

An Overview of Lake Monitoring and Management in Colorado

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Introduction to Colorado Lakes

Lakes and reservoirs are important economic and aesthetic resources in Colorado. The state is home to more than 2,000 lakes and reservoirs. Approximately 75 percent are publicly owned and many of these provide recreational opportunities such as fishing and swimming and other public benefits such as drinking water supplies.

Colorado's topography varies greatly; lakes and reservoirs are found at elevations from 3,560 to greater than 12,000 feet above sea level. Lakes and reservoirs have many different characteristics, most notably natural vs. man-made origins. Natural lakes tend to be smaller and most are found at elevations above 9,000 feet (Nelson 1970). In Colorado, there are only 11 natural lakes larger than 50 surface acres. Reservoirs tend to be larger and are found at all elevations. Reservoirs have been constructed for water management since the 1880s, initially for irrigation storage and then for municipal uses (Knopf and Scott 1990). Many natural lakes have been modified to increase storage capacity and thus are managed more like reservoirs. Most waterbodies greater than 50 acres are reservoirs. Grand Lake, Shadow Mountain Reservoir, and Lake Granby, a lake and two reservoirs that are part of the Colorado Big Thompson Project are some examples of larger highly managed reservoirs (Figure 1). Many lakes and reservoirs are located in Colorado's 42 state parks. Approximately 150 lakes are located in Rocky Mountain National Park. Sprague Lake and Bear Lake are an example of the popular lakes in the national park (Figures 2 and 3). For the remainder of this article, "lake" will refer to both lakes and reservoirs.



Figure 1. Grand Lake Area, Colorado. Photo: used under license from Shutterstock, ©H. Sadura.

Colorado's Regulatory Framework

The Colorado Department of Public Health and Environment – Water Quality Control Division (Division) is responsible for maintaining, restoring, and improving the quality of state waters. The agency implements and enforces regulations adopted by the Water Quality Control Commission (Commission) and assesses water quality of the state's surface waters. The Division provides technical expertise to the Commission for rulemaking and policy-setting activities. The Division administers state programs to implement the Federal Clean Water Act. The Clean Water Act protects the quality of Colorado's ambient water bodies – rivers, streams, lakes, reservoirs, and ground waters.

The Commission is the administrative agency responsible for assigning use classifications and adopting water quality standards that protect beneficial uses of

state waters. In addition, the Commission also adopts various regulations aimed at achieving compliance with the classifications and standards. Use classifications assigned to lakes and reservoirs include water supply, recreation, aquatic life, and agriculture. Lakes must be managed to protect all uses assigned. The Commission regulations and policies can be found at: www.colorado.gov/cdphe/water-quality-control-commission-regulations.

The Division performs duties to protect Colorado surface waters. The environmental data unit provides surface water quality status and reporting services. The standards unit provides information, scientific analysis, and policy recommendations to the commission. The restoration and protection unit provides financial and technical support, collaboration, and planning services to support implementation strategies that



Figure 2. Otis, Hallett and Flattop Mountains seen from Sprague Lake in Rocky Mountain National Park, Colorado. Photo: used under license from Shutterstock, ©Kamenskiy.



Figure 3. Sunset at Bear Lake in Rocky Mountain National Park, Colorado. Photo: used under license from Shutterstock, ©cvm.

protect, improve and restore water quality. The Division's website can be found at: www.colorado.gov/cdphe/categories/services-and-information/environment/water-quality.

Colorado surface water quality classifications and standards regulations are basin-specific. That is, each set of

regulations addresses waterbodies in specific river basins (i.e., Arkansas River basin, Rio Grande River basin, etc.). These waterbodies include lakes, reservoirs, streams, and rivers.

In addition to surface water regulations, from 1984-1992 Colorado also adopted watershed protection control regulations for four reservoirs – Dillon

Reservoir (1984), Cherry Creek Reservoir (1985), Chatfield Reservoir (1989), and Bear Creek Reservoir (1992). Three of these reservoirs, Cherry Creek Reservoir, Chatfield Reservoir, and Bear Creek Reservoir are located in the Denver metro area. Dillon Reservoir (Figure 4) is located in the mountains of Summit County, Colorado. The control regulations for these reservoirs are essentially water quality implementation plans targeted at controlling eutrophication of the reservoir. Eutrophication results when excess nutrients enter a lake and stimulate a drastic increase in algae (algal bloom) that can lead to oxygen depletion when the algae die and decay, which can lead to fish kills and other problems. The strategy in the control regulations is to curtail algal growth by controlling nutrient loading to the reservoir. The control regulations grew out of USEPA Clean Lakes Program studies conducted during the 1980s. The Clean Lakes Program supported efforts by states to restore publicly-owned lakes. These reservoirs were considered to be at risk of eutrophication due to urban development and population growth.

Each control regulation is implemented by an active stakeholder association. Members of each association include cities, counties, and permitted point sources dischargers including wastewater treatment plant dischargers, and regulated stormwater dischargers. The Cherry Creek Basin Water Quality Authority implements the Cherry Creek Reservoir Control Regulation. The Chatfield Basin Authority implements the Chatfield Reservoir Control Regulation. The Bear Creek Watershed Association implements the Bear Creek Watershed Control Regulation and the Summit Water Quality Committee implements the Dillon Reservoir Control Regulation. Members of each association include cities, counties, and permitted point sources dischargers such as wastewater treatment plant dischargers and regulated stormwater dischargers.

These control regulations have been revised over the years. Initially, three of the four control regulations were based on numeric standards for total phosphorus. The Bear Creek Control Regulation was based on a narrative standard. Subsequently, the Water Quality Control Commission has adopted a numeric



Figure 4. Dillon Reservoir in autumn. Photo: used under license from Shutterstock, ©SNEHIT.

total phosphorus standard on Bear Creek Reservoir. The Commission also adopted numeric chlorophyll-*a* standards for all of these reservoirs.

In addition to the watershed control regulations lakes, several other lakes have active watershed groups working to protect water quality. For Barr Lake and Milton Reservoir, the Barr Milton Watershed Association implements TMDLs. A diverse stakeholders group worked to develop the Clear Creek/Standley Lake Watershed Agreement in 1993 that focuses on watershed water quality as it affects Standley Lake. Grand Lake, Shadow Mountain Reservoir and Lake Granby have many watershed stakeholders. Colorado is fortunate to have numerous water quality partners to address water quality in lakes and rivers.

Colorado's Lake Monitoring and Assessment Program

The division maintains a lake monitoring program to support water quality assessment. The division spends approximately \$35,000 on the program annually. This represents 6.3 percent of the total surface water monitoring budget. Most of the surface water monitoring program money is spent on water quality analysis. Remaining money is spent on equipment maintenance. Information on the lake monitoring

program can be found at: www.colorado.gov/cdphe/lakes-monitoring.

The lake monitoring program produces data used for several purposes. The division determines if lakes are meeting their designated uses and standards by comparing water quality measurements against applicable water quality standards. If standards and uses are not met, a lake is identified as

impaired on the state's 303(d) List of Impaired Waters. Seventy-seven lakes are on Colorado's 303(d) list (Figure 5).

For impaired lakes, already identified on the 303(d) list, monitoring data are used to validate the listing or to support de-listing. The state is required to develop Total Maximum Daily Loads (TMDLs) for waterbodies on the 303(d) list and monitoring data support the development of TMDLs. The lake monitoring program also provides data to evaluate the trophic status of Colorado lakes. Finally, monitoring data are used to develop new water quality standards (e.g., nutrient criteria), or help anticipate needs for new standards (e.g., emerging contaminants).

The lake monitoring program operates on a five-year rotation with sampling focused in the river basins of one quadrant of the state for a given year. No distinction is made between lakes and reservoirs in the design of the sampling program. Lakes are prioritized for the following reasons: (1) if the lake provides insight into water quality trends in the basins, (2) if the lake is on the monitoring and evaluation list, and (3) if the division has little or no data from a lake. The division then selects approximately ten lakes from the basins of focus to sample three times each during the growing season of July to September. Additionally, in late August, the division conducts one sampling event on 10-15 lakes from the

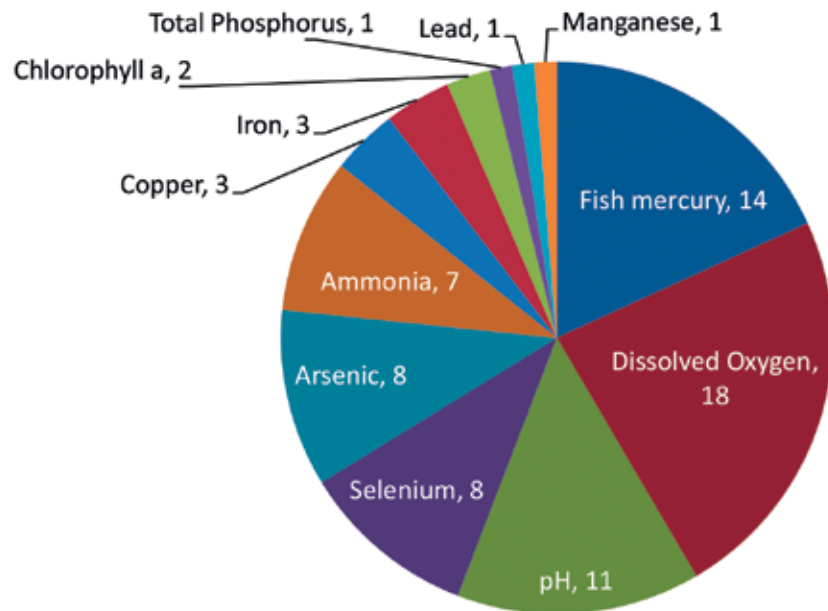


Figure 5. Number of lakes listed as impaired by parameter (Colorado 303[d] List of Impaired Waters).

basins in the next quadrant to help with site selection the following year. The fifth year is used to collect supplementary data from lakes across the state where water quality issues are suspected and provide time to focus on special projects.

The monitoring program collects several kinds of data from each lake. Vertical profiles of temperature, dissolved oxygen, pH, and specific conductance are measured at one-meter intervals. Water quality samples are collected from near the surface and near the bottom. These samples are analyzed for a suite of chemical parameters including nutrients, metals, and inorganics. The surface sample is also analyzed for chlorophyll-*a* content and phytoplankton composition. The Division collaborates with EPA to conduct limited cyanotoxin testing.

The division also assesses water quality data collected through partner monitoring programs. These partners represent water providers, municipalities, watershed-based water quality authorities, associations, forums, and other state and federal agencies. There are various other entities that conduct routine monitoring of publicly owned reservoirs including the U.S. Geological Survey, the U.S. Army Corps of Engineers, Denver Water, and others such as cities, regional councils of governments and river basin associations. Many are members of Colorado Lake and Reservoir Management Association (CLRMA) and the North American Lake Management Society (NALMS).

As reported in Colorado's 2016 Integrated Water Quality Monitoring and Assessment Report, Colorado has assessed 59 percent of its lake acres for at least one use. Over the past 20 years, Colorado has monitored 98 lakes.

Colorado Funding Assistance Program

There is no targeted funding program for lakes in Colorado. However, Colorado has a Nonpoint Source (NPS) Program that provides funding, primarily from Federal Section 319 grants, for watershed planning, targeted TMDL development, best management practices (BMPs) implementation, and specific monitoring activities, all of which help to evaluate and control nonpoint sources of pollution. For many years, these funds have played an important role in addressing nonpoint source impacts to lakes throughout the

state. For example, nonpoint source funds were used to develop watershed plans for Chatfield Reservoir, Barr Lake, and Milton Reservoir. These plans prioritized nonpoint source actions necessary to help protect and restore lake water quality. Nonpoint source funds also supported development of a TMDL for Barr Lake, and Milton Reservoir and the funds were used for mercury monitoring on Horsetooth and Elkhead Reservoirs in support of statewide mercury TMDL development. TMDLs are foundational for understanding the pollutant reductions necessary to ensure lakes meet water quality standards. NPS funds have also been used for BMP implementation to address nonpoint source pollution impacts to lakes from impaired waterbodies in watersheds throughout the state. These funds also support monitoring in National Water Quality Initiative watersheds that are impacted by nutrients. In particular, NPS Program funds have helped increase understanding about the effectiveness of agricultural conservation practices in reducing nonpoint sources of nutrients impacting DeWeese Reservoir.

Colorado division staff and lake management partners will be happy to discuss Colorado lakes at the 2017 North American Lake Management Society Symposium in Denver, Colorado.

References

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LAKE and RESERVOIR MANAGEMENT

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