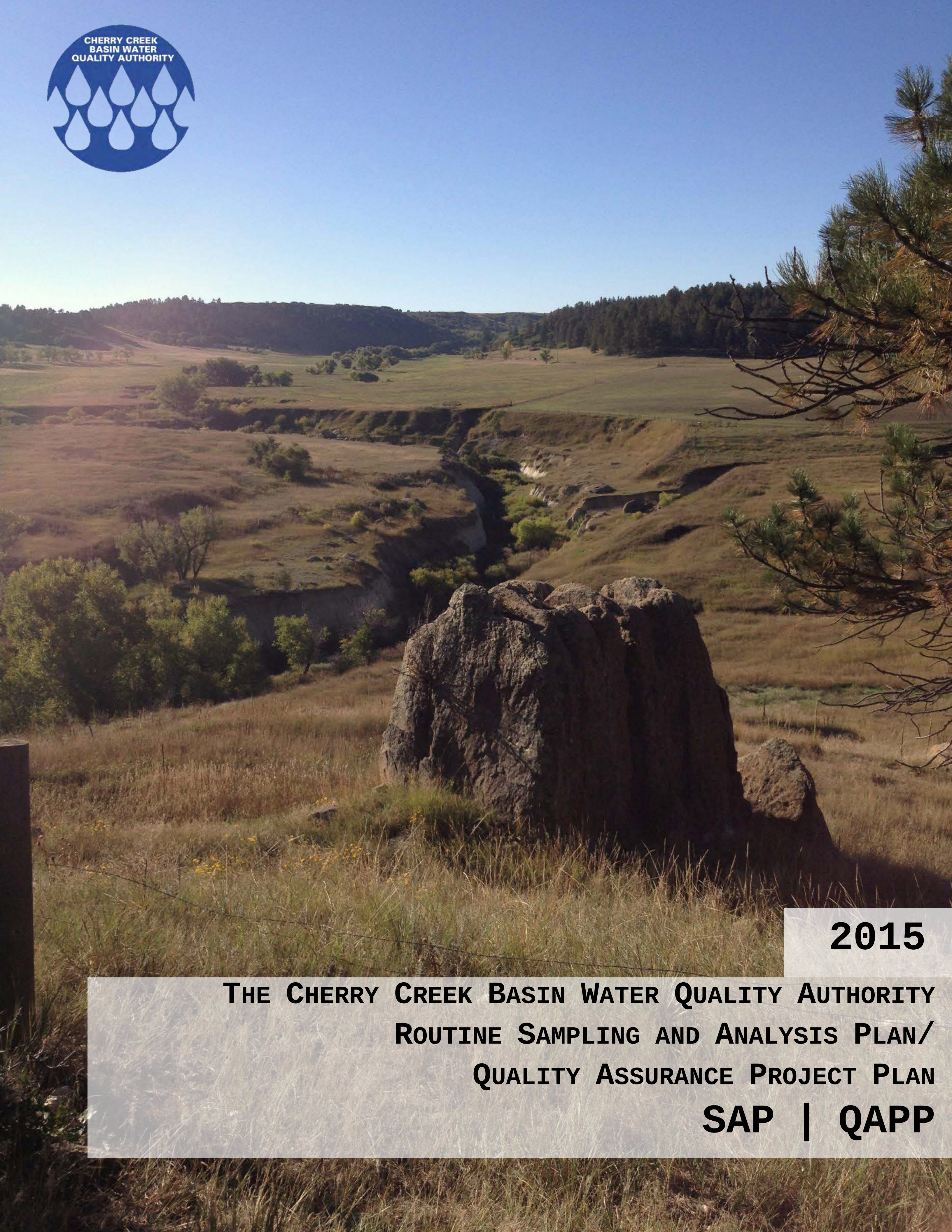
CHERRY CREEK BASIN WATER QUALITY AUTHORITY



2015

THE CHERRY CREEK BASIN WATER QUALITY AUTHORITY ROUTINE SAMPLING AND ANALYSIS PLAN/ QUALITY ASSURANCE PROJECT PLAN

SAP | QAPP

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1.0 Introduction

The Cherry Creek Basin Water Quality Authority (Authority) was formally created in 1988 by the Colorado State Legislature by statue (see Colorado Revised Statues (C.R.S.) 25.8.5-101 et seq.). The Authority was created as a quasi-municipal corporation and political subdivision of the state, and was provided with specific authorities. The Authority is tasked with improving, protecting, and preserving the water quality of Cherry Creek and Cherry Creek Reservoir as well as achieving and maintaining state water quality standards for the reservoir and watershed. The Authority has the power to develop and implement plans and studies for water quality controls for the reservoir and watershed to achieve and maintain the water quality standards, and make recommendations regarding water quality projects and programs to achieve water quality standards. The Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) includes long-term monitoring of nutrient levels within the reservoir and its tributaries, nutrient levels in precipitation and groundwater, and chlorophyll *a* levels within the reservoir. The overall goal of the monitoring program is to assess attainment of the water quality standards (including beneficial uses and the numeric criteria adopted to protect the uses) and to assess the effectiveness of the Authority's actions.

2.0 Purpose

The Cherry Creek Basin Water Quality Authority (Authority) is required to samples biological, physical, and nutrient parameters in the Cherry Creek Reservoir and its tributaries under Regulation 72, the Cherry Creek Reservoir Control Regulation. Pursuant to this charge, the monitoring program is to meet the following purposes stemming from Regulation 72:

- For the purpose of supporting and calibrating the reservoir water quality model, as anticipated by Regulation 72[1];
- For the purpose of meeting parameter-specific monitoring required of the Authority by Regulation 72 and additional non-specified monitoring determined by the Authority to be supportive of Authority goals;
- For the purpose of meeting nutrient Pollutant Reduction Facility (PRF) monitoring required of the Authority by Regulation 72;

[1] As future special studies are identified, the SAP/QAPP will be reviewed to determine if any modifications need to be made to support the new study. In some instances, a short, stand-alone SAP may be more appropriate. "Special studies" are anticipated by Regulation 72, the Cherry Creek Reservoir Control Regulation, Section 72.8.4: "Special studies may include, but are not limited to, the following areas of investigation: (a) Feasibility study of nutrient removal from point sources; (b) Quantification of effectiveness of nonpoint source concentration-based phosphorus control strategies called PRFs; (c) Quantification of effectiveness of regulated stormwater concentration-based phosphorus control strategies called BMPs; and (d) Quantification of the effectiveness of source control BMPs that include low-impact development techniques." The reservoir model qualifies as a special study. A special study such as a side-by-side comparison of methods for cyanobacteria analysis, e.g., filtering vs. settling, would also require a separate special SAP.

- For the purpose of assessing the effects of the destratification system, as required of the Authority by Regulation 72 as part of its PRF monitoring for nutrients and additional monitoring as may be determined by the Authority;
- For the purpose of determining attainment of applicable water quality standards, as required of the Authority by Regulation 72; and
- For the purpose of evaluating nutrient sources and transport, evaluating fate and transport of phosphorus, and calculating flow-weighted phosphorus concentrations, as required of the Authority by Regulation 72.
- For the purpose of calculating flow-weighted nitrogen concentrations and evaluating the fate and transport of nitrogen, as well as calculating mass balances for both phosphorus and nitrogen inputs and losses from the reservoir, as determined by the Authority to be supportive of its goals, according to the 2010 expansion of Regulation 72 to consider all nutrients, and not just phosphorus.

3.0 Sampling Program Objectives

The Authority's long-term goals serve as assessment end-points for the reservoir and watershed (for example, protection of beneficial uses, and preservation and enhancement of water quality). The sampling program helps the Authority evaluate whether it is attaining its long-term goals. Specific objectives of the sampling program are to:

- Determine biological productivity in the reservoir, as measured by chlorophyll *a* concentrations and collect other data (i.e., phytoplankton) related to the effect of chlorophyll *a* on beneficial uses;
- Determine the concentrations of phosphorus and nitrogen species in the reservoir and streams, and how it changes over time;
- Determine the annual flow-weighted phosphorus concentration and changes to the concentrations entering the reservoir from streams and precipitation and the phosphorus export from the reservoir via the outlet structure;
- Determine the effectiveness of pollutant removal by Pollutant Reduction Facilities; and
- Determine the effectiveness of the destratification system[2] in protecting the beneficial uses by reducing the algal biomass as measured by chlorophyll *a* and reducing cyanobacteria production as measured by species identification, enumeration, and biovolume.

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[2] Note that the destratification system was originally designed to achieve the following goals: 1) reduce the release of phosphorus and nitrogen nutrients from the bottom sediments into the water column of the reservoir in a typical year by 810 lbs/yr and 1140 lbs/yr, respectively; 2) decrease the seasonal mean (July-Sept) chlorophyll *a* concentrations by approximately 8 ug/L under typical year conditions; 3) decrease annual peak chlorophyll *a* concentrations by up to 30 ug/L; 4) increase dissolved oxygen concentrations in the deepest and most vulnerable zones of the reservoir into the range of 5 mg/L; and 5) reduce the production of blue-green algae by making the habitat of the reservoir less suitable for the production of blue-green algae via vertical mixing. (AMEC Earth & Environmental, Inc., Alex Horne Associates, Hydrosphere Resource Consultants, Inc. (December 5, 2005). *Feasibility Report Cherry Creek Reservoir Destratification.)*

The SAP/QAPP identifies field and laboratory protocols necessary to achieve high quality data. The 2014 SAP/QAPP is intended to build off of the 2008 Sampling and Analysis Plan and Quality Assurance Work Plan (GEI 2008) and includes: quality assurance objectives for the measurement of data in terms of accuracy, representativeness, comparability, and completeness; field sampling and sample preservation procedures, laboratory processing and analytical procedures; and guidelines for data verification and reporting; quality control check; corrective actions; and quality assurance reporting.

4.0 Regulation No. 72 Requirements

Regulation 72 states that the Authority shall develop and implement, in conjunction with local governments, a routine annual water quality monitoring program of the Cherry Creek watershed and Cherry Creek Reservoir. The monitoring program shall include monitoring of the reservoir water quality and inflow volumes, alluvial water quality, and nonpoint source flows. Monitoring shall include, but not be limited to nitrate, nitrite, ammonia, total phosphorus, total soluble phosphorus, and orthophosphate concentrations.

- Routine monitoring of surface water, ground water, and the reservoir shall be implemented to determine the total annual flow-weighted concentration of nutrients to the reservoir; and
- Monitoring of PRFs shall be implemented to determine inflow and outflow nutrient concentrations.

The Authority shall consult with the Colorado Water Quality Control Division (Division) in the development of the monitoring program to ensure that the monitoring plan includes the collection of data to evaluate nutrient sources and transport, to characterize reductions in nutrient concentrations, and to determine attainment of water quality standards in Cherry Creek Reservoir. In addition, the Authority shall consult with the Division and other appropriate entities in development of any water quality investigative special studies.

The monitoring data shall be used by the Authority to determine phosphorus fate and transport, calculate annual flow-weighted phosphorus concentrations, document compliance with the applicable water quality standards, analyze long-term trends in water quality for both the reservoir and the Cherry Creek watershed, and calibrate water quality models (72.8).

Reporting requirements are also required under Regulation 72. The Authority shall submit an annual report on the activities to the Commission and Division by March 31 of each year (72.9).

The SAP/QAPP facilitates the above Regulation 72 requirements, and ensures a high quality, auditable, and well-documented monitoring program.

5.0 Review and Updates

A review of the SAP/QAPP shall be performed by the Technical Advisory Committee (TAC) or Water Quality Committee when there are material changes made to the sampling program (e.g. new monitoring sites, additional parameters, laboratory changes, changes in personnel, etc.), and any updates shall be made as needed. In addition, a review and update of the SAP/QAPP shall be conducted by the TAC or Water Quality Committee in preparation for Water Quality Control Commission (WQCC) Rule Making Hearings (RMH) and other special studies, as needed. Changes and amendments shall be incorporated into the SAP/QAPP in a timely manner, and shall be well-documented.

6.0 Timeline

Sampling and data collection shall be implemented per Regulation 72. The Cherry Creek Basin is subject to the hearing timelines of the Cherry Creek Reservoir Control Regulation (Regulation 72), statewide water quality standards (Regulation 31), Cherry Creek water quality standards (Regulation 38), statewide water quality standards assessment (Regulation 93), and other regulations (Regulation 22, 43, 61, 85). As these regulations change, the SAP/QAPP may need to be revisited and may change. The next Water Quality Control Commission Triennial Review Informational Hearing for Regulation 72 will be held in May 2015. Figure 1 below shows the timeline of regulation hearings pertaining to the Cherry Creek Basin.

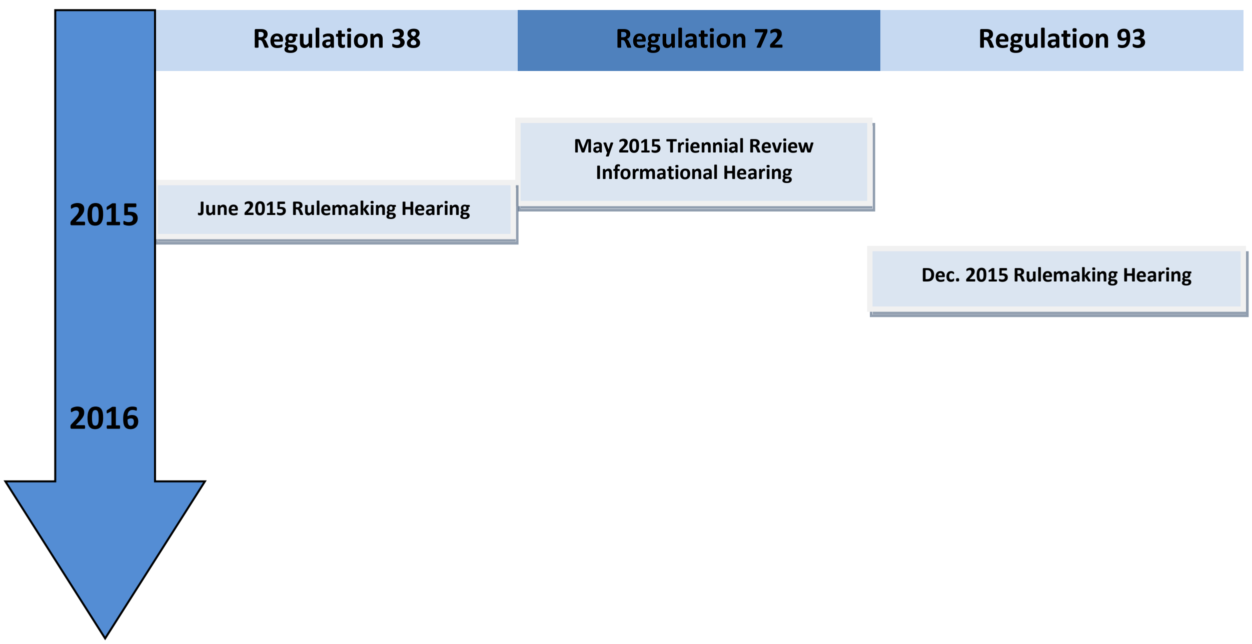

Figure 1: Water Quality Control Commission Regulation Hearing Timeline

7.0 Project Description

The Authority has been collecting water quality data since 1994. The data has provided an extensive site-specific data set for Cherry Creek Reservoir and its tributaries. This SAP/QAPP has been designed to better define water quality conditions and to gain a better understanding of changes of nutrients in the reservoir and its tributaries and the effectiveness of PRFs. The following includes an overview of sampling site locations, sampling teams and structures, sampling parameters, and frequency of sampling.

7.1 Sample Site Locations

Reservoir, watershed, and PRF sampling shall be routinely conducted at 13 sites, including three sites in Cherry Creek Reservoir, eighteen stream monitoring sites (on Cherry Creek, Cottonwood Creek, Piney Creek, and McMurdo Gulch), and eight alluvial groundwater sites along Cherry Creek mainstem, and one site on Cherry Creek downstream of the Reservoir (Figure 2). Data from many of these monitoring sites are used to assess the effectiveness of several of the Authority's PRFs (Figure 3). In addition to these routine monitoring sites, 10 transect sites (D1 to D10) were established from the approximate mid-point of the dam face extending perpendicular across the destratification zone in the Reservoir, as well as three continuous temperature logging sites near routine reservoir monitoring sites.

All sampling sites are summarized below. Site coordinates for the currently monitored sites can be found in Appendix A. Information on sites that were previously monitored but have been abandoned is found in Appendix B.

7.1.1 Cherry Creek Reservoir Monitoring Sites

CCR-1 — This site is also called the Dam site, and was established in 1987. Site CCR-1 corresponds to the northwest area within the reservoir (Knowlton, 1993). Sampling was discontinued at this site in 1996 and 1997 following determination that this site exhibited similar characteristics to the other two sites. Sampling recommenced in July 1998 at the request of consultants for Greenwood Village.

CCR-2 — This site is also called the Swim Beach site, and was established in 1987. Site CCR-2 corresponds to the northeast area within the reservoir (Knowlton, 1993).

CCR-3 — This site is also called the Inlet site, and was established in 1987. Site CCR-3 corresponds to the south area within the reservoir (Knowlton, 1993).

D-1 to D-10 — These sites are a series of transect profile locations that start near the dam face (D1) and continue across the Reservoir to CCR-3. The transect corresponds to Transect D of the Destratification Feasibility Report (AMEC 2005).

7.1.2 Stream Monitoring Sites

7.1.2.1 Cherry Creek

Castlewood — This site has been sampled since 1994, and is located in Castlewood Canyon State Park where the Homestead Trail crosses Cherry Creek. It is located about 0.2 miles north of the USGS gaging station known as "Cherry Creek near Franktown."

CC-1	This site was established in 2012 on Cherry Creek. This site is located on Cherry Creek approximately 380 m upstream of where Bayou Gulch Road crosses Cherry Creek near Parker Road.
CC-2	This site has been sampled since 1994 and is located on Cherry Creek below the Pinery's wastewater treatment plant. This site is located approximately 0.85 km upstream of Stroh Road.
CC-4	This site has been sampled since 1994, and is located on Cherry Creek below the confluence with Sulphur Gulch and below the outfall for Parker's AWT plant. This site is located approximately 0.50 km downstream of Main Street in Parker.
CC-5	This site has been sampled since 1994, and is located on Cherry Creek immediately downgradient of the confluence with Newlin Gulch. This site is located where Pine Lane crosses Cherry Creek, approximately 0.65 km west of Parker Road.
CC-6	This site has been sampled since 1994, and is located on Cherry Creek downgradient of Parker's North AWT plant. However, the discharge from this AWT plant is transported via pipeline to Sulphur Gulch. This site is located approximately 1.38 km downstream of Cottonwood Drive and 0.41 km west of Parker Road.
CC-7 EcoPark	This site was reestablished in 2013 on Cherry Creek at the downstream boundary of Cherry Creek Valley Ecological Park (EcoPark). This site is approximately 1.7 kilometers (km) upstream (south) of Arapahoe Road, and serves to monitor water quality conditions downstream of the EcoPark Stream Reclamation Project (PRF). This site also provides more accurate flow estimates in this reach of Cherry Creek. (The original CC-7 site, located ¾ mile south of Arapahoe Road, was abandoned in 2000 due to development.)
CC-8	This site has been sampled since 1994, and is located on Cherry Creek, approximately 0.5 miles north of Arapahoe Road.
CC-9	This site was re-established in 2012 on Cherry Creek, and is located in Cherry Creek State Park just upgradient of Cherry Creek Reservoir. This site is located immediately downstream of where East Lake View Drive crosses Cherry Creek in Cherry Creek State Park.
CC-10	This site is on Cherry Creek immediately downstream of the Shop Creek confluence, approximately 0.5 km upstream of Cherry Creek Reservoir. This site provides data to estimate phosphorus loads to the Reservoir from Cherry Creek and includes inputs from upstream tributaries, including Shop Creek.
CC-O	This site was established in 1987, and is located on Cherry Creek downstream of Cherry Creek Reservoir and upstream of the Hampden Avenue-Havana Street junction in the Kennedy Golf Course near the historical USGS gage (06713000).

In 2007, Site CC-O (also identified in the past as Site CC-Out at I225) was relocated immediately downstream of the dam outlet structure and is used to monitor the water quality of the Reservoir outflow.

7.1.2.2 Cottonwood Creek

CT-P1 This site was established in 2002, and is located on Cottonwood Creek just north of where Caley Avenue crosses Cottonwood Creek, and west of Peoria Street. This site monitors the water quality of Cottonwood Creek before it enters the Peoria Pond PRF, also created in 2001/2002 on the west side of Peoria Street.

CT-P2 This site was established in 2002 and is located on Cottonwood Creek at the outfall of the PRF, on the west side of Peoria Street. The ISCO® stormwater sampler and pressure transducer is located inside the outlet structure. This site monitors the effectiveness of the PRF on water quality.

CT-1 This site was established in 1987 where the Cherry Creek Park Perimeter Road crosses Cottonwood Creek. It was chosen to monitor the water quality of Cottonwood Creek before it enters the Reservoir. During the fall/winter of 1996, a PRF, consisting of a water quality/detention pond and wetland system, was constructed downstream of this site. As a result of the back-flow from this pond inundating this site, this site was relocated approximately 250 m upstream near Belleview Avenue in 1997. In 2009, this site was relocated approximately 75 m upstream of the Perimeter Road as it crosses Cottonwood Creek, due to the Cottonwood Creek stream reclamation project. This site is now approximately 200 m upstream of the PRF. It is also used to evaluate the effectiveness of the PRF by documenting the stream concentrations above the PRF.

CT-2 This site was established in 1996, and was originally located downstream of the Perimeter Pond on Cottonwood Creek. The ISCO pressure transducer and staff gage was located in a section of the stream relatively unobstructed by vegetation, and approximately 50 m downstream of the PRF. However, over the years the growth of vegetation considerably increased along the channel, creating problems with accurately determining stream flow. Eventually, when no accurate and reliable streamflow measurements could be performed in 2003, other locations were evaluated. In August 2004, the pressure transducer and staff gage were relocated inside of the outlet structure for the PRF to mitigate problems associated with streamflow measurements by providing a reliable multilevel weir equation. In 2013, modifications to the PRF overflow elevation and internal weir structure changed the relationship of the multilevel weir equation, resulting in unreliable stream flow estimates. In 2014, the weir elevations were resurveyed and the weir equations were adjusted accordingly. Water quality samples are collected from the outlet structure. This site monitors the effectiveness of the PRF on Cottonwood Creek water quality and provides information on the stream before it enters the Reservoir.

7.1.2.3 Piney Creek

PC-1 This site will be established in 2015 in a reach of Piney Creek upstream of the confluence with Cherry Creek, and downstream of the Piney Creek Stream Reclamation Project.

7.1.2.4 McMurdo Gulch

MCM-1 This site was established in 2012 on McMurdo Gulch, approximately 150 m upstream of the McMurdo Gulch Stream Reclamation Project boundary. This site is also 120 m upstream of the confluence with an unnamed tributary that receives runoff from the Castle Oaks Subdivision. This site serves as the upstream monitoring location for the McMurdo Gulch Stream Reclamation project.

MCM-2 This site was established in 2012 on McMurdo Gulch, approximately 80 m upstream of the Castle Oaks Drive Bridge crossing of McMurdo Gulch, near the North Rocky View Road intersection. This site serves as the downstream monitoring location for the McMurdo Gulch Stream Reclamation Project. This site is located within the project boundary, and consistently maintains base flows, whereas the reach further downstream was often dry due to surface flow becoming subsurface.

7.1.3 Precipitation Sampling Site

PRECIP This site is located near the Quincy Drainage, upstream of the Perimeter Road. The sampler consists of a clean, inverted trash can lid used to funnel rainfall into a one-gallon container. While this collection vessel is maintained and cleaned on a routine basis, precipitation will wash any atmospheric dry fall that has accumulated between cleanings into the one-gallon container. Therefore, these data more appropriately represent a “bulk” atmospheric deposition component for the reservoir.

7.1.4 Alluvial Groundwater Sites

MW-1 This alluvial well monitor has been sampled since 1994, and is located approximately 270 m southeast of where Bayou Gulch Road crosses Cherry Creek near Parker Road.

MW-2 This alluvial well monitor has been sampled since 1994, and is located downstream of the Pinery’s wastewater treatment plant. This site is located approximately 0.85 km upstream of Stroh Road.

MW-3c This alluvial well monitor has been sampled since 2012, and is located near the KOA tower approximately 0.49 km southwest of the Parker Road and Twentymile Road intersection. The original alluvial well MW-3 was abandoned in 2009 and replaced by MW-3b which was then abandoned in 2010.

MW-5	This alluvial well monitor has been sampled since 1994, and is located immediately downgradient of the confluence with Newlin Gulch. This site is located where Pine Lane crosses Cherry Creek, approximately 0.65 km west of Parker Road.
MW-6	This alluvial well monitor has been sampled since 1994, and is located downgradient of Parker's North AWT plant. However, the discharge from this AWT plant is transported via pipeline to Sulphur Gulch. This site is located approximately 1.38 km downstream of Cottonwood Drive and is approximately 0.41 km west of Parker Road.
MW-7a	Site MW-7a was established in 2013 as part of monitoring for the Eco-Park Reclamation Project. This alluvial well monitor has been sampled since 2013, and is located at the downstream boundary of Cherry Creek Valley Ecological Park (EcoPark). This site is approximately 1.7 km upstream of Arapahoe Road. (The original site MW-7 was located adjacent to the Arapahoe Ford #2 production well; it was abandoned as a water quality monitoring site in 2000 due to development.)
MW-9	This alluvial well monitor has been sampled since 1994, and is located in Cherry Creek State Park near the Nature Center. This site is monitored to assess alluvial groundwater that is entering Cherry Creek Reservoir.
Kennedy	This alluvial well monitor has been sampled since 1994, and is located on the Kennedy Golf Course to monitor groundwater quality downgradient from Cherry Creek Reservoir.

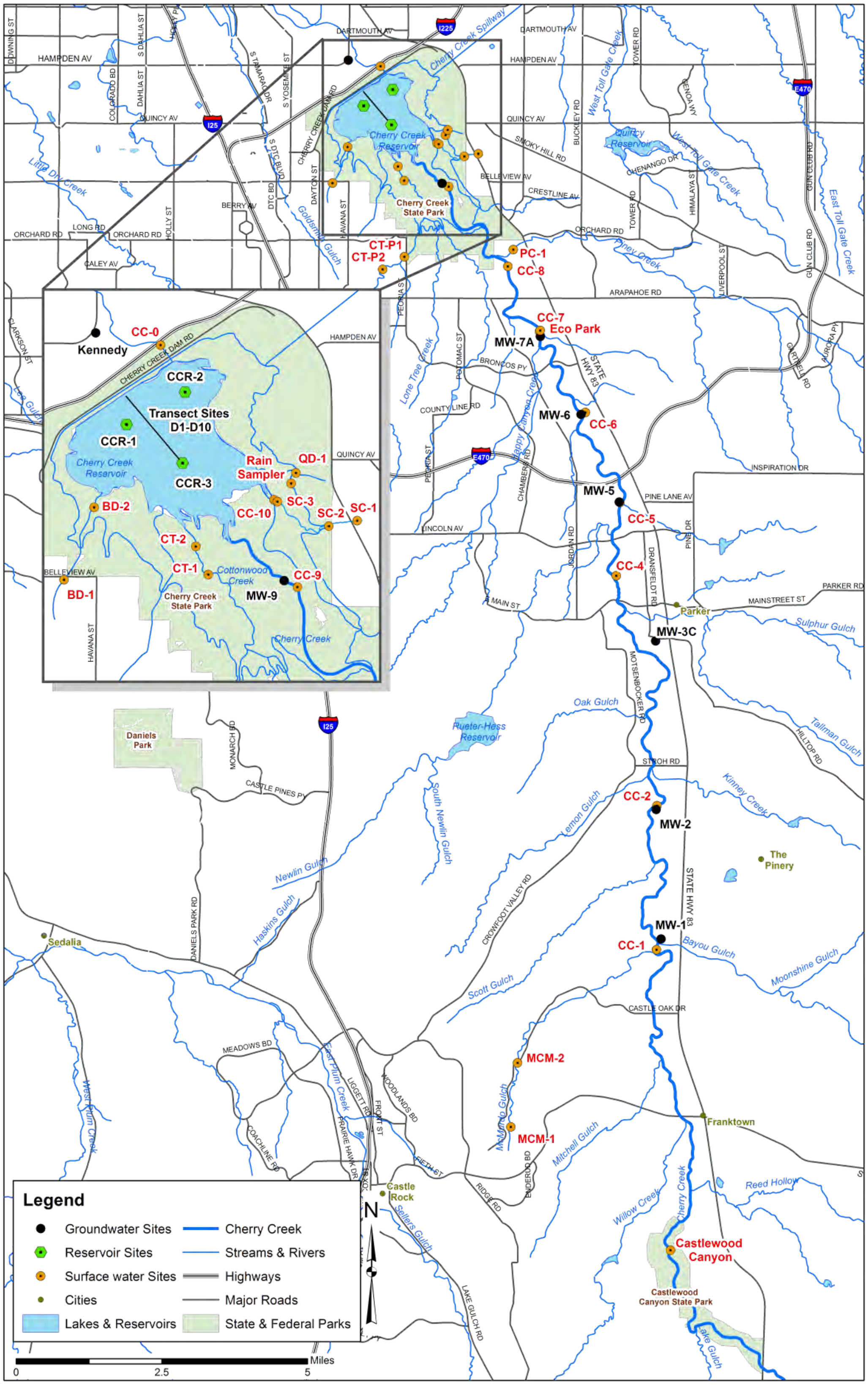

Figure 2: Sample Sites on Cherry Creek Reservoir, Surface Water Monitoring Sites, and Alluvial Groundwater Sites.

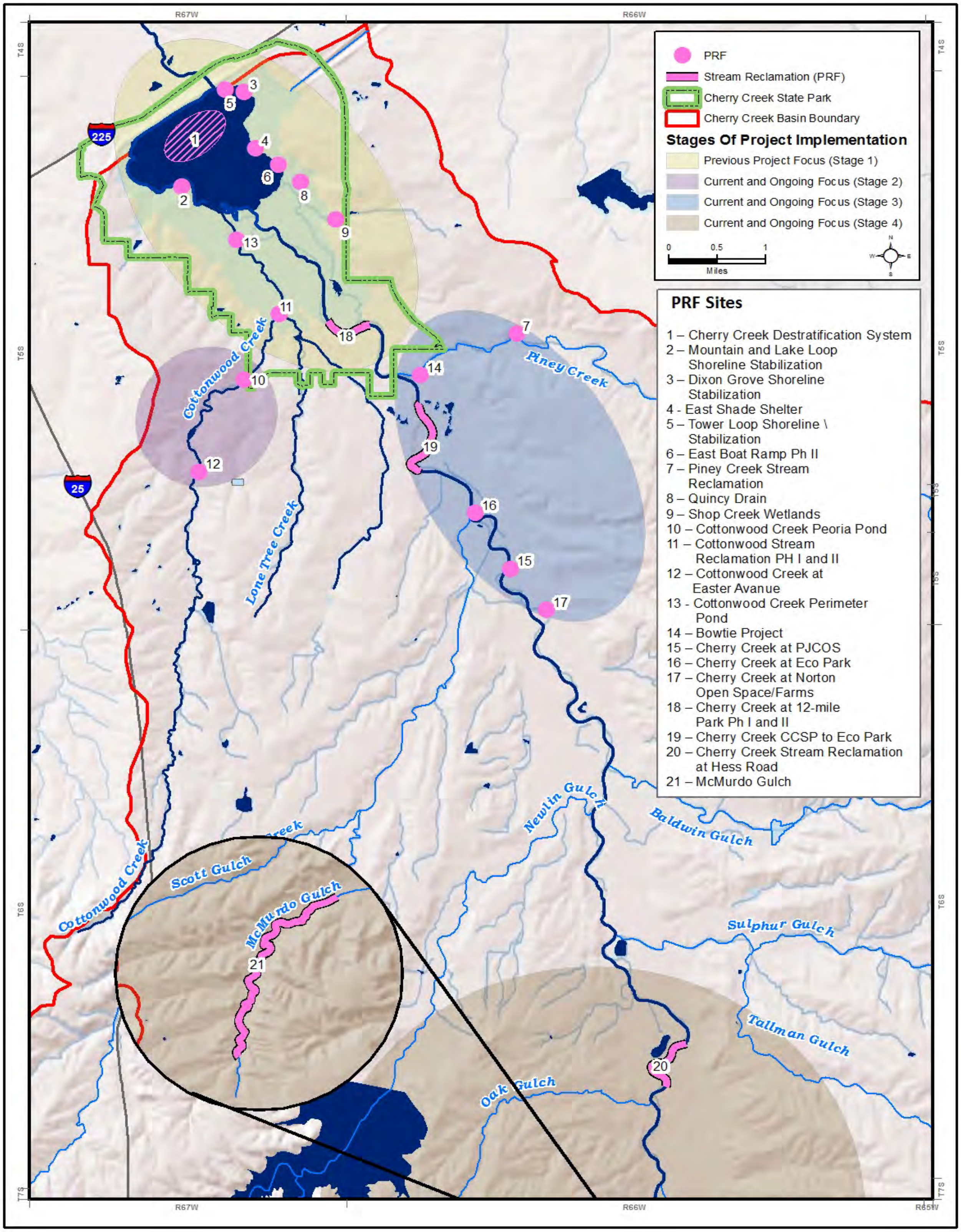

Figure 3: Pollutant Reduction Facility (PRF) Sites Located Throughout the Cherry Creek Watershed.

7.2 Sampling Parameters and Frequency

To ensure a high level of accuracy and precision, sampling and analyses shall be conducted according to the protocols and method and detection limits set forth in this SAP/QAPP. Monitoring parameters include physical, inorganic, organic, and biological parameters. Table 1 summarizes reservoir sampling parameters and sampling frequencies for sites within the reservoir. Table 2 summarizes similar information for stream and alluvial groundwater monitoring.

Table 1. Reservoir Sampling Parameters and Frequency.

ANALYTE	Monthly Vertical Profile WQ Sonde (Oct – April)	Monthly Nutrient-Biological Samples (Photic Zone)		Monthly Nutrient Profile (4m-7m)	Bi-monthly Sonde & Nutrient Samples (May-Sept)	Precipi-tation	Destratifica-tion Transect Vertical Profile WQ Sonde (Jun-Aug)
	CCR-1, CCR-2, CCR-3	CCR-1, CCR-3	CCR-2	CCR-2	CCR-1, CCR- 2, CCR- 3	Rain Sampler	**11 Sites** (D-1, D-2, D-3, D-3.5, D-4, D-5, D-6, D-7, D-8, D-9, D-10)
Physical							
Temperature	x				x		x
Conductivity	x				x		x
pH	x				x		x
Dissolved Oxygen	x				x		x
Oxidation/Reduction Pot'l	x				x		x
1% Transmittance	x				x		
Secchi disk	x				x		
Temperature, Continuous (15-minute interval)	x						
Inorganics							
Total Nitrogen		x	x	x	x	x	
Total Dissolved Nitrogen		x	x	x	x	x	
Ammonia as N		x	x	x	x	x	
Nitrate+Nitrite as N		x	x	x	x	x	
Total Phosphorus		x	x	x	x	x	
Total Dissolved		x	x	x	x	x	
Orthophosphate as P		x	x	x	x		
Organics							
Total Organic Carbon			x	x	x		
Dissolved Organic			x	x	x		
Total Volatile Suspended		x	x		x		
Total Suspended Solids		x	x		x		
Biological							
Chlorophyll *a*		x	x		x		
Phytoplankton			x		x		
Zooplankton			x		x		

Table 2. Stream and Groundwater Sampling Parameters and Frequency.

ANALYTE	Monthly Surface Water Samples	Storm Event Surface Water ISCO Samples	Bi-annual Surface Water Samples	Bi-annual Groundwater Samples
	10 sites (CC-0, CC-10, CC-7-EcoPark, CT-1, CT-2, CT-P1, CT-P2, MCM-1, MCM-2, PC-1)	**7 sites** (CC-10, CC-7-EcoPark, CT-1, CT-2, CT-P1, CT-P2, PC-1)	**9 sites** **(Castlewood, CC-1, CC-2. CC-4. CC-5, CC-6, CC-8, CC-9)**	**8 sites** (MW-1, MW-2, MW-3c, MW-5, MW-6, MW-7a, MW-9, Kennedy)
Physical				
Temperature	X		X	X
Conductivity	X		X	X
pH	X		X	X
Dissolved Oxygen	X		X	X
Oxidation/Reduction Pot'l				X
Water Level, Continuous (15-minute interval)		X		X **(MW-9 only)**
Discharge, Rating Curve		X		
Inorganics				
Total Nitrogen	X	X		
Total Dissolved Nitrogen	X	X		
Ammonia as N	X	X	X	X
Nitrate+Nitrite as N	X	X	X	X
Nitrate as N			X	X
Nitrite as N			X	X
Total Phosphorus	X	X	X	
Total Dissolved Phosphorus	X	X	X	X
Orthophosphate as P	X	X	X	X
Chloride			X	X
Sulfate			X	X
Organics				
Total Organic Carbon				X **(MW-9 only)**
Dissolved Organic Carbon				X **(MW-9 only)**
Total Volatile Suspended Solids	X	X		
Total Suspended Solids	X	X		

Note that the Total and Dissolved Organic Carbon samples collected at CCR-1, CCR-2, CCR-3, and MW-9, and the water levels at MW-9, are being collected at the request of the Authority's Reservoir Modeler as input for the model, and should be revisited and perhaps discontinued when this SAP/QAPP is next updated.

7.3 Authority Roles and Participation

The Authority is responsible for the following tasks:

- Manage the water quality monitoring contract
- Prepare the Annual Report to the Colorado Water Quality Control Commission
- Ensure periodic outside Peer Review is solicited at appropriate times
- Coordinate the monitoring program and budgetary needs arising from regulatory changes and new facility monitoring needs (e.g., PRFs)
- Identify and coordinate monitoring needs for any new special studies (see footnote 1 on the bottom of page 3 for more detail re: special studies)
- Periodically review and revise, as needed, the Sampling Program Objectives (see Section 3.0)
- Ensure the monitoring program complies with Regulation 72 requirements (see Section 4.0)
- Provide periodic review and updates to this SAP/QAPP (see Section 5.0)

7.4 Sampling Teams and Structure

The monitoring consultant shall be responsible for implementing sampling requirements per the SAP/QAPP. All personnel involved in the investigation and in the generation of data are a part of the overall project and quality assurance program. The following roles have specifically delegated responsibilities, which is structured to ensure the highest quality of data collection, management, and reporting.

7.4.1 Project Manager

The Project Manager is responsible for fiscal oversight and management of the project and for ensuring that all work is conducted in accordance with the Scope of Service, Sampling and Analysis Plan, and approved procedures. Tasks include:

- Maintain routine contact with the project’s progress;
- Regularly review the project schedule, and review all work products; and
- Evaluate impacts on project objectives and the need for corrective actions based on quality control checks.

7.4.2 Quality Assurance Manager

The Quality Assurance Manager is responsible for the aquatic biological and field sampling portions of the project as well as the technical management of the monitoring program and reporting. The Quality Assurance Manager shall be responsible for evaluation and review of all data reports relevant to the project and perform data verification. The Quality Assurance Manager shall work with the Project Manager to determine the need for corrective actions and, together, will make recommendations for any needed changes to either sampling methodologies or laboratory analytical procedures. Tasks include:

- Ensure data collection is in accordance with the Sampling and Analysis Plan;
- Maintain a repository for all documents relating to this project; and

- Coordinate with the Authority, the WQCD, and the Authority's other consultants to ensure compliance with the Cherry Creek Reservoir Control Regulation 72.

7.4.3 Analytical and Biological Laboratory Managers

The Analytical Laboratory Manager will ensure that all water quality and chlorophyll *a* samples are analyzed in a technically sound and timely manner. The Analytical Laboratory Manager shall be responsible for ensuring all laboratory quality assurance procedures associated with the project are followed, including proper sample entry, sample handling procedures, and quality control records for samples delivered to the laboratory. The Analytical Laboratory Manager will be responsible for all data reduction and verification, and ensure that the data is provided in a format agreed upon between the Project Manager, the Analytical Laboratory Manager, and the Authority. The Biological Laboratory Manager(s) will ensure that phytoplankton and zooplankton identification, enumeration, and biovolume/biomass analyses are analyzed in a technically sound and timely manner, in accordance with the requirements of this SAP/QAPP. The Biological Laboratory Manager(s) shall be responsible for ensuring all laboratory quality assurance procedures associated with the project are followed, including proper sample entry, sample handling procedures, and quality control records for samples delivered to the laboratory.

7.4.4 Sampling Crew

The field sampling efforts shall be conducted by individuals qualified in the collection of chemical, physical, and biological surface water samples. Field tasks and sampling oversight will be provided by the Quality Assurance Manager. The Sampling Crew shall be responsible for following all procedures for sample collection, including complete and accurate documentation.

7.5 Field Methodologies

7.5.1 Reservoir Sampling

7.5.1.1 Transparency

Transparency shall be determined using a Secchi disk and Licor quantum sensors. The Secchi reading shall be slowly lowered on the shady side of the boat, until the white quadrants disappear, at which point the depth is recorded. The disk is then lowered roughly 1 m further and slowly brought back up until the white quadrants reappear and again the depth is recorded. The Secchi disk depth is recorded as the average of these two readings.

Licor quantum sensors provide a quantitative approach to determine the depth at which 1 percent of the light penetrates the water column. This is considered the point at which light no longer can sustain photosynthesis in excess of oxygen consumption from respiration (Goldman and Horne 1983) and represents the deepest portion of the photic zone. This is accomplished by using an ambient and underwater quantum sensor attached to a data logger. The ambient quantum sensor remains on the surface, while the underwater sensor is lowered into the water on the sunny side of the boat. The underwater sensor is lowered until the value displayed on the data logger is 1 percent of the value of the ambient sensor, and the depth is recorded.

7.5.1.2 Depth Profile Measurements

Measurements for dissolved oxygen, temperature, conductivity, pH, and oxidation/reduction potential (ORP) shall be collected at 1 m intervals, including the surface and near the water/sediment interface, using a multiparameter sonde. The sonde shall be calibrated prior to each sampling episode to ensure accurate readings.

In addition to the monthly/bimonthly profile data, three transect profiles shall be performed, one each in June, July, and August at up to eleven sample locations through the deep-water zone. The sample locations and transect will be consistent with locations previously established by AMEC during its destratification feasibility study. Latitude and longitude coordinates for these locations are shown in Appendix A. Measurements of dissolved oxygen, temperature, conductivity, pH, and ORP shall be collected at 1 m intervals, including the surface and near the water/sediment interface using a multiparameter sonde.

In an effort to minimize probe contamination at the water/sediment interface, a depth sounding line is used to determine maximum depth. The bottom profile measurement is collected approximately 10 cm from the benthos.

7.5.1.3 Continuous Temperature Monitoring

Continuous temperature monitoring to document the water column profiles shall be performed at three locations in the Reservoir (CCR-1, CCR-2, and CCR-3). At each site, Onset HOBO® Water Temp Pro data loggers shall be deployed at 1 m increments, from the 1 m layer to near the sediment/water interface and configured to collect 15-minute interval temperature data.

The temperature arrays shall be deployed using the State Park's buoy system, beginning in March/April and operated through October/November, with periodic downloading of data to minimize potential loss of data. This deployment schedule will overlap with the proposed operational schedule of the destratification system.

7.5.1.4 Water Samples

A primary task of the monitoring program is to characterize the chemical and biological constituents of the upper 3 m layers of the reservoir. This layer represents the most active layer for algae production (photic zone), and represents approximately 54 percent of the total lake volume given the typical lake level of 5550 ft. At each reservoir site, water from the surface, and 1 m, 2 m, and 3 m depths is sampled individually using a 2-liter vertical Van Dorn water sampler and combined into a clean 5-gallon container to create a composite photic zone sample (Table 3). The vertical Van Dorn sampler is lowered to the appropriate depth, such that the middle of the sampler is centered on the selected depth. The “messenger” is sent to activate the sampler and the water is retrieved. Four one-liter aliquots are collected from the composite photic zone sample and stored on ice, until transferred to the laboratory for chemical and biological analyses (Table 2). Nutrient analyses shall be performed on all reservoir water samples. Chlorophyll *a* analyses shall be performed on all photic zone composite samples. Phytoplankton analyses shall be performed on all photic zone composite samples. See Table 4 on page 24 for the list of analytes, laboratory methods, and detection limits.

At Site CCR-2, profile water samples are also collected on 1 m increments, starting from 4 m and continuing down to the 7 m depth. The 7 m sample is collected as close to the water/sediment interface as possible, without disturbing the sediment. At times, if the reservoir is unusually full, it may be necessary to collect an additional profile water sample, such as occurred after the September 2013 precipitation events. The sampler and 5-gallon container are rinsed thoroughly with lake water between sites. Based on this sampling scheme, the number of samples collected at each site is shown in Table 3 below:

Table 3. Number of Reservoir Samples Collected.

Reservoir Site	Upper 3 m Composite (Photic zone)	1 m Depth Profiles	Number of Samples
CCR-1	1	0	1
CCR-2	1	4	5
CCR-3	1	0	1
Total Samples/Sample Event	**3**	**4**	**7**

7.5.1.5 Zooplankton Samples

Zooplankton samples shall be collected at each reservoir site (CCR-1, CCR-2, and CCR-3) and composited to create one sample per sampling event. The zooplankton sample should always be collected following the collection of water samples, so as not to compromise the integrity of the water samples. Collection of a vertical water column zooplankton sample is performed using an eight inch mouth, 80 µm mesh Turtox Student Net. The zooplankton net is rinsed with reservoir water and lowered to the 6 m depth at sites CCR-1 and CCR-2 and 4 m at Site CCR-3. At each site, the net is slowly retrieved and the concentrated sample is drained into the sample container with all organic matter being rinsed from the net and into the sample container. Each site tow is composited into the same sample container and preserved with 70% alcohol. The diameter of the tow net and combined length of each tow is recorded to provide an estimate of the water volume sampled. The zooplankton are identified, enumerated, and estimates of biomass are performed.

7.5.2 Stream Sampling

7.5.2.1 Monthly Base Flow Sampling

One sample shall be collected from each stream site on a monthly basis, when there is sufficient flow (CT-1, CT-2, CT-P1, CT-P2, CC-10, EcoPark, Piney Creek, MCM-1, and MCM-2). Samples shall be collected as mid-stream mid-depth grab samples using a 5-gallon container. Two one-liter aliquots are collected from this grab sample and stored on ice, until transferred to the laboratory for chemical analyses.

7.5.2.2 Storm Event Sampling

Samples from storm flow events are collected using ISCO automatic samplers, which are programmed to collect samples when the flow reaches a threshold level. The threshold level is determined by analyzing annual hydrographs from each stream and determining storm levels. When the threshold is reached, the ISCO collects a sample every 15 minutes for approximately 2.5 hours (i.e., a timed composite) or until the water recedes below the threshold level. This sampling procedure occurs at CT-1, CT-2, CT-P1, CT-P2, CC-10, EcoPark, and Piney Creek. Following the storm event, water collected by the automatic samplers is combined (timed composite) into a clean 5-gallon container, with two 1 liter (L) aliquots collected from the composited sample and stored on ice until transferred to the laboratory for analysis. Approximately 4 L would be collected from the 24 bottles, with each bottle contributing a sample amount representative of the flow at which it was collected. Up to seven storm samples shall be collected from each of the monitoring sites during the April to October storm season.

7.5.2.3 Continuous Water Level Monitoring

At sites containing an ISCO automated sampler, continuous water level is also monitored using an ISCO flow module and pressure transducer. Rating curves are developed for each sampling site by measuring stream discharge (ft^3/sec) with a Marsh McBirney Model # 2000 flowmeter, and recording the water level at the staff gage (ft) and ISCO flowmeter (ft). Discharge is measured using methods outlined in Harrelson et al. 1994. To determine flow rate, the level must be translated into flow rate using a stage-discharge relationship. Since stage-discharge relationships can change over the years, the relationship is calibrated annually using a flow meter to record stream flow measurements three to four times per year at a range of flows. These data are combined with historical data, as long as stream geomorphology conditions are similar, to validate and modify the stage-discharge relationship for that site. If the staff gage is reset, moved to a new location, or geomorphology conditions have changed, then a new stage-discharge relationship is created for that site.

Water level data are collected on 15-minute intervals and stored in the ISCO sampler. These data are downloaded on a monthly basis to minimize the risk of data loss due to power failure or ISCO failure. The flow data and stage-discharge rating curves shall be checked throughout the year by comparing calculated flow estimates to actual flow measurements recorded in the field with a flowmeter.

The USACE also reports daily inflow to Cherry Creek Reservoir as a function of storage, based on changes in reservoir level. This daily inflow value incorporates information regarding measured outflow, precipitation, and evaporation. The Authority monitors inflow to the Reservoir using gaging stations on Cherry Creek and Cottonwood Creek to provide a daily surface inflow record. Given the differences in the two methods for determining inflow, combined with the potential of unmonitored alluvial and surface flows that may result in greater seepage through the adjacent wetlands during storm events, and other unmonitored surface inflows (i.e., Belleview and Quincy drainages), an exact match between USACE and calculated inflows is not expected. Therefore, the Authority normalizes their streamflow data to match the USACE computed inflow value.

7.5.3 Watershed Surface Water Sampling

The Cherry Creek mainstem monitoring was initiated in 1994. The monitoring includes semiannual sampling at seven surface water sites along Cherry Creek (Castlewood, CC-1, CC-2, CC-4, CC-5, CC-6, CC-8, and CC-9). Other sites are included on the Cherry Creek mainstem (e.g. CC-7 (EcoPark), CC-10, and CC-0) which are monitoring on a more frequent basis as part of the Reservoir and PRF efforts. The following constituents are monitored on a semi-annual basis at the seven Cherry Creek mainstem sites:

- Nitrite + Nitrate
- Nitrite
- Nitrate
- Ammonia
- Total dissolved phosphorus
- Total phosphorus
- Soluble reactive phosphorus (AKA Orthophosphate)
- Chloride
- Sulfate

Historically, the sampling frequency was on a monthly basis, but was reduced to semiannual monitoring (May and November) in 2003.

7.5.4 Alluvial Groundwater Sampling

Cherry Creek alluvial groundwater sites are generally paired with mainstem surface water sites to provide corresponding data. Groundwater sampling was initiated in 1994, and includes semiannual sampling at eight alluvial sites along Cherry Creek

(MW-1, MW-2, MW-3c, MW-5, MW-6, MW-7a, MW-9, and Kennedy) for the following constituents:

- Nitrite + Nitrate
- Nitrite
- Nitrate
- Ammonia
- Total dissolved phosphorus
- Soluble reactive phosphorus (AKA Orthophosphate)
- Chloride
- Sulfate

The sampling frequency was reduced from monthly monitoring to semiannual monitoring (May and November) in 2003.

7.5.5 Precipitation Sampling

After each monitored storm, the sample bottle shall be removed, stored on ice, and transferred to the laboratory for analysis of phosphorus and nitrogen fractions. The sampler shall be inspected and cleaned of any accumulations of unimportant precipitation on a weekly basis. This will minimize extraneous "dry fall" from being washed into the sampler between monitored storm events. A precipitation event of greater than 0.25 inches at the Centennial Airport KAPA weather station is generally a sufficient storm event that activates ISCO samplers and storm event monitoring.

8.0 Laboratory Procedures

The sampling and analyses shall be conducted in accordance with the methods and detection limits provided in the table below.

The turnaround time is variable and generally ranges from 30 days for most routine chemical analyses up to 120 days for biological (i.e., phytoplankton and zooplankton) analyses, but the turnaround time will depend on the analyses to be performed, the number of samples, and the laboratory backlog. Rapid turnaround time is generally available for an additional fee by most laboratories. In the case of cyanotoxin analyses, the turnaround time is generally 2-3 days, but rapid turnaround times (i.e., 12 hours) are generally available for an additional fee by most laboratories.

Table 4. List of Analytes, Abbreviations, Analytical Methods, Recommended Hold Times, and Detection Limits for Chemical Laboratory Analyses.

Parameter	Abbreviation	Analytical Method	Recommended Hold Times	Detection Limit
Physicochemical				
Total Nitrogen	TN	10-107-04-4-B*	< 24 hrs before digestion; < 7 days after digestion	2 µg/L
Total Dissolved Nitrogen	TDN	10-107-04-4-B	48 hrs	2 µg/L
Nitrate/Nitrite Nitrogen	NO_3+NO_2	10-107-04-1-C	48 hrs	2 µg/L
Ammonium Ion Nitrogen	NH_4	10-107-06-2-A	24 hrs	3 µg/L
Total Phosphorus	TP	10-115-01-4-B*	< 24 hrs before digestion	2 µg/L
Total Dissolved Phosphorus	TDP	10-115-01-4-B	48 hrs	2 µg/L
Soluble Reactive Phosphorus	SRP	10-115-01-1-T	48 hrs	2 µg/L
Total Suspended Solids	TSS	SM 2540D	7 days	4 mg/L
Total Volatile Suspended Solids	TVSS	SM 2540 E	7 days	4 mg/L
Total Organic Carbon	TOC	SM 5310 B	28 days	0.16 mg/L
Dissolved Organic Carbon	DOC	SM 5310 B	28 days	
Chloride	Cl	EPA 300.0/SW846 9056	28 days	0.1 mg/L
Sulfate	SO_4	EPA 300.0/SW846 9056	28 days	0.1 mg/L
Biological				
Chlorophyll *a*	Chl	SM 10200 H (modified)**	< 24 hrs before filtration	0.1 µg/L
Phytoplankton	--	SM 10200 B.2.a SM 10200 C.2 SM 10200 .D.2 SM 10200 E.4 SM 10200 F.2.c	NA	NA
Zooplankton	--	SM 10200 B.2.B SM 10200 C.4 SM 10200 D.4 SM 10200 E.4 SM 10200 .G	NA	NA

* TP and TN can be measured from same digest.
** "modified" means the ethanol is heated to reduce the time necessary for extraction

Method References:

American Public Health Association, American Water Works Association, and Water Environment Federation. (2005). *Standard Methods for Examination of Water and Wastewater.* (21st Edition). Washington DC 1985.

Lachat Instruments. Methods List - Methods List for Automated Ion Analyzers Flow Injection Analyses-Ion Chromatography. (September 2013). http://www.lachatinstruments.com/download/LL022-Rev-7.pdf

Pfaff, John D. August 1993. Method 300.0 - Determination of Inorganic Anions by Ion Chromatography, Inorganic Chemistry Branch, Chemistry Research Division, Revision 2.1. Environmental Monitoring Systems Laboratory, Office Of Research and Development, U.S. Environmental Protection Agency. Cincinnati, Ohio 45268 http://water.epa.gov/scitech/methods/cwa/bioindicators/upload/2007_07_10_methods_method_300_0.pdf

http://www.epa.gov/wstew/hazard/testmethods/sw846/online/index.htm

8.1 Biological Laboratory Analysis

Biological analyses for the samples collected in the study, include chlorophyll a, phytoplankton (identification, enumeration, and biovolume), and zooplankton (identification, enumeration, and biomass). The methods of these analyses, with appropriate QA/QC procedures shall be in accordance with the methods provided in Table 1.

8.2 Laboratory Quality Assurance/Quality Control Protocols

Analytical laboratory equipment calibrations are performed every time new standards are prepared (minimum of once per week). Instrument values are compared to known standard concentration and if the correlation coefficient of the standard curve is less than 0.999, the instrument is recalibrated or standards are remade, with the process being completed until the instrument passes the test. Pseudo-replicate analyses are performed on each sample analyzed (i.e., sample analyzed twice) and the percent difference must be within 10 percent, if the resultant concentration is above the minimum detection limit. If the difference of the pseudo-replicate analyses are >10 percent, a new analytical sample is placed in a clean test tube and analyzed. During a sample analysis run, check standards are analyzed between every 5 samples (or 10 replicates). The check standards consist of one high range standard, one mid-range standard, and the control blank (zero). Check standards analyzed before and after each group of samples must be within 10 percent of the theoretical value. If standards are outside of this range, new analytical samples and standards are placed in clean test tubes and analyzed to try to determine the source of the error. Sample values are not accepted until the problem has been resolved and all check standards pass the QC criteria. One matrix spike is run for every 10 samples analyzed (or 20 replicates). The percent recovery for matrix spikes must be ± 20 percent.

Following sample analyses, a final QC check is performed to determine if all parameters measured are in agreement. Final analyses for each sample are compared to ensure that concentrations of total phosphorus ≥ total dissolved phosphorus ≥ orthophosphate and that the concentration of total nitrogen ≥ total dissolved nitrogen ≥ nitrate/nitrite an ammonia. If parameters are not in agreement samples are reanalyzed.

9.0 Program Quality Assurance/Quality Control Protocols

Field Sampling

All field team members will be responsible for visually inspecting and monitoring for contamination and should a bottle be contaminated it will be replaced with a clean one. To provide Quality Control/Quality Assurance (QC/QA) information on the field samples, both field blanks and field duplicates shall be collected and will comprise approximately 10 percent of the total number of samples analyzed for the project. The field blank and duplicate samples will be labeled and stored with the field collected samples and analyzed using the same laboratory methods. The QC/QA samples will provide information on sampling and analytical error.

Laboratory

The analytical and biological laboratories will follow their in-house Quality Assurance Plans (QAP), which will be consistent with specific state requirements. These documents will be available to the Authority upon request.

10.0 Data Validation and Usability

All field data and chain-of-custody (COC) forms will be reviewed the Field Team Leader for correctness. The QA Manager will be responsible for data validation, and will review the field book, laboratory's results and reports for accuracy and will report any issues to the Project Manager. Laboratory data will be reviewed to ensure that appropriate methods were used and that data are qualified with method detection limits. Any problems that arise will be brought to the attention of the Project Manager and it is this person's responsibility to accept or reject the data.

11.0 Data Verification, Reduction, and Reporting

Data verification shall be conducted to ensure that raw data are not altered. All field data, such as those generated during any field measurements and observations, will be entered directly into a bound Field Book. Sampling Crew members will be responsible for proof reading all data transfers, if necessary. All data transfers will be checked for accuracy.

The Quality Assurance Project Manager will conduct data verification activities to assess laboratory performance in meeting quality assurance requirements. Such reviews include verification that: 1) the correct samples were analyzed and reported in the correct units; 2) the samples were properly preserved and not held beyond applicable holding times; 3) instruments are regularly calibrated and meeting performance criteria; and 4) laboratory QA objectives for precision and accuracy are being met.

Data reduction for laboratory analyses is conducted by Consultant's personnel in accordance with EPA procedures, as available, for each method. Analytical results and appropriate field measurements are input into a computer spreadsheet. No results will be changed in the spreadsheet unless the cause of the error is identified and documented.

A data control program will be followed to insure that all documents generated during the project are accounted for upon their completion. Accountable documents include: Field Books, Sample Chain of Custody, Sample Log, analytical reports, quality assurance reports, and interpretive reports.

Data shall be summarized and provided to the Authority's Technical Advisory Committee on a monthly basis and presented in the Annual Report.

12.0 References

AMEC Earth & Environmental, Inc., Alex Horne Associates, Hydrosphere Resource Consultants, Inc. (December 5, 2005). *Feasibility Report Cherry Creek Reservoir Destratification.*

American Public Health Association. (20th Edition American Public Health Association). *Standard Methods for Examination of Water and Wastewater.* Washington DC: 1985.

Cheryl C. Harrelson, C. P. (1994). *Stream channel reference sites: an illustrated guide to field technique.* Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station 61 p.: Gen Tech. Rep. RM-245.

Denver Regional Council of Governments. (1985). *Cherry Creek Basin Water Quality Management Master Plan.* Prepared in Cooperation with Counties, Municipalities, and Water and Sanitation Districts in the Cherry Creek Basin and Colorado Department of Health.

Goldman, C. a. (1983). *Limnology.* NY: McGraw-Hill Company.

Knowlton, M. a. (1993). *Limnological Investigations of Cherry Creek Lake.* Final report to Cherry Creek Basin Water Quality Authority.

U.S. Environmental Protection Agency (EPA). (August 1999). *Site-Specific Sampling and Analysis Plan Template.*

U.S. Environmental Protection Agency. (December 2000). *Peer Review Handbook, 2nd Edition.* Washington, DC 20460: Science Policy Council.

APPENDIX A – Sampling Site Locations

Waterbody	ID	Latitude	Longitude
Cherry Creek Reservoir	CCR-1	39°38'34.68"N	104°51'41.88"W
Cherry Creek Reservoir	CCR-2	39°38'49.09"N	104°51'08.15"W
Cherry Creek Reservoir	CCR-3	39°38'17.46"N	104°51'09.69"W
Cherry Creek Reservoir	D-1	39°38'47.04"N	104°51'34.27"W
Cherry Creek Reservoir	D-2	39°38'43.13"N	104°51'31.93"W
Cherry Creek Reservoir	D-3	39°38'39.66"N	104°51'29.20"W
Cherry Creek Reservoir	D-3.5	39°38'36.42"N	104°51'26.95"W
Cherry Creek Reservoir	D-4	39°38'33.91"N	104°51'24.64"W
Cherry Creek Reservoir	D-5	39°38'30.57"N	104°51'22.50"W
Cherry Creek Reservoir	D-6	39°38'27.78"N	104°51'20.76"W
Cherry Creek Reservoir	D-7	39°38'25.01"N	104°51'18.02"W
Cherry Creek Reservoir	D-8	39°38'22.46"N	104°51'15.87"W
Cherry Creek Reservoir	D-9	39°38'19.75"N	104°51'13.29"W
Cherry Creek Reservoir	D-10	39°38'17.52"N	104°51'10.12"W
Cherry Creek	Castlewood	39°21'28.58"N	104°45'49.69"W
Cherry Creek	CC-1	39°25'57.80"N	104°46'05.10"W
Cherry Creek	CC-2	39°28'6.90"N	104°46'04.20"W
Cherry Creek	CC-4	39°31'33.10"N	104°46'50.50"W
Cherry Creek	CC-5	39°32'38.70"N	104°46'46.00"W
Cherry Creek	CC-6	39°33'59.40"N	104°47'25.70"W
Cherry Creek	CC-7	39°35'12.06"N	104°48'18.63"W
Cherry Creek	CC-8	39°36'10.40"N	104°48'55.10"W
Cherry Creek	CC-9	39°37'28.10"N	104°50'03.60"W
Cherry Creek	CC-10	39°38'00.46"N	104°50'17.22"W
Cherry Creek	CC-O	39°39'10.60"N	104°51'22.52"W
Cottonwood Creek	CT-P1	39°36'07.96"N	104°51'20.03"W
Cottonwood Creek	CT-P2	39°36'19.23"N	104°50'55.01"W
Cottonwood Creek	CT-1	39°37'27.73"N	104°50'54.95"W
Cottonwood Creek	CT-2	39°37'40.27"N	104°51'00.94"W
Piney Creek	PC-1	39°36'23.21"N	104°48'52.02"W
McMurdo Gulch	MCM-1	39°23'19.54"N	104°48'53.63"W
McMurdo Gulch	MCM-2	39°24'16.60"N	104°48'46.01"W
Precipitation	PRECIP	39°38'12.40"N	104°50'8.47"W
Groundwater	MW-1	39°26'07.50"N	104°45'59.80"W
Groundwater	MW-2	39°28'03.50"N	104°46'4.90"W
Groundwater	MW-3c	39°30'34.57"N	104°46'05.07"W
Groundwater	MW-5	39°32'39.10"N	104°46'46.88"W
Groundwater	MW-6	39°33'57.70"N	104°47'30.90"W
Groundwater	MW-7a	39°35'07.55"N	104°48'17.63"W
Groundwater	MW-9	39°37'25.00"N	104°50'11.20"W
Groundwater	Kennedy	39°39'15.80"N	104°52'0.20"W

APPENDIX B –Abandoned Sampling Sites

<u>Historical Surface Water Sites (Abandoned)</u>

CC-3	This site was located 1 mile south of West Parker Road. It is no longer used as a water quality sampling location.
CC-7	This was the original CC-7 site, located ¾ mile south of Arapahoe Road. It was abandoned in 2000 due to development.
CC-10A	This site was established in 1999 on an intermittent channel of Cherry Creek. CC-10A is active during spring runoff and some precipitation events. Flow measurements at this site were used to provide additional data on total inflows into the Reservoir. This site has not been monitored since 2001.
SC-1	This site was established in 1987, immediately east of Parker Road on Shop Creek. Originally, SC-1 monitored phosphorous levels prior to the confluence with Cherry Creek. From 1990 through 2001, this site monitored water quality upstream of the Shop Creek detention pond/wetland PRF. This site has not been monitored since 2001.
SC-2	This site was established in 1990, and was located west of Parker Road at the outlet from the Shop Creek detention pond. This site monitored the water quality as it left the detention pond. This site has not been monitored since 2001.
SC-3	This site is located 35 m upstream of its confluence with Cherry Creek, and was used to monitor the water quality of Shop Creek before it joins Cherry Creek. Sampling ceased at this site in 2013 because flow and total phosphorus loads were less than one percent of the total annual flow-weighted load entering the reservoir.
QD-1	This site was established in 1996 on Quincy Drainage, above of the Perimeter Road wetlands, which were constructed in 1990 just downstream of the outlet for the Quincy Road/Parker Road stormwater drain. This site monitored water quality of the Quincy Drainage upstream of the wetlands and a new PRF, consisting of a water quality/berm system, established in late 1995, downstream of the Perimeter Road. This site has not been monitored since 2001.
BD-1	This site was established in mid-1996 at the suggestion of State Parks personnel, and is used to monitor the inflow to an old stock pond on this drainage near Belleview Avenue. This site has not been monitored since 2001.
BD-2	This site was established in mid-1996 at the suggestion of State Parks personnel, and is used to monitor this drainage as it crosses the Perimeter Road before entering the Reservoir. This site monitors the nutrient removal abilities of the

historic stock pond and natural wetland system. This sites has not been monitored since 2001.

Historical Groundwater Sites (Abandoned)

MW-4b — This site was located downstream of Sulphur Gulch, and was abandoned in 2002 due to development.

MW-7 — This site was located south of Arapahoe Road near EcoPark, and it was abandoned in 2000 due to development.

MW-8 — This site was the Arapahoe Deem production well, located north of Arapahoe Road. It was abandoned as a sampling site in 2000 due to development.