Clearwater Valley
Watershed Restoration Plan

December 2023

CRC

Clearwater Resource Council

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List of Acronyms

AHOD	Areal Hypolimnetic Oxygen Deficit
AIS	Aquatic Invasive Species
BMP	Best Management Practice
CRC	Clearwater Resource Council
DEQ	Department of Environmental Quality
DNRC	Department of Natural Resources and Conservation
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FWP	Fish Wildlife and Parks
HUC	Hydrologic Unit Code
MSDI	Montana Spatial Data Infrastructure
SCD	Sufficient Credible Data
SWCC	Southwest Crown of the Continent

TD	Trapping district
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
USFS	United States Forest Service
WRP	Watershed Restoration Plan

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1.0 Introduction

1.1 Background and goals

The Clearwater Valley sits on the southern edge of what is known as the Crown of the Continent Ecoregion. As such, it contains some of the most pristine conditions remaining in the lower 48. The Valley supports populations of grizzly bear, wolverine, wolves, mountain lions, Canada lynx, elk, moose, bull trout, westslope cutthroat trout, and numerous other species, many of which have not fared well in other areas. It contains a chain of lakes connected by the Clearwater River or tributary streams to the River. It also contains the community of Seeley Lake, an unincorporated town of around 2000 people.

In 2009, the Blackfoot Challenge produced and adopted the Blackfoot Subbasin Plan. This watershed plan included the Clearwater sub-watershed as part of the overall planning area. However, much of that plan featured actions and concerns specific to the Blackfoot River corridor, with a focus on TMDLs, and impacts associated with agriculture and irrigation, none of which particularly addressed the greatest issues of concern in the Clearwater Valley. For example, the Subbasin Plan did not address water quality concerns or other threats to the lakes in the Clearwater Valley. The Clearwater Valley is now facing various risks to its water quality, both to its lakes and streams. Particular concerns related to contamination from non-agricultural nutrient loading and sedimentation as well as other factors warrant development of a Watershed Restoration Plan for the Clearwater Valley.

This Clearwater Basin Watershed Restoration Plan (Plan) has several purposes. First, the Plan has compiled available information on the status of the lakes and streams within the Clearwater Valley. Second, the Plan has identified the current and anticipated threats to the lakes, streams and aquatic resources, and the status of these threats. Third, the Plan has identified where information on lakes, streams, and aquatic resources is lacking, and proposes future monitoring to fill these information gaps. Finally, the Plan identifies known issues, and proposes short and long-term actions that can be taken to address these issues.

Relevant information presented in the Blackfoot Subbasin plan provided some baseline information as a starting point for this Plan. This information was augmented with considerable data collected in the Clearwater watershed, including new data collected since 2009. These combined data were used to develop site-specific improvements that can be undertaken to improve the quality and resiliency of our waters that impact the Valley's waters. The Plan is not meant to be static in nature. It will be consistently reviewed to reflect goals, objectives and actions that have been met, and will incorporate new issues as they arise.

2.0 Watershed Characteristics

2.1 Geography and Topography

The Clearwater Valley encompasses biologically rich and diverse lands in portions of Missoula and Powell counties in Western Montana. Seeley Lake is located in a north-northwest trending intermontane basin located west of the Continental Divide in northwestern Montana. The Valley is bounded by the Mission Mountains to the west and the Swan Range on the east. Topography and elevation of the region range widely from the lakes and streams in the Valley to the peaks of the surrounding mountain ranges. The glaciated topography in the vicinity and south of the town exhibits relatively varied relief typical of kettles and kame potholes and terraces, drumlins, extensive glacial fluvial outwash materials, and recessional and terminal moraines.

Elevation ranges from 3,789 ft at the confluence of the Clearwater River into the Blackfoot River at the southern end of the Valley and reaches a maximum of 9,083 ft on Ptarmigan Point in the Swan Range (CRC 2008).

The Clearwater Valley is located within the Blackfoot Subbasin, which is identified by the US Geological Survey (USGS) 8-digit Hydrologic Unit Code (HUC) 17010205. The Blackfoot Subbasin is located at the southern edge of the Crown of the Continent Ecoregion within the Columbia River Basin, which encompasses over 10 million acres of some of the most unspoiled lands on the entire North American continent (Figure 1).

The Clearwater Valley is comprised of 14 individual subwatersheds: the Upper Clearwater River, Lower Clearwater River, West Fork Clearwater River, Morrell Creek, Trail Creek, Seeley Lake, Deer Creek, Upper Placid Creek, Lower Placid Creek, Placid Lake, Boles Creek, Blanchard Creek, Blackfoot River-Lost Prairie Creek, and Salmon Lake (Figure 2). This restoration plan will colloquially refer to the yellow region in figure 2 as the “Clearwater Valley” or “Clearwater Watershed” (interchangeably) but in technical terms, it is an amalgamation of 14 subwatersheds.

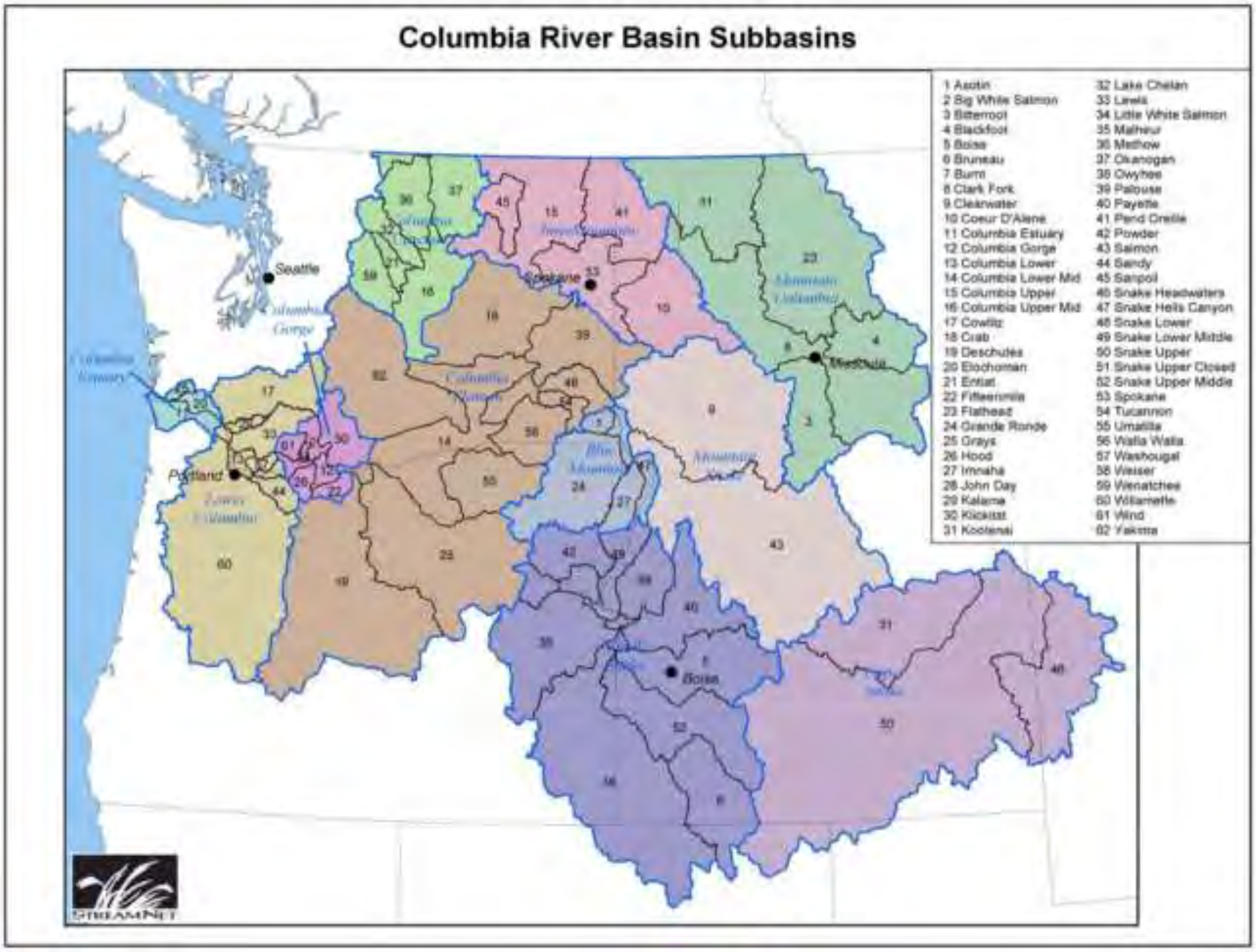


Figure 1: The Blackfoot Subbasin (#4 on the above map) is located on the eastern side of the Columbia River Basin. *Map source: 2009 Blackfoot Subbasin Plan*

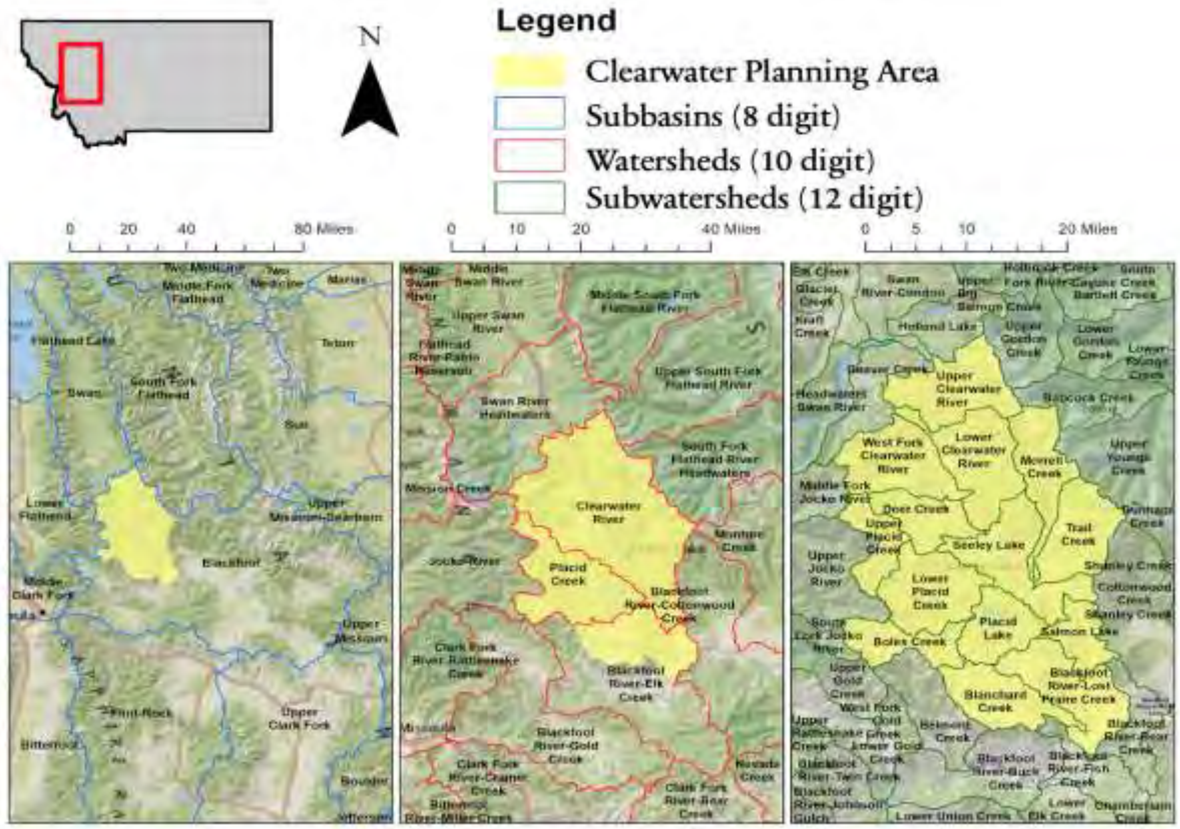


Figure 2: Location of the Clearwater planning area in relation to surrounding subbasins, watersheds, and subwatersheds. *Data source: USGS national hydrography watershed boundary dataset.*

Glacial forces shaped the Clearwater Valley's unique topography up to 15,000 years ago, and formed a succession of lakes which from north to south include: Clearwater Lake, Rainy Lake, Lake Alva, Lake Inez, Seeley Lake, Big Sky Lake, Placid Lake, and Salmon Lake (Figure 3). In addition, a number of smaller lakes occur across the Valley including Summit Lake, Marshall Lake, Hidden Lake, Tupper's Lake, Spook Lake, Emerald Lake, and others.

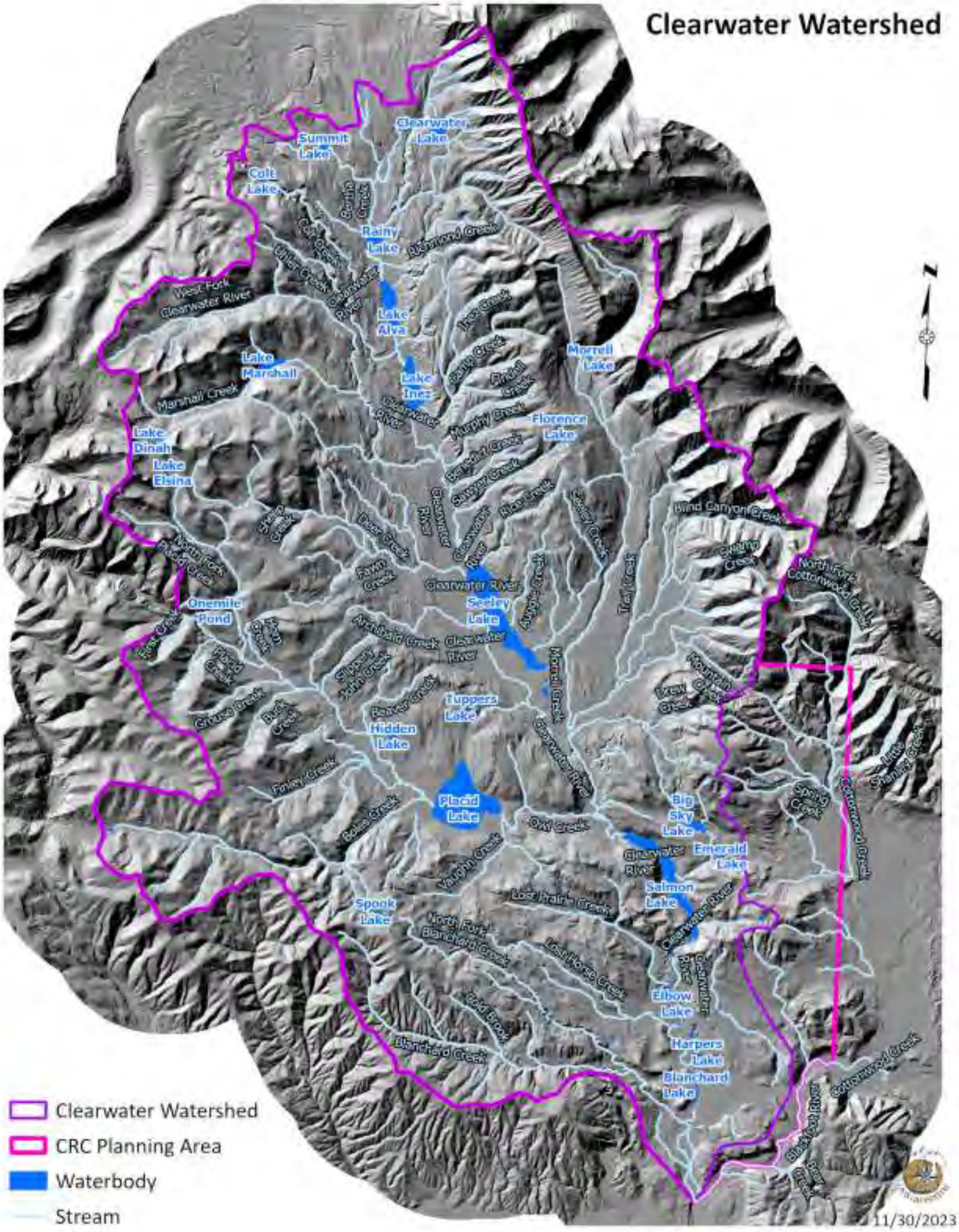
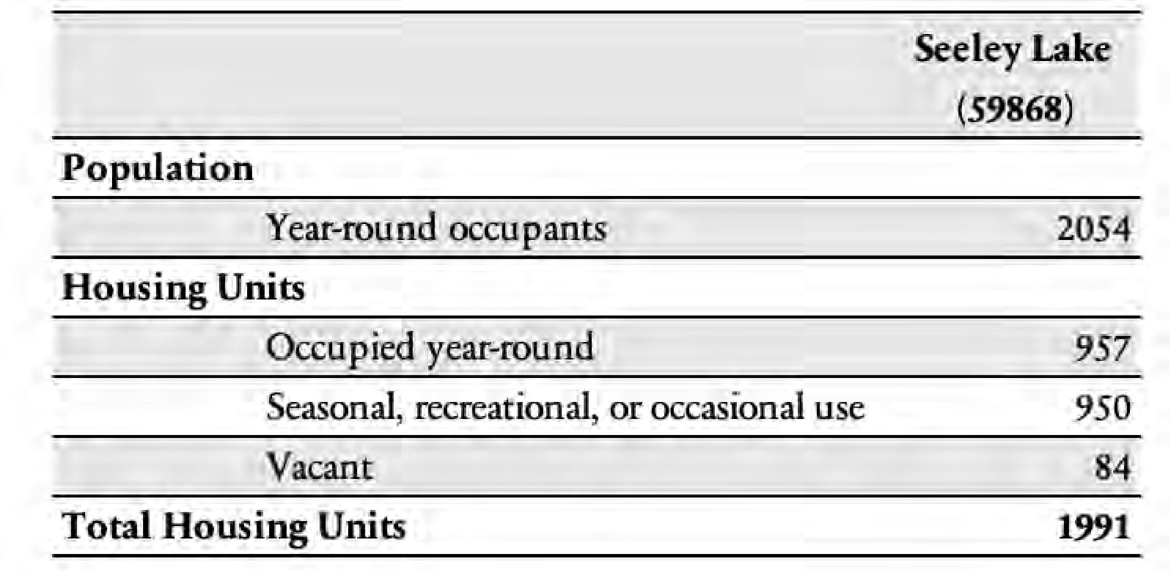


Figure 3: The Clearwater Valley in Northwest Montana.

2.2 Land ownership, population, and demographics

As estimated by the US Census Bureau in 2020, Seeley Lake has a population of 1,566 year-round occupants, making it the 72nd most populated city in the state of Montana out of 455 cities. These data did not include all of the Clearwater Valley and differed from census data collected in 2010. In 2021, the median household income of Seeley Lake households was $42,714. The 1213 estimated housing units reported in 2021 were split between year-round occupants (64%) and seasonal/recreational/occasional occupants. Additional information on population and housing units collected during the 2010 census and types of occupancy in the Seeley Lake region is provided in Table 1.

Table 1: Estimated population of the Seeley Lake (59868) region. *Data source: 2010 US Census Bureau*



		Seeley Lake (59868)
Population		
	Year-round occupants	2054
Housing Units		
	Occupied year-round	957
	Seasonal, recreational, or occasional use	950
	Vacant	84
Total Housing Units		**1991**

Land ownership in the Clearwater Basin is mixed between various public and private entities (Figure 4). Land ownership in 2023 was 54% U.S. Forest Service, 8% MT Department of Natural Resources and Conservation, 14% MT Fish, Wildlife, & Parks, and 23% private lands split between 15% The Nature Conservancy (TNC) and 8% smaller private residential properties, and 1% lakes. TNC has been incrementally selling land back to the public domain for management by the U.S. Forest Service, U.S. Bureau of Land Management, and MT Fish Wildlife and Parks. This is helping to create a contiguous area of publicly owned land, in contrast to the checkerboard pattern of public-private ownership dating back more than a century that has made historical land management difficult.

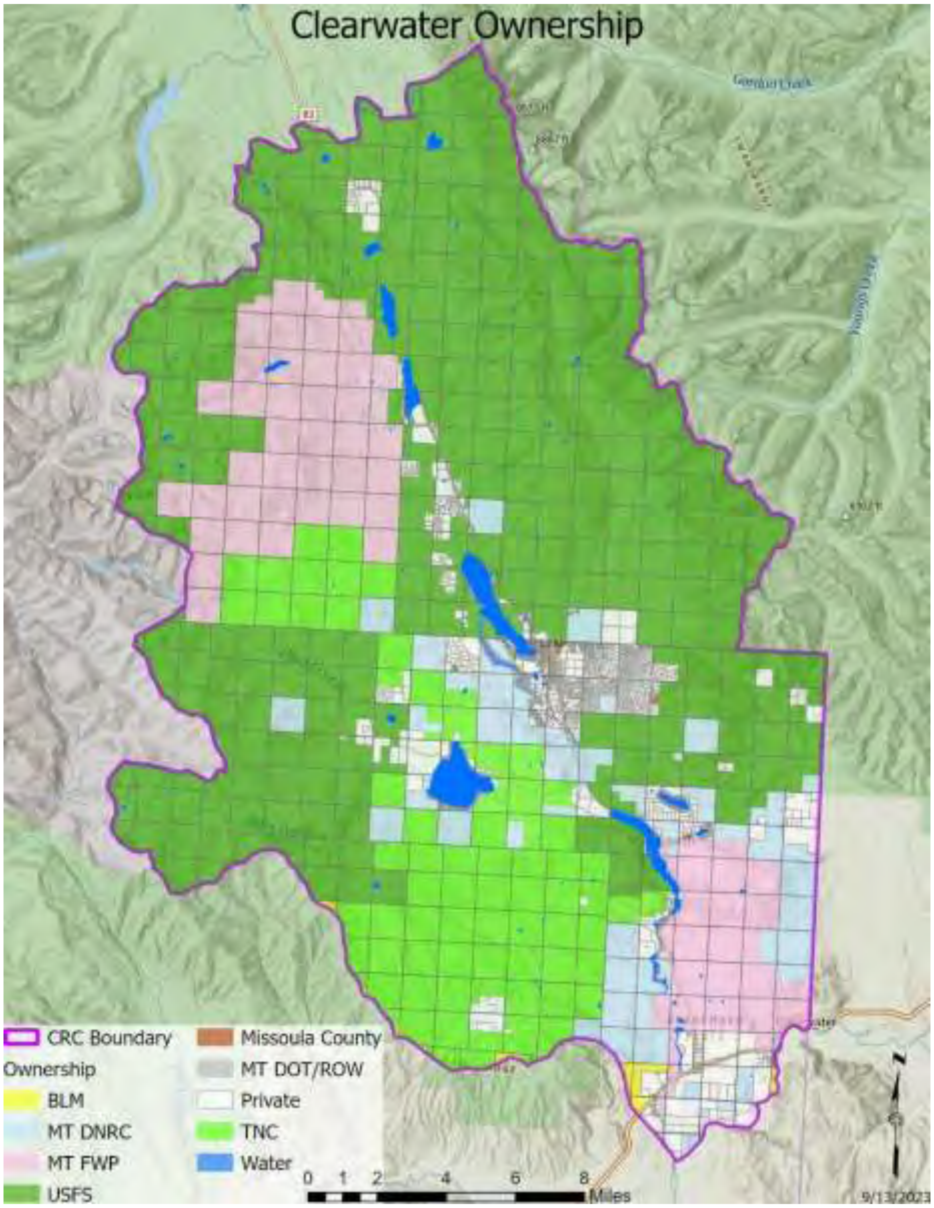


Figure 4: Land ownership (12/2023) in the Clearwater Valley.

2.3 Climate

The climate in the Seeley Lake area is similar to other mid-elevation intermountain basins of the Northern Rocky Mountains west of the Continental Divide. Based on Western Regional Climatic Center data for the period of record, annual precipitation averages 21.53 inches. Monthly average precipitation ranges from 1.11 inches in July to 2.67 inches in December and 2.76 inches in January. Summer thunderstorms and winter snows provide a majority of the precipitation in the area. According to data from the Seeley Lake Ranger Station, average seasonal snowfall is 120 inches, but higher levels of precipitation ad snowfall occur at higher elevations of the basin. The average annual temperature in Seeley

Lake is 41.3 °F, with temperature extremes ranging from -53 °F in 1937 to 102 °F in 2007 (Western Regional Climate Center, n.d.).

Recent trends in climate have been consistent with anticipated effects of climate change. General warming, increased variability in precipitation, and drier summers could have vast implications for both aquatic and terrestrial ecosystems in the Clearwater Basin. From Seeley Lake Ranger Station data, the average temperature in July 2007 of 71.6 °F was more than 3 °F warmer than any previous July on record (Western Regional Climate Center, n.d.). Further, the wider Columbia River Basin region saw minimum air temperatures increase by ~2 °F and maximum temperatures increase by ~2.3 °F from 1970 to 2006. Precipitation has shown indications of decline during the same period (Littell et al. 2011). Climate change projections for the Pacific Northwest suggest that average annual air temperatures will increase by 3.2 °F by the 2040s and 5.3 °F by the 2080s, relative to average temperatures from 1970-1999 (Mote et al. 2008).

Climate investigations have estimated that the Columbia River Basin's average mean-annual temperature has increased by approximately 2 °F since the late 1800s (US DOI BOR 2016). Also, the Columbia River Basin has experienced a general decline in spring snowpack since the mid-20th century due to more precipitation occurring as rain (rather than snow) and earlier snowmelt runoff.

2.4 Geology and Soils

The present hydrology of the Clearwater Basin can be explained by its geological history. The Seeley-Swan valleys were formed by continental glaciation when the Cordillerian ice sheet advanced through northern Montana (CRC 2008). Smaller mountain glaciers formed in the Mission and Swan Mountain Ranges. The geology of the Clearwater Valley is characterized by sloping glacial features of undifferentiated glacial drift composed of argillites, siltites, and quartzites.

The Clearwater River basin is bounded by a high angle normal fault on the east. The Clearwater River basin occupies the southern tip of the easternmost extension of the Rocky Mountain Trench. This extensive trench-like feature is characterized by north-northwest trending listric normal faults that bound the down-dropped basin. Listric normal faults are believed to decrease their angle of dip with depth and result from extensional tectonics (stretching of the earth's crust). The crustal block beneath the basin is thought to be down-dropped several miles relative to the surrounding blocks (the mountains) and is east tilted. Structurally, the Clearwater Valley continues into the Swan Valley, but a drainage divide separates the 2 basins. Swan Lake was formed behind the terminal moraine originating from the combination of two glaciers, one from the cirque of Holland Lake, and the other from the Lindbergh Lake area. These two lakes are located in the ice gorge depression of the two glaciers. Rainy Lake is behind the terminal moraine of an off-shoot of the same ice that formed the Swan Lakes. The remaining Clearwater Lakes are typical ice block lakes formed from a glacier to the south of the Swan glacier which flowed down the trench to the

Clearwater junction with the Blackfoot River. Lake Alva and Lake Inez were originally a single lake that was split in two by glacial till.

Continental and local mountain glacial activity have heavily sculpted and influenced this region. Four major glacial advances occurred in Montana during the Pleistocene Epoch (10,000 – two million years ago) (Alden 1953). Ice covered the northern third of the state during the maximum extent of the glacial advance. The Rocky Mountain Trench was a primary avenue for the repeated southward advance and retreat of the Flathead Lobe of the Cordilleran Ice Sheet. It appears that at least 3 major glacial episodes are recorded in the Seeley Lake area and these episodes deposited Pleistocene age glacial till throughout the basin. This till is composed of heterogeneous, poorly sorted sand, gravel, pebbles, cobbles, and boulders in a sandy to clayey matrix. The glacial till can be up to 600 feet thick on the basin floor with a significantly thinner mantle along the sides of the valley. It should be noted that glacial activity in the area allowed significantly large volumes of glacial ice to flow into and south through the valley and to shape the Swan and Clearwater Valleys into the distinctive U-shaped glacial valleys. As glacial ice melted and the glaciers retreated, streams and rivers carried large volumes of reworked glacial debris, which settled out of suspension as unconsolidated, moderately sorted, glacial-outwash deposits of sand, gravel, pebbles, and cobbles. These deposits are collectively called Quaternary Alluvium and will often exhibit obvious kame and kettle topography (from in-place stagnant melting of large segments of glacial materials and the entrained sediment load), glacially sculpted drumlin ridges, coarse fluvial (stream) terraces, and moraine-like deposits. Some other features of the extensive and repeated glaciations of the area are the aligned ridges and scoured out lake basins, polished bedrock outcrops, isolated cirques and arêtes in the mountains. Modern streams have only begun to erode and transport some of this material as evidenced by the outlet of Seeley Lake that is still located on the middle of the west shore of the lake. After the last glacial retreat from the valley, the Clearwater River managed to overfill the debris dam south of Seeley Lake, then begin draining the lake along a new outlet on the west shore.

Surface soils in the Clearwater Watershed region are composed primarily of organic detritus and decaying material from trees, shrubs, and grasses. It is underlaid with residual soils from glacial till. Soils are primarily deep, moderately coarse to medium textured (CRC 2008). The majority of the soils in the Basin are not considered prime farmland (89%). In some areas that are not identified as having national or statewide importance, land is considered to be farmland of local importance, which is identified by the appropriate local agencies. 10% of the soil area in the basin is designated as farmland of local importance. Farmland of statewide importance generally includes areas of soils that nearly meet the requirements for prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods (0.52% of the basin's area). Lastly, the land that has the best combination of physical and chemical characteristics for producing various crops is considered prime farmland, which makes up just 0.32% of the basin's area (Table 2, Figure 5).

Table 2: Classification of soils as prime and important farmland area.
Data source: USDA Natural Resource Conservation Science, Web Soil Survey

Farm Classification	Percent Area
Not prime farmland	89.47
Farmland of local importance	9.67
Farmland of statewide importance	0.52
Prime farmland if irrigated	0.32

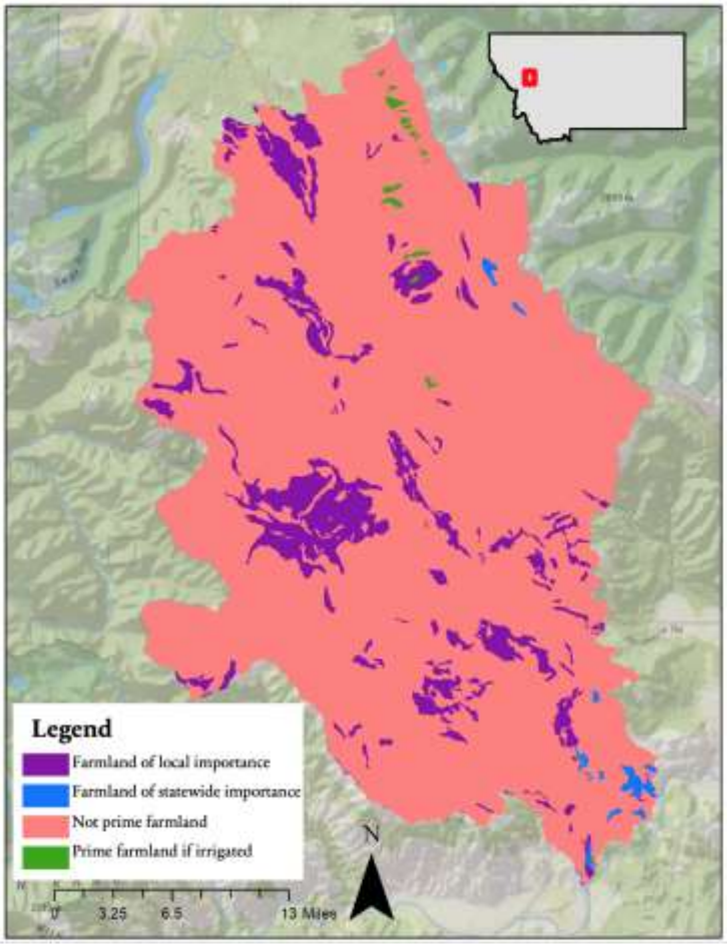


Figure 5: Classification of soils as prime and important farmland area. *Data source: USDA Natural Resource Conservation Science, Web Soil Survey*

2.5 Hydrology

The Clearwater River flows north to south through the length of the watershed and enters Seeley Lake at the north end. Snowmelt, direct precipitation, surface runoff, and lateral inflow from alluvial and bedrock aquifers contribute to flow in the Clearwater River, its tributaries, and Seeley Lake. Other than beaver dams, it does not appear that the Clearwater River has been dammed or diverted along its course, other than temporary dams erected during the early logging era to create floods to carry logs downstream to a mill in Bonner.

DNRC completed a hydrologic analysis of a reach of the Clearwater River to be utilized in a larger-scale floodplain study of Missoula County. This study includes hydrologic analysis to estimate the 10, 4, 2, 1, and 0.2 percent annual chance flood discharges for the Clearwater River (MT DNRC 2017).

As described in the DNRC's 2017 Hydrology Design Report, there is one USGS gaging station present on the Clearwater River with 19 years of historical discharge data (1975-1992, 1997). The five highest annual peak discharges recorded at the gage are listed in Table 3.

Table 3: Clearwater River Gaging Station Peak Discharges.
Data source: MT DNRC Hydrology Design Report

Ranking	**USGS Gage No. 12339450 near Clearwater (345.0 mi^2)**	
	Date	**Peak Discharge (cfs)**
1	May 28, 1997	3,800
2	May 17, 1975	2,900
3	April 24, 1989	2,790
4	May 12, 1976	2,320
5	May 19, 1982	2,030

All historical annual peak discharges occurred in either April or May, and the most severe flooding on the Clearwater River typically occurs in the spring and early summer as a result of snowmelt and/or rainfall runoff.

2.6 Land Cover

Land cover is variable throughout the Clearwater Basin. The three largest land cover categories by area are conifer-dominated forest and woodland (xeric-mesic), recently burned, and floodplain/riparian, which together account for 67% of the land in the basin (Figure 6). Each of these three major land cover categories are explained in greater detail below.

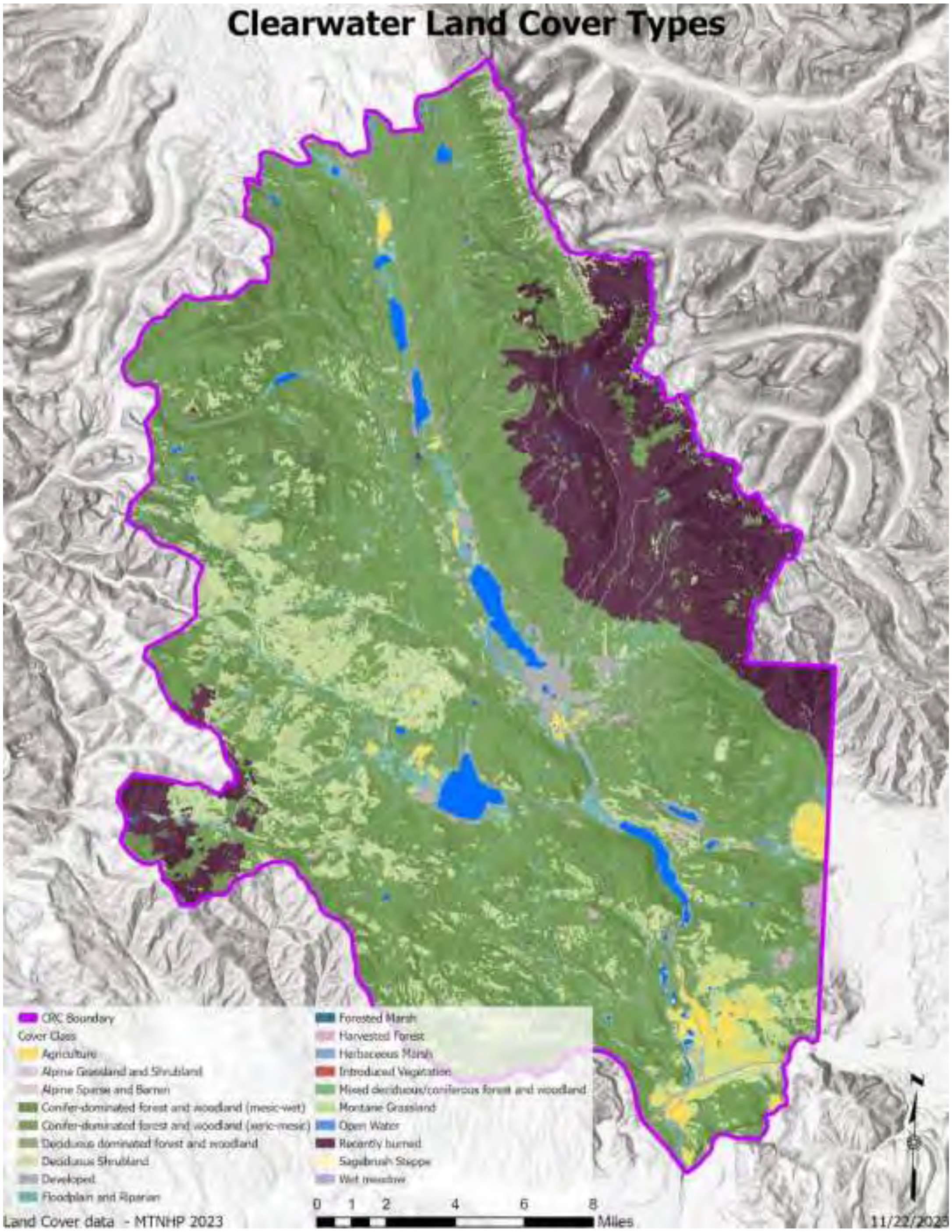


Figure 6: Dominant land cover classifications in the Clearwater Basin (conifer dominated forest and woodland (xeric-mesic), recently burned, floodplain and riparian, harvested forest, montane grassland, conifer dominated forest and woodland (mesic-wet), developed, deciduous shrubland, and open water). *Data source: Montana National Heritage Program landcover framework.*

Conifer-dominated forest and woodland (xeric-mesic): Xeric and mesic refer to the amount of moisture in an environment, xeric referring to habitat types with little moisture, and mesic referring to habitat types with moderate moisture content. Within this land cover category are 10 sub-categories, with one of these sub-categories, Rocky Mountain Dry-Mesic Montane Mixed Conifer Forests, occurring with the greatest frequency in the Clearwater Basin, and is described in greater detail:

Rocky Mountain Dry-Mesic Montane Mixed Conifer Forests: This ecological system, composed of highly variable montane conifer forests, is found throughout Montana. It is associated with a sub-mesic climate regime with annual precipitation ranging from 10-39 inches, with most precipitation occurring during winter, and April through June. Winter snowpack typically melts off in early spring at lower elevations. Elevations range from valley bottoms to 5,500 feet in northwestern Montana and up to 7,500 feet on warm aspects in southern Montana. In northwestern and west-central Montana, this ecological system forms a forest belt on warm, dry to slightly moist sites. It generally occurs on gravelly soils with good aeration and drainage and a neutral to slightly acidic pH. In the western part of the state, it is seen mostly on well drained mountain slopes and valleys from lower treeline to up to 5,500 feet. Douglas-fir is the dominant conifer both as a seral and climax species. West of the Continental Divide, occurrences can be dominated by any combination of Douglas-fir and long-lived, seral western larch, grand fir, ponderosa pine, and lodgepole pine. Aspen and western white pine have a minor status, with western white pine only in extreme western Montana *(MT.gov n.d.).* It should be noted that in the Clearwater Watershed, grand fir and western white pine do not occur in any substantial amounts, and historically the watershed supported significant areas of very large western larch and ponderosa pine.

Recently burned: Two major fires (the 2007 Jocko Lakes fire and 2017 Rice Ridge fire) burned large swaths of land on the east and west sides of the basin in recent decades. The Jocko Lakes fire began on August 3, 2007 on the eastern shore of the Jocko Lakes, 10 miles west of Seeley Lake. The fire burned 36,388 acres of land, and came within a mile of Seeley Lake, becoming the nation’s top wildfire priority at the time (CRC 2017). The Rice Ridge fire began on July 24, 2017 during Montana’s worst fire year since 1910. Like the Jocko Lakes fire, it was the nation’s top wildfire priority at the time as it rapidly grew from 40,000 to over 100,000 acres (Lundquist 2018). This fire burned approximately 155,900 acres of land northeast of Seeley Lake (Figure 7).

In 2023, the Colt Lake fire burned over 7,000 acres from mid-July to early August. An abnormally wet August allowed this fire to be contained with little spread during what normally would have been a dry, fire-prone time of the year.

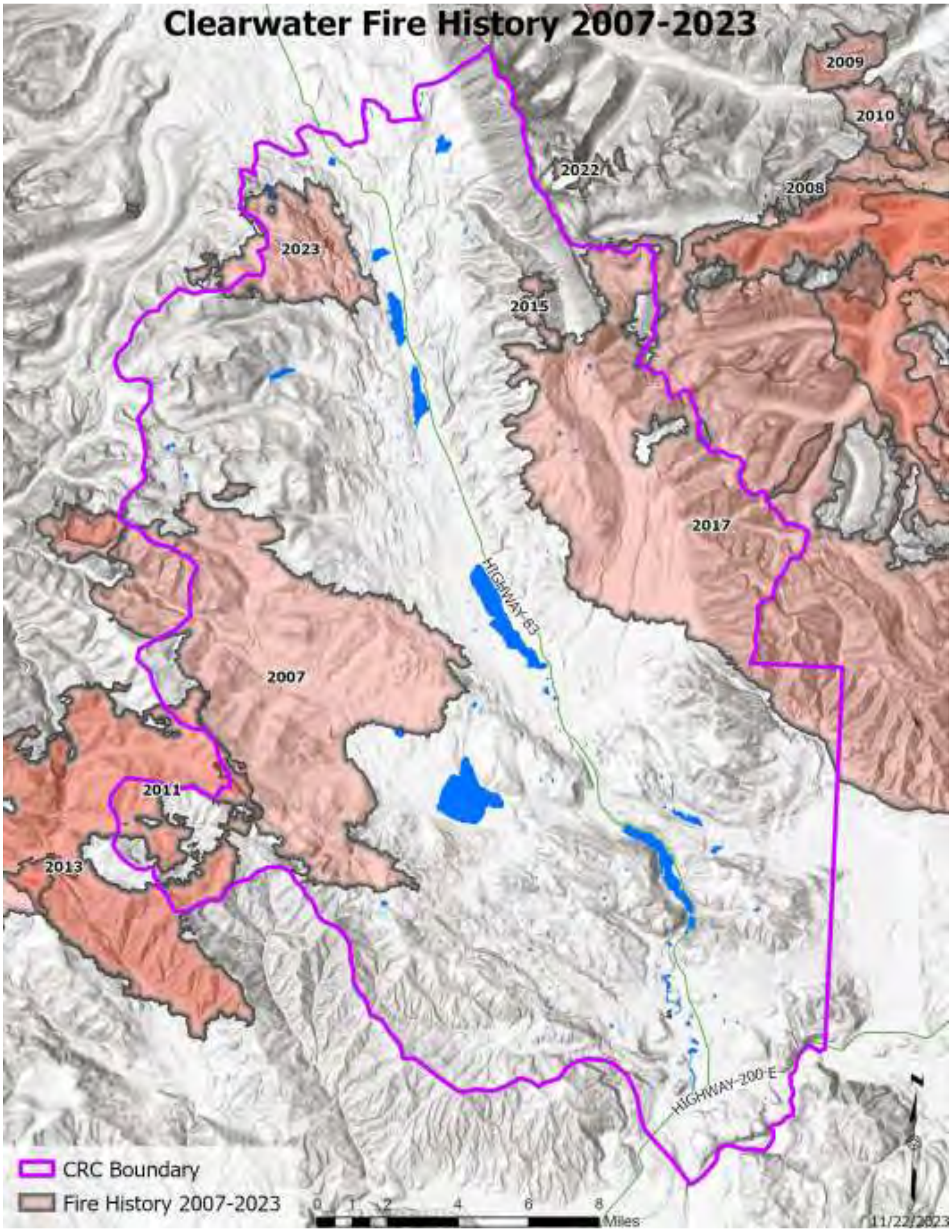


Figure 7: Map of fire boundaries occurring between 2007 and 2023 in the Clearwater Valley.

Floodplain/riparian: Floodplain and riparian areas are dominant land cover categories surrounding the vast interconnected network of streams and lakes throughout the basin. Within this land cover category are 7 sub-categories, 1 of which occurs with the greatest frequency in the Clearwater Valley, described in greater detail below:

Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland: This ecological system is found throughout the Rocky Mountain region. In Montana, sites occur at elevations of 2,000-4,000 feet west of the Continental Divide. It generally comprises a mosaic of multiple communities that are tree-dominated with a diverse shrub component. It is dependent on a natural hydrologic regime with annual to episodic flooding, so it is usually found within the flood zone of rivers, on islands, sand or cobble bars, and along streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers, or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains, swales and irrigation ditches. In some locations, occurrences extend into moderately high intermountain basins where the adjacent vegetation is sage steppe. Black cottonwood is the key indicator species. Other dominant trees may include boxelder maple, narrowleaf cottonwood, eastern cottonwood, Douglas-fir, peachleaf willow, or Rocky Mountain juniper. Dominant shrubs include Rocky Mountain maple, thinleaf alder, river birch, red oiser dogwood, hawthorne, chokecherry, skunkbush sumac, willow, rose, silver buffaloberry, or snowberry (MT.gov n.d.).

2.7 Lakes and Streams

The State of Montana classifies the Clearwater River as B-1 surface water in the Administrative Rules of Montana (ARM 17.30.601-.646). Surface waters designated as B-1 are to be maintained as suitable for drinking, culinary, and food processing purposes after conventional treatment for the removal of naturally present impurities. These waters must also be maintained as suitable for bathing, swimming, and recreation; growth and propagation of salmonoid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply.

2.8 Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of substrate development and the types of plant and animal communities living in the substrate and on its surface. The single feature that most wetlands share is a substrate that is at least periodically saturated with or covered by water. The Classification of Wetlands and Deepwater Habitats of the United States was developed to support a detailed inventory and periodic monitoring of the nation's wet habitats using remote sensing. The structure of this classification is hierarchical, progressing from Systems and Subsystems at the most general levels to Classes, Subclasses, and Dominance Types (Cowardin et al. 1979).

According to data downloaded from the National Wetlands Inventory, the Clearwater Valley contains approximately 11,603 acres of wetlands. Lakes are the largest category of mapped wetlands in the basin (4103 acres), followed by freshwater forested/shrub wetlands (3097 acres), freshwater emergent wetlands (2166 acres), riverine regions (1590 acres), and freshwater ponds (648 acres) (Figure 8).

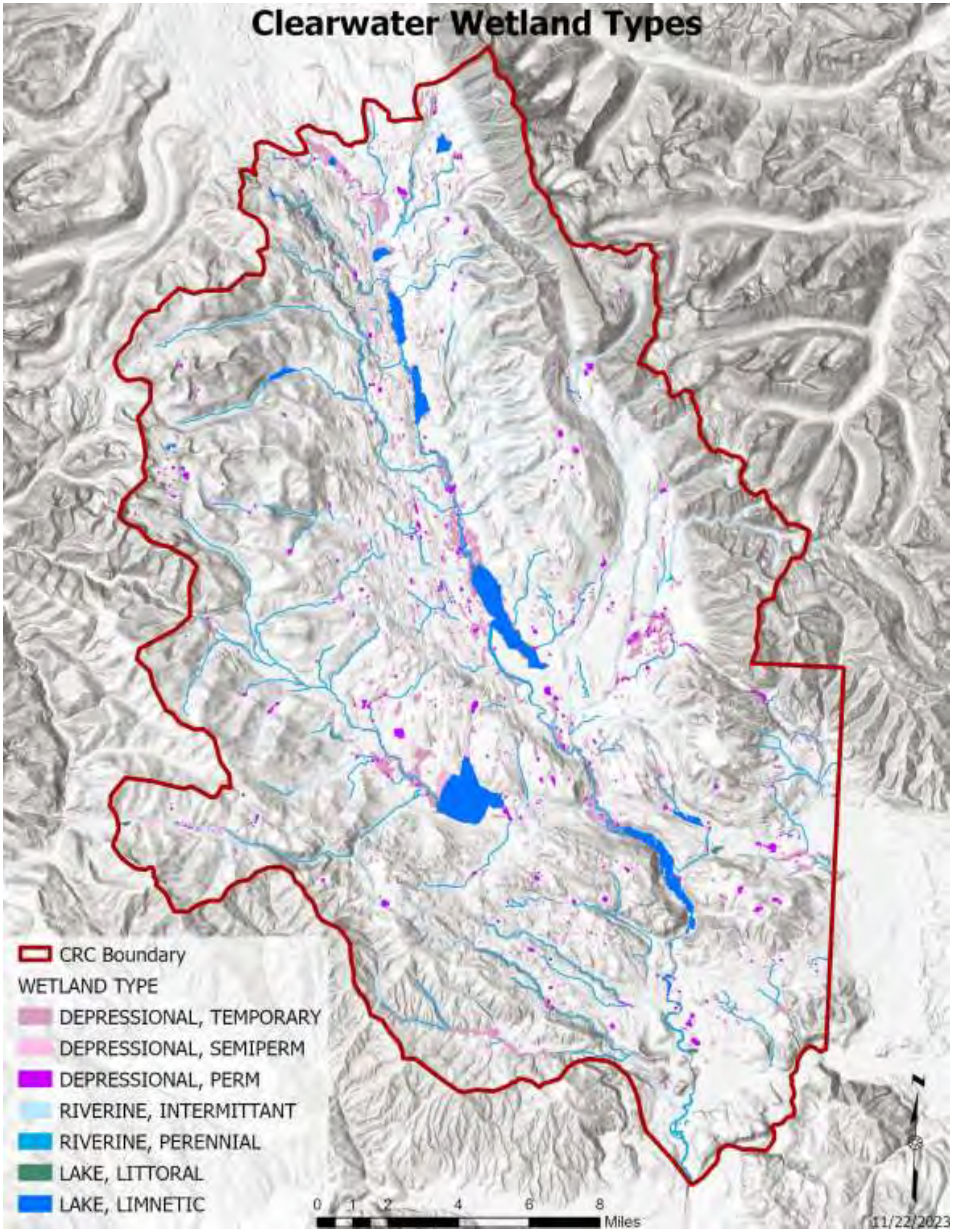


Figure 8: Wetlands in the Clearwater Valley. *Data Source: National Wetlands Inventory*

Wetlands can be further broken down into subcategories, as defined in Table 4. Important terminology in the table includes:

- **Lacustrine**: The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with 30 percent or greater areal coverage; and (3) total area of at least 8 hectares (ha) (20 acres).
- **Limnetic**: This subsystem includes all deepwater habitats (i.e., areas > 2.5 m [8.2 ft] deep below low water) in the Lacustrine System. Many small Lacustrine Systems have no Limnetic Subsystem.
- **Littoral**: This subsystem includes all wetland habitats in the Lacustrine System. It extends from the shoreward boundary of the System to a depth of 2.5 m (8.2 ft) below low water, or to the maximum extent of nonpersistent emergents if these grow at depths greater than 2.5 m.
- **Unconsolidated bottom:** The Class Unconsolidated Bottom includes all wetlands and deepwater habitats with at least 25 percent cover of particles smaller than stones and a vegetative cover less than 30 percent.
- **Aquatic Bed:** The Class Aquatic Bed includes wetlands and deepwater habitats where plants that grow principally on or below the surface of the water (i.e., surface plants or submergents) are the uppermost life form layer with at least 30 percent areal coverage.
- **Palustrine**: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2.5 m (8.2 ft) at low water; and (4) salinity due to ocean-derived salts less than 0.5 ppt.
- **Emergent**: In this wetland Class, emergent plants—i.e., erect, rooted, herbaceous hydrophytes, excluding mosses and lichens—are the tallest life form with at least 30% areal coverage. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.
- **Forested**: In Forested Wetlands, trees are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. Trees are defined as woody plants at least 6 m (20 ft) in height.
- **Scrub-shrub:** In Scrub-Shrub Wetlands, woody plants less than 6 m (20 ft) tall are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. The “shrub” life form actually includes true shrubs, young specimens of tree species that have not yet reached 6 m in height, and woody

plants (including tree species) that are stunted because of adverse environmental conditions.

- **Unconsolidated shore:** The Class Unconsolidated Shore includes all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; (2) less than 30 percent areal cover of vegetation other than pioneer plants; and (3) any of the following Water Regimes: Irregularly Exposed, Regularly Flooded, Irregularly Flooded, Seasonally Flooded, Seasonally Flooded Saturated, Temporarily Flooded, Intermittently Flooded, Regularly Flooded-Tidal Fresh, Seasonally Flooded-Tidal Fresh, and Temporarily Flooded-Tidal Fresh.
- **Lower perennial:** This Subsystem is characterized by a low gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.
- **Upper perennial:** This Subsystem is characterized by a high gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation. The fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared with that of the Lower Perennial Subsystem, and there is very little floodplain development.
- **Intermittent:** This Subsystem includes channels that contain flowing water only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.
- **Streambed:** The Class Streambed includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide

Table 4: types of wetlands in the Clearwater Basin. *Data Source: National Wetlands Inventory*

NWI Code	Wetland Type	Acres
Lacustrine (Lakes)		

L1UB	Limnetic, Unconsolidated Bottom	3901
L2AB	Littoral, Aquatic Bed	202
Palustrine		
PAB	Aquatic Bed	599
PEM	Emergent	2166
PFO	Forested	602
PSS	Scrub-Shrub	2495
PUB	Unconsolidated Bottom	48
PUS	Unconsolidated Shore	0.3
Riverine		
R2AB	Lower Perennial, Aquatic Bed	0.8
R2UB	Lower Perennial, Unconsolidated Bottom	183
R3UB	Upper Perennial, Unconsolidated Bottom	202
R3US	Upper Perennial, Unconsolidated Shore	1
R4SB	Intermittent, Streambed	1135

R5UB	Unknown Perennial, Unconsolidated Bottom	67

2.9 Species of Concern

2.9.1 Bull Trout

Bull trout is a native salmonid that was once widely distributed throughout the Columbia River Basin. Bull trout were listed as a threatened species by the USFWS in 1998. Both bull trout and westslope cutthroat trout exhibit a range of life history types characterized by their migratory behavior. Populations with migratory life histories typically spawn and rear offspring in smaller tributary streams. Juveniles rear in natal streams for one to several years, and older juveniles may migrate to larger rivers or lakes to mature. At maturation, adults return to the tributaries to spawn and may make subsequent migrations to and from lakes and rivers. Some individuals or populations may stay in the natal or nearby streams throughout life and represent a “resident” life history. Migratory life histories tend to mature at larger sizes and can support larger more resilient populations because of increased fecundity. Migratory forms, however, also face greater risks by moving through environments supporting numerous predators and extreme environmental conditions that vary from year to year. The varied expression of life history represents an important component of biological diversity that contributes to the stability and persistence of populations in dynamic environments, such as the mountain streams of western Montana. The Clearwater Valley with its network of large lakes is unique in the Blackfoot and Upper Clark Fork basins because it supports all three life history forms. Because climate change and other environmental disruptions may influence lake, river, and headwater tributary systems in different ways, maintenance of this diversity may be an important hedge for long-term species and fisheries conservation. (e.g. Hilborn et al. 2005)

The Bull Trout Recovery Plan designates the Clearwater River and lakes as core areas for bull trout (US FWS 2015). The recovery plan also projects that the Clearwater Lakes will see a 35% decline in cold water habitat between 2040 and 2080, which would jeopardize the continued existence and growth of bull trout populations. In addition to further urbanization of the Seeley Lake region, climate change is expected to threaten viable bull trout habitat through dewatering and increasing water temperatures. Bull trout are a sensitive species, requiring low sediment levels in their spawning streams, as sediment can suffocate developing embryos before they hatch. Additionally, embryos require cold water temperatures and gravel substrate with high permeability to allow water to flow over their eggs. The Recovery Plan suggests action items that could be implemented to address primary threats in the Clearwater Valley, which include decommissioning roads in East Fork Clearwater and improving habitat through best management practices and conservation easements (among other actions).

The Clearwater Valley supports several bull trout populations, but the status varies across the occupied streams (Figures 9 and 10). Bull trout have the lowest temperature tolerances of any native fish in the Clearwater Valley, and spawning and early rearing occur principally in larger, high elevation streams or other sites heavily influenced by groundwater. Maintaining bull trout populations requires maintaining relatively large stream areas of cold water and limited sediment loads. Weaker populations may be threatened by invasion of, and hybridization with, non-native brook trout. Non-native brown trout may also directly compete with or prey on bull trout in nursery areas and migratory corridors. Populations can persist as isolated resident populations if the isolated stream habitats are extensive and in good condition, but migratory life histories and movement among populations appears to be important for long-term persistence of the species in many areas. Threats include damage to streams or stream banks, removal of shade over critical sections of streams, impacts from roads including sediment runoff, oil, salt or other chemical runoff, fragmentation of habitat through physical barriers to migration or extremely low flows, invasion of brook trout, brown trout or other species that may compete with or prey on juvenile bull trout, and the degradation of lakes that serve as important rearing areas. Developments near bull trout streams may cause impacts to this species through changes to stream channels, flows, or water quality. Changes to the density of riparian vegetation and forest canopies surrounding streams and reduced flows because of water development can lead to substantial increases in stream temperatures. Increased nutrient loading in lakes can result in eutrophication and oxygen depletion that reduces or eliminates suitable rearing habitat for migratory forms.

On-going research by MT FWP and the University of Montana has identified three primary areas currently utilized by migratory bull trout. Morrell Creek and the West Fork and East Fork Clearwater rivers support significant populations of bull trout that move from natal habitats in these headwaters to mature in the major lakes. Historically, some fish may have moved to the Blackfoot River as well. The entire mainstem Clearwater River above Salmon Lake serves as an important migratory corridor and also supports some spawning and seasonal rearing. Remnant bull trout populations still occur in Blind Canyon Creek, Boles Creek, Marshal Creek and Marshall Lake and Inez/Camp Creeks. Bull trout now appear to be locally extinct or at extremely low numbers in Trail, Deer, and Blanchard creeks. Predation by introduced northern pike which are now abundant in Salmon, Seeley and Inez lakes may have an important influence on bull trout (Berg 2003) and may contribute to the decline and even extinction of weaker populations. Long-term conservation of bull trout in the Clearwater Valley will depend on the maintenance of the core populations. Restoration and maintenance of high-quality habitat and/or open migration corridors for remnant and historically important streams could extend the productivity and long-term conservation prospects.

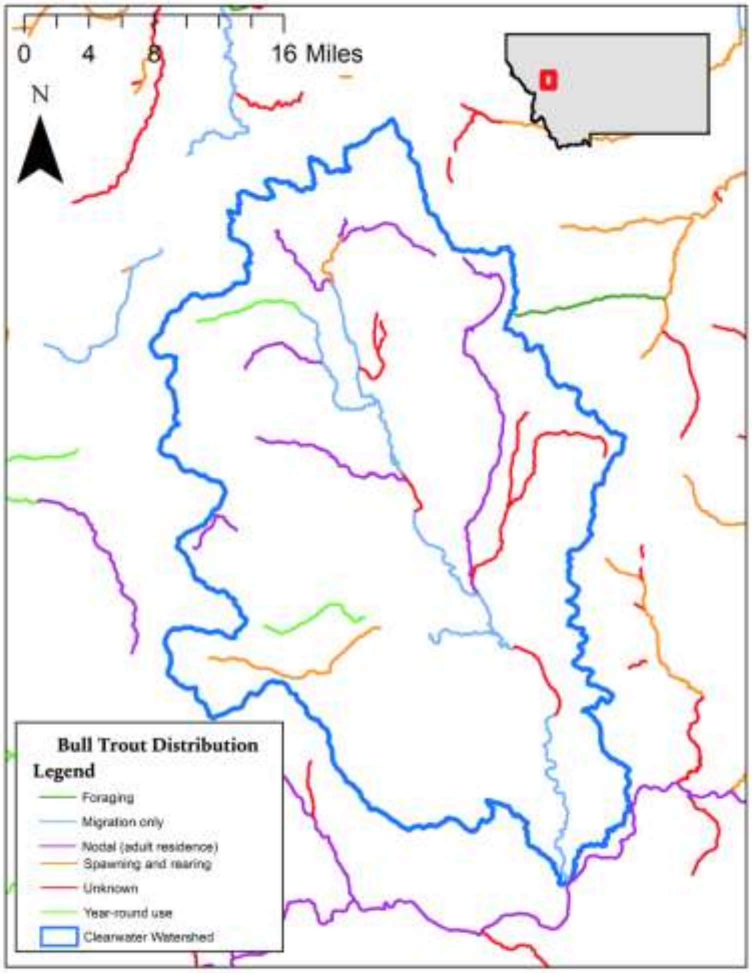


Figure 9. Bull trout distribution in and around the Clearwater Basin. Usage categories include foraging, migration only, nodal, spawning and rearing, year-round use, and unknown. *Data Source: StreamNet*

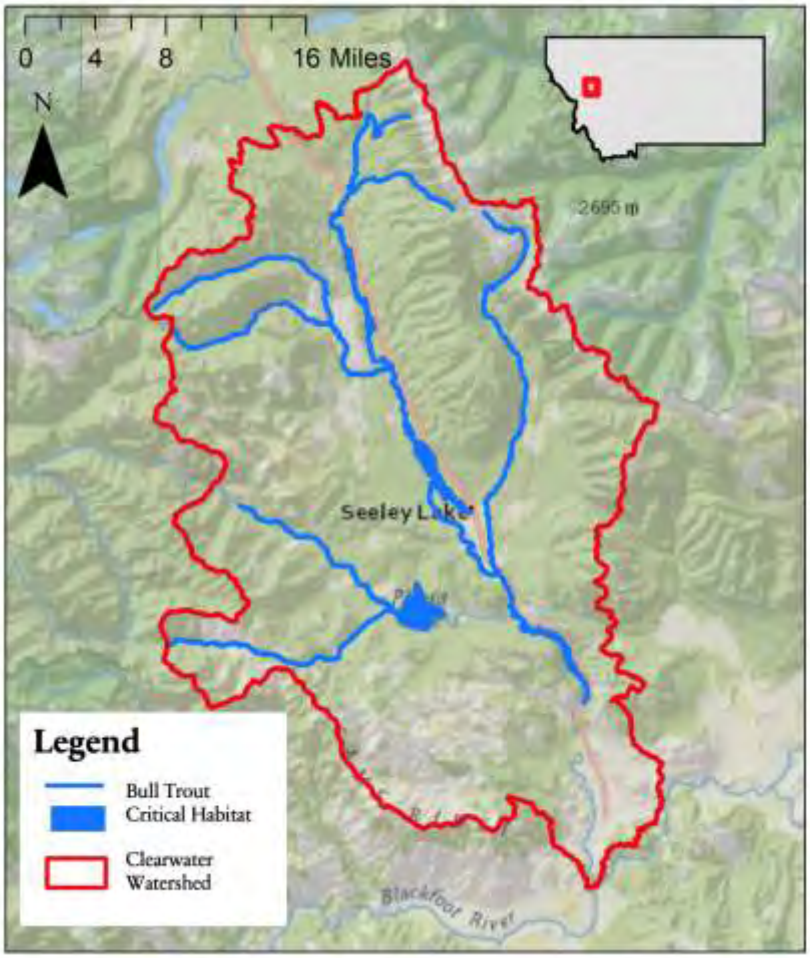


Figure 10. Critical habitat designations for bull trout in the Clearwater Basin. *Data Source: StreamNet*

2.9.2 Westslope Cutthroat Trout

Westslope cutthroat trout have been petitioned for listing in parts of their range but are deemed unwarranted for listing at present. Westslope cutthroat trout still occur in approximately 60% of stream habitat in the native range, but many populations have been compromised by hybridization and subsequent genetic introgression with introduced (nonnative) rainbow trout (Shepard et al. 2005). Westslope cutthroat trout are a “species of special concern” with MT FWP and a “sensitive species” in Region 1 of the USFS.

The westslope cutthroat trout is more widely distributed than bull trout and occurs throughout the lakes, river, and streams of the Clearwater Valley (Figure 11). Cutthroat spawn and rear in a wider range of tributary streams than bull trout and may commonly persist in isolated resident populations. Migratory cutthroat trout support a valuable sport fishery in the lakes and larger mainstem rivers and streams, but natural populations have been at low numbers in recent years. MT FWP periodically stocks hatchery fish to supplement the lake fisheries. This species, while not as sensitive as bull trout to changes in stream temperatures or habitat condition, is threatened by the same factors as bull trout. The combination of habitat degradation, invasive species, and migration barriers has contributed to substantial declines in abundance and distribution across the species range. Hybridization with introduced rainbow trout is a particular concern. Because hybrids are fertile, hybrid swarms (every individual is a hybrid) often result representing extinction of the local genetic resource. Hybrids still exhibit many of the ecological characteristics of native cutthroat trout and often support important fisheries. For these reasons, conservation management of westslope cutthroat trout often attempts to conserve the evolutionary legacy of remnant, genetically pure populations above intentional barriers (i.e. preempt invasion of hybrid or rainbow trout) as well as the ecological value of larger migratory (and likely hybridized) forms in streams with full access to good quality river and lake habitats.

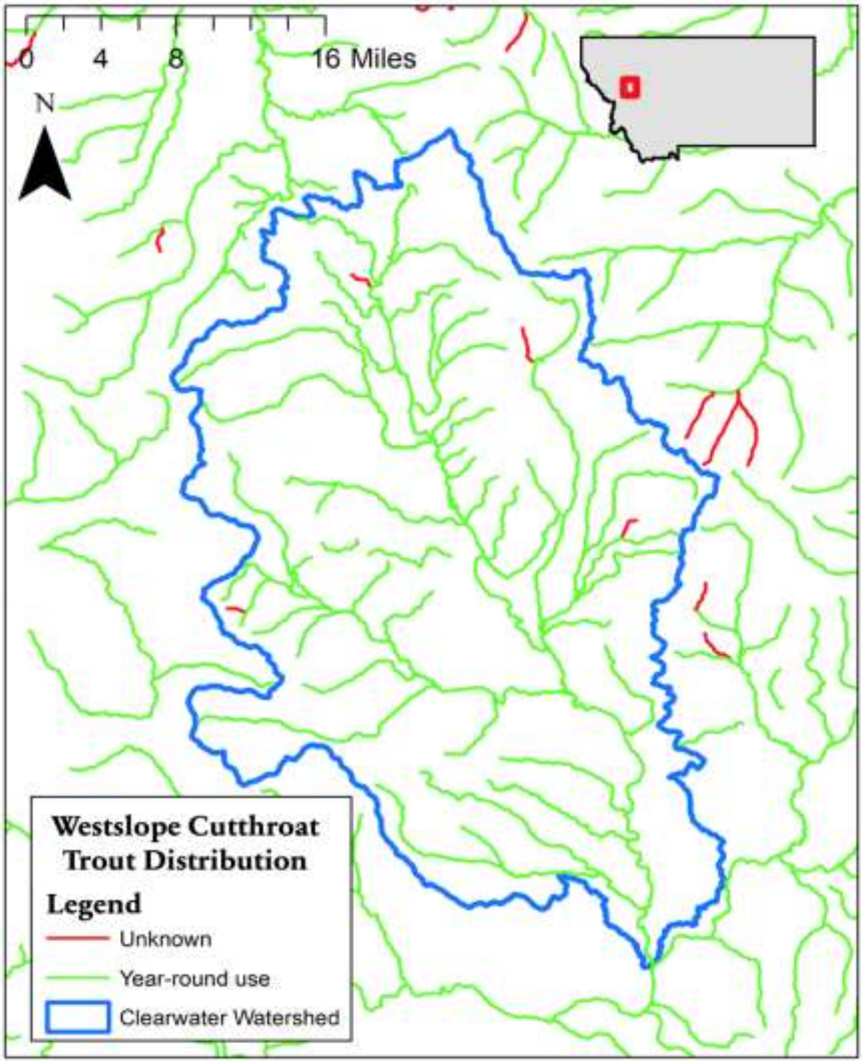


Figure 11: Westslope cutthroat trout distribution in and around the Clearwater Basin. Westslope cutthroat trout are widely distributed throughout the basin year-round, though some of the streams are designated as "unknown" due to lack of data. *Data Source: StreamNet*

2.10 Transportation Networks

As the Clearwater Basin has rapidly developed over the past century, roads have subsequently developed to meet a growing demand for accessibility throughout the basin. A GIS analysis of transportation network elements in the Clearwater Valley was completed using Montana transportation framework data. These data were also analyzed with high-resolution national hydrography data to determine the number of stream/road intersections in the basin. According to this analysis, there are 272 total road/stream intersections in the Clearwater Valley. Additionally, there are 24 bridges, 955 miles of road (paved and unpaved), and 93 miles of trails as documented by the Montana transportation framework (Figure 12).

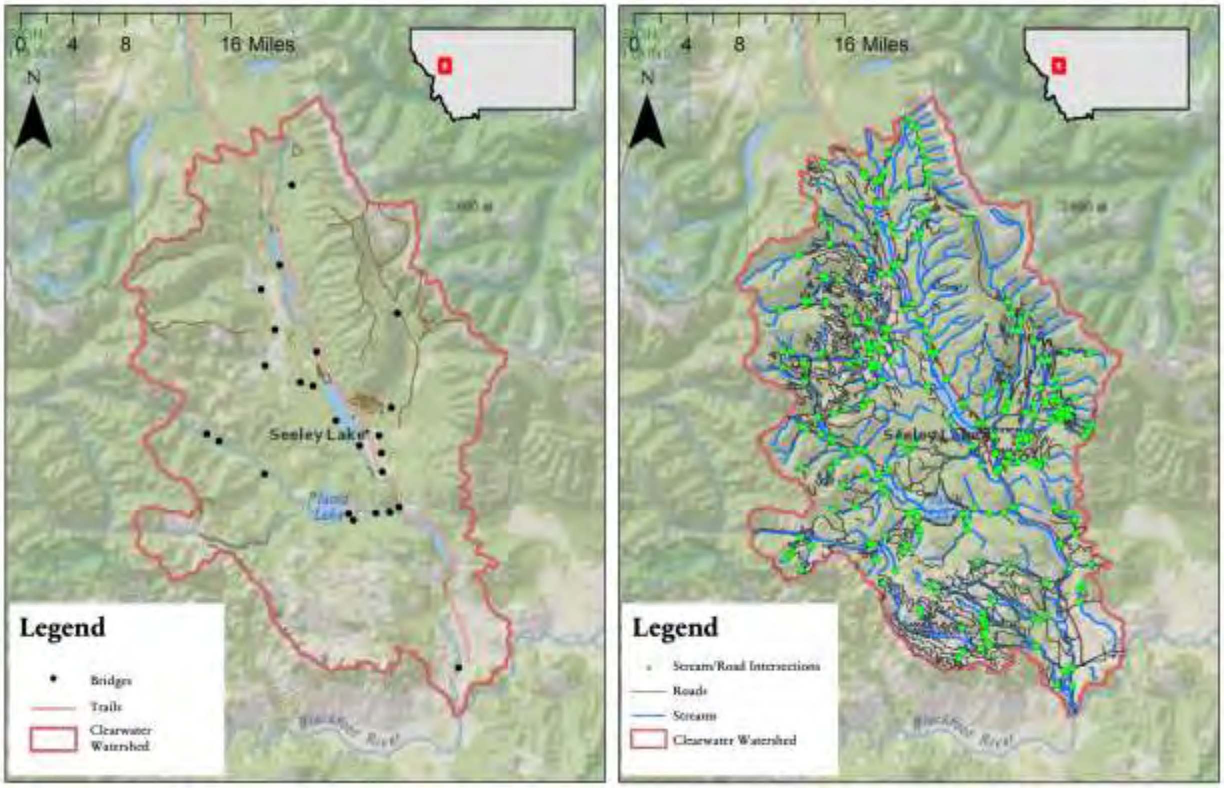


Figure 12: Left: bridges and trails within the Clearwater Valley. Right: Roads, streams, and road/stream intersections in the Valley. *Data source: USGS National Hydrography Dataset, MSDI transportation dataset.*

Road densities are high throughout much of the land formerly owned by private timber companies and contribute to the depressed status of some native fish populations. Road crossings and fish passage capabilities were evaluated in 2005 through a sampling of road erosion capabilities and culvert conditions, including a number of sites within the Clearwater Watershed (River Design Group 2005). The report found approximately two-thirds of the sampled culverts (94 total) had either inadequate perch heights or inadequate culvert size to channel size ratios to facilitate fish passage. In addition, the study reported that Blanchard Creek, a tributary of the Clearwater River, had a very high number of roads and road crossings within the watershed. Roads were determined to be a major source of sediment delivery to streams in the areas studied, with Blanchard Creek noted for its high rate of sediment delivery.

In recent years, projects have been completed to reduce road impacts on streams in the Clearwater Valley. In 2015, a project on Trail Creek, a third order tributary to Morrell Creek, was completed by the River Design Group to improve fish passage conditions and eliminate entrainment of native westslope cutthroat trout and bull trout into an existing, unscreened irrigation canal (River Design Group 2017). In 2020, a decommissioning and revegetation project was completed on Morrell Creek by the Big Blackfoot Chapter of Trout Unlimited. This project decommissioned 1.6 miles of road and moved the road to an upland area where it would not impact the stream. The goal was to improve floodplain function, water quality, and habitat conditions for native fish in Morrell Creek, which are limited by excess sediment (Fish Management Bureau 2015). Other projects to improve transportation networks throughout the Valley have been completed or are ongoing.

3.0 Watershed Condition

3.1 Stream Water Quality

Surface waterbodies in the Clearwater Valley hold significant value to the Seeley Lake community. Lakes and streams are economically, recreationally, and ecologically significant. The streams, whether first order tributaries or third order rivers, feed into and through the lakes that compose the centerpiece of the Valley.

The Clearwater Resource Council (CRC) began monitoring streams in the Clearwater Valley in 2008. In 2013, with funding primarily provided from the Southwest Crown Collaborative, a citizen science pilot project was initiated with the goal of examining potential linkages between sediment delivery (via road erosion) and in-channel water quality conditions. Road erosion can be a potential source of nutrients, notably phosphorus that adheres to suspended sediment that can be transported in the water column rather than deposited in the channel bed (Naiman et al. 1992; Craft et al. 1999; Ellis et al. 1999).

CRC in collaboration with local schools, volunteers, and neighboring organizations conducted extensive sampling to characterize turbidity, total suspended solids (TSS) and nutrient concentrations (total nitrogen and phosphorus) in Clearwater Valley streams (Rieman and Wallenburn 2014; Rieman and Wallenburn 2015; Rieman and Wallenburn 2017; Dixon et al. 2020).

Sampling extended across the basin including most of the major tributaries to the larger Valley bottom lakes. The number of sites and parameters varied somewhat each year, depending on funding. Samples were collected multiple times throughout the year between February and September, with effort focused most during the highest flows in April, May and June. Because earlier work showed that these metrics were strongly influenced by discharge, sampling was focused on the timeframe around spring runoff. Sampling locations (Figure 13) were selected in an effort to identify potentially important sources that could influence downstream lakes.

Turbidity was analyzed on a Hach 2100C turbidimeter with standard calibration procedures. Nutrients and TSS were analyzed by the Flathead Lake Biological Station. In addition to water quality sampling, continuous discharge was also measured at a single site and used to estimate loading of nitrogen and phosphorus.

Additional sampling was not planned after 2017. However, in late summer 2017 two large wildfires, the Liberty Fire (>28,000 acres) and the Rice Ridge Fire (~160,000 acres), burned across parts of the Clearwater Valley. At least five streams experienced moderate or severe fire in a substantial portion their watersheds. It was generally agreed that continued monitoring of burned and unburned streams would be valuable. Sampling continued in 2018, 2019, and 2020 until funds were exhausted.

The total mass of nitrogen and phosphorus exported from each watershed was estimated by multiplying the estimated total discharge in each sampling interval by the concentration in the appropriate sample and summing over the sampling season. We also normalized the estimated nutrient export for comparison among watersheds by dividing by watershed area.

The discharge of Morrell Creek was used as the basis for flow estimation and comparison among the study streams. At the Morrell gage site, flow depth was continuously recorded in 1-hour intervals using a pressure logger in a stilling well at the gage. Discharge for each sampling period at each study site was estimated by scaling flows (percentage) against those observed in Morrell Creek (Rieman and Wallenburn 2014).

Results indicated that water quality varied substantially within and among streams across the Valley and that continued monitoring would be important in resolving nutrient sources potentially influencing lake water quality. In the first year of sampling, results varied widely among and within the sampled streams throughout the season (Figures 14-16).

The highest turbidity values were observed in Blind Canyon, Deer, Seeley and Rice Creeks (Figure 17). Trail, Mountain and Black Canyon Creeks were consistently the least turbid. In general, turbidity values peaked with the highest flows in April and May. Maximum turbidity ranged by an order of magnitude from about 2.6 NTU in Mountain and Black Canyon Creeks to 37.6 NTU in Blind Canyon Creek. Means ranged about five-fold from about 1.1 NTU in Black Canyon Creek to 5.4 NTU in Seeley Creek. Streams were generally least turbid as low flow conditions were approached in August. Nitrogen and phosphorus also varied seasonally and among streams though differences were less dramatic than with turbidity. Total phosphorus peaked during high flows and ranged from about 13 µg/l in Trail Creek to 39 µg/l in Blind Canyon Creek. For reference, the proposed water quality standard for Montana streams in this region is 25 µg/l (Suplee and Watson 2013). Total phosphorus and turbidity were positively correlated (r=0.73) as anticipated, though there was substantial variation in total phosphorus at lower turbidities.

Total nitrogen tended to peak in winter and spring before and during highest flows and during the lowest temperatures. Peak concentrations ranged from 152 to 481 µg /l among streams. The proposed water quality standard for total N in streams of this region is 275 µg /l (Suplee and Watson 2013). The highest concentration of N across streams was before or during high flow, while the lowest concentrations were observed during late summer when streams were warm and biological uptake of nitrogen was likely highest (e.g., Gardner and McGlynn 2009).

Several streams were consistently high (Rice, Seeley, Deer: Figure 18) or consistently low (Trail, Upper Cottonwood, Morrell) in all three measures of water quality. Other streams were high in total P (Black Canyon), or total N (Mountain), but low in turbidity or the other nutrients. This finding is consistent with earlier work (EPA 1977). Three sites (Seeley Creek, Rice Creek, Deer Creek) were part of a nutrient loading study conducted by EPA (1977). That study estimated nutrient concentrations throughout the year on all three streams and the total nutrient load for nitrogen and phosphorus for Seeley Creek and Deer Creek. Each of these streams has a history of intensive forest management and was considered to be a potentially important nutrient source for Seeley Lake. In the past, Deer Creek was listed as water quality impaired under the 303d process for the State of Montana.

In the first year of sampling, the estimated export of total phosphorus ranged from ~20 kg, to more than 450 kg among the sampled streams. Deer Creek was the most important source contributing almost two times the total phosphorus of any other stream. The export of total phosphorus by watershed area ranged from 8.66 and 8.99 kg/km2 in Deer and Seeley Creeks, respectively, to 3.86 kg/km^2 in Trail Creek. Estimated export of total nitrogen ranged from about 140 kg in Little Shanley Creek to more than 4,200 kg in Deer Creek. The relative export ranged from about 37 kg/km^2 in Little Shanley Creek to about 81 kg/km^2 in Deer Creek and 114 kg/km^2 in Seeley Creek. The estimated export of total phosphorus from Deer Creek in 2013 was about 62% of that in 1975, while total nitrogen was about 31%. The estimated export of total phosphorus in Seeley Creek in 2013 was more than twice as high as that in 1975, while total N was slightly lower. While nutrients were sampled in Rice Creek in 1975, export of nitrogen and phosphorus was not estimated for Rice Creek in 1975. Comparison of nutrient concentrations measured in Deer, Seeley, and Rice Creeks in 1975 and 2013 showed mixed patterns. Concentrations of total phosphorus and nitrogen measured in Deer Creek were generally higher in1975 than on similar dates in 2013. In Seeley Creek, total phosphorus concentrations appeared to be mostly higher in 2013 than 1975, while total nitrogen appeared to be mostly lower In Rice Creek both phosphorus and nitrogen appeared to be lower in 2013, but the frequency of sampling in Rice Creek in 1975 was much less than the other streams so comparisons were limited. Detailed results of the first year of sampling are available on CRC's website (Rieman and Wallenburn 2014).

Nutrient loading was re-evaluated after the 2016 sampling year (Rieman and Wallenburn 2017). Calculations of mass loading normalized by contributing area show that of the total nutrient loading of the Clearwater River below Owl Creek and immediately upstream of Salmon Lake, 90% of P and 81% of N came from Owl Creek or the Clearwater River above Owl Creek.

Estimates for nutrient loading to Seeley Lake (EPA 1977) estimated that Deer Creek and the Clearwater River were the major sources of nutrient loading contributing 17% and 64% of the total, respectively. Rieman and Wallenburn (2017) redid the loading estimates for the Valley. They reported that 71% and 66% of the P and N at the outflow of Seeley

Lake came from the Clearwater River above the lake, 15% and 18% respectively from Deer Creek, and 8% and 12% respectively from unknown sources that might include groundwater or the lake itself.

Seeley, Rice and Richmond Creeks showed elevated concentrations in all metrics. Each of these streams had been flagged as potential concerns in 2013 (Rieman and Wallenburn 2014). Deer Creek showed particularly elevated concentrations of N and had been identified as an area of concern in the past. Deer Creek also represents a significant portion of the total nutrient load entering Seeley Lake. Boles and Placid creeks showed particularly elevated concentrations of P and could account for most of the N and P in Owl Creek below Placid Lake. Owl Creek showed particularly elevated concentrations of both nutrients and an estimated 35% of total N and 45% of total P destined for the Clearwater River immediately above Salmon Lake.

To directly evaluate the relationship between roads and water quality, scatter plots were created of turbidity, N and P with measures of the Geomorphic Road Analysis and Inventory Package (GRAIP) sediment delivery software package (USFS 2012). However, only an incomplete summary of the road metrics for all streams was available. Scatter plots of turbidity against road sediment showed no relationship (Rieman and Wallenburn 2014). Scatter plots of N, P, and the normalized composite of all three variables were generally positive, but sample sizes were limited. Reanalysis is recommended.

After the initial year of monitoring, stream sampling was performed in 2016-2020. Sampling varied from the initial year due to the nature of citizen science, meaning the availability of volunteers throughout the sampling season. However, the same parameters of turbidity, total nitrogen and total phosphorus were collected. Over the entire period of available sampling (1975, 2013, 2016-2020), the following trends were observed:

- Values of turbidity, total nitrogen and total phosphorus all increased in the year (2018) after extensive wildfire in 2017 (Figures 14-16) but by 2019, most values were decreasing.
- Rice, Seeley, and Deer Creek had high nitrogen and phosphorus concentrations in the initial EPA (1977) study (Figures 17 and 18).
- Rice, Seeley, and Deer Creeks had consistently high values of turbidity, nitrogen, and phosphorus (Figures 17 and 18).
- Seeley Creek consistently ranked among the highest in concentrations of nutrients and turbidity.
- Loading of nitrogen and phosphorus to downstream lakes is influenced by the size of the contributing watershed more than the concentration of nutrients. Streams with the largest contributing areas (Morrell Creek and Deer Creek) are generally more important due to their higher annual discharge volume.

- The initial year of sampling indicated that 4,200 kg of nitrogen was exported from Deer Creek to the Clearwater River and then to Seeley Lake. This magnitude of loading is significant.
- Deer Creek appears to continue to be a significant contributor of the mass of nitrogen and phosphorus entering the Clearwater River.
- Morrell Creek nutrient levels sampled above the town of Seeley Lake and below the town of Seeley Lake showed consistent increases in nutrients as the Creek traversed the more developed area.
- Owl Creek showed high levels of nutrients and could be a significant contributor to downstream locations, particularly Salmon Lake.

Figure 13. Locations of stream sampling sites conducted in the Clearwater Valley between 2013 and 2020.

Table 5. Names, three letter codes, location, elevation, drainage area, and mean annual flow for streams sampled in the Clearwater Valley between 2013 and 2020.

Site Name	Site **Code**	Latitude **°N**	Longitude **°W**	Elevation **(ft)**	Drainage Area **(km^2)**	Mean Annual Flow **(cfs)**
Morrell Creek @ Cottonwood	MDM	47.19403	-113.45562	4194	68.39	40.47

Lakes Rd

Trail Creek @ Cottonwood Lakes Road	TRL	47.19064	-113.43141	4265	40.01	19.94
Blind Canyon Creek > Trail Creek	BLI	47.19705	-113.42330	4281	23.88	12.23
Deer Creek @ Boy Scout Road	DER	47.21035	-113.54176	4042	51.70	25.14
Seeley Creek @ SOS Road	SEL	47.18307	-113.48162	4124	13.51	2.98
Mountain Creek @ Stockings	MTN	47.17679	-113.42311	4386	16.88	5.40
Rice Creek @ Ranger Station Rd	RIC	47.21526	-113.52072	4065	7.38	1.50
Swamp Creek	SWP	47.18862	-113.42317	4333	12.12	5.87
East Fork Clearwater R. @ Hwy 83	EFC	47.34684	-113.58779	4180	45.15	28.11
West Fork Clearwater R. @ USFS Rd 463	WFC	47.25227	-113.58351	4153	87.65	65.41
Richmond Creek @ Hwy 83 (est.)	RCM	47.32545	-113.57875	4239	5.02	1.91
Placid Creek > Boles Creek	PLC	47.11986	-113.54896	4137	128.16	64.79
Boles Creek > Placid Creek	BOL	47.11953	-113.54912	4136	51.52	34.60
Owl Creek > Clearwater R. (est.)	OWL	47.11589	-113.45695	3953	235.89	110.90
Clearwater R. < Seeley Lake	LCL	47.18433	-113.51684	3960	385.29	171.64
Clearwater R. > Seeley Lake	UCL	47.23570	-113.53805	4045	258.31	131.57
Camp Creek @ Hwy 83	INZ	47.27176	-113.55724	4150	28.64	9.83
Uhler Creek @ Westside Road	UHL	47.29386	-113.58204	4203	8.49	2.99
Colt Creek @ FSR 646	CLT	47.32857	-113.59657	4474	10.20	4.08
Bertha Creek @ Summit Park Rd	BER	47.36367	-113.59835	4110	13.68	4.23

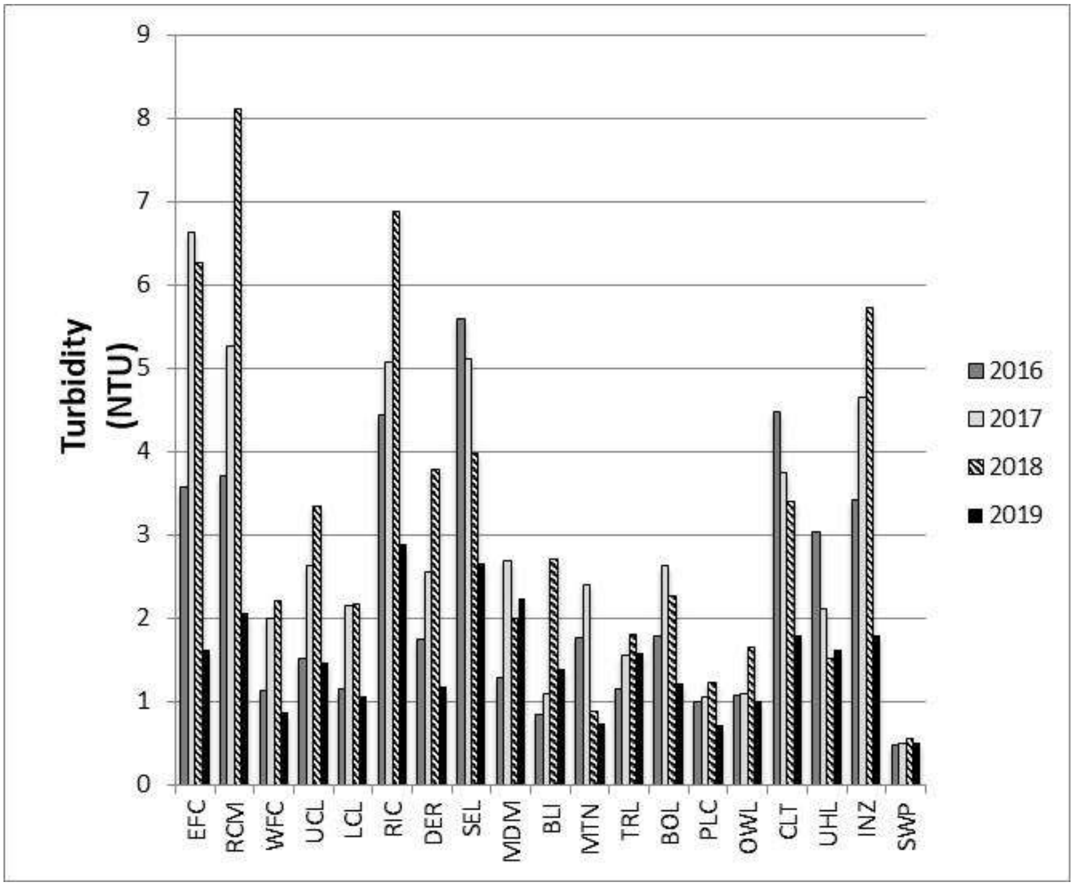


Figure 14. Results of turbidity sampling in Clearwater Valley streams from 2016-2019. MDM is Morrell Creek at Cottonwood Lakes Rd., TRL is Trail Creek, BLI is Blind Canyon Creek, DER is Deer Creek, SEL is Seeley Creek, MTN is Mountain Creek, RIC is Rice Creek, SWP is Swamp Creek, EFC is East Fork Clearwater River, WFC is West Fork Clearwater River, RCM is Richmond Creek, PLC is Placid Creek, BOL is Boles Creek, OWL is Owl Creek, UCL is Clearwater River above Seeley Lake, LCL is Clearwater River below Seeley Lake, INZ is Camp Creek, UHL is Uhler Creek, CLT is Colt Creek, and BER is Bertha Creek.

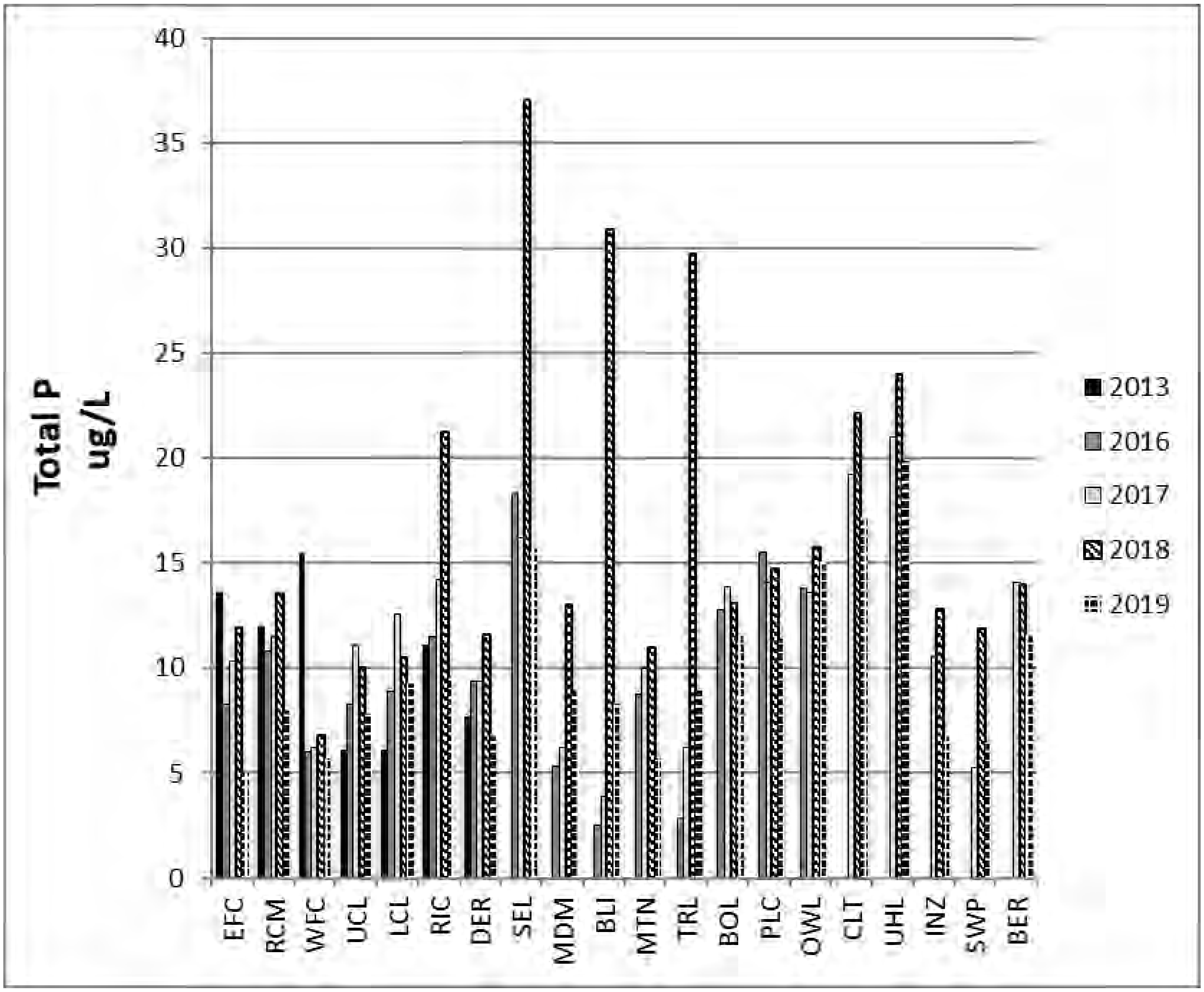


Figure 15. Total phosphorus sampled in Clearwater Valley streams between 2013 and 2019. MDM is Morrell Creek at Cottonwood Lakes Rd., TRL is Trail Creek, BLI is Blind Canyon Creek, DER is Deer Creek, SEL is Seeley Creek, MTN is Mountain Creek, RIC is Rice Creek, SWP is Swamp Creek, EFC is East Fork Clearwater River, WFC is West Fork Clearwater River, RCM is Richmond Creek, PLC is Placid Creek, BOL is Boles Creek, OWL is Owl Creek, UCL is Clearwater River above Seeley Lake, LCL is Clearwater River below Seeley Lake, INZ is Camp Creek, UHL is Uhler Creek, CLT is Colt Creek, and BER is Bertha Creek.

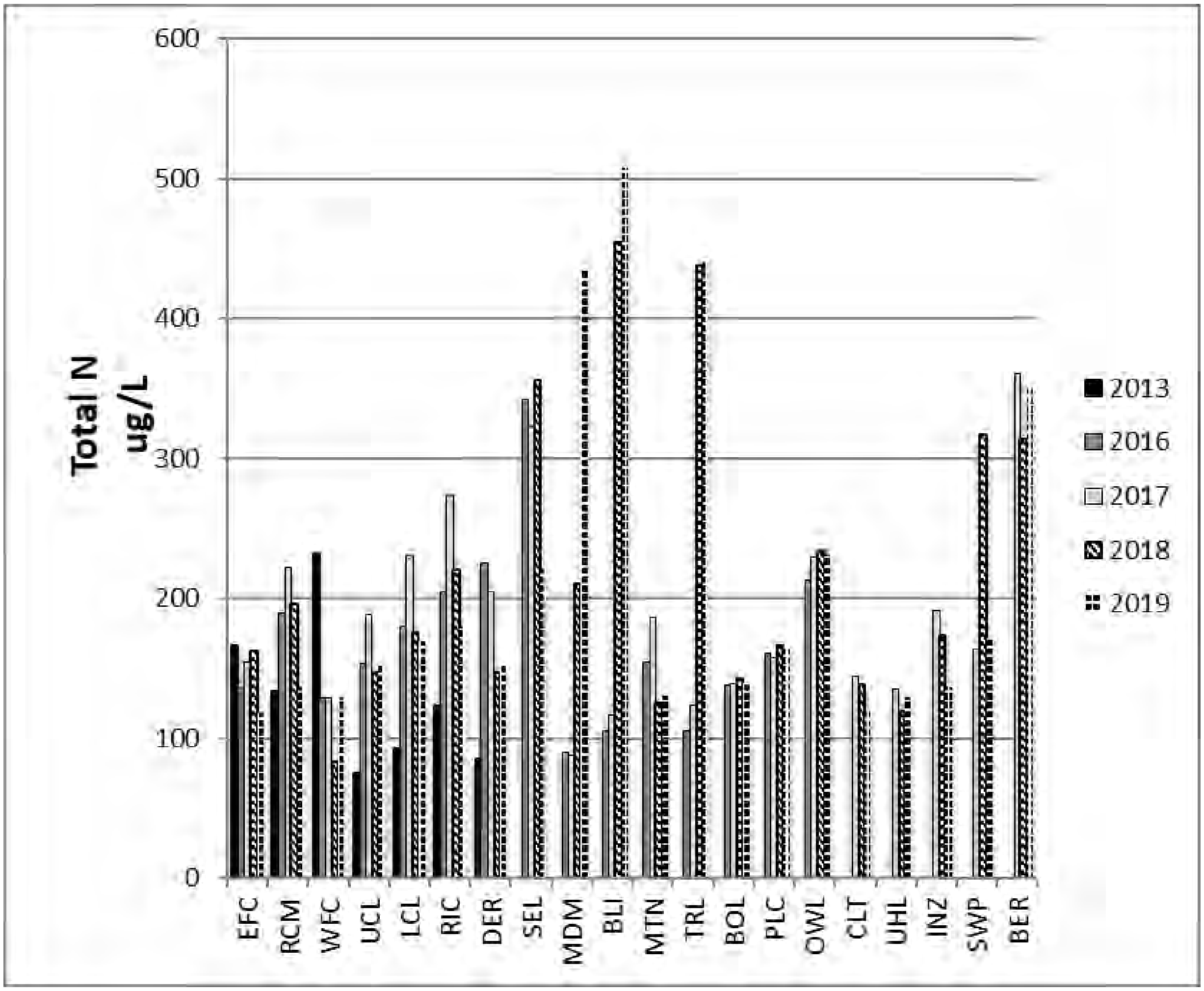


Figure 16. Total nitrogen in Clearwater Valley streams sampled between 2013 and 2019. MDM is Morrell Creek at Cottonwood Lakes Rd., TRL is Trail Creek, BLI is Blind Canyon Creek, DER is Deer Creek, SEL is Seeley Creek, MTN is Mountain Creek, RIC is Rice Creek, SWP is Swamp Creek, EFC is East Fork Clearwater River, WFC is West Fork Clearwater River, RCM is Richmond Creek, PLC is Placid Creek, BOL is Boles Creek, OWL is Owl Creek, UCL is Clearwater River above Seeley Lake, LCL is Clearwater River below Seeley Lake, INZ is Camp Creek, UHL is Uhler Creek, CLT is Colt Creek, and BER is Bertha Creek.

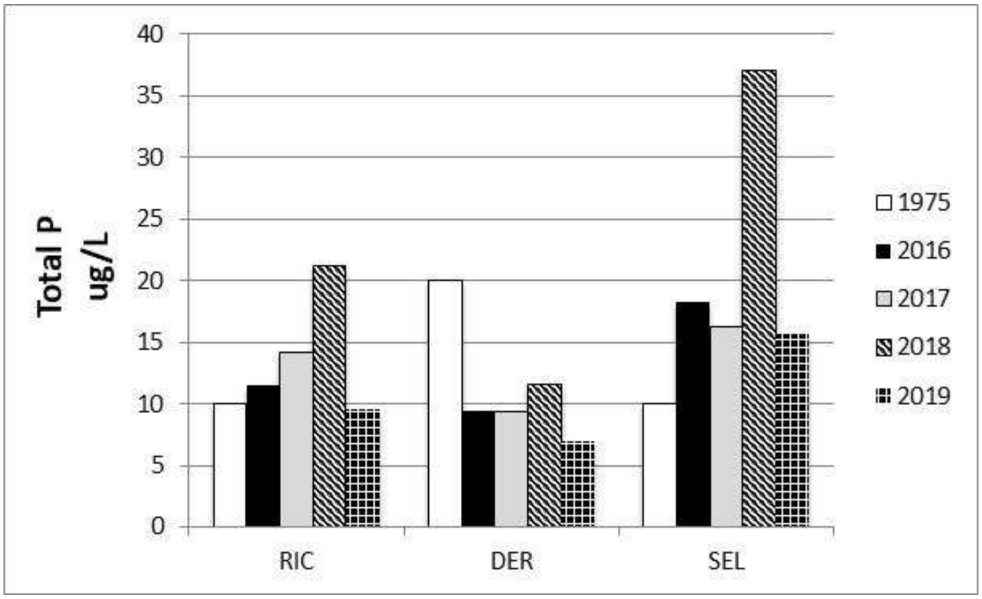


Figure 17. Total phosphorus in Rice Creek (RIC), Deer Creek (DER), and Seeley Creek (SEL) sampled in 1975 and then again from 2016-2019.

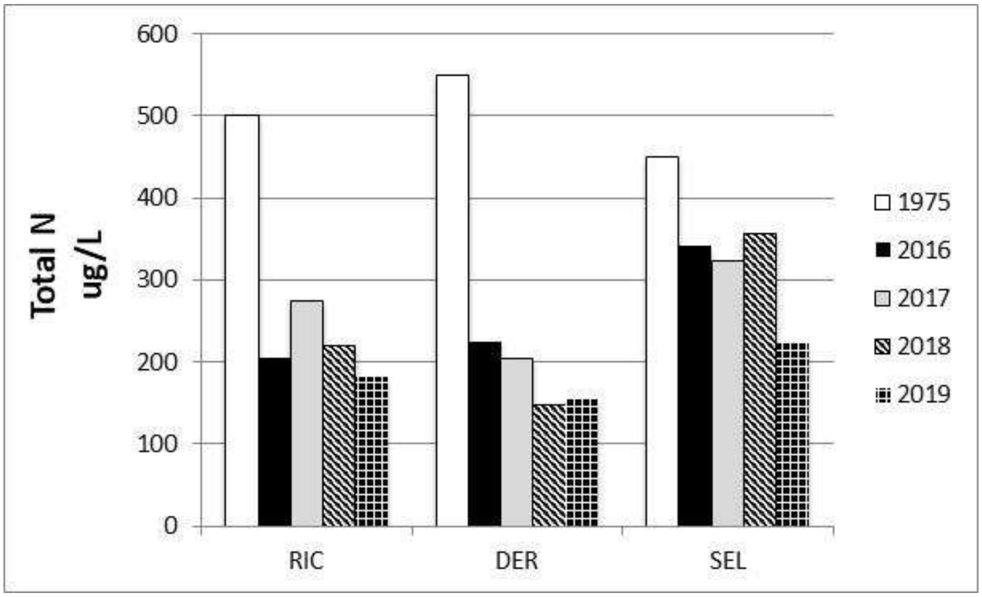


Figure 18. Total nitrogen sampled in Rice Creek (RIC), Deer Creek (DER), and Seeley Creek (SEL) in 1975 and again from 2016-2019.

3.2 Lake Water Quality

3.2.1 Background

Since 2008, CRC has worked with community members to build a foundational knowledge of the conditions of our lakes, how they function, and their vulnerability to change. In late summer of 2008, CRC initiated a community-based lake-monitoring program, which was continued and expanded in subsequent years. Major lakes in the Clearwater Basin have been sampled over the years from roughly May through September. For 2023, This was the 15th full season of sampling, and six lakes were monitored: Lake Alva, Big Sky Lake, Lake Inez, Placid Lake, Salmon Lake, and Seeley Lake. Clearwater and Rainy Lakes were included in previous years, but monitoring on these two lakes was discontinued in 2020.

Two measures used to determine lake health are Secchi transparency and surface temperature. These parameters have been measured the most consistently in the 15 years on the major lakes in the basin. Secchi transparency is a simple metric widely used in both community-based monitoring and higher-level scientific research. Because water transparency is directly influenced by the amount of phytoplankton (microscopic plants or algae in open water), it can be a good index of the amount of plant growth in the lake. Plant growth can be positive because it indicates productivity within the aquatic system. However, once such growth exceeds a certain threshold, it can be a sign of nutrient pollution and precede a switch to eutrophic conditions.

Temperature is an important parameter to study in correspondence with Secchi transparency because dramatic changes in temperature can affect plant growth, thus affecting other aspects of aquatic health. In addition, many native fish like the threatened bull trout rely on consistently cold water to survive. Water temperature fluctuations, whether due to anthropogenic or natural reasons, can lead to declines in native fish populations. Temperature is also correlated with oxygen levels in aquatic systems, as cold water holds more oxygen than warm water. Identifying temperature trends can help predict or prepare for other changes within the lake systems in the Clearwater Watershed.

Dissolved oxygen is a key component to lakes’ ability to support diverse aquatic life, and a foundational knowledge of oxygen levels is important in understanding the health of our lakes and how conditions may be changing. Different types of aquatic organisms require different levels of oxygen depending on how large or complex the animal is and where it lives in the water column. Smaller benthic creatures are often more adapted to lower oxygen levels, while larger fish require higher oxygen levels.

Low levels of oxygen (hypoxia) or no oxygen (anoxia) can occur when excess organic materials, such as large algal blooms, are decomposed by microorganisms. During this decomposition process, dissolved oxygen (DO) in the water is consumed. In some water bodies, DO levels fluctuate periodically, seasonally, and even as part of the natural daily ecology of the aquatic system. However, anthropogenic nutrient inputs can negatively affect DO, and if levels drop substantially, sensitive animals may relocate, decline in health, or even die.

Adkins (2023) conducted a literature review to support the preparation of this Plan. This review reported: “Dissolved oxygen (DO) levels are a crucial indicator of the oxygen available to aquatic organisms in a water body (Weinke and Biddanda 2017). The DO and temperature depth profiles are useful in characterizing the mixing status of a water body, the rate of hypolimnetic oxygen depletion, the period of anoxic conditions in water & sediments, and assessing whether a lake is suitable for sensitive fish species (Paul et al. 2022). Anoxic conditions may create favorable conditions for blue-green (BG) algae, which may produce toxic microcystins. The absence of oxygen in the bottom sediments can also lead to the release of dissolved constituents such as heavy metals, inorganic phosphorus, ammonia, and hydrogen sulfide (Paul et al. 2022).

Thermal stratification of lakes, characterized by little mixing between layers that differ in temperature and chemical concentrations (including nutrients), is a phenomenon influenced by density differences associated with temperature (Gibson 2000). Many lakes are stratified during winter and summer seasons, while mixing occurs during spring and fall. Deeper lakes generally exhibit more stratification, while shallower lakes experience more mixing (Paul et al. 2022).

Globally, there is an increasing trend toward greater hypoxia (insufficient oxygen to support fish) in deeper waters, which many scientists attribute to climate change. The warming climate reduces solubility of oxygen in water and intensifies lake stratification, reducing mixing and downward transport of oxygen (Weinke and Biddanda 2017; Gibson 2000). And oxygen-consuming respiration increases with temperature while increased nutrient loading may support more oxygen demanding life.

Historically, there has been hypolimnetic oxygen depletion in summer in Salmon and Seeley Lakes (Watson 2012). In CRC’s 2020-2023 data, hypolimnetic oxygen depletion was observed in nearly all lakes sampled, with the highest rates in Big Sky. Understanding this phenomenon is essential to deciphering whether this phenomenon is linked to human-caused eutrophication, where increased nutrient loading increases algal production, resulting in higher decomposition rates in bottom waters. This process can result in the formation of anoxic "Dead zones," harmful algal blooms, and fish kills. In 2012, The freshwater aquatic life protection standards in Montana specified that the State's water quality standards for dissolved oxygen aim for a 5ppm minimum as a 7-day mean; however, when early life stages are present, the 7-day mean standard is elevated to 9.5 ppm (Watson 2012). However, these standards may have become more complex since this time.”

Under some conditions associated with low oxygen near the lake bottom, stored nutrients can be released, making the lake a source of nutrients for itself and other lakes downstream. This change in conditions is called a “tipping point” and is associated with eutrophication, a condition where an excess of nutrients can cause dense plant growth followed by death of animal life due to lack of oxygen. It can be extremely difficult to reverse these conditions once they occur. In her 2012 analysis of potential loading sources for Clearwater Lakes, Watson noted that because of the population growth near Seeley and Salmon Lakes in recent years, and the most recent total P data, it is likely that these two lakes are near the tipping point between mesotrophic and eutrophic. This further suggests that it is critical to expand monitoring efforts to learn about water quality and prevent habitat degradation. Because DO is vital to the functioning of lake systems, it is one of the most important parameters in our understanding of lake trophic statuses, human impacts, and long-term trends. Historical DO monitoring by CRC and other local entities is summarized below.

3.2.2 Methods

The methods used to measure transparency and surface temperature between 2011-2020 are outlined in CRC's sampling and analysis plan (available from CRC). In summary, the approach is as follows: transparencies were measured with a 20 cm black and white quadrant Secchi disk suspended on a fiberglass tape measure. The disk was lowered into the water until it disappeared from view. This was performed twice, and the two readings were averaged. The following measures were followed in an attempt to control some of the limiting factors associated with Secchi readings: data were recorded between 11 am and 3 pm, without sunglasses, on the shady side of the boat, two times at each site.

The surface temperature was measured with a mercury thermometer attached to a floating bottle so that it read the temperature approximately 18 inches below the lake's surface. Once the floating thermometer was placed in the water, it was left submerged for a few minutes until the temperature stabilized. After stabilization, volunteers recorded the temperature in degrees centigrade.

CRC commenced Secchi transparency and surface temperature monitoring at the deepest spots on 8 lakes in 2009: Lake Alva, Big Sky Lake, Clearwater Lake, Lake Inez, Placid Lake, Rainy Lake, Salmon Lake, and Seeley Lake. Monitoring has continued consistently on these lakes until 2020, when Rainy and Clearwater Lakes were discontinued. Monitoring frequencies and time periods varied on each lake each year depending on volunteer availability.

A YSI Pro20 dissolved oxygen meter with a polarographic sensor was used to collect the dissolved oxygen profiles on each lake. The instrument provides measurements of DO in mg/L and % saturation, along with temperature in degrees centigrade. Prior to each set of measurements at each lake, the instrument was calibrated using a self-calibration capability designed into the instrument. Measurements were then taken at the surface and through the water column at each site. Refer to each year's report for a more complete description of methods and how they varied.

CRC commenced DO monitoring in 2009 on 3 lakes: Seeley, Alva, and Inez. Until 2020, DO profiles had not been recorded consistently on many of the other lakes in the watershed.

DO was consistently measured 5 times between spring and early fall on all 6 lakes beginning in 2021.

Also beginning in 2021, CRC initiated sampling of additional water quality parameters in six lakes: Lake Alva, Lake Inez, Seeley Lake, Placid Lake, Salmon Lake, and Big Sky Lake. Water samples were collected and sent to the Flathead Biological Station for analysis of total nitrogen (TN), total phosphorus (TP), nitrite and nitrates, and soluble reactive phosphorus. Samples were also taken at various locations for determination of *E. coli* levels. In addition, a Sonde EX03 hydrolab was used to sample lake waters for pH, specific conductance, chlorophyll, and blue green algae.

Table 6. Water quality parameters measured in six lakes in the Clearwater Valley.

Parameter or Data Type	**Collection Approach**	**Justification for Collecting**
Total Nitrogen (TN)	Parameters measured via water samples analyzed by an analytical lab	Existing nutrient impairments, track trends over time for comparisons.
Total Phosphorus (TP)	Parameters measured via water samples analyzed by an analytical lab	Existing nutrient impairments, track trends over time for comparisons
Nitrite plus Nitrate (NO_{2+3}), Soluble Reactive Phosphorus, Cl and SO4	Parameters measured via water samples analyzed by an analytical lab	Indicators of anthropogenic pollution
E. coli		Potential indicator of septic leachate reaching surface waters, if paired with additional eDNA analysis of *E. coli* source.
pH	Parameters measured *in situ* with Sonde EXO3 field meter.	Description water quality measurements.
Water temperature	thermometer	
Specific conductance (SC)	Hydrolab	
Total Algae	Hydrolab	
Dissolved oxygen (DO)	Measured in situ with YSI Pro 20 DO Meter.	

Parameter or Data Type	Collection Approach	Justification for Collecting
Photos	Taken with digital camera	Tracking site conditions, benthic algae conditions, and other site conditions; low-cost.

3.2.3 Secchi transparency and surface temperature results

There were no drastic changes or trends apparent in the Secchi data throughout 2009-2020. In general, there have been consistent differences between lakes and common patterns within lakes across years. For all lakes monitored through CRC's program, both Secchi depth and surface temperature typically increased as the summer progressed. There is year to year variability in each lake's mean transparencies and temperatures, but overall there have been no consistent declines or improvements in conditions throughout the entire period of monitoring (Figures 19 and 20). Lee et al. (1995) suggested criteria for trophic status of lakes (Table 7).

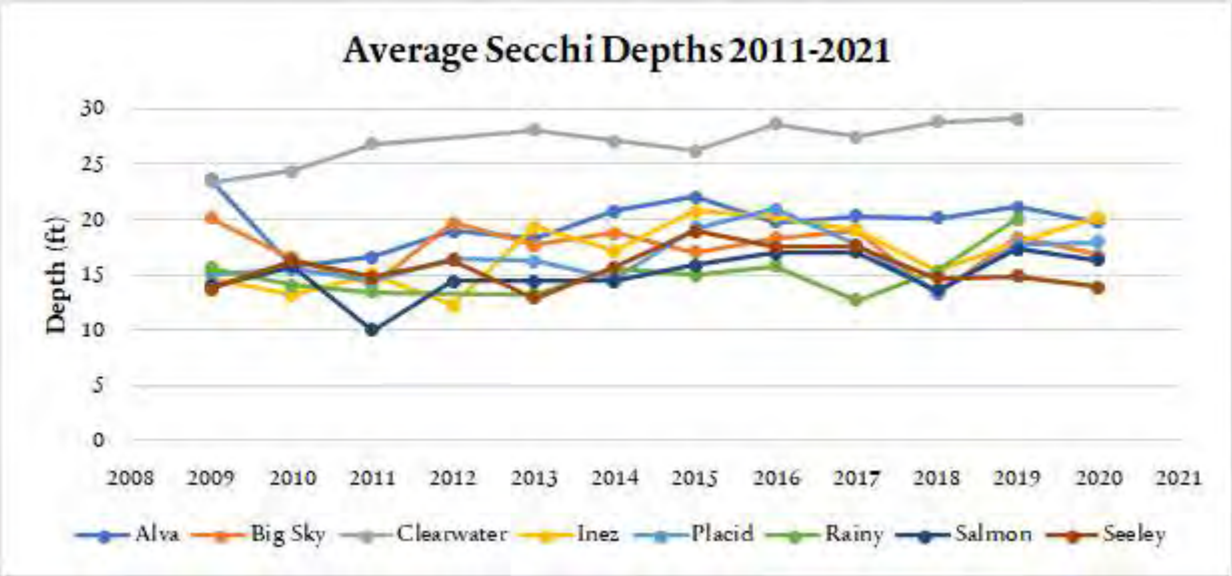


Figure 19. Yearly averages of Secchi depths recorded at one or more sites in eight lakes in the Clearwater Watershed, 2009 through 2020. Note that as of 2020, Clearwater and Rainy Lakes were omitted from monitoring.

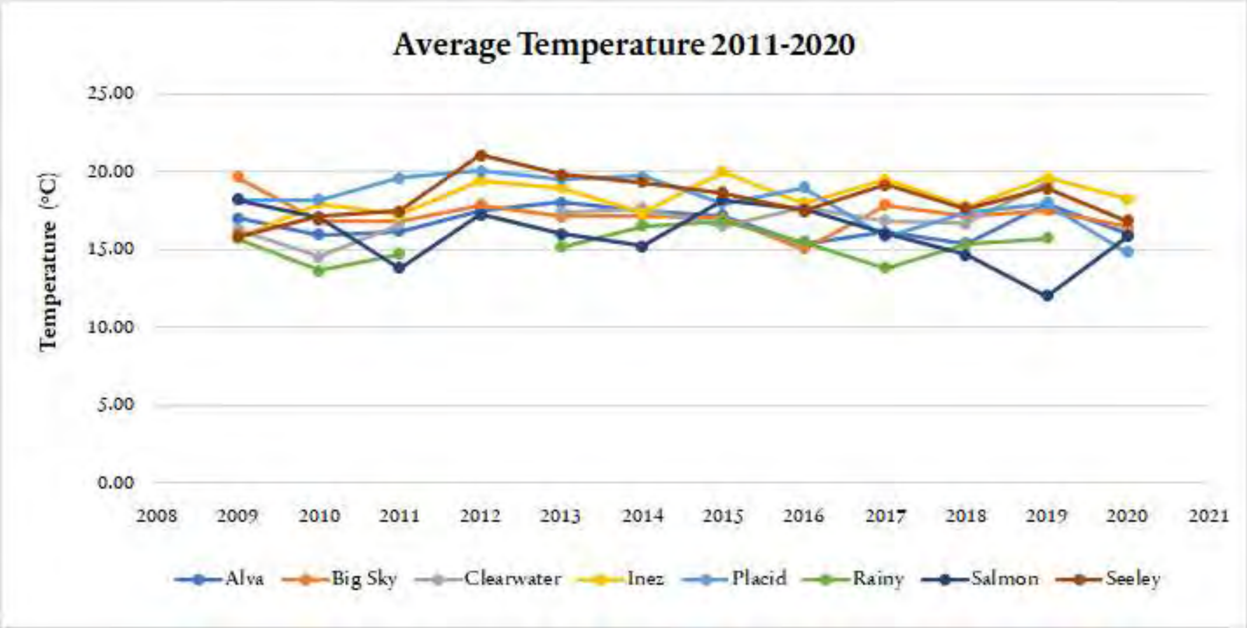


Figure 20. Yearly averages of surface temperatures recorded at one or more sites in eight lakes in the Clearwater Watershed, 2009 through 2020. Note that as of 2020, Clearwater and Rainy Lakes were omitted from monitoring.

Table 7. Criteria for lake trophic state from Lee et al. 1995.

Classification	**Average Planktonic Algal Chlorophyll (ug/L)**	**Average Secchi Depth (ft)**	**Average In-Lake Total P (ug P/L)**
Oligotrophic	< 2	> 15	< 7.9
Oligotrophic-mesotrophic	2.1-2.9	15-12.5	8-11
Mesotrophic	3.0-6.9	12-8	12.-27
Mesotrophic-eutrophic	7.0-9.9	8-6	28-39
Eutrophic	>10	<6	>40

Transparencies in 2020 ranged from a low of approximately 7 feet on Seeley Lake in May to a high of 26 feet on Lake Inez in July. Transparencies were generally the lowest early in the year and increased in depth throughout the summer (with some fluctuations). When stream flows peak during spring runoff, the amount of sediments and thus turbidity increase, decreasing the lakes' transparency as a result. As snowmelt and runoff decline with the progression of summer, transparencies begin to increase.

Lake Alva has consistently shown relatively deep Secchi depths, and the last 7 years of data have been consistent with this trend, with an average transparency of approximately 20 feet in 2020 (Figure 21). From 2011-2020, Lake Alva's Secchi depths have been recorded below the oligotrophic boundary (Figure 21). Conversely, Seeley Lake consistently has some of the shallowest mean transparencies, and recent data have been between the "oligotrophic" and "eutrophic" depth boundaries (Figure 21). An oligotrophic lake is low in nutrients but high in oxygen, while a eutrophic lake is high in nutrients and dense in plant growth that often results in oxygen depletion when such growth decomposes. Before 2018, data points are mixed above and below the "oligotrophic" boundary. If this trend in decreased clarity persists on Seeley Lake, aquatic life could be affected by the underlying processes driving this change.

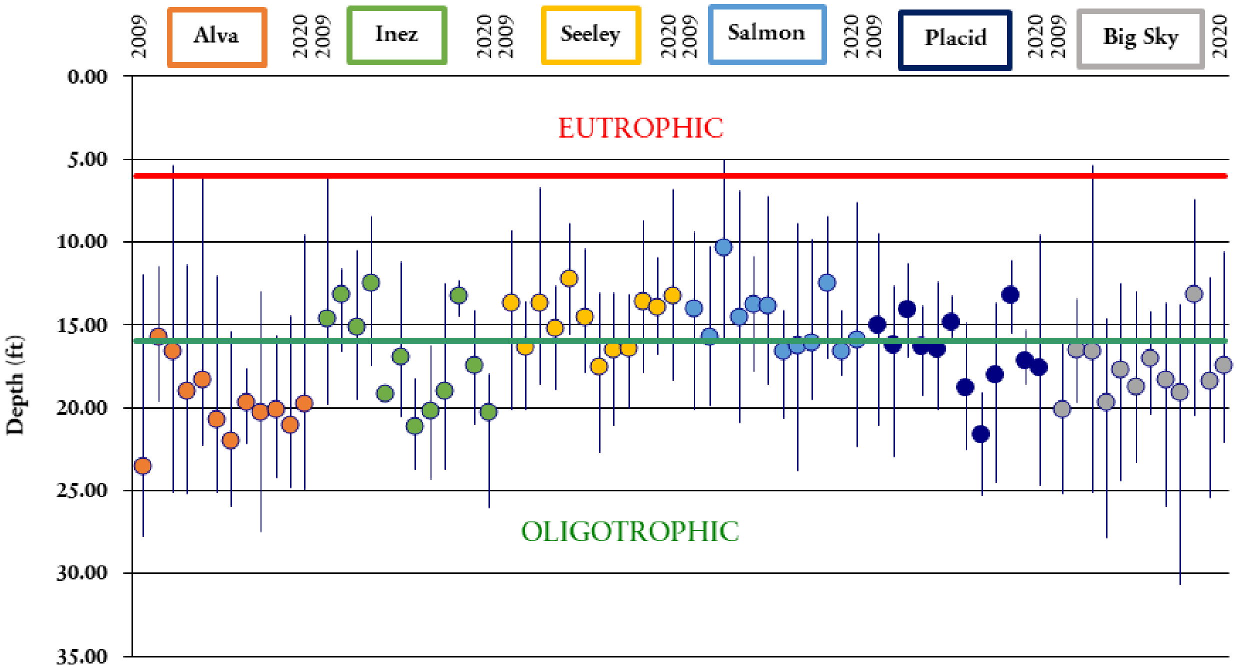


Figure 21. Continued mean (solid point) and range (vertical line) of Secchi transparencies recorded in six lakes in the Clearwater River Basin, 2009 through 2020. The red and green lines represent the bounds for transparencies considered indicative of eutrophic and oligotrophic conditions, respectively.

For the remaining lakes (Inez, Salmon, Placid, and Big Sky) the mean Secchi transparency in 2018 was one of the shallowest of all time. However, 2019 and 2020 showed deeper transparencies for all of these lakes, bringing each lake back to oligotrophic levels. One hypothesis is that the Rice Ridge Fire, which burned a large swath of land east of Seeley Lake, affected transparencies in 2018, which was 1-year post-fire. This hypothesis is supported by our stream monitoring data, which show decreased clarities in the fire affected streams 1-year post-fire.

Clearwater Lake, which was discontinued from the monitoring program in 2020, historically showed the deepest Secchi transparencies each year and was consistently classified as an oligotrophic water body based on these Secchi readings. Yearly averages ranged between 26 and 30 feet, which is deeper than that of any other lakes (Figure 19). On the other hand, Rainy Lake, which was also discontinued from the monitoring program after 2019, showed some of the shallowest yearly averages. For example, in 2017, Rainy Lake had a yearly average of only 12.75 ft (Figure 19).

Transparencies naturally vary through time in response to differences in streamflow or lake flushing, weather and patterns of warming, and other influences. The data could also vary due to inherent limitations in the methodology of collecting data via the Secchi disk. Many factors can influence Secchi data, such as a change in weather conditions, time of day of observation, or the person making observations. Differences within a lake that persist for 4-5 continuous years will be important when considering whether fundamental changes in lake trophic conditions are occurring; however, as of 2020, we have not observed any long-term continual changes in transparency.

Lake temperatures have also remained fairly consistent over the past ten years. There were no anomalies or dramatic changes in the temperature data in this most recent year of data collection. From 2011-2020, yearly temperature averages have never been lower than 12°C or higher than 22°C (Figure 21). In the most recent data collection year, no lake had a yearly average temperature lower than 14°C or higher than 19°C (Figure 20). Continued monitoring will be important so that future temperature data can be compared to that of the last 10 years in order to make conclusions regarding change.

3.2.4 Dissolved oxygen results

Throughout the years of DO monitoring on the various lakes in the Clearwater Basin, the lakes have consistently shown declines in DO concentrations with depth throughout the summer. Concentrations were often below levels considered stressful for cold water fish (~4 mg/L) in many of the lakes. DO declines appear to be the most dramatic at sites on the southern ends of each lake. This was documented in Seeley Lake throughout the years of monitoring, where the amount of DO was consistently higher in the north basin and progressively lower going south. This was because the volume of water, and hence the total amount of oxygen possible, is less in the shallower portions of the lake, which are present in the southern ends. Because there is less oxygen available to be consumed (even though it was consumed at a similar rate) in the south basin, oxygen concentrations reach lower levels in this basin earlier than in either the north or central basin. This makes the north basin the healthiest environment for fish, the central somewhat less, and the south the most stressed. This trend of decreasing DO from north to south has also been documented in Salmon Lake.

Dissolved oxygen measurements indicate substantial depletion of oxygen in Seeley and Salmon Lakes. A decline in dissolved oxygen with the progression of summer is generally related to the decomposition of organic material from near surface algal production or through biological oxygen demand in the sediments from material accumulated through time, or both. The magnitude of the oxygen demand can be an important clue to the trophic status of the lake and can influence the availability of nutrients within the lake, as well as to the rivers and lakes downstream.

Areal hypolimnetic oxygen depletion (AHOD) rates and transparency were used to estimate Trophic Status Indices (TSIs) on Seeley and Salmon lakes (when sufficient data were collected), which allow us to compare lake conditions over time (Figure 22). The TSIs calculated from transparency and AHOD for Seeley Lake were similar and indicate that Seeley Lake is mesotrophic with no apparent trend in the recent or historical data.

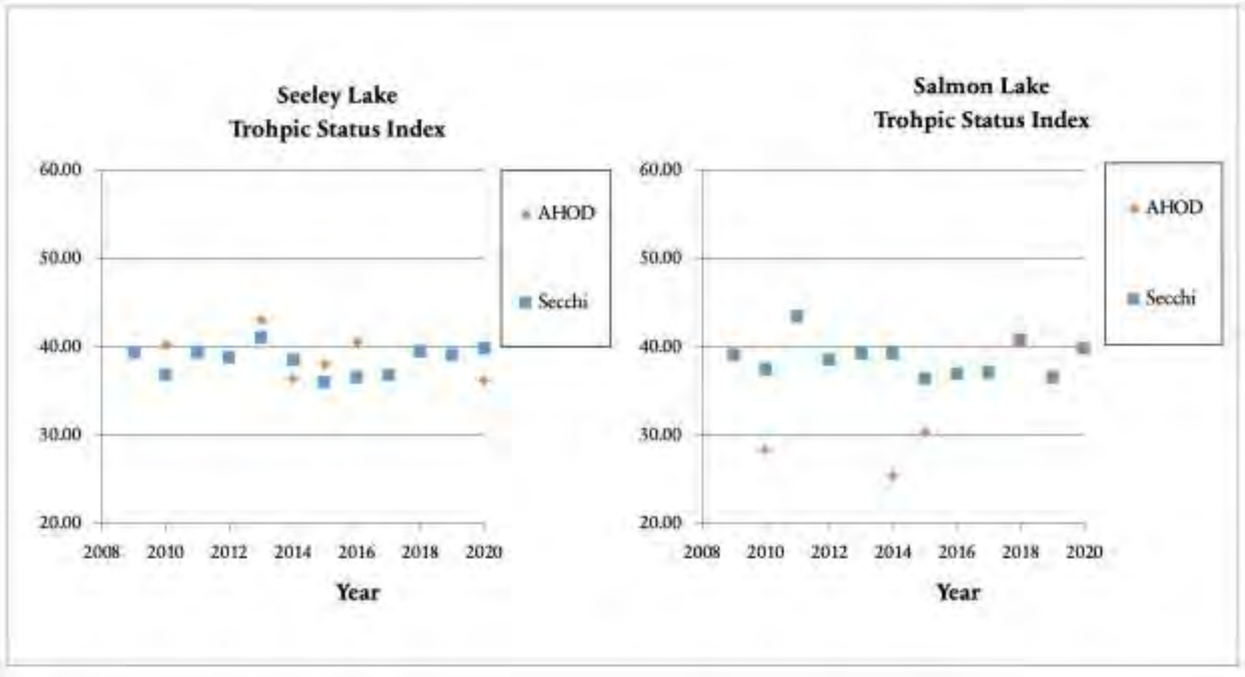


Figure 22: The trophic status index (TSI) calculated from areal hypolimnetic oxygen depletion (AHOD) and Secchi transparency for Salmon and Seeley Lakes from 2009 through 2020. Index values higher than 50 are considered eutrophic; those below 30 are considered oligotrophic. Methods for TSI, values for earlier years, and other metrics are available in Watson (2012).

Although no overall trends were evident in the data collected on Seeley Lake over time and TSI has remained in the mesotrophic range, Seeley's oxygen depletion is cause for concern and DO monitoring should continue. Concerns about rapid deterioration of water quality with continued or even accelerated nutrient loading remain. Rieman and Wallenburn (2014) found evidence that nutrient loading from Deer Creek, one of the most important nutrient sources for the lake in the past, has declined over the last 30+ years. At the same time, groundwater contamination could be increasing (Watson 2012; MT DEQ 2002). Additional nutrient information on both potential groundwater sources and other watersheds would be useful. In the interim, the lake data generated through the monitoring program provide a strong foundation for long-term evaluation of the conditions in Seeley Lake.

The TSIs calculated from transparency indicated that Salmon Lake is mesotrophic while the oxygen information indicates the lake is oligotrophic. This is consistent with earlier work where oxygen depletion rates produced more optimistic estimates of lake trophic status than any other measure of lake condition. We don't fully understand the discrepancy. It is possible that low oxygen concentrations near the bottom of the lake began to limit oxygen consumption as the season progressed and we could be underestimating the maximum rate of depletion. More frequent sampling early in the season might help resolve the inconsistencies.

Regardless of the estimated AHOD it is clear that Salmon Lake does experience extended anoxic (0 mg/L) or near anoxic conditions in the summer hypolimnion. That is troublesome because it could contribute to internal nutrient loading from lake sediments (Watson 2012) and to poor habitat conditions for cold water fish. Large-scale and persistent algae blooms in late summer have been visually identified in previous years and add to the concern. Given the available information, we conclude that Salmon Lake is well into the mesotrophic range, experiences substantial oxygen depletion, and further deterioration of water quality remains an important possibility (Watson 2012).

Lake trophic state does not equate to water quality; however, a lake moving along the trophic spectrum from oligotrophic to mesotrophic or from mesotrophic to eutrophic following human population growth in the watershed is usually the result of a human-caused increased nutrient load in the lake. Currently, the data for Seeley and Salmon Lakes do not show any marked shifts along the trophic spectrum, but more robust annual dissolved oxygen monitoring would help confirm these trends and help detect early warning signs of water quality depletion.

DO monitoring was conducted in all six of the lakes in 2021-2023. Comparisons of DO levels across the lakes are shown in Figures 23-25. These data support the same conclusions as found with the 2009-2020 sampling. However, the DO levels observed in Big Sky Lake are a concern, as this lake exhibited very low DO levels at depth throughout the entire sampling season. While Big Sky Lake’s secchi disk readings were good, the DO levels are a significant concern.

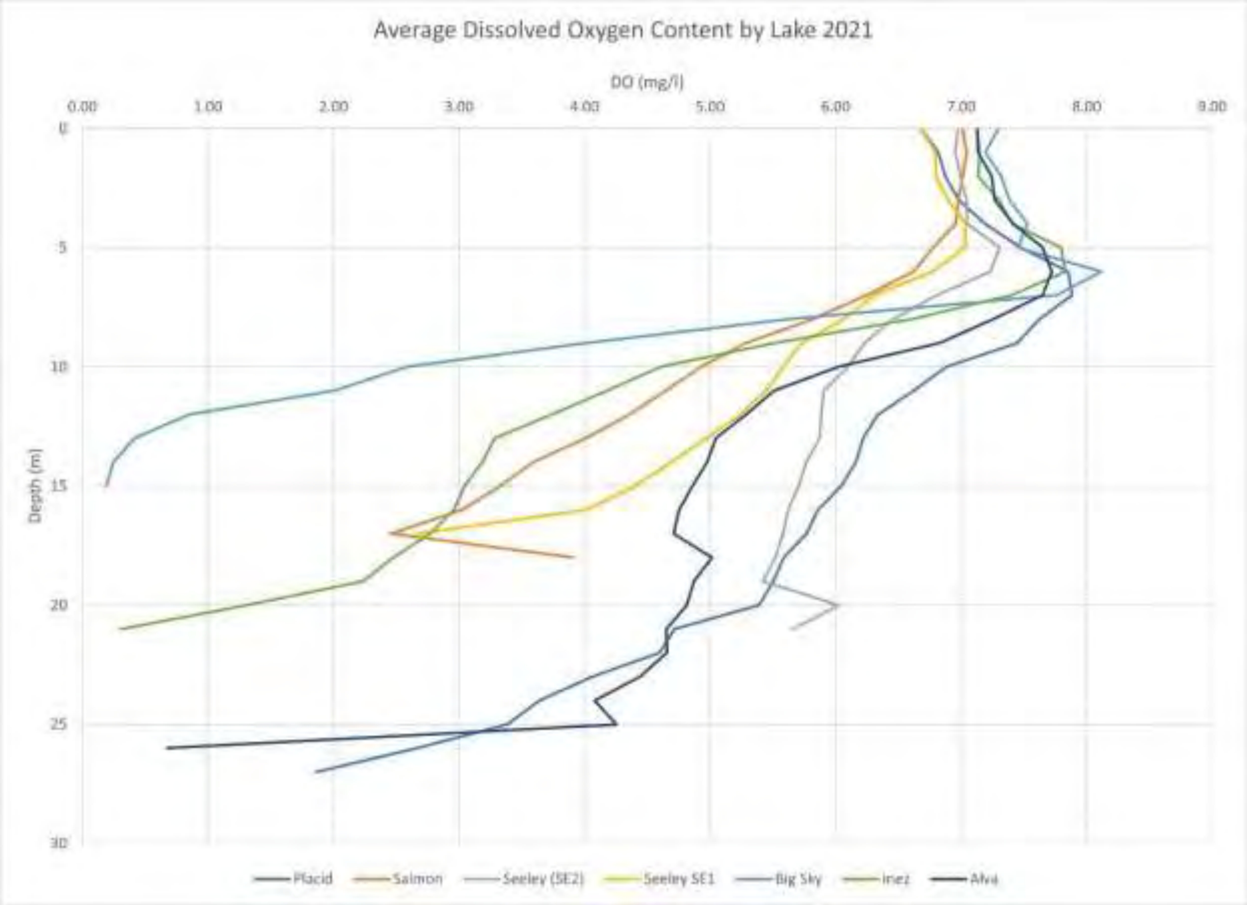


Figure 23. Dissolved oxygen by depth averaged across the 5 sampling times for each of the sampled lakes in 2021.

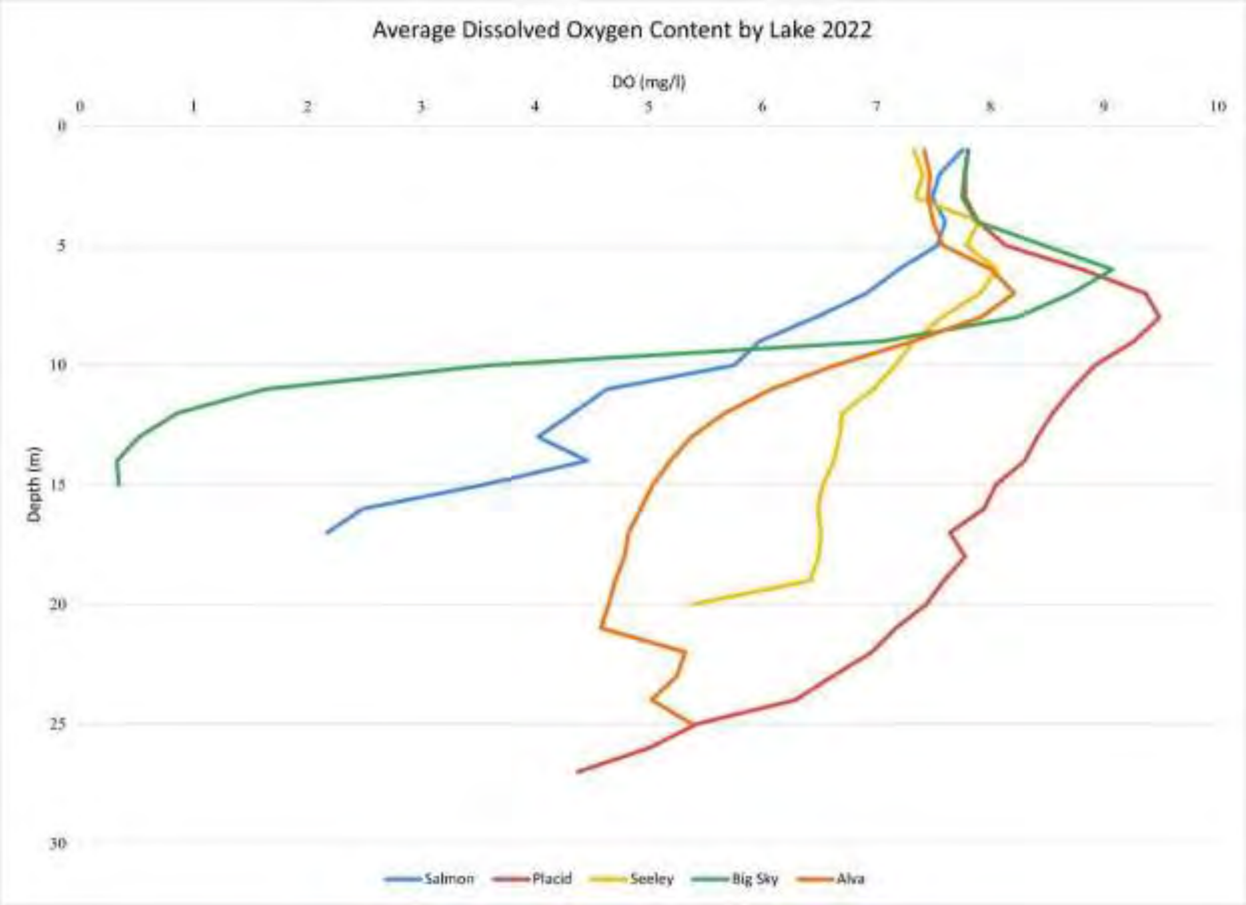


Figure 24. Dissolved oxygen by depth averaged across the 5 sampling times for each of the sampled lakes in 2022.

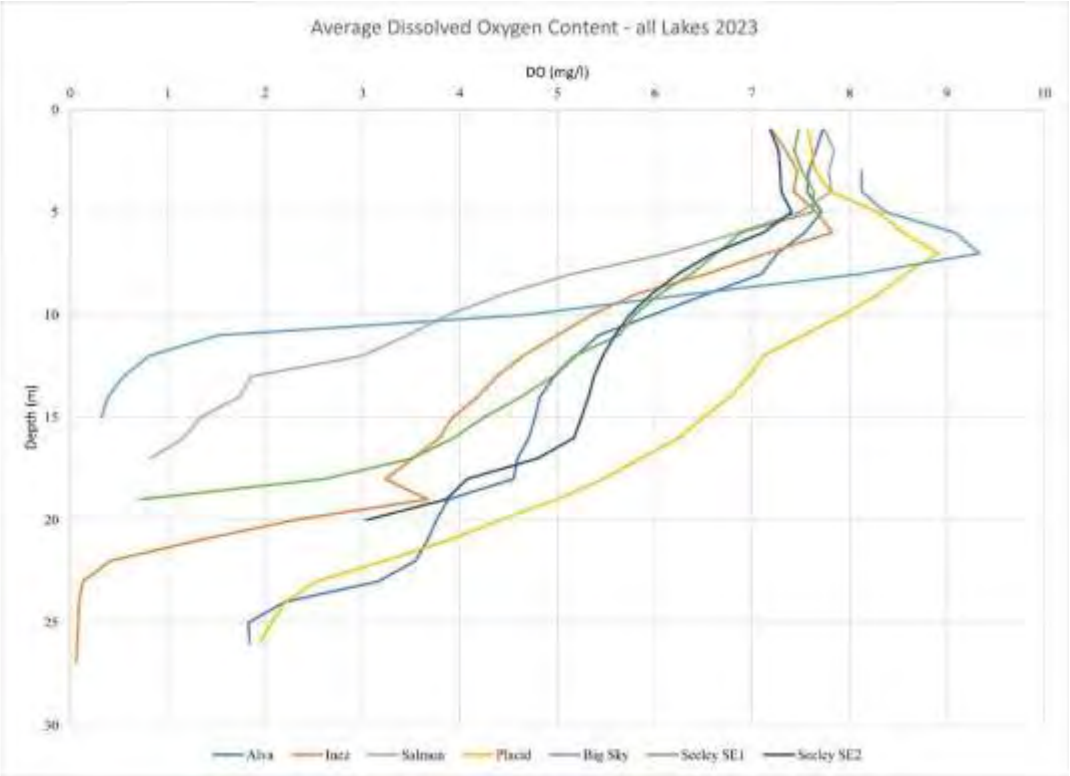


Figure 25. Dissolved oxygen by depth averaged across the 5 sampling times for each of the sampled lakes in 2023.

3.2.4 Nutrient Analyses- Results

Additional parameters for water quality in lakes were added to monitoring by CRC in 2021. In 2021 and again in 2023, sampling was conducted in each of the 6 lakes with varying numbers of surface and deep samples collected. These samples were analyzed for total nitrogen (TN), total phosphorus (TP), soluble reactive phosphorus, and nitrates/nitrites. In addition, hydrolab (Sonde EX03) sampling was also conducted. Some of the sampled parameters recorded most readings below lab sampling minimum detections (e.g., soluble reactive phosphorus, nitrites/nitrates), while others did not show results indicating any potential issues relative to the status of the lakes (e.g., pH, specific conductance). The most informative data that were collected were for TN and TP, as well as the ratio of TN/TP. These results are listed in Table 8. Graphs of nutrient sampling results for each lake are included in the Appendix.

In 2022, nutrient sampling concentrated on Seeley Lake, where multiple surface locations were sampled as well as a deep location. Results for total nitrogen and total phosphorus are shown in Figures 26-27. It should be noted that sampling site SE 14 was at the outlet of the lake at the bridge on Riverview Drive. This site consistently had the highest total nitrogen and total phosphorus levels. *E. coli* samples collected at this site in 2023 found on 6/27/23 a reading of 13 cfu/100mL, on 8/2/23 the level was 128 cfu/100mL, and on 9/25/23 it was 11 cfu/100mL. These results indicate that both nutrients and *E. coli* are entering the slowly moving waters through this lake outlet somewhere along its course between the lake and the bridge.

Table 8. Nutrient sampling results for Lake Alva, Lake Inez, Seeley Lake, Placid Lake, Salmon Lake, and Big Sky Lake for sampling conducted in 2021 and 2023. S TN is surface total nitrogen, S TP is surface total phosphorus, S TN/TP is the ratio of surface total nitrogen to surface total phosphorus, D TN is deep total nitrogen, D TP is deep total phosphorus, and D TN/TP is the ratio of deep total nitrogen to deep total phosphorus. Numbers in parentheses are the sample size.

Lake	Date	S TN	S TP	S TN/TP	D TN	D TP	D TN/TP
Alva	5/17/2021	195 (1)	6.9 (1)	28.3 (1)	575 (1)	19.5 (1)	29.5 (1)
Alva	7/14/2021	167 (1)	4.5 (1)	37.1 (1)	224 (1)	13.1 (1)	17.1 (1)
Alva	8/23/2021	168 (1)	4.6 (1)	36.5 (1)	196 (1)	7.7 (1)	25.5 (1)
Alva	9/17/2021	151 (1)	3.8 (1)	39.7 (1)	281 (1)	61.6 (1)	4.6 (1)
Alva	5/29/2023	194 (1)	5.8 (1)	33.4 (1)	181 (1)	5.3 (1)	34.2 (1)
Alva	6/23/2023	298 (1)	8 (1)	37.3 (1)	209 (1)	9.4 (1)	22.2 (1)
Alva	8/24/2023	194 (1)	6.3 (1)	30.8 (1)	522 (1)	45.2 (1)	11.5 (1)
Alva	9/19/2023	190 (1)	4.6 (1)	41.3 (1)	237 (1)	7.6 (1)	31.2 (1)
Inez	5/17/2021	202.6 (4)	6.9 (4)	29.4 (4)	228 (4)	17.1 (1)	13.3 (1)
Inez	7/14/2021	150.8 (4)	4.3 (4)	35.1 (4)	194 (4)	18.8 (1)	10.3 (1)
Inez	8/24/2021	170.8 (4)	6.6 (4)	25.9 (4)	294 (4)	33.8 (1)	8.7 (1)
Inez	9/17/2021	170.5 (4)	5.9 (4)	28.9 (4)	281 (4)	61.6 (1)	4.6 (1)
Inez	5/25/2023	197 (1)	8.2 (1)	24.0 (1)	214 (1)	12.1 (1)	17.7 (1)
Inez	7/6/2023	180 (1)	7.1 (1)	25.4 (1)	206 (1)	17.1 (1)	12.0 (1)
Inez	8/4/2023	197 (1)	7.5 (1)	26.3 (1)	220 (1)	8 (1)	27.5 (1)
Inez	8/24/2023	229 (1)	6.8 (1)	33.7 (1)	768 (1)	128 (1)	6.0 (1)
Inez	9/19/2023	192 (1)	6.7 (1)	28.7 (1)	231 (1)	8.5	27.2 (1)

Seeley	3/9/2021	282.3 (3)	7.3 (3)	38.7 (3)	240.5 (2)	14.3 (2)	16.8 (2)
Seeley	5/27/2021	149.3 (8)	5.1 (8)	29.3 (8)	167.5 (2)	7.3 (2)	22.9 (2)
Seeley	7/19/2021	177.4 (5)	5.4 (5)	32.9 (5)	206 (1)	28.7 (1)	7.2 (1)
Seeley	8/31/2021	184.4 (8)	6.3 (8)	29.3 (8)	164.5 (2)	18.8 (2)	8.75 (2)
Seeley	9/14/2021	178 (8)	6.0 (8)	29.7 (8)	166.5 (2)	19.6 (2)	8.5 (2)
Seeley	5/23/2023	226 (3)	9.9 (3)	22.8 (3)	183.5 (2)	9.5 (2)	19.3 (2)
Seeley	6/5/2023	184.3 (3)	7.9 (3)	23.3 (3)	161 (2)	7.9 (2)	20.4 (2)
Seeley	7/27/2023	180.7 (3)	7.5 (3)	24.1 (3)	162 (2)	7.4 (2)	21.9 (2)
Seeley	8/25/2023	203.7 (3)	7.9 (3)	25.8 (3)	175 (2)	16.1 (2)	10.9 (2)
Seeley	9/21/2023	191 (3)	6.3 (3)	30.3 (3)	170.5 (2)	16.5 (2)	10.3 (2)
Placid	3/9/2021	230.5 (2)	8.7 (2)	26.5 (2)	406.5 (2)	25.3 (2)	16.1 (2)
Placid	6/2/2021	294 (4)	10.5 (4)	28.0 (4)	250 (1)	10.4 (1)	24.0 (1)
Placid	7/13/2021	200.2 (4)	5.2 (4)	38.5 (4)	264 (1)	13.6 (1)	19.4 (1)
Placid	8/30/2021	201 (4)	6.5 (4)	30.9 (4)	204 (1)	59.5 (1)	3.4 (1)
Placid	9/15/2021	218 (4)	6.5 (4)	33.5 (4)	340 (1)	71.4 (1)	4.8 (1)
Placid	5/25/2023	245.5 (3)	10.6 (3)	23.2 (3)	216 (1)	10.3 (1)	21.0 (1)
Placid	7/25/2023	205.3 (3)	5.9 (3)	34.8 (3)	274 (1)	9.8 (1)	28.0 (1)
Placid	6/21/2023	192.3 (3)	5.7 (3)	33.7 (3)	352 (1)	18 (1)	19.6 (1)
Placid	8/23/2023	221.3 (3)	7.5 (3)	29.5 (3)	368 (1)	59.9 (1)	6.1 (1)
Placid	9/20/2023	243 (3)	6.8 (3)	35.7 (3)	344 (1)	69 (1)	5.0 (1)
Salmon	6/1-6/5/2021	211.2 (5)	10.2 (5)	20.7 (5)	(0)	(0)	(0)
Salmon	7/15/2021	154.6 (5)	5.2 (5)	29.7 (5)	240 (1)	20.6 (1)	11.7 (1)
Salmon	8/26/2021	186 (5)	8.7 (5)	21.4 (5)	249 (1)	49.5 (1)	5.0 (1)
Salmon	9/16/2021	175.6 (5)	9 (5)	19.5 (5)	220 (1)	78.2 (1)	2.8 (1)

Salmon	5/26/2023	180.3 (3)	10.6 (3)	17.0 (3)	227 (1)	9.2 (1)	24.7 (1)
Salmon	7/28/2023	152 (3)	7.1 (3)	21.4 (3)	210 (1)	19.8 (1)	10.6 (1)
Salmon	6/22/2023	155.7 (3)	6.6 (3)	23.6 (3)	193 (1)	7.4 (1)	26.1 (1)
Salmon	8/23/2023	336 (3)	10.7 (3)	31.4 (3)	177 (1)	15.7 (1)	11.3 (1)
Salmon	9/20/2023	263.7 (3)	12.5 (3)	21.1 (3)	313 (1)	135 (1)	2.3 (1)
Big Sky	5/18/2021	408 (1)	14.7 (1)	27.8 (1)	693 (1)	54.8 (1)	12.6 (1)
Big Sky	7/12/2021	167 (1)	4.5 (1)	37.1 (1)	224 (1)	13.1 (1)	17.1 (1)
Big Sky	8/23/2021	374 (1)	9.1 (1)	41.1 (1)	1700 (1)	238 (1)	7.1 (1)
Big Sky	9/13/2021	402 (1)	9.2 (1)	43.7 (1)	1860 (1)	258 (1)	7.2 (1)
Big Sky	5/24/2023	321 (1)	13.3 (1)	24.1 (1)	750 (1)	84 (1)	8.9 (1)
Big Sky	6/8/2023	392 (1)	14.5 (1)	27.0 (1)	781 (1 (1))	121 (1)	6.5 (1)
Big Sky	6/22/2023	402 (1)	11.3 (1)	35.6 (1)	1030 (1)	172 (1)	6.0 (1)
Big Sky	8/23/2023	349 (1)	10.3 (1)	33.9 (1)	391 (1)	13.4 (1)	29.2 (1)
Big Sky	9/28/2023	418 (1)	8.3 (1)	50.4 (1)	1560 (1)	278 (1)	5.6 (1)

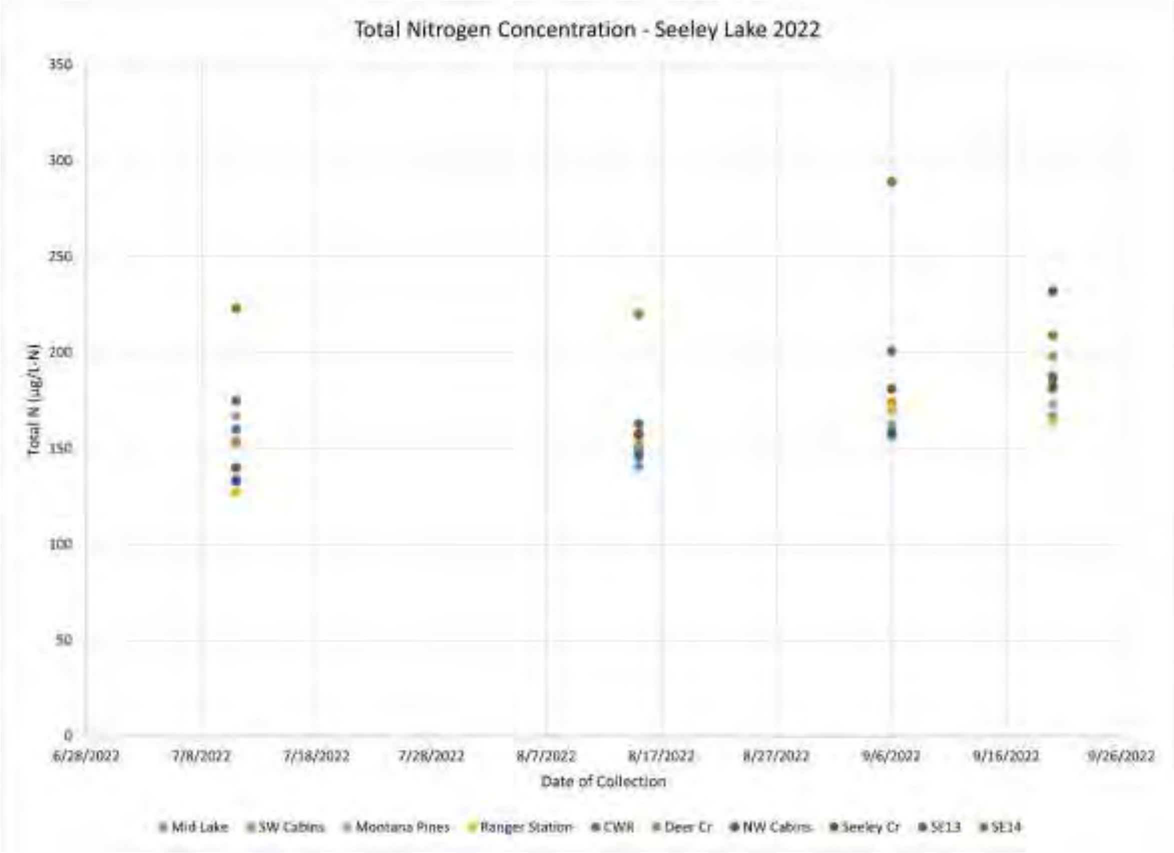


Figure 26. Total nitrogen levels across 7 surface sample locations and 1 deep sample (Mid Lake) for Seeley Lake in 2022.

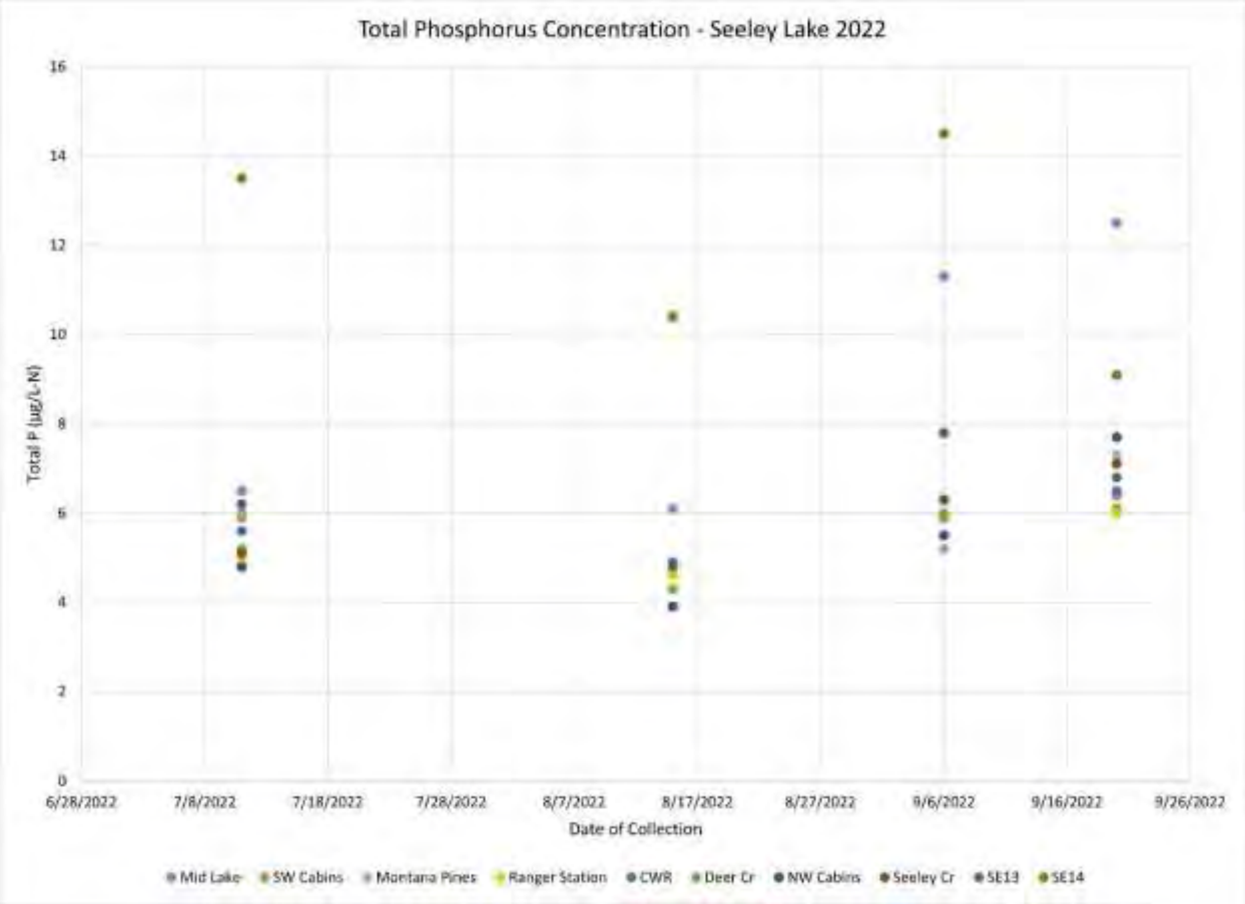


Figure 27. Total phosphorus levels for 7 surface sampling locations and 1 deep lake sample (Mid Lake) for Seeley Lake in 2022.

3.2.5 Historical lake monitoring conducted by non-CRC entities

Throughout the past few decades, various local entities (researchers, nonprofits, and government agencies) have conducted monitoring on numerous water bodies in the Clearwater Basin. Of the major lakes in the basin, Seeley and Salmon have been monitored with the greatest consistency and frequency. Although these lakes have been monitored more frequently than the others, significant gaps exist in our general understanding of water quality and associated anthropogenic impacts. The following section will summarize the historical data collected on various lakes in the Basin. Tables 9 and 10 list the historical data sources including the types and amounts of data presented for Seeley Lake and Salmon Lake respectively.

Watson (2012) compiled and analyzed historical water quality data for Seeley and Salmon Lakes, which will be summarized in the following section. Studies of Seeley and Salmon Lakes and water resource issues of the Clearwater Valley were surveyed in the peer reviewed literature, government reports, and from documents and other materials provided by local groups such as the Seeley Lake Sewer and Water districts. Available water quality data for Seeley and Salmon Lakes were entered in a Seeley-Salmon database.

Prior to the formation of CRC, various local researchers collected data on the status of the major lakes in the Valley. Because methods and timing of measuring lake conditions varied over the years, a subset of most comparable data were used to compute TSI values (Figure 28) and AHOD values. And only these values are used to evaluate trends over time.

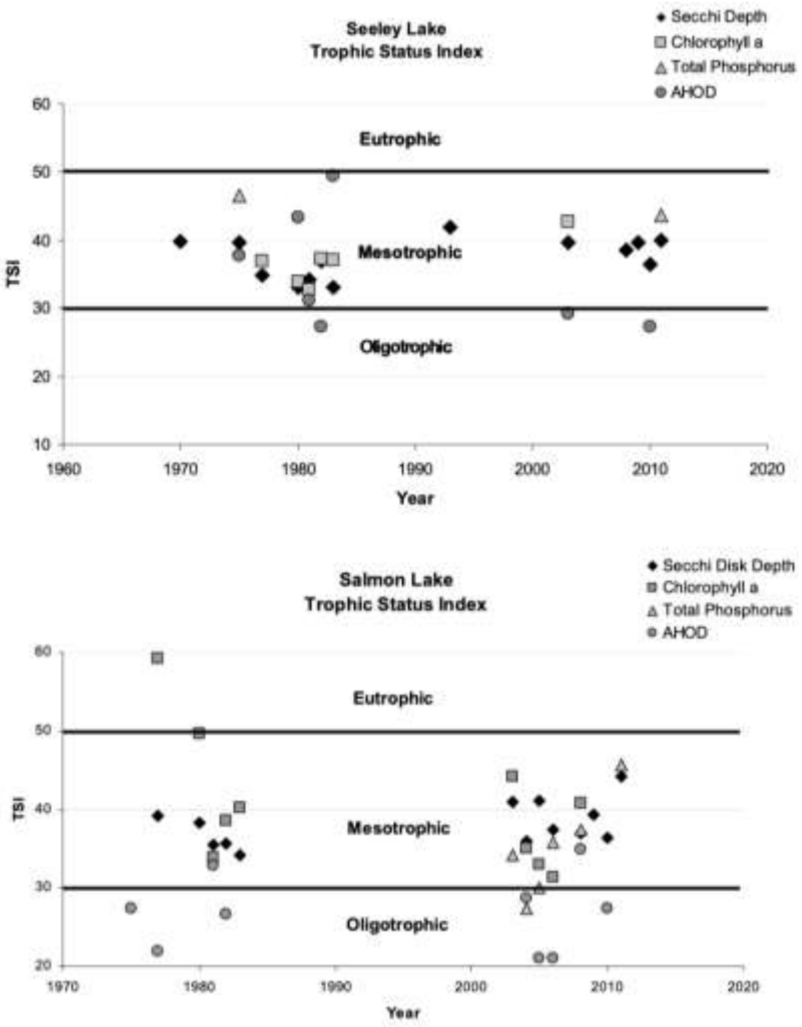


Figure 28: Trophic State Index values for Seeley Lake (top) and Salmon Lake (bottom), based on summer chlorophyll a, Secchi depth, AHOD, and spring turnover total phosphorus data from 1970's to 2011.

AHOD estimates for Seeley and Salmon lakes vary dramatically among years, and there is no apparent trend in AHOD over time in these lakes. Historically, Seeley has varied from 0.3 to 0.85 g/m2/day (from mesotrophic to hypereutrophic) while Salmon has varied from 0.1 to 0.44 (oligotrophic to eutrophic). AHOD calculated for different sites and over different time intervals in Salmon Lake showed almost as much variation over the summer of 2010. As with the AHOD values, Walker's AHOD TSI values show Salmon's historical values fall in the same range as the range of 2010 values, while Seeley has some historical values that are much higher than those seen in 2010.

Carlson Trophic State Index (TSI) values for the lakes from the 1970's to the present are also summarized in Figure 28. These values are based on summer chlorophyll a, Secchi depth, AHOD and on spring TP. Although some of the earliest observations in both Salmon Lake and Seeley Lake are the highest observed, there is no discernible trend over time in these values. Most of the TSI values fall in the mesotrophic range, and given the variability observed within and among years (and differences in sites and timing), the earliest observations are simply too limited to draw any conclusion about differences with current conditions.

Juday and Keller (1984) completed some of the most comprehensive historical monitoring, which included various biological and chemical variables collected on 13 lakes from 1974 through 1983. Among the data collected and analyzed by Juday and Keller in the 1970s were dissolved oxygen profiles on the 6 major lakes in the Clearwater Valley. Selections from Juday and Keller's 1970s DO dataset were compared to 2020 data (Figure 29). For 4 lakes (Placid, Alva, Inez, and Big Sky), 1970s and 2020 data were comparable, with no significant differences in DO levels through the water column. Seeley Lake showed a decrease in surface DO and increase in DO at depth. Salmon Lake showed an overall decrease in DO through the water column from the 1970s to 2020. Note that much of the 1970s and 2020 data are excluded from the graphs in Figure 29, and further comparisons and analyses are necessary to confirm any trends that may be occurring.

Dissolved Oxygen Levels: 1970s vs 2020

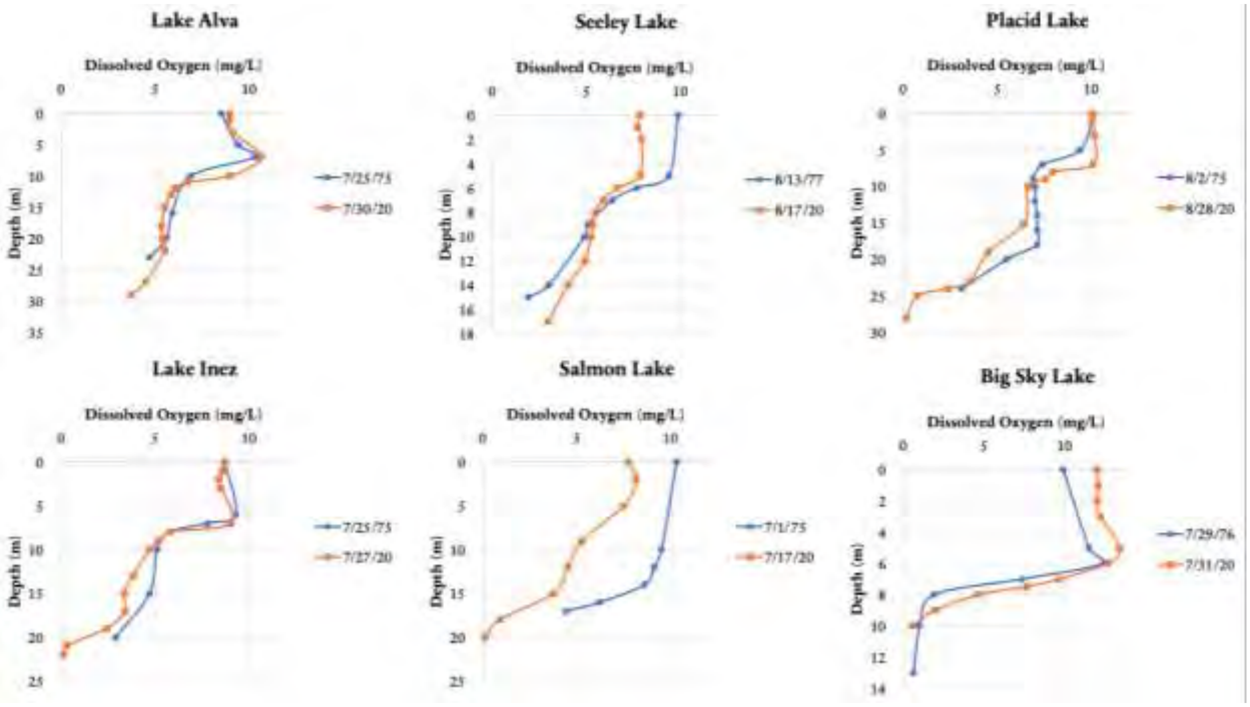
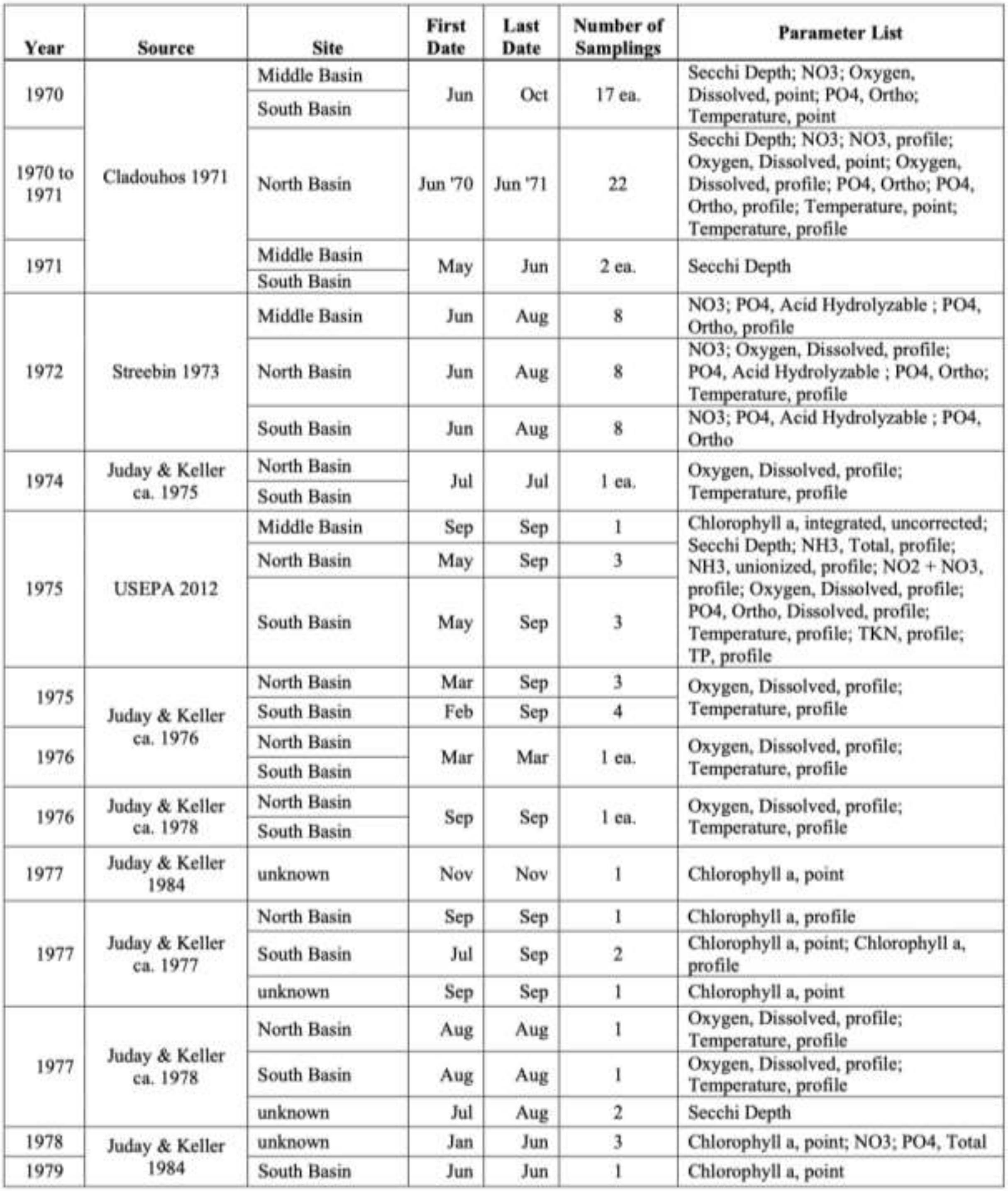


Figure 29: Dissolved oxygen (mg/L) vs depth (m) in 2020 and the 1970s for 6 lakes in the Clearwater Valley: Lake Alva, Seeley Lake, Placid Lake, Lake Inez, Salmon Lake, and Big Sky Lake.

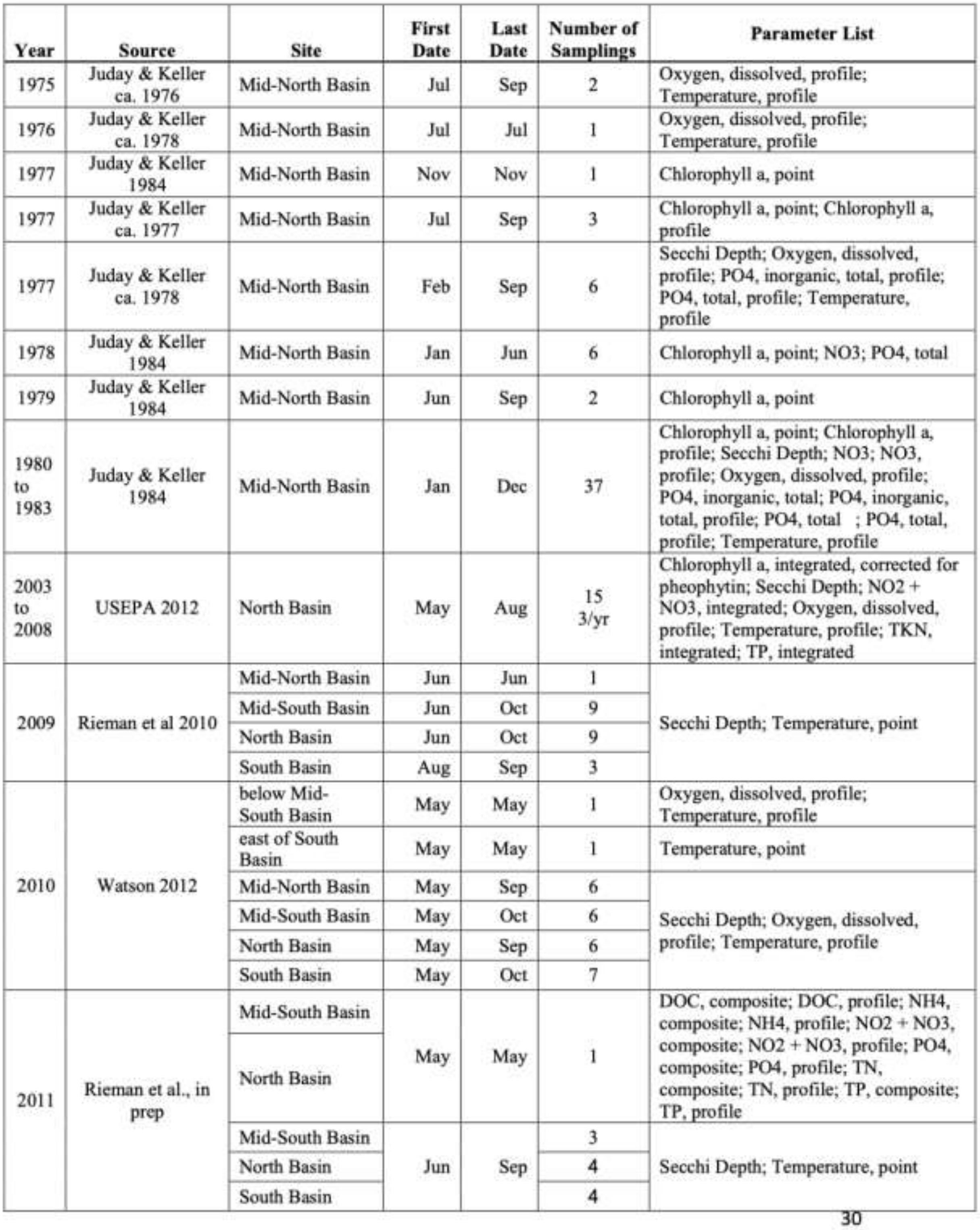
Work from the 1970s was also replicated by the University of Montana in 2003, which suggested that some improvements in conditions may have occurred in Placid, Inez, and Alva in the decades following Juday and Keller's study (Watson 2012). Historical conclusions have been variable and inconsistent through time. Because DO levels can fluctuate for many reasons (both anthropogenic and natural), comparing data between lakes and years is difficult without consistency in methodology and sites. Additionally, watershed conditions in 1970 were drastically different from today, with Seeley Lake's history of intense logging. For these reasons, water quality data from the 1970's cannot be used as a baseline for pre-urbanized conditions, as the region was greatly influenced by logging among other anthropogenic activities. It is interesting to note that the DO profile for Big Sky Lake was relatively consistent between the 1970's and 2020.

Table 9: Seeley Lake Historical Database Contents



Year	Source	Site	First Date	Last Date	Number of Samplings	Parameter List
1970	Cladouhos 1971	Middle Basin	Jun	Oct	17 ea.	Secchi Depth; NO3; Oxygen, Dissolved, point; PO4, Ortho; Temperature, point
		South Basin				
1970 to 1971		North Basin	Jun '70	Jun '71	22	Secchi Depth; NO3; NO3, profile; Oxygen, Dissolved, point; Oxygen, Dissolved, profile; PO4, Ortho; PO4, Ortho, profile; Temperature, point; Temperature, profile
1971		Middle Basin	May	Jun	2 ea.	Secchi Depth
		South Basin				
1972	Streebin 1973	Middle Basin	Jun	Aug	8	NO3; PO4, Acid Hydrolyzable ; PO4, Ortho, profile
		North Basin	Jun	Aug	8	NO3; Oxygen, Dissolved, profile; PO4, Acid Hydrolyzable ; PO4, Ortho; Temperature, profile
		South Basin	Jun	Aug	8	NO3; PO4, Acid Hydrolyzable ; PO4, Ortho
1974	Juday & Keller ca. 1975	North Basin	Jul	Jul	1 ea.	Oxygen, Dissolved, profile; Temperature, profile
		South Basin				
1975	USEPA 2012	Middle Basin	Sep	Sep	1	Chlorophyll a, integrated, uncorrected; Secchi Depth; NH3, Total, profile; NH3, unionized, profile; NO2 + NO3, profile; Oxygen, Dissolved, profile; PO4, Ortho, Dissolved, profile; Temperature, profile; TKN, profile; TP, profile
		North Basin	May	Sep	3	
		South Basin	May	Sep	3	
1975	Juday & Keller ca. 1976	North Basin	Mar	Sep	3	Oxygen, Dissolved, profile; Temperature, profile
		South Basin	Feb	Sep	4	
1976		North Basin	Mar	Mar	1 ea.	Oxygen, Dissolved, profile; Temperature, profile
		South Basin				
1976	Juday & Keller ca. 1978	North Basin	Sep	Sep	1 ea.	Oxygen, Dissolved, profile; Temperature, profile
		South Basin				
1977	Juday & Keller 1984	unknown	Nov	Nov	1	Chlorophyll a, point
1977	Juday & Keller ca. 1977	North Basin	Sep	Sep	1	Chlorophyll a, profile
		South Basin	Jul	Sep	2	Chlorophyll a, point; Chlorophyll a, profile
		unknown	Sep	Sep	1	Chlorophyll a, point
1977	Juday & Keller ca. 1978	North Basin	Aug	Aug	1	Oxygen, Dissolved, profile; Temperature, profile
		South Basin	Aug	Aug	1	Oxygen, Dissolved, profile; Temperature, profile
		unknown	Jul	Aug	2	Secchi Depth
1978	Juday & Keller 1984	unknown	Jan	Jun	3	Chlorophyll a, point; NO3; PO4, Total
1979		South Basin	Jun	Jun	1	Chlorophyll a, point

Table 10: Salmon Lake Database Contents



Year	Source	Site	First Date	Last Date	Number of Samplings	Parameter List
1975	Juday & Keller ca. 1976	Mid-North Basin	Jul	Sep	2	Oxygen, dissolved, profile; Temperature, profile
1976	Juday & Keller ca. 1978	Mid-North Basin	Jul	Jul	1	Oxygen, dissolved, profile; Temperature, profile
1977	Juday & Keller 1984	Mid-North Basin	Nov	Nov	1	Chlorophyll a, point
1977	Juday & Keller ca. 1977	Mid-North Basin	Jul	Sep	3	Chlorophyll a, point; Chlorophyll a, profile
1977	Juday & Keller ca. 1978	Mid-North Basin	Feb	Sep	6	Secchi Depth; Oxygen, dissolved, profile; PO4, inorganic, total, profile; PO4, total, profile; Temperature, profile
1978	Juday & Keller 1984	Mid-North Basin	Jan	Jun	6	Chlorophyll a, point; NO3; PO4, total
1979	Juday & Keller 1984	Mid-North Basin	Jun	Sep	2	Chlorophyll a, point
1980 to 1983	Juday & Keller 1984	Mid-North Basin	Jan	Dec	37	Chlorophyll a, point; Chlorophyll a, profile; Secchi Depth; NO3; NO3, profile; Oxygen, dissolved, profile; PO4, inorganic, total; PO4, inorganic, total, profile; PO4, total ; PO4, total, profile; Temperature, profile
2003 to 2008	USEPA 2012	North Basin	May	Aug	15 3/yr	Chlorophyll a, integrated, corrected for pheophytin; Secchi Depth; NO2 + NO3, integrated; Oxygen, dissolved, profile; Temperature, profile; TKN, integrated; TP, integrated
2009	Rieman et al 2010	Mid-North Basin	Jun	Jun	1	Secchi Depth; Temperature, point
		Mid-South Basin	Jun	Oct	9	
		North Basin	Jun	Oct	9	
		South Basin	Aug	Sep	3	
2010	Watson 2012	below Mid-South Basin	May	May	1	Oxygen, dissolved, profile; Temperature, profile
		east of South Basin	May	May	1	Temperature, point
		Mid-North Basin	May	Sep	6	Secchi Depth; Oxygen, dissolved, profile; Temperature, profile
		Mid-South Basin	May	Oct	6	
		North Basin	May	Sep	6	
		South Basin	May	Oct	7	
2011	Rieman et al., in prep	Mid-South Basin	May	May	1	DOC, composite; DOC, profile; NH4, composite; NH4, profile; NO2 + NO3, composite; NO2 + NO3, profile; PO4, composite; PO4, profile; TN, composite; TN, profile; TP, composite; TP, profile
		North Basin				
		Mid-South Basin	Jun	Sep	3	Secchi Depth; Temperature, point
		North Basin			4	
		South Basin			4	

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3.3 TMDL Summary from 2011

The Total Maximum Daily Load (TMDL) program identifies sources of pollution to streams, rivers, and lakes within Montana and determines how much pollution those waters can sustain and still fully support beneficial uses. Plans are written by the Department of Environmental Quality, and outline how to reduce pollution to impaired waters while offering ways to assist local communities with finding solutions to maintain clean water (MT DEQ 2011). The Clearwater Valley is located within the Middle Blackfoot-Nevada Creek planning area; as such, the *Middle Blackfoot - Nevada TMDL and Water Quality Improvement Plan* (2008) along with the plan addendum (2014) were used to summarize the causes and sources of pollution in the Clearwater region (Figure 30). Targets for restoring water quality are established in this document and summarized in the following section. In addition, descriptions of impairments from this report are included in the Appendix.

Within the *Middle Blackfoot-Nevada TMDL and Water Quality Improvement Plan* five 303(d) listed streams in the Clearwater basin were identified as having sediment loading and other non-point pollution issues: Buck Creek, Richmond Creek, Deer Creek, Blanchard Creek, and the West Fork Clearwater River (Table 11). The TMDL also summarized issues on Seeley and Salmon lakes and recommended further monitoring, a more detailed review of available data to determine appropriate monitoring parameters and frequency, compilation of sufficient data for a watershed loading and lake response model, and better definition of nutrient source loadings.

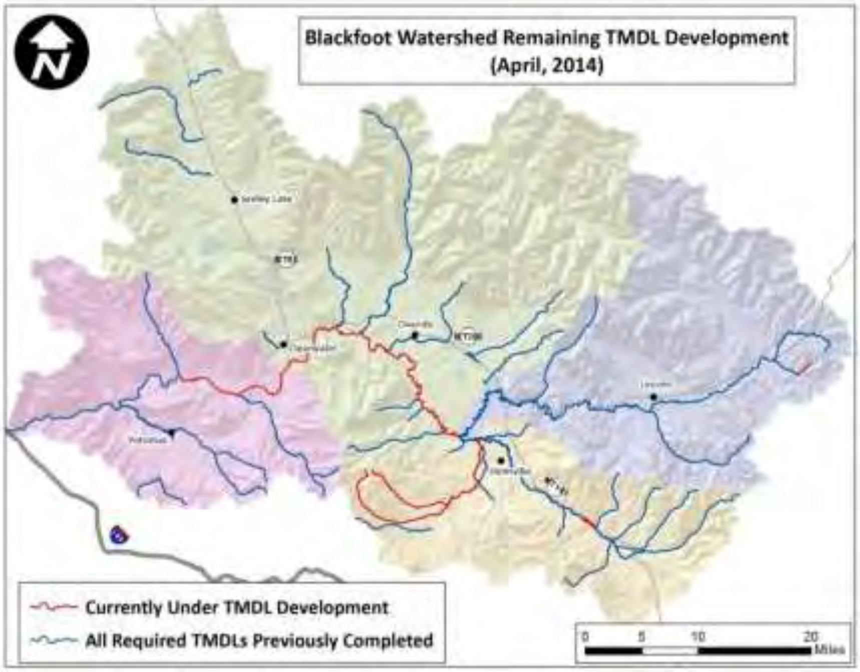


Figure 30: The Blackfoot River watershed divided into the Blackfoot Headwaters (gray shaded area), Nevada Creek (tan shaded area), Middle Blackfoot (light green shaded area),

and Lower Blackfoot (pink shaded area) TMDL planning areas. Together, they compose the Blackfoot Watershed TMDL Project Area. The Clearwater Valley is located within the Middle Blackfoot region.

Table 11: Seven bodies of water and their associated listing histories and impairment justifications from *Middle Blackfoot-Nevada TMDL and Water Quality Improvement Plan*.

Waterbody	**Listing histories and impairment justifications**
Richmond Creek	**Richmond Creek was listed in 1996 as impaired for non-priority organics and siltation with runoff from logging operations cited as the principal impairment source.** The stream has not been listed in subsequent years due to lack of sufficient credible data (SCD). DEQ conducted assessment and sampling in 2003. A riparian habitat assessment by DEQ and macroinvertebrate samples (Bollman, 2004) all supported a finding of full support. However, riffle pebble count data indicated excess fine sediment and the 2006 listing concluded partial support for aquatic life and cold water fishery uses due to sedimentation/siltation. All other uses are listed as fully supporting.
West Fork Clearwater River	The cold-water fishery use on 10 miles of the **West Fork was listed as threatened due to nonpriority organics and siltation in 1996 with silvicultural activities listed as the impairment source**. Beneficial uses other than cold water fishery were not assessed in 1996, and the stream was not listed from 2000 to 2004 due to lack of SCD. Streebin and others (Streebin et al. 1973) reported severe logging related damage to streambanks, and FWP (1977) reported a deteriorating fishery trend and reduced beaver complex extent resulting from road sources and other natural sources. Bull trout in the West Fork were rare according to data downloaded from the Montana Fisheries Information System (MFISH) database in 1992 and 1994. The Montana Bull Trout Scientific Group (1995) designated the West Fork as a "core" area for fluvial bull trout. Thomas (1992) reported bull trout occurrence as rare with competition form contaminating brook trout. Reassessment of the West Fork by DEQ occurred in September of 2003 at two assessment and sampling sites located above and below the Marshall Creek confluence. Water column samples, field parameters, and substrate particle size measurements, as well as macroinvertebrate, periphyton, and Chl-a samples, were collected. The results described a cold stream with low levels of fine sediment and low to non-detectable concentrations of nutrients and metals. The macroinvertebrate and periphyton assessment indicated full support for aquatic life (Bollman 2004, Bahls 2004). The West Fork Clearwater River is listed as fully supporting of all beneficial uses except primary contact recreation in 2006 due to elevated Chl-a.

Deer Creek	The cold-water fishery use of the entire length of **Deer Creek from its headwater to its mouth on Seeley Lake was listed as threatened in 1996 due to non-priority organics and siltation. Silviculture was given as the impairment source**. The stream was removed from subsequent lists due to a lack of SCD. Early water chemistry data from the late 1960s, the 1970s, and the early 1980s documented extremely elevated nitrate nitrogen and TP concentrations in the heavily logged watershed. DEQ conducted assessments at two sampling locations in 2003. Chl-a concentrations were elevated at both assessment sites. The site upstream of the Sheep Creek confluence had a Chl-a result of 94.8 mg/m2; the site between Sheep Creek and the mouth had a Chl-a value of 65.2 mg/m2. Nutrient concentrations, however, were less than the method detection limits or well below levels associated with undesirable aquatic plant growth. Field notes from the assessment speculate that the low nutrient concentrations may reflect thorough nutrient uptake by algae and aquatic vascular plants. Macroinvertebrate samples collected in 2003 reflected healthy and diverse aquatic life conditions, functioning reach scale habitat, and good water quality at both assessment sites. However, the 2003 assessment concluded elevated fine sediment in channel substrate pebble counts, and the stream was listed due to sedimentation/siltation in 2006.
Buck Creek	**In 1996, the support for cold-water fishery was listed as threatened due to siltation** for a 2.4-mile segment of Buck Creek upstream from its mouth on Placid Lake. An assessment by DEQ in August of 2004 could not include biological or water chemistry sampling due to dry channel conditions. Aside from the substrate and channel morphology reassessment effort on Buck Creek in 2004, no additional assessment has occurred. Therefore, neither aquatic biology nor water chemistry data are available for Buck Creek, resulting in a lack of SCD for determining use support. Due to the lack of SCD, the stream was listed as being "Not Assessed" in 2006.
Blanchard Creek	**A 3-mile reach of Blanchard Creek from its North Fork confluence to its mouth on the Clearwater River was listed as impaired due to habitat alterations and siltation in 1996.** The habitat alteration cause is more specifically referred to as "alteration in stream-side or littoral vegetative covers," and the siltation cause is referred to as "sedimentation/siltation" in the 2006 listing. A flow alteration listing was added in 2004. These listings stem from a DHES **stream habitat assessment contracted in 1991 that reported severe grazing impacts to stream banks and riparian vegetation** concentrated on state-owned lands and severe dewatering segment wide. A water leasing project in 1994 improved flow conditions and young-of-year trout densities (Pierce et al., 1994), but abandonment of leasing in subsequent dry years was followed by reductions in fish numbers (Pierce et al. 2002b). Personal communication with a local landowner documented continued riparian overgrazing and weed infestation on state lands in 1999.

	More recently, a macroinvertebrate and habitat assessment by Bollman (2004) concluded partial support for aquatic life due to shortened riffle segments, channel over-widening, fine gravel build up in the channel substrate, sub-optimal flow status, and little woody vegetation establishment on stream banks with evidence of grazing related bank damage.
Seeley Lake	**Seeley Lake was listed as partially supporting aquatic life, cold-water fishery, and contact recreation uses in 1996 due to organic enrichment**. Seeley was classified as mesotrophic in the early 1970s (Cladouhos 1971), and this classification was confirmed in the 1990s (Rezanka and Butler 1998). Data for nutrients, oxygen, and Secchi depth have been constant to lower over this period. However, nitrogen from an increasing number of shoreline septic systems has been a source of water quality concern. Similar to Salmon Lake, a recent introduction of northern pike has caused compositional changes that, as yet, have unknown fisheries consequences. Poly-chlorinated biphenyl (PCB) compounds were detected in sediment during a study by Phillips and Bahls (1994). A fish consumption advisory of one meal/week was issued for rainbow trout due to PCB bioaccumulation, but no PCBs were ever detected in fish tissue. Sediment mercury levels measured during the same study (0.08-0.1µg/g) were lower than typical background concentrations. There have been no indications of nuisance algae blooms. A single case of an elevated fecal coliform count occurred at a swimming beach in 1973, but the data was judged to be too old to represent current conditions. Seeley Lake is currently listed as fully supporting.
Salmon Lake	**Salmon Lake was listed as impaired in 1996 due to nutrients, organic enrichment, and siltation.** These listings stemmed from fish surveys from the 1950s through the 1970s that indicated higher than normal numbers of non-game fish (Whitney and Averett 1958, Marcoux 1973). A DHES assessment by Phillips and Bahls (1994) concluded an impacted fishery due to temperature and lack of shoal area physical factors possibly due to turbidity from an east shoreline roadway. Nutrient concentrations measured since the mid-1980s appear to be within the normal range. No excess algal growth was documented. Interpretation of Chl-a as a trophic status indicator concluded that the lake is currently less nutrient-rich than at the start of the record during the late 1970s. Temperature and depth profiles demonstrate anoxic hypolimnium conditions in July with recovery during August. A maximum temperature of about 23°C occurs during July and August. Temperature plots indicate that lake stratification has shifted little since the early 1980s. The lake fishery has historically been diverse with small numbers of trout, whitefish, and kokanee and abundant non-salmonid species. Bull trout and WSCT are present in very small numbers. Lack of salmonids is likely due to rapid warming in early June followed by more rapid cooling in the fall. The temperature regimen is believed to be naturally occurring. An illegal introduction of northern

	pike occurred in the drainage in the late 1980s or early 1990s and now comprises an increasing proportion of the fishery. Pike introduction is the largest factor limiting the fish populations, having reduced pre-introduction fish densities by 70% to 90%. Currently fish populations fluctuate with abundance of northern pike. Water quality and habitat are not currently limiting uses. Salmon Lake water quality is listed in 2006 as fully supporting.

The *Middle Blackfoot-Nevada TMDL and Water Quality Improvement Plan* also identified probable causes and sources for the impairments it identified for water bodies in the Clearwater Valley. Table 12 lists what were identified as causes and sources from 1996 and 2006.

Table 12: Probable causes and sources for impaired waters in the Clearwater Valley from the *Middle Blackfoot-Nevada TMDL and Water Quality Improvement Plan*.

Water Body	**1996 Causes**	**1996 Sources**	**2006 Causes**	**2006 Sources**
Richmond Creek from headwaters to mouth (Lake Alva)	Non-priority Organics Siltation	Harvesting, Restoration, Residue Management Silviculture	Sedimentation/ siltation	Forest roads (road construction and use)
West Fork Clearwater River from headwaters to mouth (Clearwater River)	Non-priority Organics Siltation	Harvesting, Restoration, Residue Management Silviculture	Chl-a	Natural Sources Unknown Sources
Deer Creek from headwaters to mouth (Seeley Lake)	Non-priority Organics Siltation	Harvesting, Restoration, Residue Management Silviculture	Sedimentation/ siltation	Forest roads (road construction and use) Silviculture Harvesting
Seeley Lake	Organic Enrichment/ DO	Land Development Silviculture	None (fully supporting)	None
Buck Creek from headwaters to the mouth (Placid Creek)	Siltation	Silviculture	Not assessed	None identified

Salmon Lake	Nutrients Organic Enrichment/ DO Siltation	Agriculture Land Development Silviculture	None (fully supporting)	None
Blanchard Creek from the North Fork to the mouth (Clearwater River)	Habitat alterations Siltation	Agriculture Pasture Land	Alteration in stream-side or littoral vegetative covers Low Flow Alteration Sedimentation/ siltation	Agriculture Grazing in Riparian or Shoreline Zones Flow Alterations from Water Diversions Highway/Road/Bridge Runoff (non-construction related)

4.0 Threats and Impairments

4.1 Septic Systems

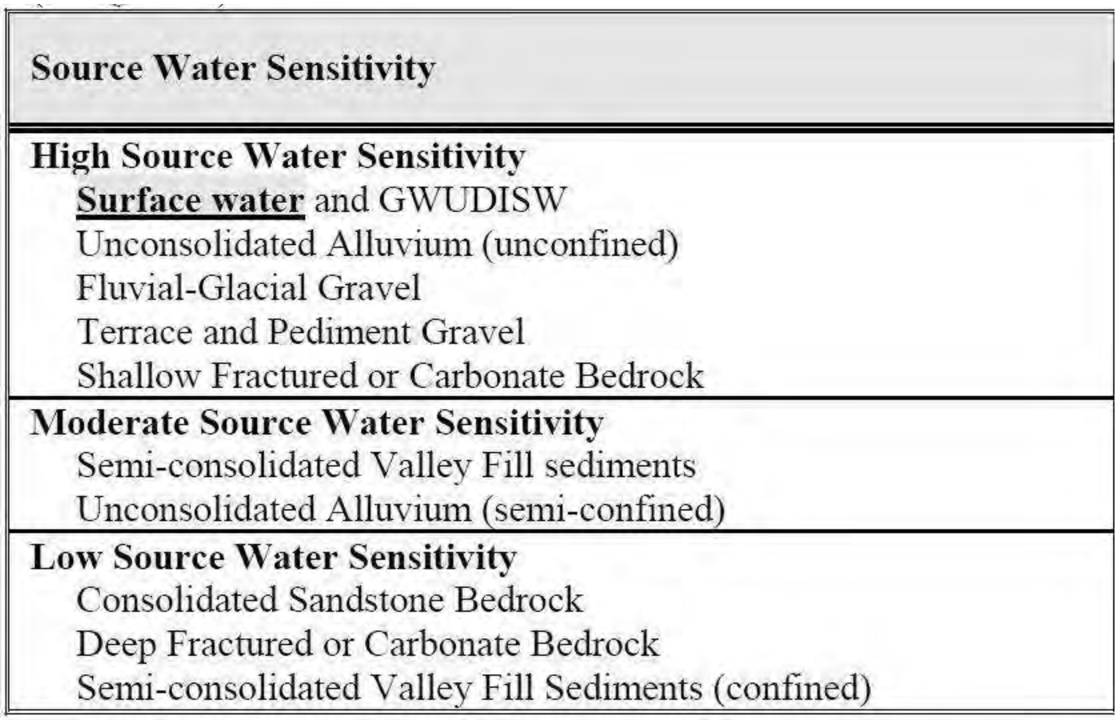
Due to rapid development in Seeley Lake and the subsequent proliferation of wells and septic tanks, concerns have been raised over the potential depletion of water quality, both surface and groundwater. As recently as December 2023, the Missoula County environmental health manager asserted that "the groundwater directly under the community of Seeley Lake is contaminated with elevated levels of nitrate. The nitrate contamination is caused by the combination of dense development, served completely by on-site septic systems and the hydrogeologic properties of the aquifer in this area."

Population growth has increased significantly in recent years (Figures 31 and 32). As Figures 31 and 32 show, most of this growth has occurred adjacent to the major lakes in the Valley (Figure 33). The community of Seeley Lake has no central wastewater collection or treatment system, and the public water-supply is drawn from Seeley Lake. As septic systems age, nutrients begin to break through the soil and reach the groundwater, and ultimately surface water. As such, the growth in septic systems around the lakes in the Clearwater Valley will undoubtedly increase nutrient loading into the lakes.

Septic systems were identified as a contaminant risk to the Seeley Lake Water District PWS in the Seeley Lake Public Water Supply Source Water Delineation and Assessment Report (SWDAR) (MT DEQ 2002). This report "identifies potential contaminant sources near the PWS water intake" and assesses the need for source water protection planning. The PWS water intake is located in the middle of Seeley Lake and withdraws water from the lake. The lake water intake is located approximately 2 miles north of town off the east shore. It is about 300 feet offshore, and about 70 feet deep (that is 4 feet off the bottom), (Vince Chappell, pers. comm.). Water withdrawn from the lake is pumped up to Rice Ridge about 1.75 miles north of town where the treatment plant is located.

Because the PWS of Seeley Lake is from a surface water supply, the source water is classified as highly sensitive to contamination, in accordance with Montana Source Water Protection Program aquifer/source water sensitivity criteria (1999). The criteria considered in this determination is listed below (Table 13).

Table 13. Criteria to determine source water sensitivity (MT DEQ 1999). GWUDISW is Ground Water Under the Direct Influence of Surface Water



Source Water Sensitivity
High Source Water Sensitivity **Surface water** and GWUDISW Unconsolidated Alluvium (unconfined) Fluvial-Glacial Gravel Terrace and Pediment Gravel Shallow Fractured or Carbonate Bedrock
Moderate Source Water Sensitivity Semi-consolidated Valley Fill sediments Unconsolidated Alluvium (semi-confined)
Low Source Water Sensitivity Consolidated Sandstone Bedrock Deep Fractured or Carbonate Bedrock Semi-consolidated Valley Fill Sediments (confined)

Surface water flow and groundwater flow within most of the community of Seeley Lake appears to drain to the lake. Consequently, groundwater contamination from in-town sources may also flow toward and discharge into Seeley Lake. However, flow patterns within Seeley Lake are not well understood. This has an impact on the understanding on whether contaminant sources like septic leachate from the community of Seeley Lake are located upgradient of the PWS surface water intake or not.

One of the greatest identified risks to the PWS is the presence of large capacity septic systems in and around the community of Seeley Lake at the south end of lake. The potential hazard is increased by the lack of a centralized sewer and wastewater treatment system. A large capacity septic system is defined as one that services at least 20 persons per day for more than 6 months of the year. The SWDAR states "large capacity septic systems can be major sources of contamination around a lake and can act as underground injection wells that allow water and water borne contaminants to recharge local groundwater. This is especially important if any of the businesses in the area dispose of liquid waste contaminants improperly by flushing them into their onsite septic systems or similar injection wells/dry wells."

For most contaminant sources, the Seeley Lake Water District PWS was rated as having a "low" hazard rating (Table 14, shown as Table 8 of the SWDAR), except for moderate hazard due to large capacity septic systems and stormwater runoff. However, susceptibility was rated as "low" (at the time of assessment, over 20 years ago) due to dilution and possible downgradient location of some of the contaminant sources.

Table 14. Hazard of potential contaminations sources for Seeley Lake. Source: SWDAR, MT DEQ 2002.

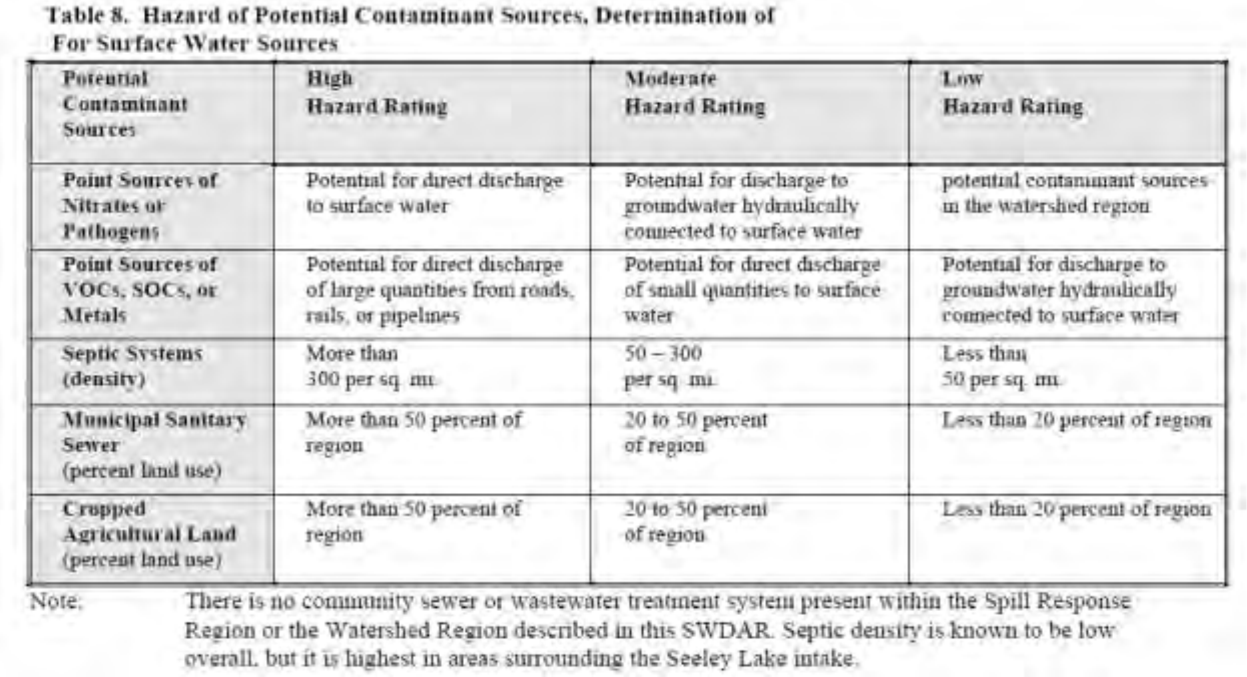


Table 8. Hazard of Potential Contaminant Sources, Determination of For Surface Water Sources

Potential Contaminant Sources	**High Hazard Rating**	**Moderate Hazard Rating**	**Low Hazard Rating**
Point Sources of Nitrates or Pathogens	Potential for direct discharge to surface water	Potential for discharge to groundwater hydraulically connected to surface water	potential contaminant sources in the watershed region
Point Sources of VOCs, SOCs, or Metals	Potential for direct discharge of large quantities from roads, rails, or pipelines	Potential for direct discharge of small quantities to surface water	Potential for discharge to groundwater hydraulically connected to surface water
Septic Systems (density)	More than 300 per sq. mi.	50 – 300 per sq. mi.	Less than 50 per sq. mi.
Municipal Sanitary Sewer (percent land use)	More than 50 percent of region	20 to 50 percent of region	Less than 20 percent of region
Cropped Agricultural Land (percent land use)	More than 50 percent of region	20 to 50 percent of region	Less than 20 percent of region

Note: There is no community sewer or wastewater treatment system present within the Spill Response Region or the Watershed Region described in this SWDAR. Septic density is known to be low overall, but it is highest in areas surrounding the Seeley Lake intake.

The SWDAR specifically states that the assessment does not "evaluate the increased concentration of septic density around the surface water intake, but this author feels that this source of contamination should be monitored. With increased development of businesses and construction of new homes, the volume of septic contaminants will increase dramatically. The construction of a community septic and wastewater treatment system will alleviate much of this threat from the areas serviced by the community system. Construction and the extension of community sewers is the only way to reduce contamination from the existing unsewered developments in and around the community of Seeley Lake."

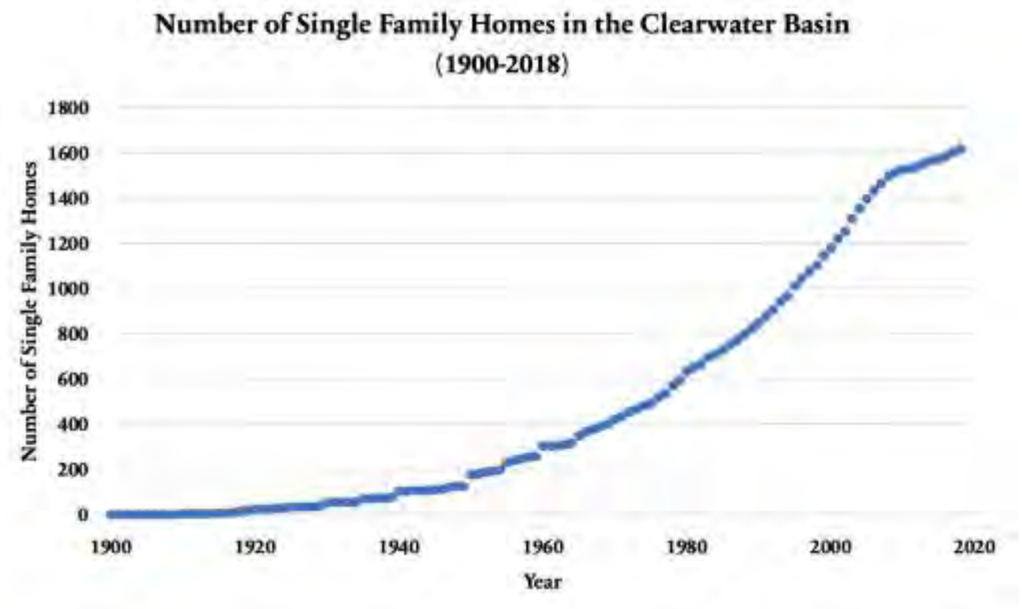


Figure 31: Number of single-family homes in the Clearwater Valley from 1900 to 2018. *Data Compiler: Headwaters Economics, Data Source: Montana Department of Revenue, Property Assessment Division*

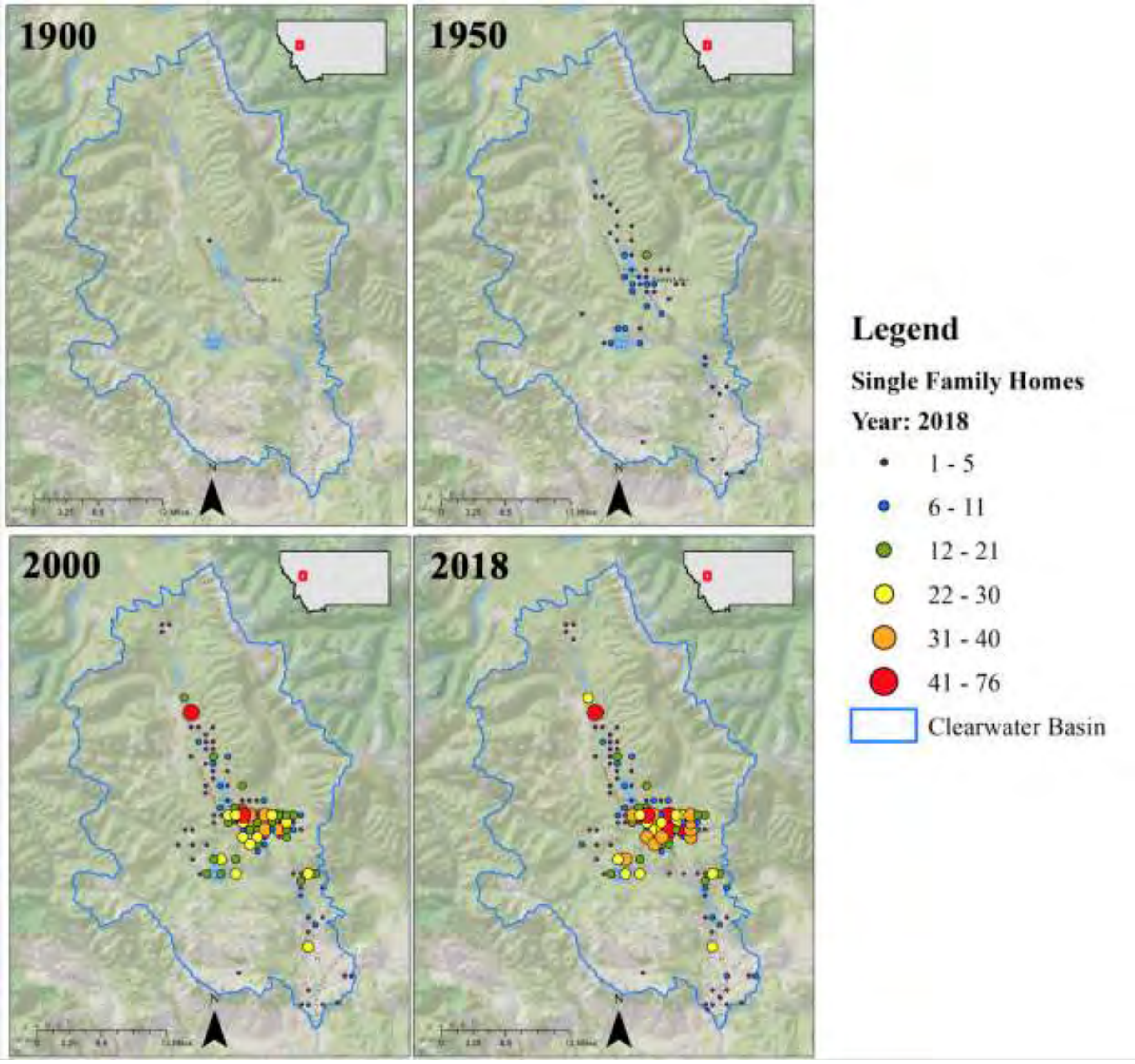


Figure 32: Number of single-family homes in the Clearwater Valley in 1900, 1950, 2000, and 2018. *Data Compiler: Headwaters Economics. Data Source: Montana Department of Revenue, Property Assessment Division*

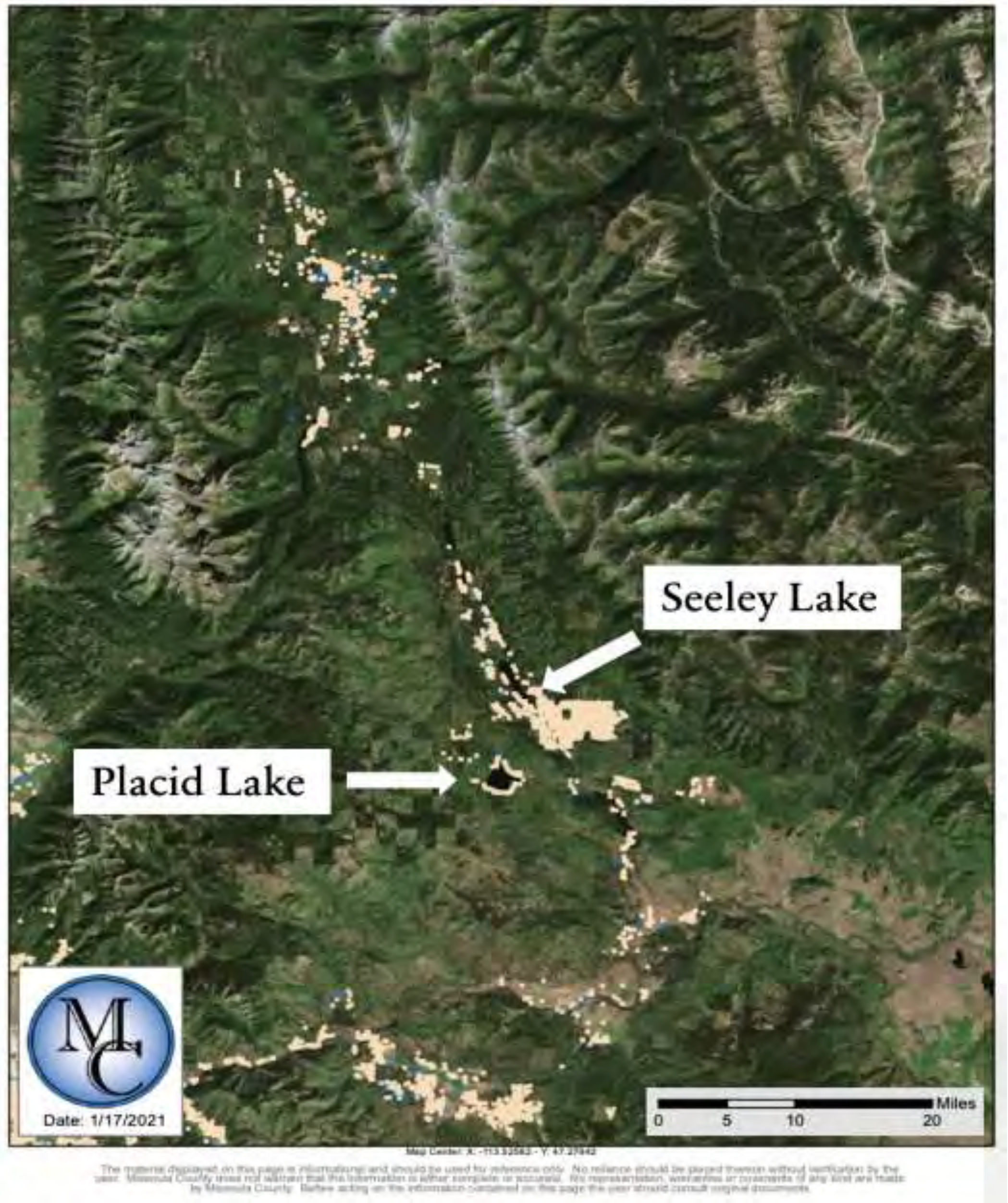


Figure 33: Location of septic systems in Missoula county. Note the high density directly adjacent to the major lakes. *Data Source: Missoula City-County Health Department*

A groundwater evaluation (Norbeck and McDonald, 1999) was completed for the Seeley Lake area by the Montana Bureau of Mines and Geology to address some of the concerns regarding possible septic contamination. Water samples were collected from 12 wells and 5 surface water sites. Surface water sample sites included Morrell Creek, Seeley Lake and the Clearwater River. The purpose of the study was to establish baseline conditions of water quality and to “evaluate the possibility of contamination from septic tank effluent” (Norbeck and McDonald 1999). The study used concentrations of phosphate, nitrate and chloride as indicators of septic effluent (Peavy, et al 1980). The tabulated values are given below (Table 15), as noted in Norbeck and McDonald (1999).

Table 15. Typical Septic Tank Effluent Characteristics (from Peavy et al 1980).

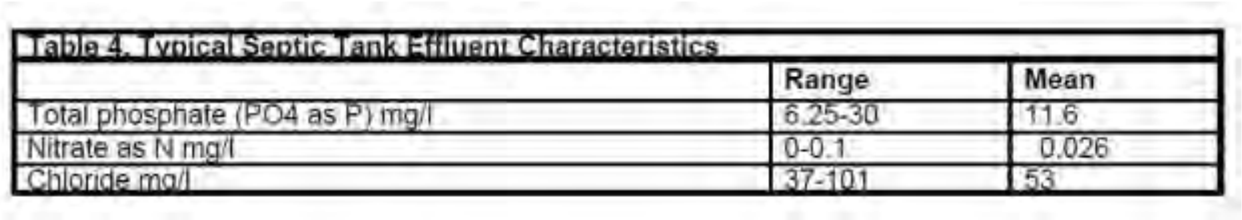


Table 4. Typical Septic Tank Effluent Characteristics

	Range	Mean
Total phosphate (PO4 as P) mg/l	6.25-30	11.6
Nitrate as N mg/l	0-0.1	0.026
Chloride mg/l	37-101	53

Results of the groundwater sampling near Seeley Lake, showed nitrate concentrations (as nitrogen) ranging from below detection to 27 mg/L with a median value of 0.20 mg/L. Background (natural) nitrate (as N) and chloride concentrations appear to be 1 mg/L and 10 mg/L, respectively. Hydrogeologic studies and USGS projections consistently estimate that the natural background concentration of nitrate in groundwater are less than 2 mg/L, (Mueller and others 1995; Halberg and Keeney 1993; U.S. Geological Survey 1999). The probability plot for nitrate (Figure 34) suggests that, for Seeley Lake, groundwater concentrations greater than 1 mg/L may be appropriately considered impacted by human sources.

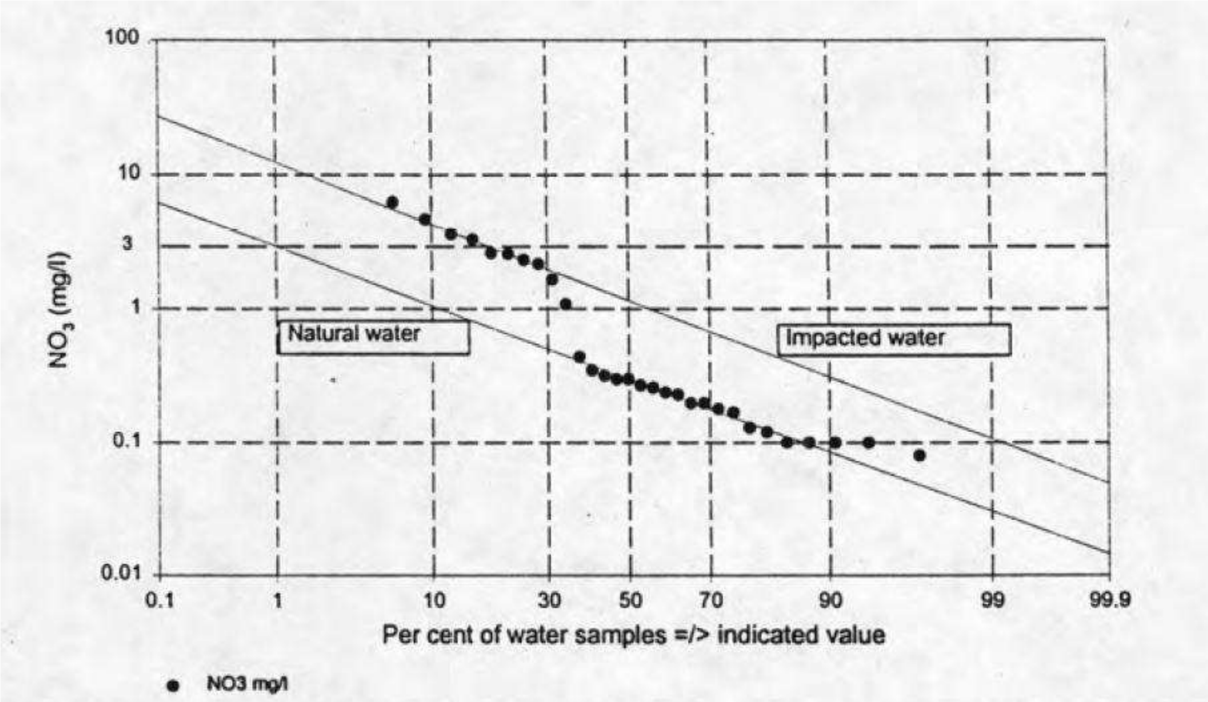


Figure 10. Probability plot - nitrate in Seeley Lake area ground water

Figure 34. Probability plot of nitrate concentrations in Seeley Lake groundwater.

This hypothesis is corroborated by the positive correlation between nitrate and chloride (Figure 35), which is suggestive of septic tank effluent contamination (Peavy et al 1980). Most sample sites with nitrate concentrations greater than 1 mg/L correspond to chloride values greater than 10 mg/L. These sites are in or down-gradient from areas representing older developments such as the townsite of Seeley Lake or the airport area. The maximum contaminant level for drinking water is 10 mg/L for nitrate (USEPA 1982).

This study concluded that the Seeley region's groundwater is likely being degraded by septic-tank effluent, as evidenced by the nitrate and chloride levels found in the groundwater (Norbeck & McDonald 1999).

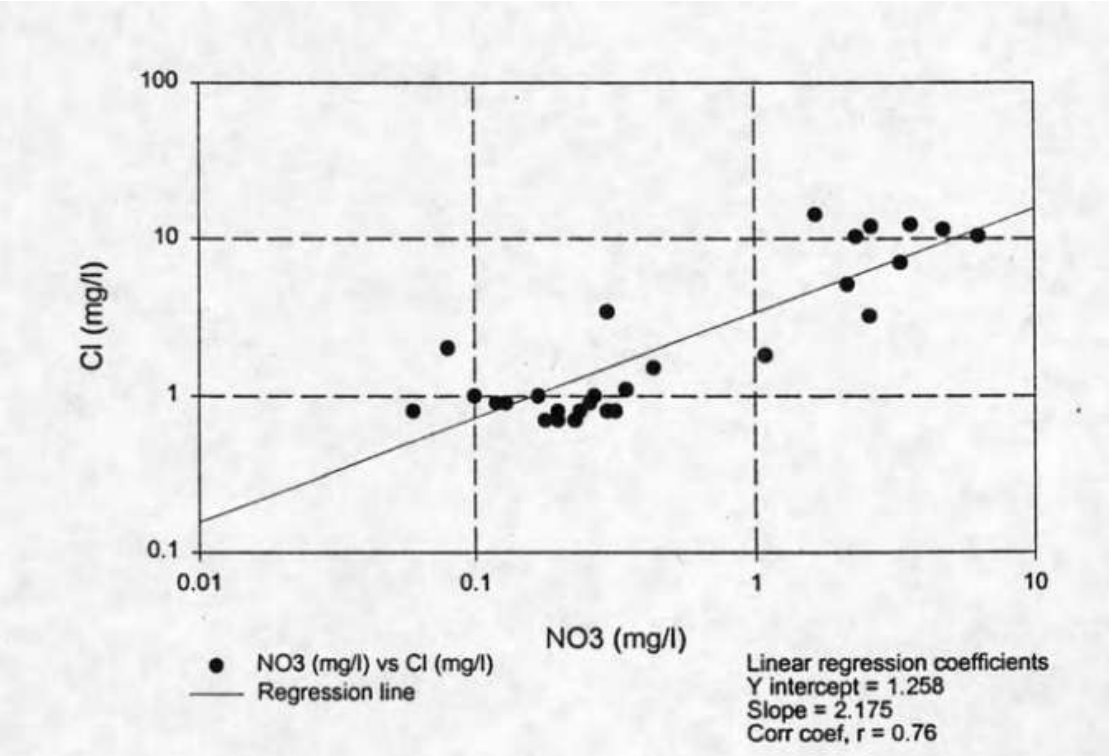


Figure 35: Nitrate vs chloride, Seeley Lake groundwater. *Data Source: Montana Bureau of Mines and Geology 1999*

Norbeck and McDonald (1999) also suggested that a visual indication of degradation may be a gradual increase in algae along the shore and decreased visibility in the water. In recent years, impacts to surface water have been observed in the form of accelerated growth of aquatic vegetation along the shorelines of Seeley Lake and the Clearwater River. More recent increases in observances of large scale algae blooms on Salmon and Placid Lakes may also be evidence of further degradation via septic influence. Conclusions from this report also suggest that additional development along the shoreline of Seeley Lake would likely result in septic tank effluent reaching the lake, but development east and south of town is not likely to threaten Seeley Lake, as groundwater is likely to flow toward the Clearwater River or Morrell Creek. The lack of publicly available data and research pertaining to the impacts of septic effluent need to be addressed. The Montana Bureau of

Mines groundwater study was completed over two decades ago, and it is plausible that further contamination has occurred in that time period due to the continued aging of septic systems and increase in number of systems as the community has grown.

The Seeley Lake Water District has historically conducted groundwater (well) and surface water (lake) monitoring data from 2004 through present day in and around Seeley Lake for various parameters, including water temperature, pH, nitrate/nitrite, chloride, total coliform, and E. coli. The well and surface water sample locations are shown in Figure 36. Nitrate-nitrite concentrations for three wells and three surface water locations are shown in Figure 37. Well #1 near Lindy's exceeded the EPA's recommended maximum contaminant level of 10 mg/L on 7 occasions. Well #2 (Baptist Church) nearly reached the MCL of 10 mg/L. Concentrations in well #3 (Kurt's Polaris) do not appear to either increase or decrease over time and have stayed below the 10 mg/L threshold (Water Quality Association 2014). Natural concentrations in groundwater rarely exceed 0.6 mg/L with primary nitrate sources coming from human waste, animal waste, or fertilizer. The surface water samples have consistently exhibited near-zero concentration values.

Figure 36 (a, b, c, d): (a-c) Nitrate/nitrite levels at three well locations in the vicinity of southern Seeley Lake, monitored by the Seeley Lake Water District over the last ~15 years. (d) Locations of wells and surface monitoring stations.

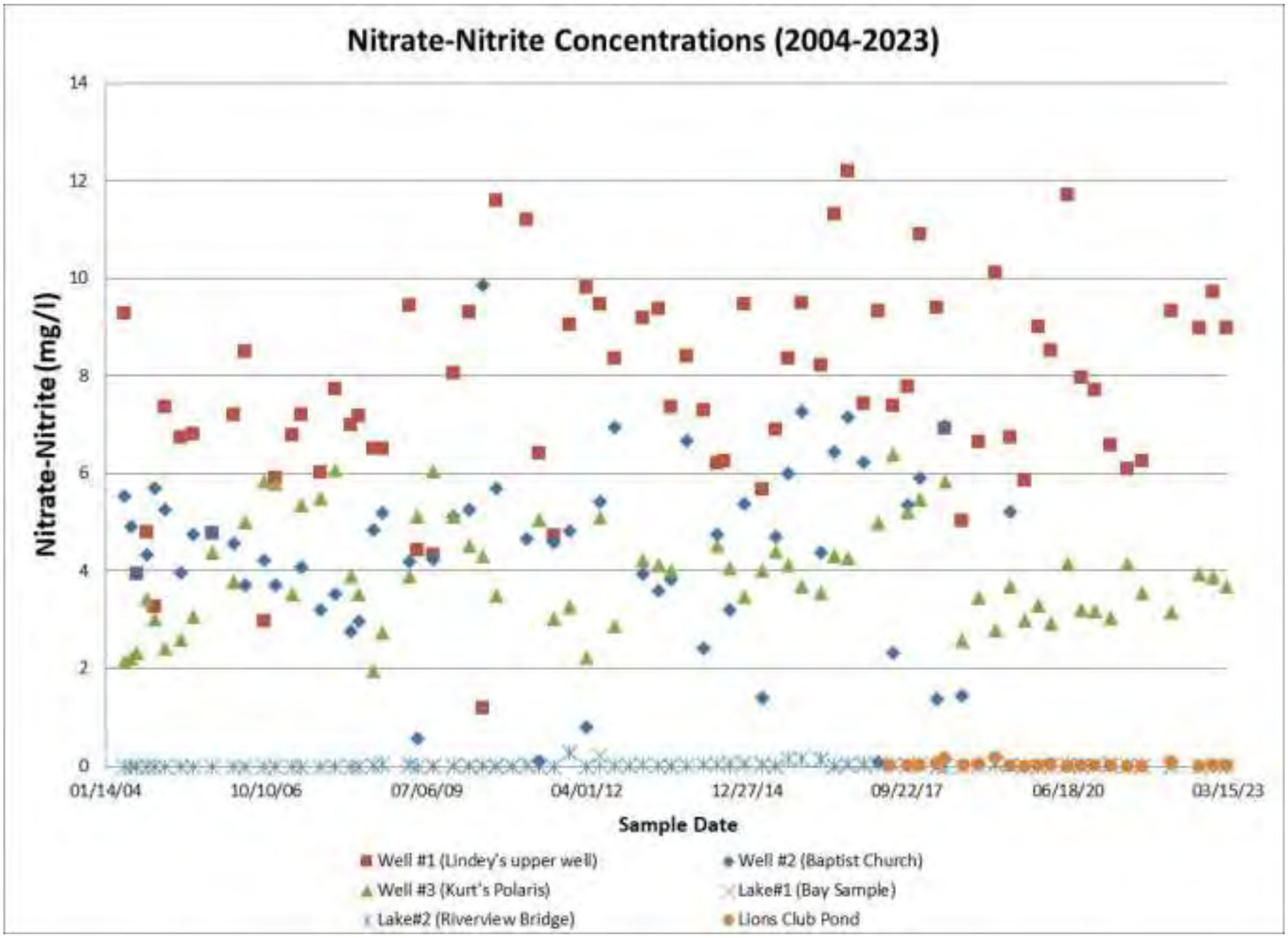


Figure 37. Nitrate-nitrite concentrations in groundwater and surface water samples collected by the Seeley Lake Water District.

Total coliform concentrations (Figure 38) show that well #1 has the greatest coliform counts, but all of the sample locations exhibited significant counts. Coliform is a specific group of bacteria not typically found in groundwater. The presence of coliform bacteria in groundwater is not an immediate indication of a health risk but is an indicator that groundwater is being influenced by surface activities and may indicate more harmful organisms might be present. In the period 2005-2008, wells #1 and 2 had 13 and 12, respectively, coliform counts that were considered “unsafe”. Well #3 had 13 coliform values considered “unsafe” during the same period. *E. coli* was measured in the surface water samples (Figure 39), which shows significant concentrations at all three locations.

Montana’s *E. coli* water quality standards are contained in the Administrative Rules of Montana (ARM). General surface water quality standards state, “standards for *Escherichia coli* bacteria are based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period analyzed by the most probable number or equivalent membrane filter methods” (ARM 17.30.620(2)). Montana’s *E. coli* criteria vary depending on use classification, recreation season, and type of criteria (Table 16) (ARM 17.30.621 through 629, and 17.30.650 through 657) (Makarowski, 2020a).

The collected samples were not part of a five-sample collection so Montana water quality standards cannot be strictly applied but a number of the more recent samples exceed Montana standards (Table 1 of Makarowski, 2020a). The allowable *E. coli* concentration varies with season and use classification of the waters. The beneficial uses of Montana waters are given in Table 17 (Makarowski (2020b). For primary recreation contact (e.g., swimming) the not to exceed limit of *E. coli* is 126 cfu/100 ml.

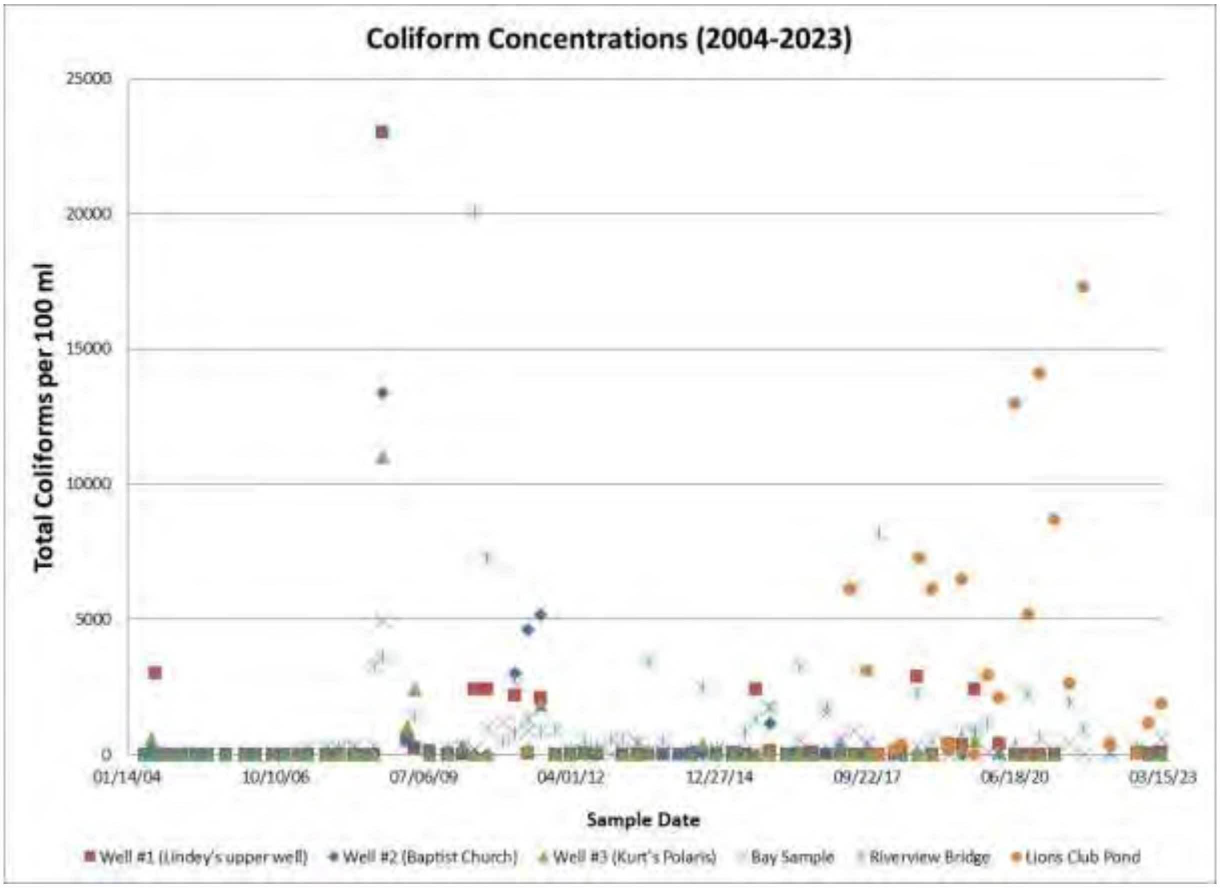


Figure 38. Total coliform values in samples collected by the Seeley Lake Water District.

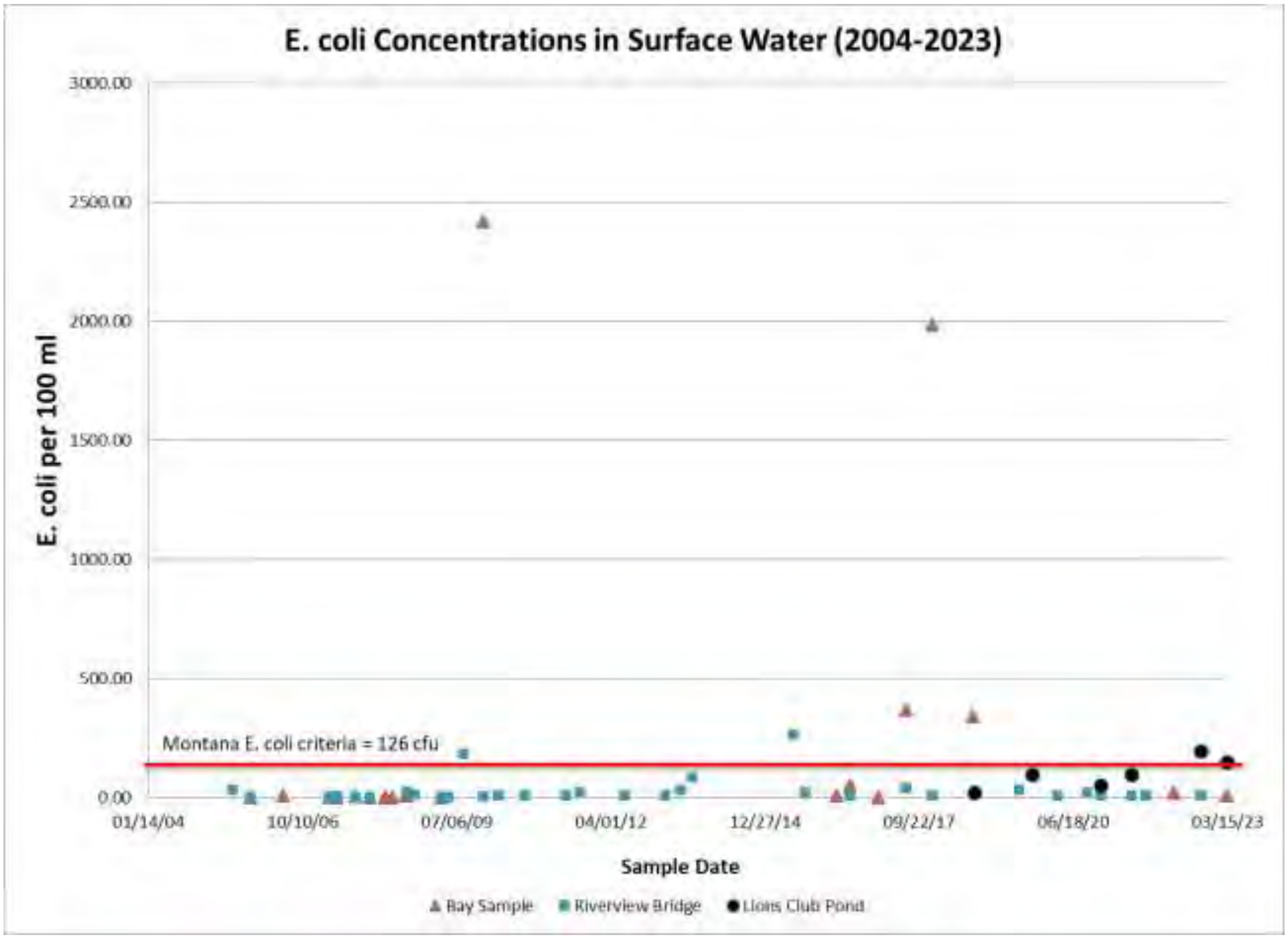


Figure 39. *E coli* values in surface water samples collected by the Seeley Lake Water District.

Table 16. Montana *E. coli* standards for different water use classifications. Source: Makarowski 2020a.

Table 1. Montana's *E. coli* Criteria

Use Classification	Beneficial Use	Applicable Time	Criteria (cfu/100ml or mpn/100ml)	
			Geometric Mean (may not exceed)	Statistical Threshold Value (10% may not exceed)
A-1 and A-closed	Drinking water	year-round	32	64
	Primary contact recreation	April 1 - October 31	126	252
	Secondary contact recreation	November 1 - March 31	630	1260
B, C, and I	Primary contact recreation	April 1 - October 31	126	252
	Secondary contact recreation	November 1 - March 31	630	1260
D, E, F, G	Secondary contact recreation	Year-round	630	1260

Table 17. Types of beneficial uses for Montana waters. Source: Makarowski, 2020b

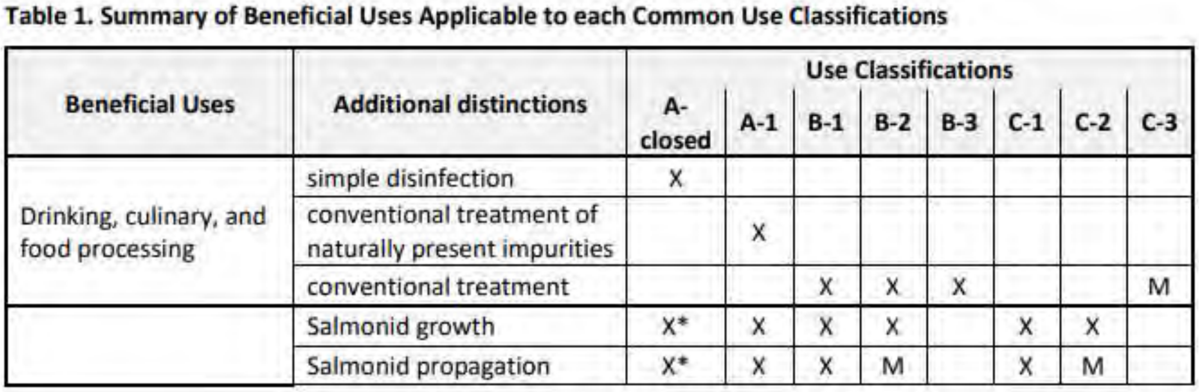
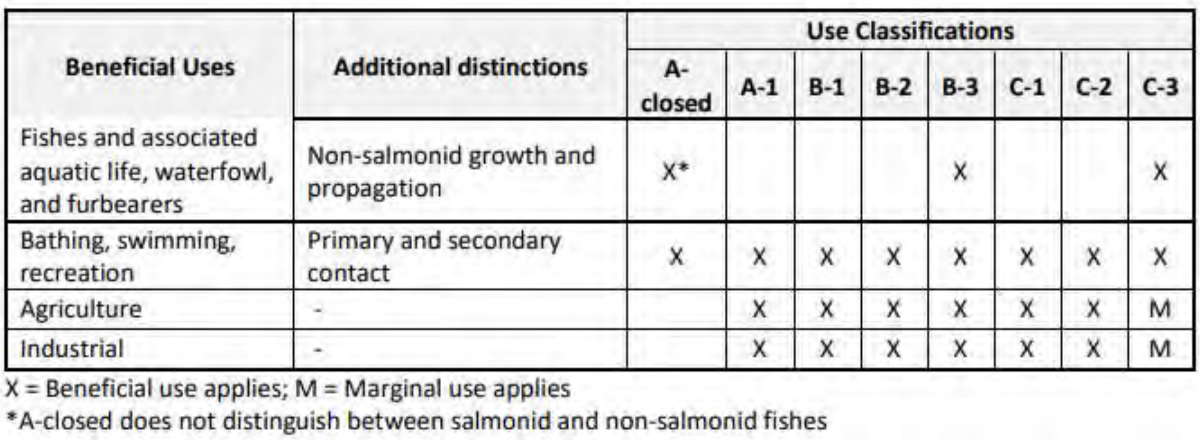


Table 1. Summary of Beneficial Uses Applicable to each Common Use Classifications

Beneficial Uses	Additional distinctions	Use Classifications							
		A-closed	A-1	B-1	B-2	B-3	C-1	C-2	C-3
Drinking, culinary, and food processing	simple disinfection	X							
	conventional treatment of naturally present impurities		X						
	conventional treatment			X	X	X			M
	Salmonid growth	X*	X	X	X		X	X	
	Salmonid propagation	X*	X	X	M		X	M	



Beneficial Uses	Additional distinctions	Use Classifications							
		A-closed	A-1	B-1	B-2	B-3	C-1	C-2	C-3
Fishes and associated aquatic life, waterfowl, and furbearers	Non-salmonid growth and propagation	X*				X			X
Bathing, swimming, recreation	Primary and secondary contact	X	X	X	X	X	X	X	X
Agriculture	-		X	X	X	X	X	X	M
Industrial	-		X	X	X	X	X	X	M

X = Beneficial use applies; M = Marginal use applies

*A-closed does not distinguish between salmonid and non-salmonid fishes

Most recently, a new set of monitoring wells have been installed in the Seeley Lake community (Figure 40). These wells are being sampled quarterly for chloride, nitrate, nitrite, total nitrogen, and total Kjehldahl nitrogen. A summary of the 2022-2023 samples (Figure 41) shows an exceedance of the maximum contaminant limit for nitrate at well #5. This exceedance occurred in June 2023. Other sampling of this well encountered dry conditions (no water). Remaining wells were below MCL standards but nitrate concentrations often approach the MCL standard and exceed expected background nitrate concentrations in groundwater. The highest nitrate concentrations were found at monitoring wells 2, 4, 5 and 13. Monitoring wells 2, 4, and 5 are located downgradient of the steepest (highest velocity) groundwater flow, based on the potentiometric surface (Figure 42) constructed by Norbeck and McDonald (1999), Nitrate and chloride concentrations are positively correlated, similar to the correlation shown in Figure 36 (Norbeck and McDonald, 1999) and exhibit a similar R-squared value. This relationship appears to add evidence that septic effluent is present in groundwater.

Figure 40. Location of new monitoring wells in Seeley Lake.

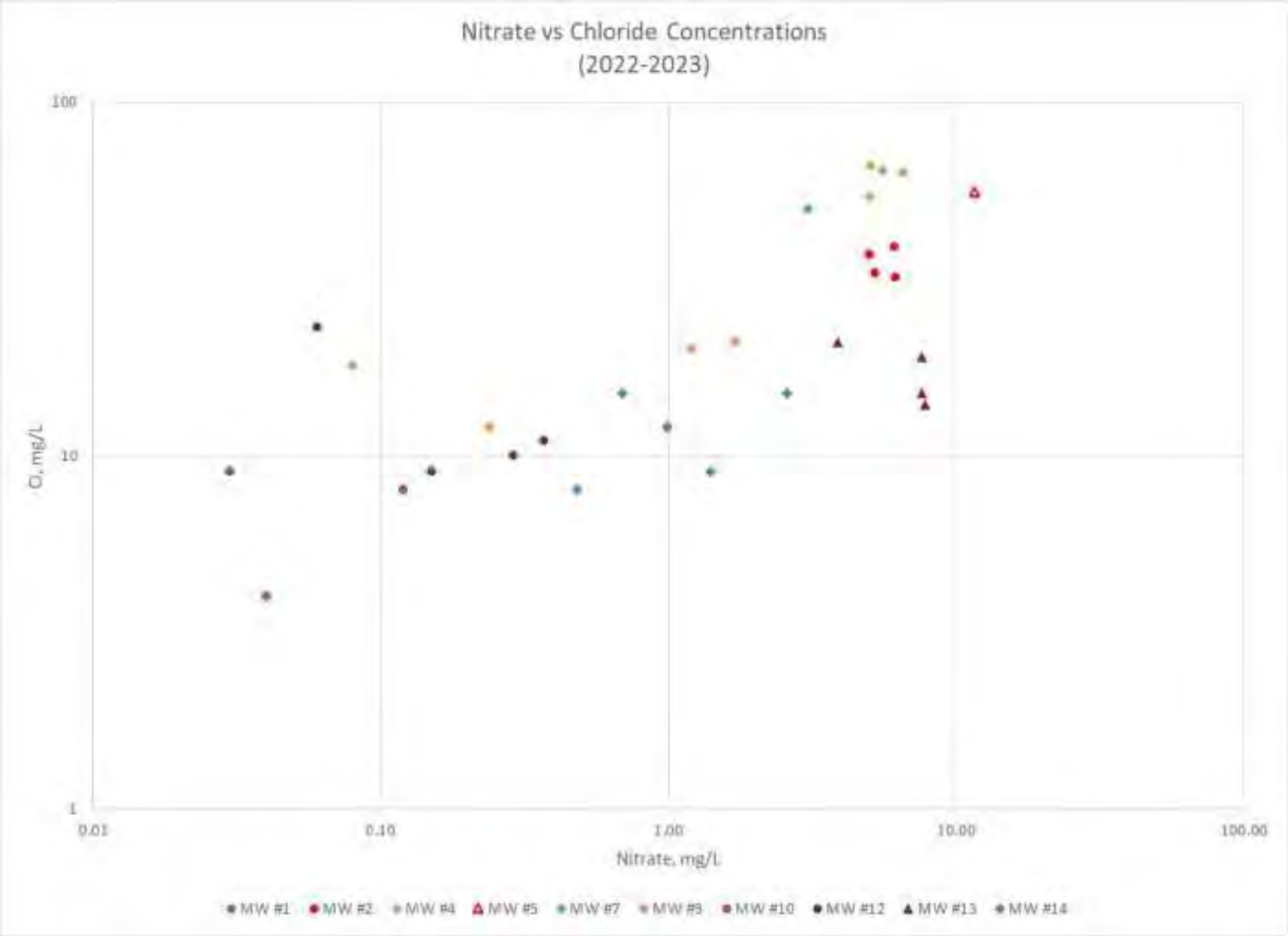


Figure 41. Nitrate versus chloride concentrations in Seeley Lake monitoring wells, 2022-2023.

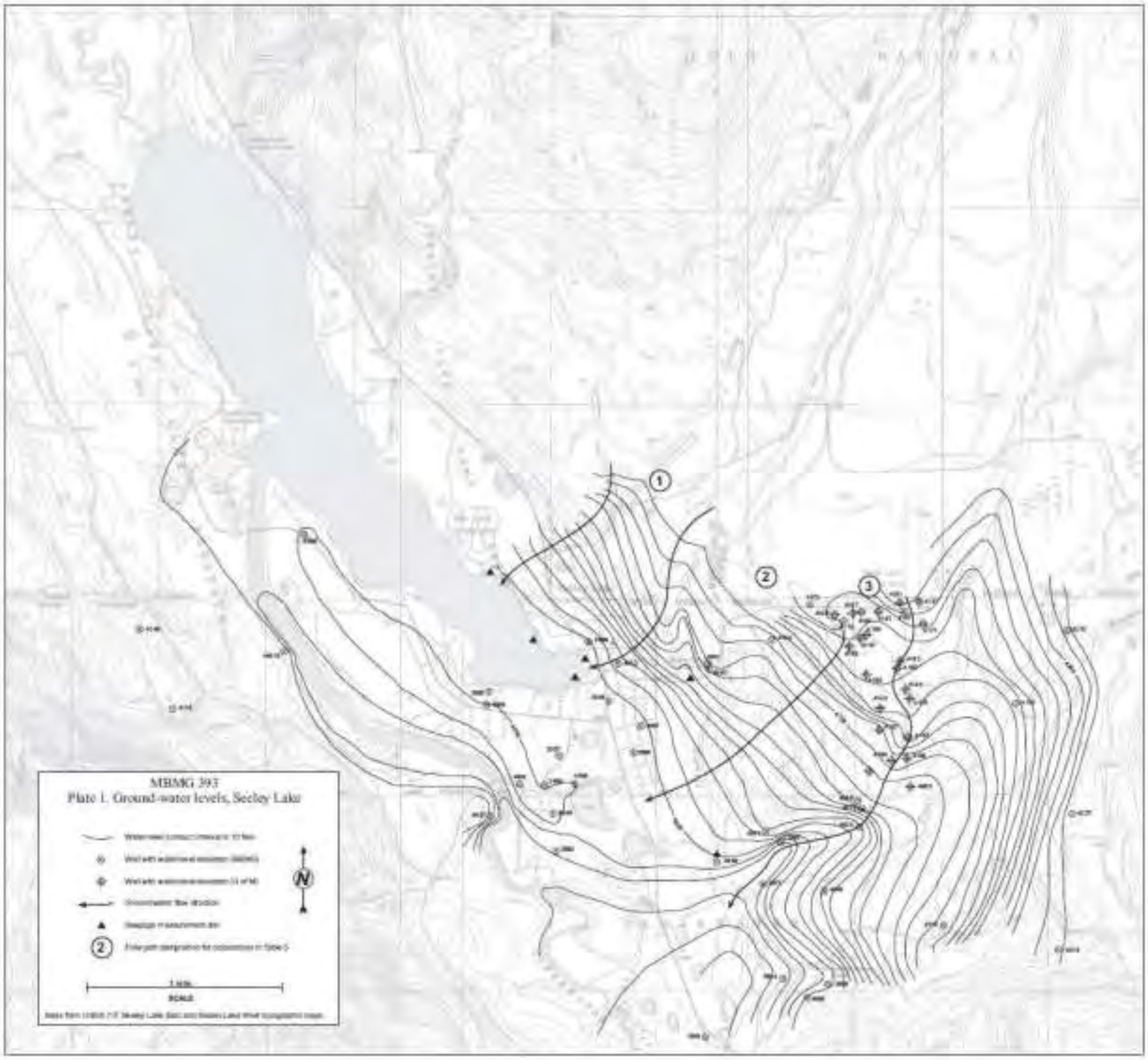


Figure 42. Potentiometric surface and direction of groundwater flow, Seeley Lake (taken from Norbeck and McDonald 1999).

Summary statistics of nitrate and chloride levels for the 3 well locations and 2 surface water locations are included in Table 18 below. Further analysis is necessary to continue tracking changes and possible water quality issues in the near future to avoid negative consequences to both the environmental and human health.

Table 18: Nitrate and chloride levels (mg/L) at 5 locations (3 groundwater well locations and 2 surface water locations).

Nitrate mg/L

Location	Mean	Median	St Dev

Well #1	6.83	6.80	2.52
Well #3	3.94	3.73	1.25
Well #2	4.37	4.57	1.60
Surface #1 (lake)	0.03	0.01	0.07
Surface #2 (lake)	0.03	0.01	0.07

Chloride mg/L

Location	Mean	Median	St Dev
Well #1	59.89	42.50	38.17
Well #3	90.22	79.50	42.62
Well #2	58.41	65.00	21.49
Surface #1 (lake)	3.98	2.00	13.39
Surface #2 (lake)	1.50	2.00	1.09

Septic tank densities were mapped around the 5 most developed lakes in the Valley: Big Sky Lake, Placid Lake, Lake Inez, Seeley Lake, and Salmon Lake (figures 43-47).

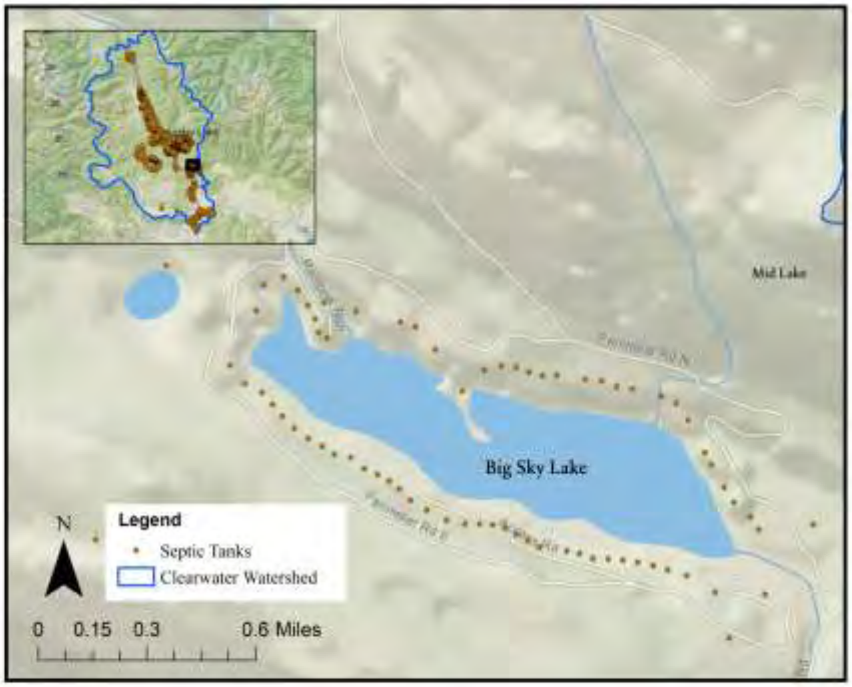


Figure 43: Septic tanks around Big Sky Lake.

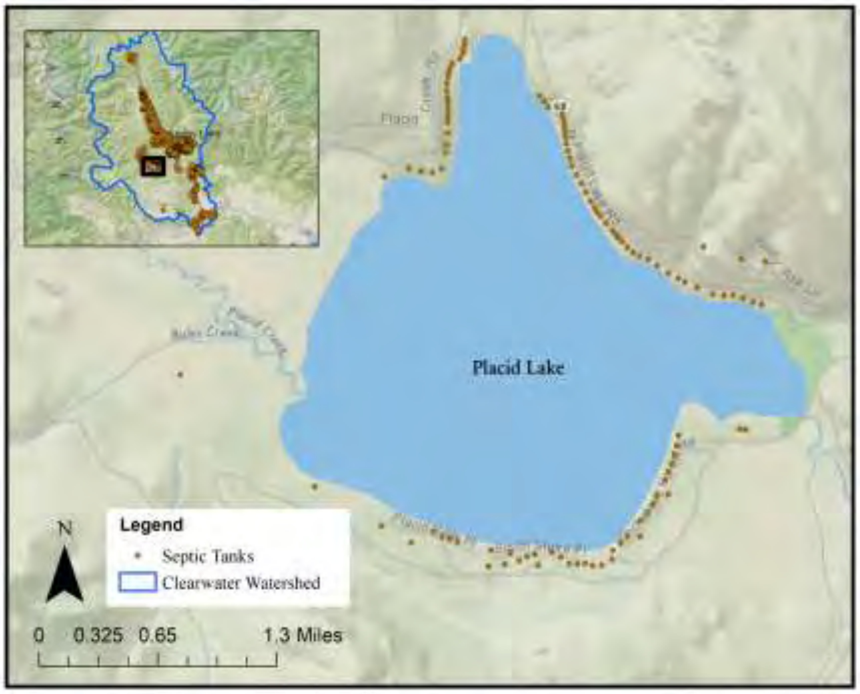


Figure 44: Septic tanks around Placid Lake.

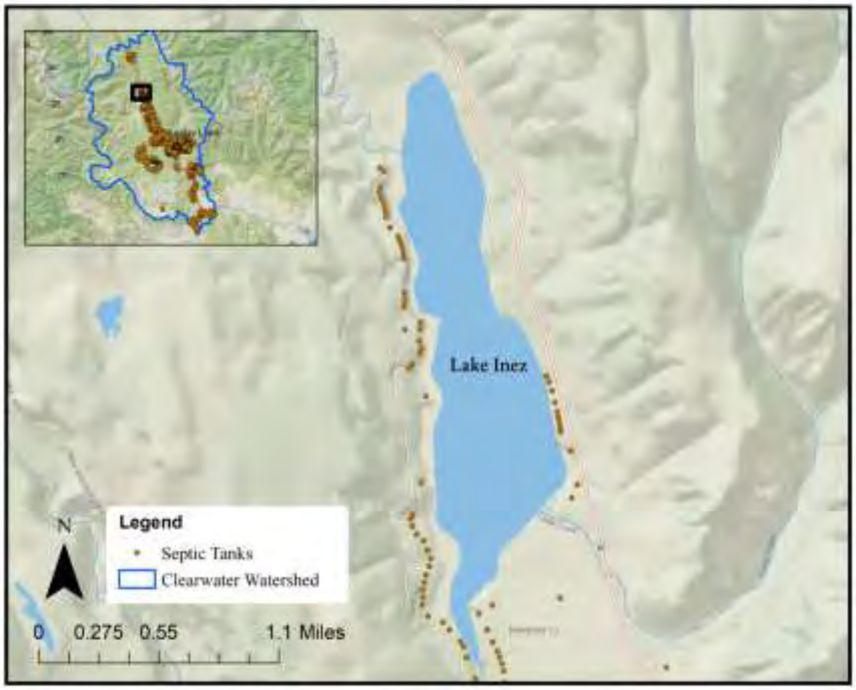


Figure 45: Septic tanks around Lake Inez.

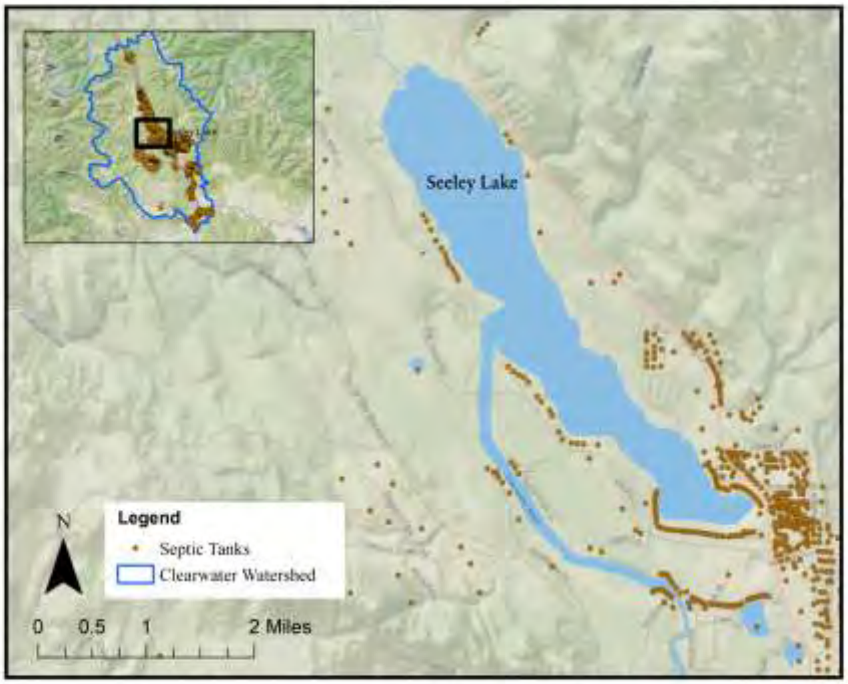


Figure 46: Septic tanks around Seeley Lake.

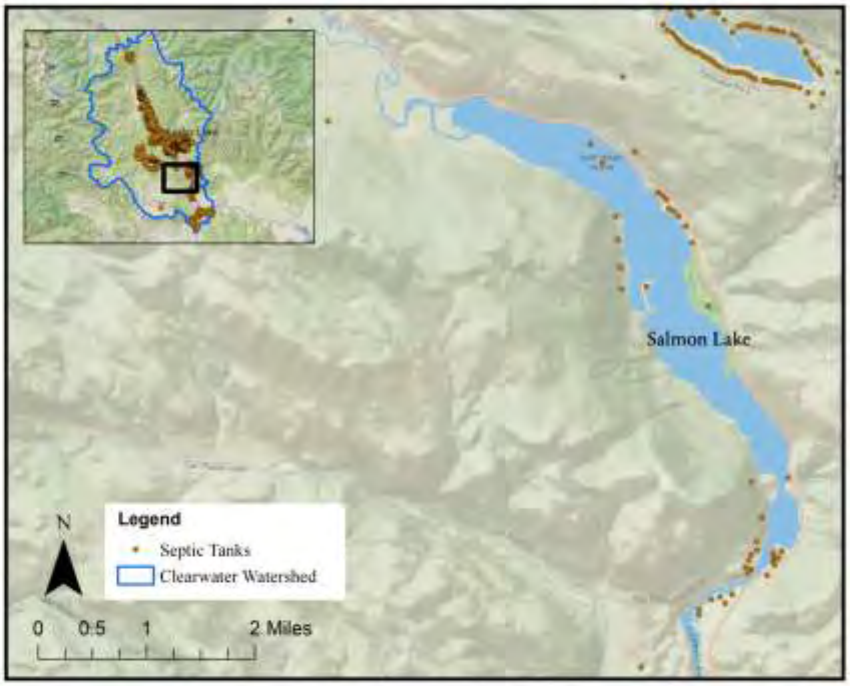


Figure 47: Septic tanks around Salmon Lake.

4.2 Algae Blooms

Persistent and large-scale algae blooms have been observed on many of the lakes in the Valley in the past few decades (Figure 48). Although the presence of algae blooms has not been recorded with much consistency, the DEQ began publishing public reports of harmful algae blooms in 2017. According to their records, in 2018, blooms were reported on Placid Lake, in 2019 on Seeley Lake and in 2020 on Inez, Seeley, Placid, and Salmon Lakes (DEQ n.d.). The 2020 blooms on Placid and Salmon Lakes were identified by the Flathead Lake Biological Station as *Anabaena*, a taxonomic group of algae capable of producing a range of toxins which can be fatal if ingested. While most blue-green algae blooms do not produce toxins, all blooms should be considered potentially toxic to both animals and humans.

Although blooms have been identified in years before 2017, they have not been officially reported in a way that quantitative conclusions can be made about the trends in algae blooms and how they may be increasing or decreasing in frequency on the lakes in the Clearwater Valley. As discussed in the 1999 Montana Bureau of Mines and Geology study, increasing algae along the shore and decreased visibility in the water could be a visual indication of degradation. Algae blooms should be monitored and reported on with more consistency in the future to track changes occurring over time. When algae blooms arise in the future, species should be identified when possible to confirm whether blooms have the potential to be toxic or not. Types of algae can also indicate what types of pollution are occurring.

Figure 48: Top: an aerial view of the 2013 Salmon Lake algae bloom, photographed by Karen Pratt on a flight piloted by David Wallenburn. Bottom: the 2020 Salmon Lake algae bloom identified and photographed by Jeff Harrits south of the state park boat launch area.

4.3 Climate Change

Climate change is expected to drastically impact native fish in the Columbia River Basin, including both bull trout and westslope cutthroat trout. Bull trout in particular seem to have a lower temperature preference and requirement than other salmonids which may further limit their range as climate change continues (Rieman & Mclntyre 1993).

As discussed in DEQ’s Montana Nonpoint Source Management Plan, recognizing the profound impact that climate change has and will have on Montana’s water quality is a vital component in planning for the future. The 2017 Montana Climate Assessment reports that “rising temperatures will reduce snowpack, shift historical patterns of streamflow in

Montana, and likely result in additional stress on Montana's water supply, particularly during summer and early fall" (C. Whitlock et al. 2017).

Specific to water quality, climate change could result in higher stream temperatures and more intense watershed disturbances (e.g. rain events, flooding, high stream flows, landslides, large forest fires, etc.) which would likely lead to negative effects to aquatic life, including native fish populations. In the mountainous regions of Montana, high elevation snowpack serves as a natural water storage system, slowly releasing water into streams and groundwater throughout the spring and summer and recharging in the fall and winter. As air temperatures warm, the snowpack is predicted to develop later and melt earlier, causing peak runoff to come earlier in the winter and spring. This could result in decreased stream flows and reduced groundwater levels in summer and fall. More precipitation is predicted in the form of rain in future decades, not snow, which could also speed melting of the snowpack. This would increase the likelihood of winter floods resulting in increased streambed scouring and streambank erosion. Periodic droughts may affect the way water is stored and used, diminishing the amount available for release to maintain flows needed for optimal stream temperatures and aquatic habitat.

Data for bull trout redds (spawning nests) were obtained from MT FWP for three streams in the Clearwater Valley: East Fork Clearwater, West Fork Clearwater, and Morrell Creek (Figure 49). According to these data from MT FWP's annual inventory, all three streams have shown sharp declines in redd counts from 2010-2019. These three streams, along with others in the Valley, are considered critical habitat for bull trout. The stark decline in redds over the past decade is likely due to climate impacts, according to local fish biologist Shane Hendrickson.

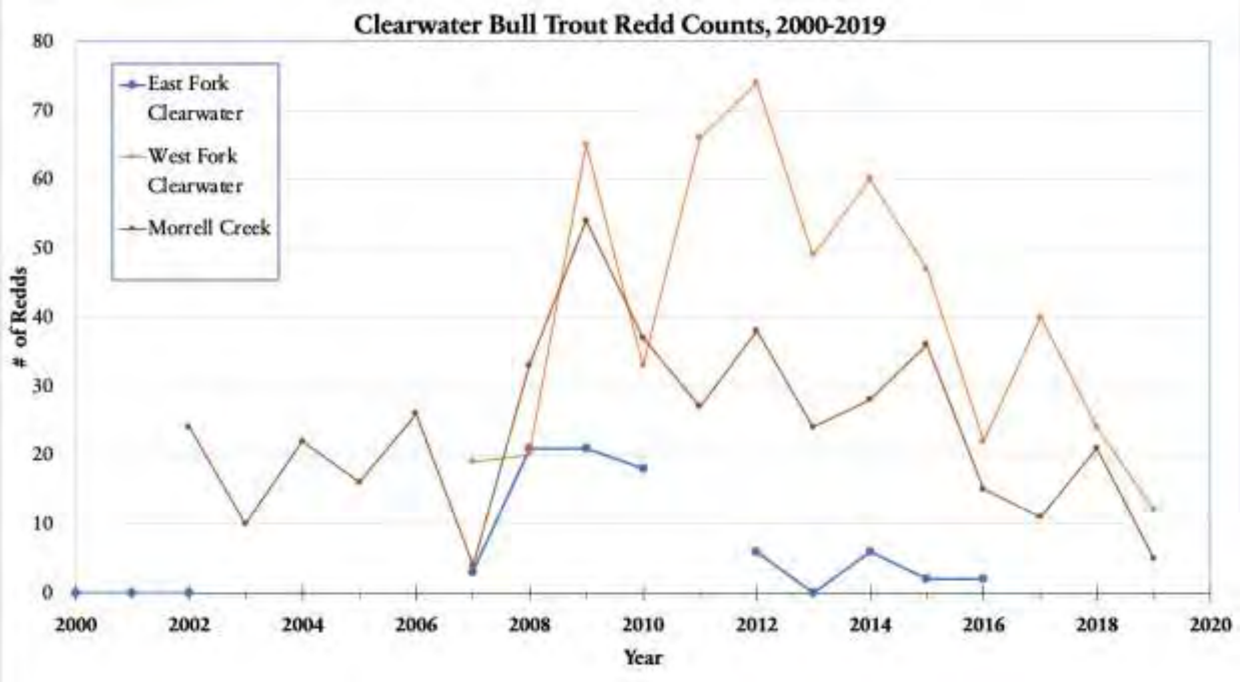


Figure 49: Annual bull trout redd counts in three Clearwater Valley streams from 2000 through 2019. *Data Source: FWP*

The USFS NorWeST stream temperature database and modeling website was used to predict climate change scenarios across the streams in the Clearwater Valley. Data were downloaded for present-day mean August stream temperatures as well as predictions for 2040 and 2080. Current mean August temperatures are mapped in Figure 50. Temperatures are lowest at the eastern and western sides of the Valley, where the stream headwaters begin at high altitudes in the Swan and Mission ranges. The mainstem of the Clearwater River, which flows through the center of the basin has some of the highest mean August temperatures, with some reaches of the river exceeding 19° C (66.2° F).

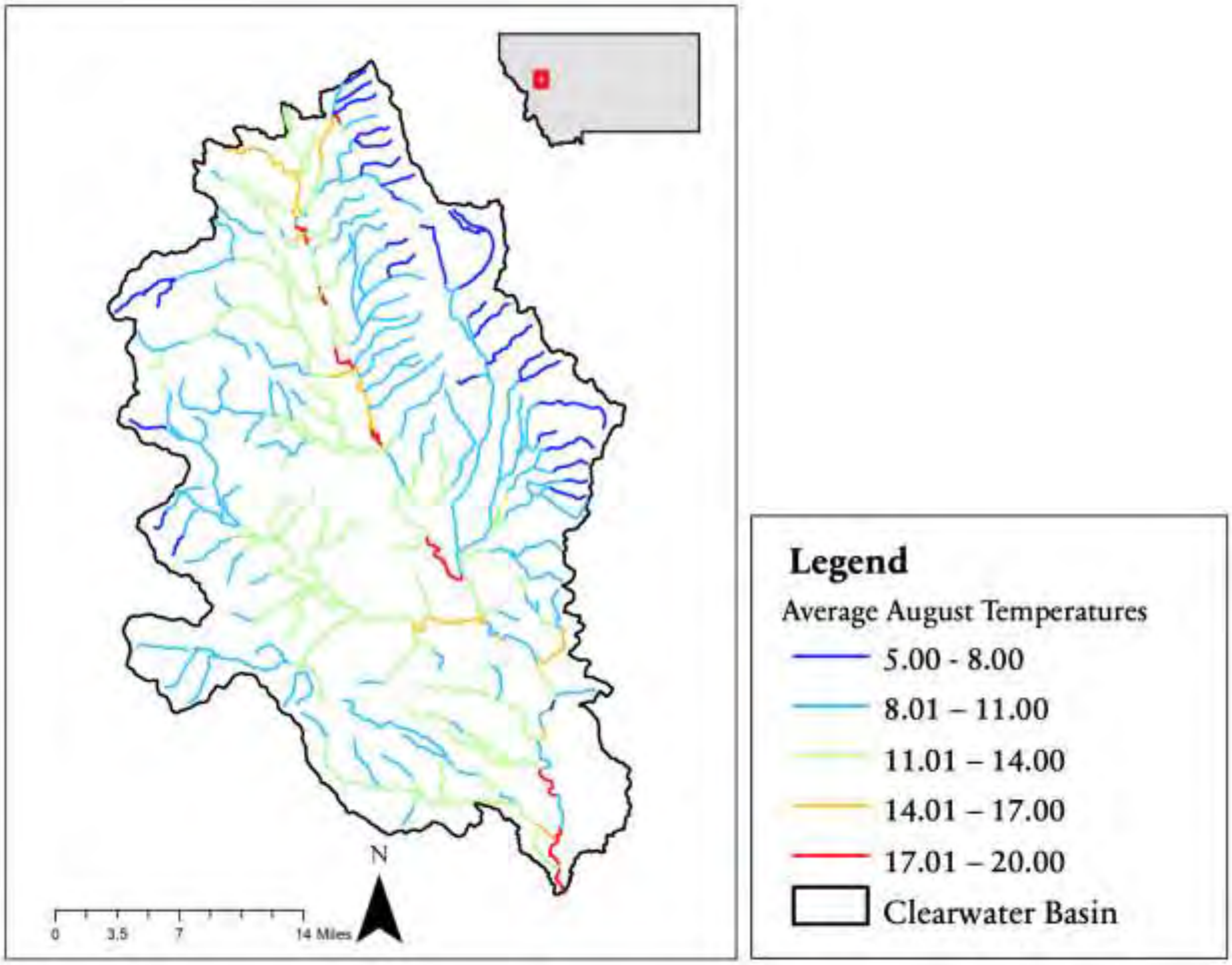


Figure 50: Average August stream temperatures in the Clearwater Valley. *Data Source: NorWeST modeled stream temperatures (USFS)*

One analysis of salmonid temperature limits defined 11° C as the upper limit of ideal stream temperatures for bull trout and cutthroat trout for the following reasons:

"Juvenile bull trout and cutthroat trout were most common at the coldest stream sites (90% of bull trout observations and 75% of cutthroat trout observations occurred at sites

≤11 °C); whereas brown trout and rainbow trout were rare at those sites. The thermal niche of brook trout overlapped that of the native species, but its occurrence peaked at a slightly warmer temperature and declined thereafter. As a compromise between minimizing species overlap and affording bull trout and cutthroat trout the largest possible habitats, we chose a mean August temperature of 11 °C to delimit the downstream extent of cold-water habitats." (Isaak et al. 2015)

NorWeST stream temperature projections for 2040 and 2080 were analyzed for the Clearwater Basin and graphed in figure 52 below. Using Isaak et al.'s rationale (above), 11 °C was used as the threshold for analysis.

According to the analysis of stream temperatures in the Valley, currently approximately 376 miles of streams in the basin are under 11 °C in August. By 2040, this mileage is expected to decrease to approximately 230 miles, and by 2080, only 142 stream miles will have a mean August temperature under 11 °C (figure 51). This stark decrease in viable habitat for fish dependent on cold-water habitats (bull trout and cutthroat trout) will be detrimental to the future survival of these species. As evidenced by the declines already occurring in redds in East and West Forks of the Clearwater River and Morrell Creek, we are already seeing the vast implications climate change is having on sensitive native species.

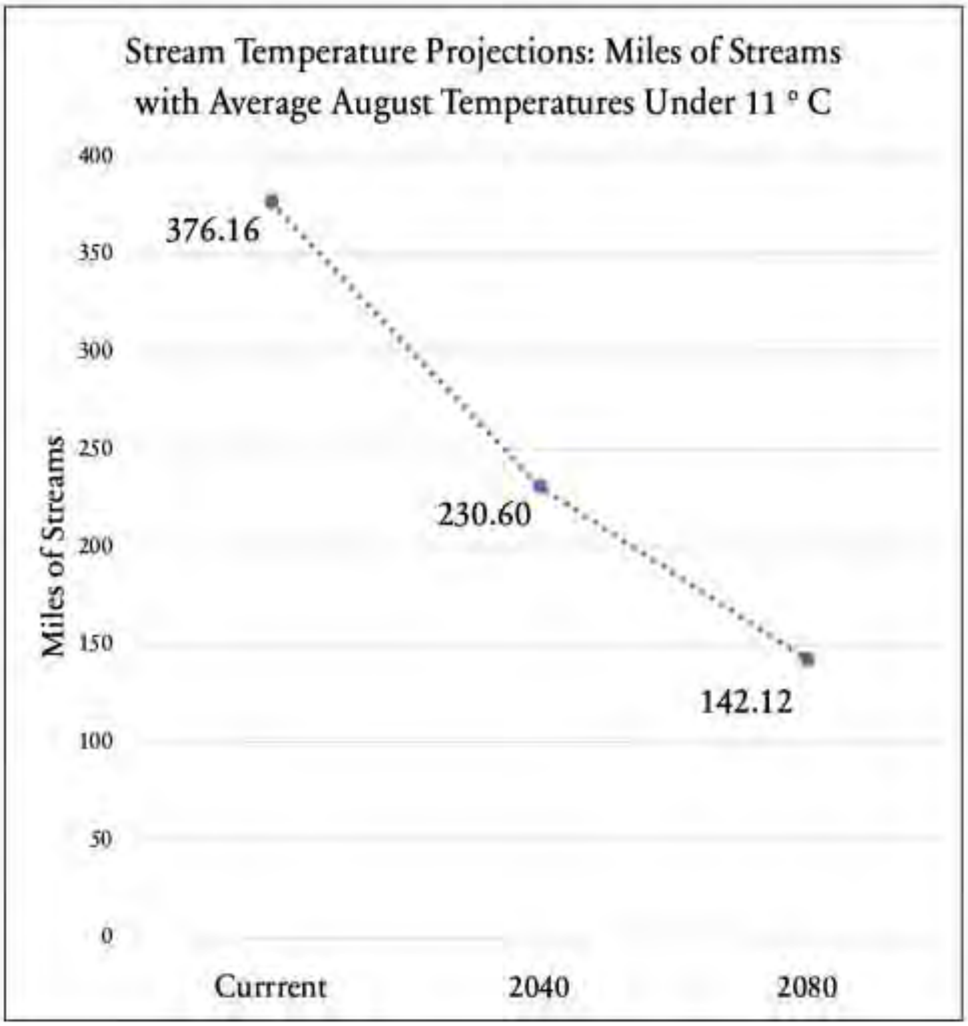


Figure 51: stream temperature projections: miles of streams with average august temperatures under 11 ° C in 2040 and 2080. *Data source: NorWeST modeled stream temperatures (USFS)*

4.4 Dams

Although the lakes in the Clearwater Valley remain relatively morphometrically unaltered by dams and other man-made structures, dams have historically impacted both the water quantity and quality of some of the lakes. In 1907 a dirt dam was built approximately 2 miles below the outlet of Seeley Lake by the Big Blackfoot Milling Company to store sufficient water for huge log drives from Seeley Lake to the Bonner sawmill 50 miles downstream (Cladouhos 1971). The dam raised the water level sufficiently to flood 300 acres of meadowland at the upper inlet end of the lake. The flooded soil and vegetation was flushed into the lake for over two decades, and the dam curtailed nutrients from passing through the lake.

Presently, concerns are being raised over the aging dam south of Placid Lake on Owl Creek. The dam was completed in 1972 and remains in place to this day. As of May 8, 2020, biologists from the MT FWP discovered a single non-native northern pike in Placid Lake, a species known to wreak havoc on native fish populations. The extent of the problem is still to be determined; however, if the Owl Creek dam is breached during high water years, this could lead to more unwanted invaders entering Placid Lake.

Unlike reservoirs which often have widely fluctuating water levels, the Clearwater Lakes' water levels remain relatively constant, varying by a few feet or less annually (Brummond et al. 2014). The levels of Lake Inez and Placid Lake are regulated to a small degree by water control structures at their outlets, and Seeley and Salmon Lakes are regulated to an even smaller degree by rocks in their channels. Despite these small anthropogenic influences, these lakes function as natural lakes, not reservoirs.

As part of Montana's statewide water rights adjudication, the MT FWP filed water right claims for seven major lakes in the Clearwater Valley: Placid, Rainy, Clearwater, Alva, Inez, Seeley, and Salmon. The claims were for recreational purposes, predominantly for angling. The water right claims contained an estimate of each lake's natural volume. These estimates were updated in 2002, and include lake capacities (acre-feet), surface areas (acres), and annual evaporation rates (acre-feet) (Table 19).

Table 19: morphometric data by lake and water right number updated in 2002. *Data Source: MT FWP water right claims.*

Lake	Water Right No.	Capacity (ac-ft)	Surface Area (ac)	Annual Evaporation (ac-ft)
Clearwater	76F 149470-00	2,087	103	300
Rainy	76F 149468-00	1,420	81	236
Alva	76F 149467-00	14,477	314	916
Inez	76F 149466-00	11,577	298	869
Seeley	76F 149471-00	58,853	1,047	3,054
Placid	76F 149472-00	64,215	1,300	3,792
Salmon	76F 149469-00	20,341	660	1,925

4.5 Dewatering

Dewatering and resulting declines in water connectivity are predominant threats of concern to the lakes' abilities to support diverse aquatic life. Adequate lake and stream levels are needed for fall spawning, and other vital life stages of native salmonids. Lower pool elevations also limit fish growth and survival by dewatering productive shoreline areas. Shallow lake margins and backwater areas are particularly sensitive to water level fluctuations and can be severely impacted by dewatering. These littoral areas support diverse aquatic vegetation and invertebrates, and act as the primary lake rearing areas for juvenile fish. Lake inflows and outflows also directly influence lake turnover rates and the availability of suitable habitat for cold water fish during water stratification at various points in the year. Salmonids rely on consistent cold-water habitats, which may be threatened by dewatering. Beyond the threats posed to aquatic life, reduced water levels may also limit public access and recreation on many of the lakes. Launching boats becomes more difficult when water levels decrease during the summer.

No formal reports currently exist that describe the extent of the dewatering issues in the Clearwater Valley, primarily due to lack of stream gages (W. L. Knotek, pers. comm. January 20, 2021). However, it is widely known that the Valley has issues with dewatering, which will likely become worse with time due to increasing urbanization and climate change. Urbanization and population growth in the region will likely lead to a higher demand for water. Climate change will likely influence the characteristics of droughts and floods, evapotranspiration, snow-rainfall ratios, and snow seasonality, all of which will in turn affect water levels and connectivity in the Clearwater Valley (de Jong 2015).

The two most serious dewatering issues in the Valley involve Owl Creek from the Placid Lake outlet to the Clearwater River confluence and the Clearwater River from Seeley Lake to the mouth of Morrell Creek (W. L. Knotek, pers. comm. January 20, 2021). Other areas that have become dewatered during severe droughts and have been historically problematic include lower Trail Creek, lower Morrell Creek, the Clearwater River between Alva and Inez Lakes, and the west fork of the Clearwater River below the Lake Inez outlet. Beaver trapping may be exacerbating the dewatering issue, especially below the outlet of Seeley Lake. Beavers are widespread throughout Montana's freshwater habitats, including the lakes and streams of the Clearwater Valley. A characteristic of beaver ecology is their ability to build dams, and as a result, to modify the landscape. This ability makes beavers highly influential geomorphic agents. Beavers are of economical, ecological, and recreational importance in western Montana. Dam building and feeding activities of beaver alter hydrology, channel geomorphology, and biogeochemical pathways and community productivity in ways that often support the survival of other species. Because of this, they are known as keystone species, or in other words, a species whose presence allows certain plants and animals to exist in an area where they may not otherwise occur (Ritter 2019). Conversely, beavers can also have negative effects, like blocking the movement of spawning fish and accumulating silt, which can disrupt spawning areas (Ritter 2019).

Although no recent comprehensive surveys have been completed on beaver abundance specifically in the Clearwater Valley, we know they exist in our region and are providing important ecological services, including increased water storage, habitat diversity and complexity, sediment retention, nutrient cycling, contaminant filtration, fisheries habitat enhancement, and increased groundwater recharge (Clark Fork Coalition n.d.). Through conversations with local stakeholders, we have also learned that beaver trapping is likely contributing to dewatering, specifically between the outlet of Seeley Lake and Morrell Creek. The Clearwater Valley is located within Trapping District 2 (TD2), which had 549 beaver harvests by trappers in 2016 (MT FWP n.d.). TD2 consistently has the second highest number of total beaver harvests in recent years, after TD3.

Water development and diversion represent a potential conflict between commercial, domestic, and natural resource values. There are over 1,500 established water rights in the Valley, including both surface diversion and groundwater (Figure 52). The Seeley Lake Water District is the only commercially developed water system and draws its supply directly from Seeley Lake. The Water District has experienced supply problems in recent years. As the town’s population grows, further water development could become important.

The Clearwater Valley is presently closed to new surface water development, but domestic groundwater development is not constrained. Surface water diversions for agricultural and other non-domestic uses also impact flows and the connectivity of stream networks important for up- and down-stream migrating fishes. Unscreened diversions have a significant effect through reduced flows, increased temperatures, and entrainment of migrating individuals. MT FWP and the Big Blackfoot Chapter of Trout Unlimited have worked with landowners to mitigate the effects of some of the diversions in the Valley in recent years, but others remain. Declining summer flows as a result of climate change could exacerbate the problems linked to stream flows and water availability for both human and ecological systems.

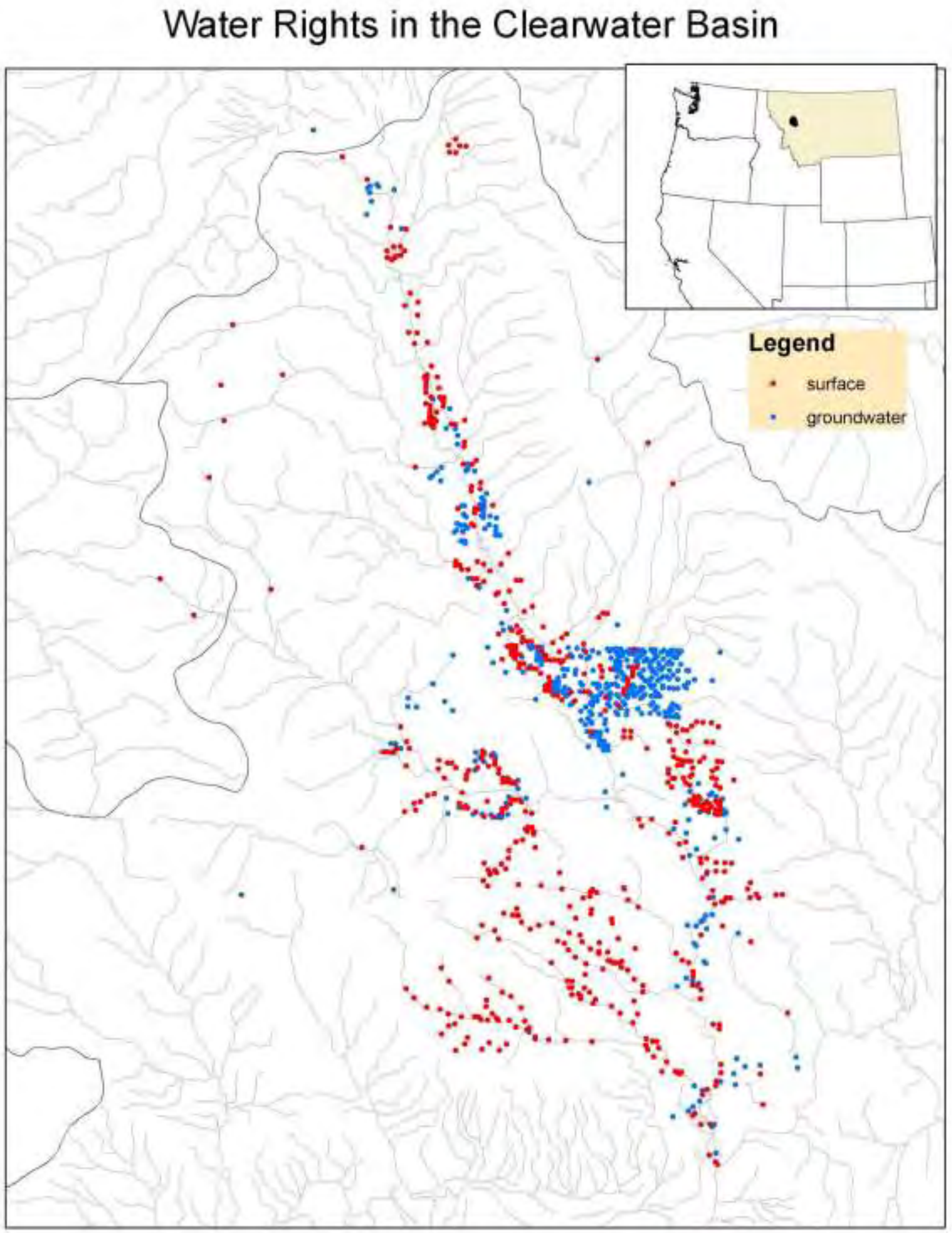


Figure 52: surface and groundwater water rights in the Clearwater Valley.

4.6 Transportation Networks

Major roads in the Clearwater Valley are few. Highway 83 is the primary access route running north-south through the Valley and is the only State Highway maintained road. Jocko Lake Road runs past Placid Lake and connects through to Highway 93, but it is a rough road and not maintained in winter. Woodworth Road connects to Highway 83 from the east and drops south to connect with Highway 200 east of the Blackfoot-Clearwater Game Range. Missoula County maintains a network of roads around the town of Seeley Lake, as well as roads out to various residential areas such as Placid Lake, Woodworth, and others. Remaining roads are primarily those owned and maintained by MT DNRC or the USFS.

Much of the Valley (~35%) was previously owned by forest companies and managed as industrial forest lands. As such, there was an extensive network of roads established on these lands. The density and condition of these roads in the past contributed significantly to sediment delivery to streams, siltation, impedance to movement by various aquatic species, and other impacts. These lands were all purchased through several conservation initiatives led by The Nature Conservancy and the Trust for Public Land with most transitioned to ownership by the U.S. Forest Service and MT Fish, Wildlife and Parks. Efforts at reducing their impacts to streams have been on-going, but many of these legacy roads still impact streams. Analysis using data generated by GRAIP and assessed using Netmap identified those road segments most likely to be still impacted streams based on their slope, proximity to streams, number of crossings, or other criteria.

Road surface erosion can produce and deliver fine sediments to adjacent streams and degrade fish habitat. Surface erosion on roads is a function of road gradient, length of road that is hydrologically connected (e.g., length of overland flow on a road surface), road width, road surfacing (native, gravel), traffic level (high to low), and time since grading (Luce and Black 1999). To help identify the most critical road segments delivering fine sediments, a road disruption index (Figure 53) was calculated based on total road density, roads within 150 feet of streams, and number of total road crossings within each watershed. Those classes were as follows: road density (miles/sq. mile) low < 1, moderate 1-2.4, high >2.4; roads within 150' of a stream, low< 0.5, moderate 0.5-1, high >1; and stream crossings within the watershed low < 1, moderate 1-4, high >4. To generate a single index they scored each of the three classes as 0, 1 and 3 respectively and summed those for each watershed as an overall index of potential disruption. Watershed disruption was classified as low, moderate, high or very high based on scores of 0-2, >2-4, >4-6, >6 respectively. The results of this analysis are displayed in Figure 53 below.

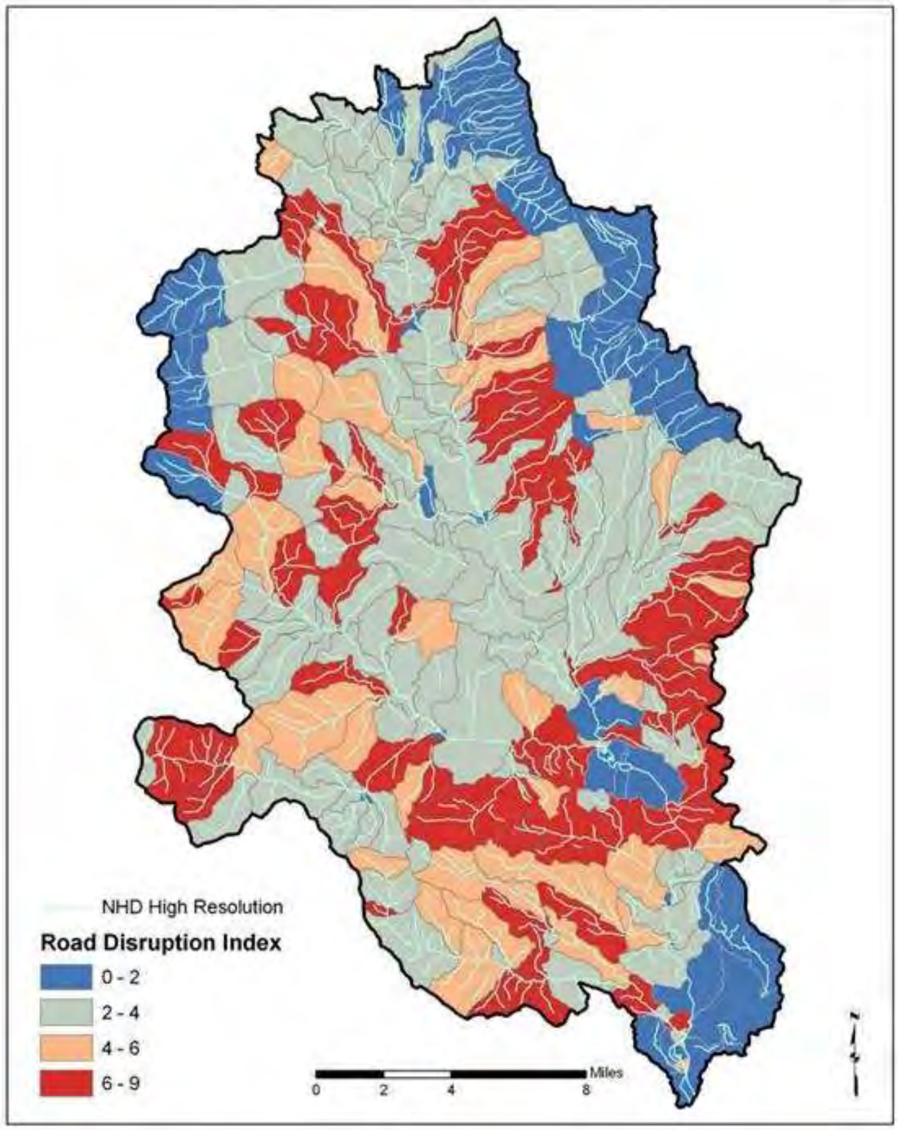


Figure 53. Road disruption index where high values indicate greatest intersection of roads and streams.

The road disruption index was combined with conservation value analyses (based on bull trout and westslope cutthroat trout distribution) to create a conservation and restoration priority map (Figure 54). Roads pose a significant threat to the survival of native fish, and many of the key bull trout-supporting streams have low road densities or a complete lack of roads at their headwaters and spawning areas. Other streams in the Valley (like Boles Creek) have seen bull trout become locally extinct due to the influence of roads, among other threats. Native fish and associated threats are discussed further in section 2.9.

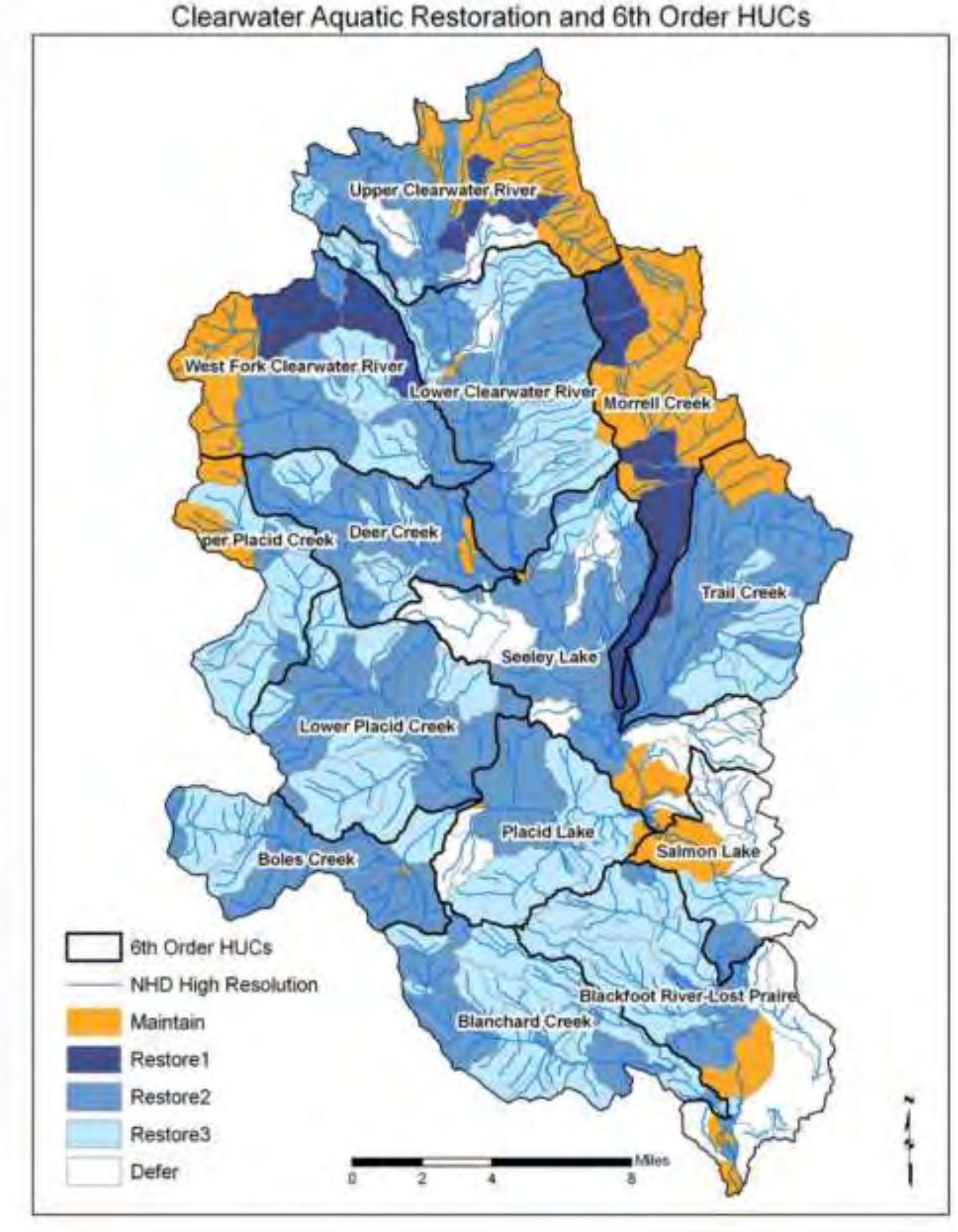


Figure 54: Conservation and restoration priorities for small watersheds in the Clearwater basin based on the integration of conservation value and watershed disruption. *Map Source: CRC's 2012 spatial prioritization of watershed actions: pilot analysis*

Transportation networks throughout the Clearwater Valley were also evaluated in 2012 using the NetMap (Benda and Miller 2007) road analysis tool. The objective of this analysis was to identify road segments that have a high likelihood of producing large amounts of fine sediment and delivering that sediment to high value streams and fish habitat. The NetMap analysis followed a similar method by first creating a composite index of habitat suitability for the Clearwater watershed (Figure 55). Morrell Creek and the West Fork of the Clearwater River and some of their tributaries (shown in red) were identified as “strongholds” for spawning and rearing.

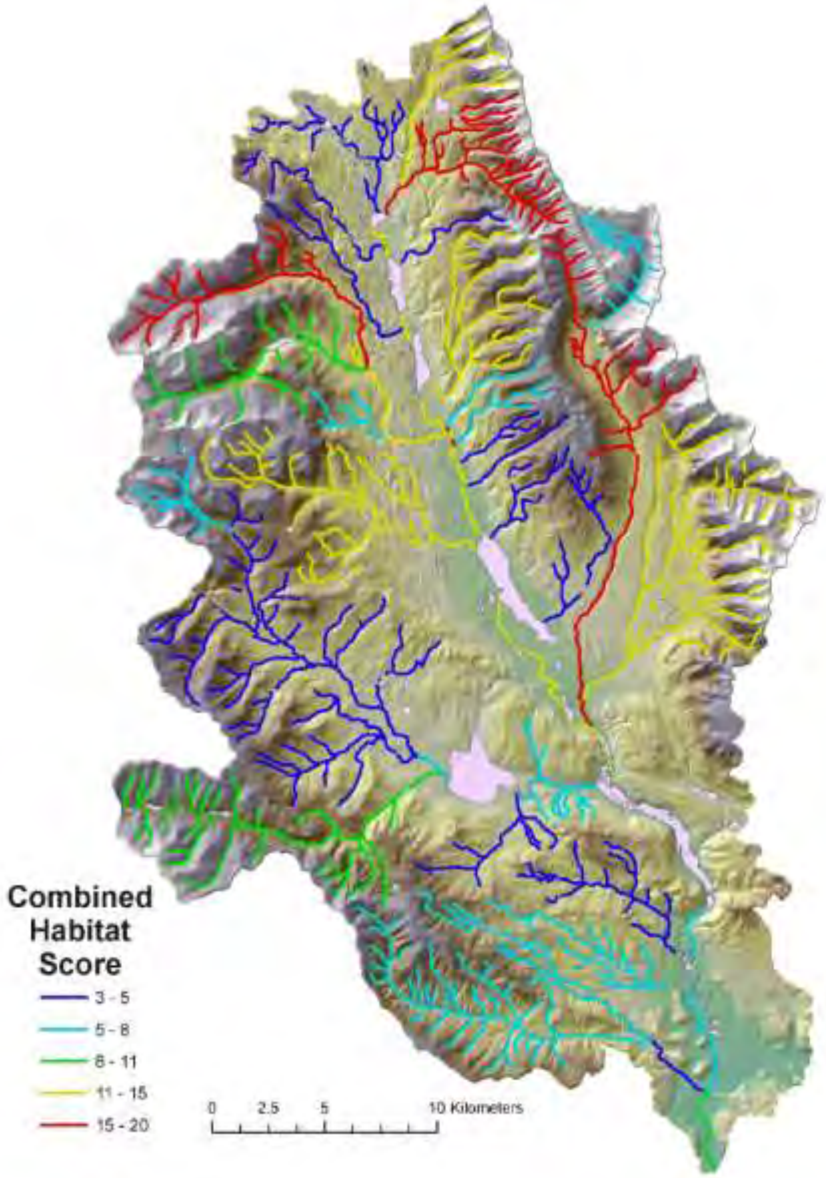


Figure 55. Composite index of habitat values for cutthroat trout and bull trout (Terrain Works 2012).

The NetMap tool was then used to calculate road hydrologic connectivity by calculating the potential length of overland flow on roads. The potential erosion generated by road segments was calculated using the Watershed Erosion Prediction Project (WEPP) road surface erosion model (Elliot et al. 1995) http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html) embedded in NetMap.

The WEPP module uses road width, drainage length, road gradient, surface material and traffic level. The tool then calculates sediment delivery to streams (t/yr), the intervening hillslope distance (and gradient) between individual road segments and the nearest streams influenced by the amount of sediment delivered to channels.

Predicted annual road surface erosion ranged from near zero to 4.7 t (metric tons, 1000 kg) per year. The average predicted erosion to streams was 0.04 t/yr with a standard deviation of 0.13 t/yr (Figure 56). The road segments (total 16,418) with the highest predicted sediment yields to streams have some combination of long road segments that are hydrologically connected, steeper gradients, and close proximity to channels (limited buffers).

Using NetMap's "overlap" tool with thresholds for road surface erosion combined with a habitat score of 10 yielded spatial matches identifying channel segments that contain both high surface erosion potential and high habitat quality (Figure 57). Similar to CRC's 2012 spatial prioritization of watershed actions, the NetMap analysis combined road erosion data with habitat quality data to prioritize regions of highest combined erosion potential and habitat quality. These regions should be prioritized in future road restoration efforts.

NetMap was also used to identify the expected sediment delivery from road segments in the Clearwater Valley. Based on these values, the top 30 road segments that were estimated to be contributing to sediment delivery to streams were identified (Table 20).

Table 20. The 30 road segments estimated to be contributing the most sediment to streams in the Clearwater Valley. ID is the segment identifier, name is the name assigned to that road, length is the length of the road segment in meters, and sediment/yr is the estimated amount of sediment in metric tons produced by the road segment in a year.

ID	NAME	Length M	Sediment/yr
66029		87.579	313.56
4337	SPOOK LAKE	69.224	367.84
4343	FINMOR	88.047	349.17
4343	FINMOR	63.929	464.04
720	RICE RIDGE	37.721	433.38
9974-2	BEAVER - FINLEY CREEK	86.151	314.16
4362	CAMP CREEK	93.677	555.91
2192	ARCHIBALD LOOP	70.517	320.10
9974-2	BEAVER - FINLEY CREEK	64.495	347.82
4353-1	MORRELL CLEARWATER NORTH	47.100	438.09
4353-1	MORRELL CLEARWATER NORTH	45.904	316.53
4353-1	MORRELL CLEARWATER NORTH	88.887	329.52
4370	CLEARWATER LAKE LOOP	59.995	312.70
4337	SPOOK LAKE	86.389	387.95
667	RICHMOND RIDGE	58.344	314.98
667	RICHMOND RIDGE	96.044	334.05
477	COTTONWOOD LAKES	91.208	320.14
463	MARSHALL LAKE	79.200	375.96
463	MARSHALL LAKE	93.973	540.22
4353	MORRELL - CLEARWATER	85.761	341.17
4362	CAMP CREEK	82.217	325.85
477	COTTONWOOD LAKES	88.879	368.25
4353	MORRELL - CLEARWATER	71.740	372.38

4361	AUGGIE - MORRELL	94.429	320.47
4353-1	MORRELL CLEARWATER NORTH	98.478	569.95
4353-1	MORRELL CLEARWATER NORTH	82.531	306.81
4353-1	MORRELL CLEARWATER NORTH	59.395	414.3
4378	BLIND CANYON	72.334	395.406
4378	BLIND CANYON	92.782	306.81
465	DEER CREEK (LAKE ELSINA)	93.433	313.38

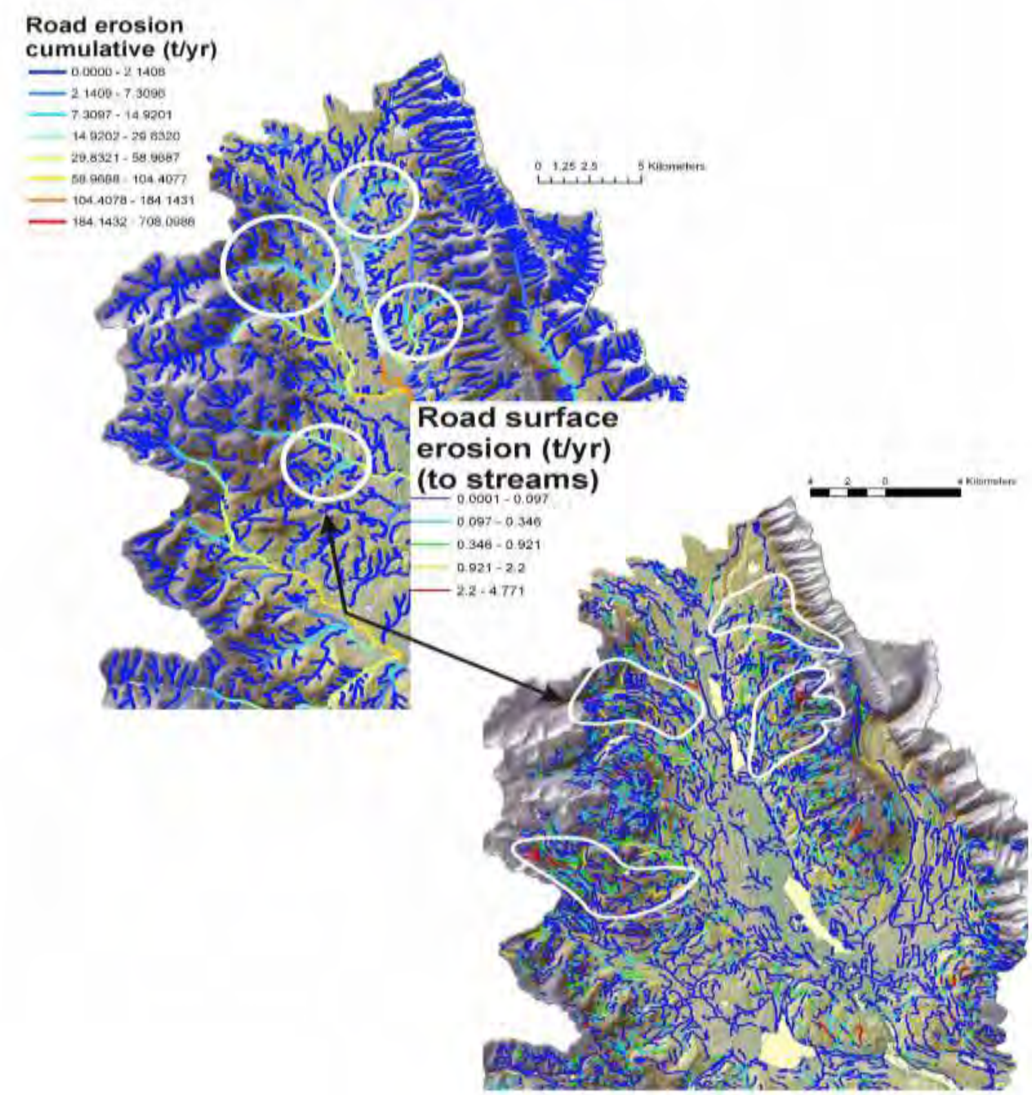


Figure 56. (Upper) Road surface erosion (delivered to streams) is aggregated (routed) downstream revealing patterns of cumulative road erosion at any spatial scale in a watershed defined by the stream network. (Lower) Cumulative patterns of road erosion (in streams) can be considered in the context of the road segments that create those patterns. The white lines (Lower) circumscribe entire road networks within individual contributing subbasins that are responsible for cumulative road surface erosion, particularly for cumulatively high values.

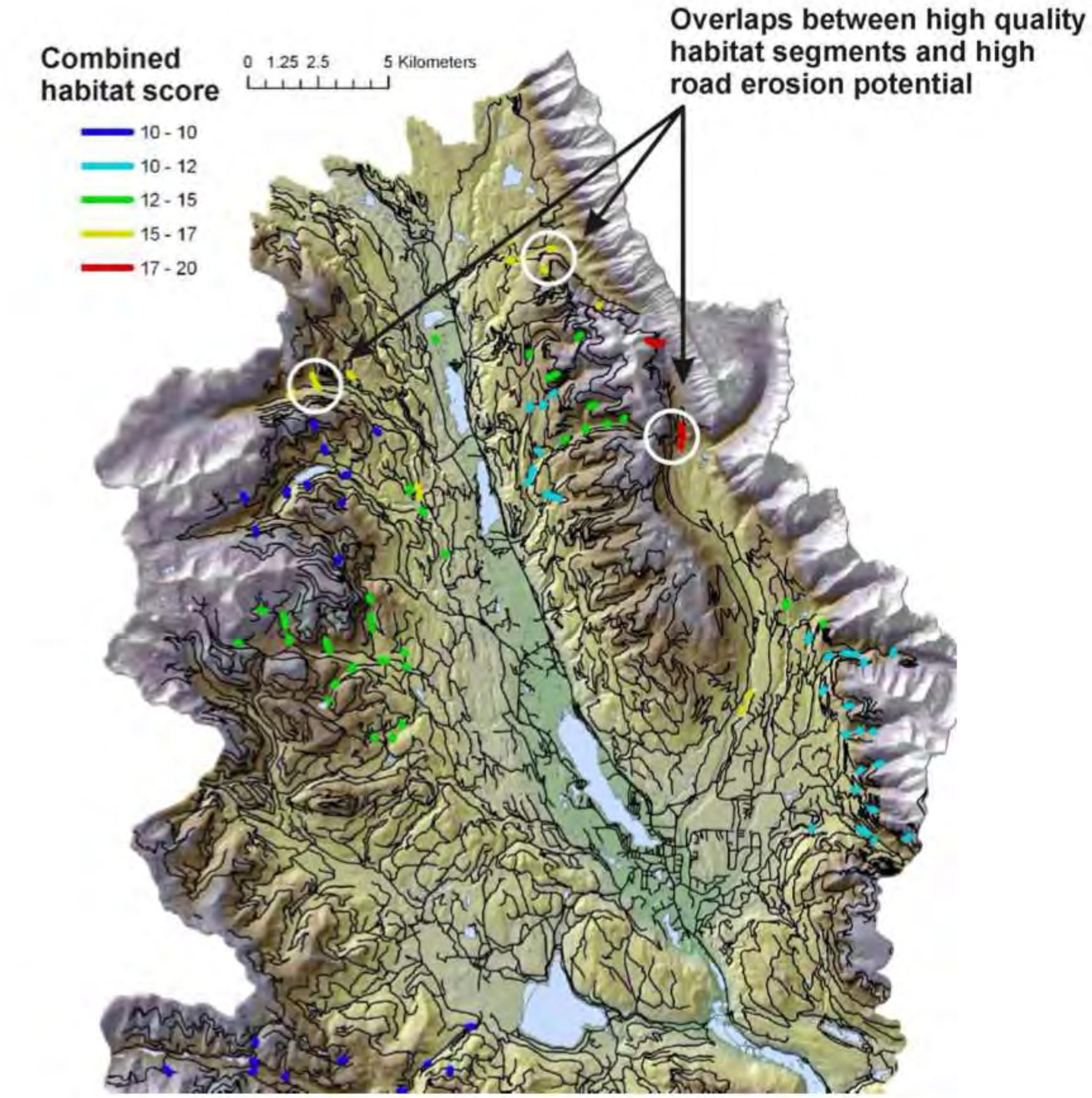


Figure 57: Stream segments where high road surface erosion potential overlaps with high quality habitat.

4.7 Aquatic Invasive Species

Invasive species are non-native species that cause economic or environmental harm. Various aquatic and terrestrial invasive species have begun to spread throughout Montana and invasive introductions are likely to continue to increase in the future.

Montana has been infested by several aquatic invasive species, including faucet snails, curly-leaf pondweed, and fragrant water-lily. As of 2020, fragrant water-lily has heavily infested the Clearwater Valley (Figure 58). This invasive species is found throughout the watershed, including many of the major lakes (Inez, Salmon, Seeley, and Placid, among others). Like many other invasive plants, fragrant water-lily can spread rapidly and form dense mats that crowd out native plants and harm swimming beaches. This invasive plant also has rhizomes that make it extremely difficult to completely eradicate. If a rhizome root is broken up, the fragments will float to new areas and can create new patches of plants (Northey 2014). As more rhizomes break up, more fragrant water-lily plants are spread and established in an environment. Their rhizomes also allow them to tolerate drought and live in a range of habitats.

Figure 58: When left untreated, fragrant water-lilies can take over entire water bodies.

Fragrant water lilies were first introduced to Salmon Lake in 1937 and have since spread to many surrounding water bodies. In 2020, the Missoula County Weed District embarked on an effort to map the spread of this invasive species and found that significant populations of water-lilies have established on 8 of the 19 water bodies surveyed in the Clearwater and Swan drainages within Missoula County. Four of the major lakes in the Clearwater Valley were mapped in 2020, with Seeley Lake having the largest area of lilies at 72 acres, followed by Placid Lake (15.7 acres), Lake Inez (6.83 acres) and Salmon Lake (5.2 acres) (Figure 59) (Missoula County Weed District 2021).

Figure 59: Fragrant water lily populations have established on four of the major lakes in the Valley, mapped above by the Missoula County Weed District. *Data source: Missoula County Weed District*

To the best of our current knowledge, invasive dreissenid mussels have not yet invaded any bodies of water in the Clearwater Valley. CRC conducts intensive AIS monitoring in and around the Clearwater Valley and has never had a sample test positive for the presence of invasive zebra or quagga mussels. However, invasive dreissenid mussels pose one of the biggest threats to Montana's waterways. Native to the Black and Caspian seas, the introduction of zebra and quagga mussels has given rise to extensive detrimental environmental and economic impacts throughout the United States. These invasive mussels are now found in every major watershed in the contiguous United States except the Columbia River drainage basin, which encompasses most of Western Montana, including the Clearwater Valley. Watercraft inspection stations play a significant role in preventing unwanted invasive mussel introductions. In 2019 alone, over 20,000 boat inspections were performed at the Clearwater Junction Watercraft Inspection Station (WIS) just south of the Clearwater Valley, making it the single busiest WIS in the entire state. Early detection and rapid response can be used to contain the spread of invasive mussels in a worst-case scenario. CRC monitors the lakes within our watershed for invasive mussel veligers to facilitate swift response measures in the event that mussels are brought into our Valley. Currently, no effective treatment exists for invasive zebra and quagga mussels. The Clearwater Basin's AIS strategy should emphasize prevention in order to avoid any scenario that would trigger a rapid response action, especially given the interconnectedness of the Clearwater chain of lakes.

Although scientists are just beginning to understand how climate change will affect the spread of invasive species, it is an important consideration when planning for the future ecologic and economic success of the Clearwater Valley. It remains uncertain whether increasing concentrations of CO_2 in the atmosphere will generally favor non-native plant species over native plant species (Szyniszewska n.d.). Some research is suggesting that elevated concentrations of CO_2 might hinder the pace of recovery of some native ecosystems after a major disturbance, like flood or fire. This could potentially lead to increased dominance of invaders in some regions. Major disturbances resulting from climate change can also transport invasive species to new areas and decrease the resistance of habitats to invasions. This is important for the Clearwater Valley as climate change is expected to change natural fire regimes. In some ecological systems, such as temperate forests and freshwater systems that currently have thermal barriers limiting the establishment of invasive species, climate change may cause these systems to be more suitable for alien species (International Union for Conservation of Nature 2017). For example, zebra and quagga mussels survive and reproduce best in waters near approximately 64ºF and 61ºF (respectively) (US Fish and Wildlife Service 2007). With increasing summer temperatures due to climate change, the optimal temperature window for dreissenid mussels could widen, allowing a greater chance for the reproduction and survival of invasive mussels in Montana waters. Many invasive species have the ability to expand rapidly to higher latitudes and altitudes as the climate warms, out-pacing native species.

5.0 Watershed Restoration Recommendations

Clearwater Valley is one of the least developed and unimpacted locations in the lower 48 states. Water quality expectations should be high, especially with the ecological, economic, recreational, and lifestyle benefits high quality water in the Valley bring to the community and the 20,000 visitors to the area each year. Thus, while comparisons or stream or lake conditions in the Clearwater Valley can be made to general water quality standards, any values approaching these standards should be viewed with concern, and potential actions taken to avoid any increased degradation.

5.1 Stream Restoration

The Blackfoot Subbasin Plan listed recommended actions for the stream segments it identified as being potentially impaired. These recommended actions are included in the Appendix. Those actions recommended reductions in sediment or nutrients in these identified streams. These reductions are summarized in Table 21.

Table 21. Recommended reductions in sediments or nutrients for streams identified in the Blackfoot Subbasin Plan.

Stream Name	**Current Load (tons/yr)**	**Needed Load Reduction (tons/yr)**	**Percent Reduction in Total Annual Load**
Richmond Creek	23	13	58%
West Fork Clearwater	693	175	25%
Deer Creek	1,399	271	19%
Blanchard Creek	335	146	44%

As noted from CRC stream monitoring, Deer Creek has seen improvements from its past sediment loading levels. However, because it still contributes considerable amounts of sediment directly into Seeley Lake, it continues to be a stream of interest, and efforts to reduce its sediment and associated nutrient loading should continue. Primary actions include identification of specific road segments that produce and transport sediments and nutrients into the Creek, and to continue monitoring sediment and nutrient levels.

CRC did not include Blanchard Creek in its stream monitoring program from 2013-2020, so its current status is not known. The recommendations from the Blackfoot Subbasin Plan would continue to be relevant, and additional monitoring of this stream is recommended to better determine its current status.

The West Fork of the Clearwater River did receive conservation attention in the past 15 years, with moving a critical road segment away from the river and decommissioning the old road. Current monitoring revealed that this stream (river) had improved conditions. While continuing efforts to reduce any road delivery of sediments and nutrients to this stream should continue as it is a critical stream for bull trout, it appears to be in an improved status.

To this previous list of streams identified in the Blackfoot Subbasin Plan, CRC recommends adding three additional streams. Seeley Creek has the highest levels of TN and TP found in the sampled streams. While this stream is relatively small, so that its total contribution of TN and TP into the Clearwater River system is not great, it still has nutrient levels that are of concern. Sources of these higher levels of nutrients have not been identified, but roads could be a factor. These sediment and nutrient loads should have a goal of being reduced by 33%, particularly for levels of TP. Additional monitoring and analysis should be conducted to better identify possible sources of these high loadings.

Morrell Creek is another critical stream in the Valley. It is a significant contributor to the Clearwater River system and is a critical stream for bull trout. It was highly impacted by the 2017 Rice Ridge fire. It also has a large network of roads. Some actions to reduce road impacts to this stream have been conducted. Additional work to reduce sediment and nutrient delivery for the stream above Cottonwood Lakes Road should continue, with an objective of a 10% reduction.

Sampling of Morrell Creek at Cottonwood Lakes Road and then at its crossing of HWY 83 show that additional nutrient loading is occurring as this stream crosses this developed area. Various sources of pollutants are likely, from septic leachate such as at a possible location near the High School to impacts of management of the golf course, to mixing with groundwater beneath the town of Seeley Lake are all possible sources. Efforts are needed to minimize sediment and nutrient delivery to this stream, with additional monitoring to try to identify specific sources and locations for more directed actions. Load levels of nutrients should be reduced to be no greater than 10% higher below town than above town.

CRC stream monitoring identified Rice Creek as a continuing concern. It maintained relatively high levels of sediment and nutrients throughout the years of monitoring. Efforts should be directed at reducing the sediment and nutrient loads in Rice Creek. A 30% load reduction in levels of TP should be the target for Rice Creek.

Boles, Placid, and Owl creeks were among the highest streams for total phosphorus and Owl Creek was also among the highest for total nitrogen (Reiman and Wallenburn 2017). Owl Creek is a significant contributor of nutrients to downstream locations, especially Salmon Lake. Monitoring of nutrient levels in this stream should continue, and efforts to identify the sources of its nutrient loading should be initiated.

The road system in outlying areas can benefit from additional work. Continued efforts should occur to identify problem crossings and improve passages where culverts may be too small or perched and impede passage. Sediment and nutrient delivery from roads should continue to be a focus. A good starting point would be to examine the top 30 road segments in terms of sediment delivery estimated through the Netmap analysis (Table 19) and to apply best management practices to these segments, or to move them if they would continue to be a significant source of sediment and nutrients.

An additional stream restoration program should be devoted to increasing the numbers of beavers inhabiting streams in the Clearwater Valley. Beavers serve as ecological engineers providing several important ecological functions to aquatic ecosystems. As discussed previously, they help slow the transport of water out of a system, raising water levels throughout the system. This would help address dewatering concerns that have been raised for the Clearwater River and Owl Creek. Second, beaver ponds help trap sediments and their associated nutrients that otherwise are carried downstream where they continue to influence the status of lakes and the Clearwater River. Third, they add structure to streams and rivers that can improve habitat conditions for native fish and other aquatic species. MT FWP should coordinate and cooperative in efforts to increase numbers of beaver in the Valley and work with agencies such as the USFS in identifying key locations where the presence of beavers will have the greatest beneficial effects.

5.2 Lake Restoration

As reported by Adkins (2023): “The establishment of numeric nutrient criteria assumes that a direct correlation exists between in-lake nutrient concentrations and anthropogenic development (MT DEQ 2014). Presently Montana lacks statewide numeric standards for nutrients in lakes and reservoirs. Although nutrient criteria for wadeable streams in our ecoregion are defined at 30 µg TP (total phosphorus) and 300 µg TN (total nitrogen), standards for lakes and reservoirs remain to be established. One exception is that standards have been set for Flathead Lake at 5 µg TP and 95 µg TN, alongside a phytoplankton chlorophyll level of 1.0 µg/L, expressed as an annual average (MT DEQ 2014). These standards could serve as guidelines for the Clearwater Lakes (which generally exceed these levels).”

The results of lake monitoring show that the trophic status of lakes in the Clearwater Valley is in the mesotrophic zone between oligotrophic and eutrophic conditions. Clearwater Lake and Lake Alva were consistently representative of oligotrophic conditions, while Seeley Lake and Salmon Lake were less oligotrophic, but still having conditions under the indicators of potential eutrophic conditions. Additional nutrient loading, particularly to Seeley and Salmon Lakes could push these lakes higher towards eutrophic conditions with resulting reduced water clarity, more algal and macrophyte production, reduced DO levels, and reduced salmonid habitat conditions.

DO levels in the lakes decreased below the hypolimnion throughout the summer and was at very low levels by the early fall. With lake water turnover, DO levels increased in deeper waters for all lakes except Big Sky Lake. DO levels should continue to be monitored to make sure their levels are not decreasing.

Nutrient sampling of the lakes showed some variability in levels. Deep lake samples tended to have higher levels of TN and TP, but still were generally at acceptable levels consistent with natural levels of these nutrients in lakes. Other nutrients including soluble reactive phosphorus and nitrates were mostly at levels less than the laboratory's detection level. Deep samples were limited to the one or two deepest locations of each lake, so variability across deep locations was not assessed. In future monitoring, additional samples from varying depths near the bottom of the lake but in locations such as in stream inlets might provide additional insights about nutrient levels throughout the lake. Surface samples collected at numerous locations around several of the lakes showed little variation in levels of TN and TP. For future monitoring of surface water nutrient levels, sampling at the lake inlet, lake outlet, and at the deep-water sampling location might be adequate.

Adkins (2023) reported: "TN:TP ratios are used to assess the likely limiting nutrient for primary production in a lake (Watson 2012). TN:TP ratios exhibit patterns across lakes, with oligotrophic lakes having higher ratios due to more natural nutrient inputs, while mesotrophic and eutrophic lakes, subject to mixed forms of nutrient inputs, often display lower ratios (Downing and McCauley 1992). A mass ratio above 23 suggests P limitation, while a mass ratio below 9 suggests N limitation. At ratios between 9 and 23, either P or N can be limiting (Guildford 2000)."

Big Sky Lake, while not displaying any algal blooms and with good secchi disk readings, clearly has nutrient levels of concern. The levels of TN and TP in surface samples tended to be about twice that of other lakes sampled in the Valley. Further, DO levels in the lake decreased to very low levels beyond around 6-7 m, and stayed at these levels throughout the year. Deep water samples had extremely high TN and TP. The deep-water results need further analysis using hypsometric data. Is the deep-water location a relatively small area that is collecting these nutrients, or are deeper waters throughout the lake showing the same trends? The sources of nutrients into Big Sky Lake need to be further investigated. It is likely that the 71 septic systems surrounding the lake with the well-drained soils in the area are a contributing factor, but without further targeted testing, this is an hypothesis. The objective for load reductions for TN and TP for Big Sky Lake is to reduce levels of these nutrients in surface waters to ½ of their current levels, and reductions in deep water to ¼ of their current levels.

The outlet of Seeley Lake upstream from the bridge at Riverview Road is also an area of concern. Water samples collected at the bridge and analyzed for nutrients and *E. coli*, while quite variable, displayed some results of concern. Nutrients generally showed increases from the surface waters collected in the lake itself to those collected at the bridge. The sources of these increases are not known, but again, septic systems of cabins along the outlet may be a source. Further investigation to determine the source(s) is needed. The objective of load reductions at the outlet should be to reduce nutrient levels to be consistent with the levels of nutrients in surface waters sampled in Seeley Lake proper.

Water samples from Placid Lake found nutrient levels that were generally acceptable, despite the fact that algal blooms have been observed in the lake. Several samples collected in the bay between the State Park and the outlet showed higher levels of nutrients, especially at the height of the summer recreational season. This may indicate that a source of nutrients occurs in the area. More specific monitoring to determine if a source of nutrients is occurring in this area, and if so, what steps need to be taken to stop this influx of nutrients.

A key objective of water quality sampling in the Clearwater Valley is to monitor the trophic status of each lake using the metrics of water quality described above (Secchi depth, temperature, DO, and nutrients), and how they appear to vary over time.

The Clearwater lakes are expected to be oligotrophic (Table 2 of Carlson and Simpson, 1996), as they are cold-water fisheries. However, the available data indicate that at least two of the lakes (Seeley Lake and Salmon Lake) may be mesotrophic: an intermediate state between oligotrophic and eutrophic. Big Sky Lake was still oligotrophic according to secchi disk readings, but its DO levels were a concern as were its nutrient levels. Trophic status can be calculated using chlorophyll, Secchi depth, and total phosphorus, and a relationship between total phosphorus, total nitrogen and chlorophyll has been developed by EPA (EPA 2021). Future monitoring should target these variables in order to better determine lake status and trends.

Water quality data have been collected over relatively short time periods at different times and different locations so definitive conclusions on the health of the lakes are limited. Multiple factors drive lake water quality and they are also linked to each other as well as being influenced by the bathymetry of the lake and its hydrologic regime.

The volume of spring runoff influences the flushing of nutrients, sediments, phytoplankton in and out of a lake, and the timing of stratification. A large runoff volume could result in less productivity unless that runoff brings in a lot of nutrients (like after a fire) or flushing out nutrients being delivered by lakeshore septic systems, which would increase productivity. Runoff might also bring in a lot of sediment –and if it is fine sediment – might keep the water column turbid for a while – lowering productivity. Consequently, nutrient concentrations may vary from year to year.

What we can say is that nutrient concentrations are variable even in the same lake, but the upper range of values indicates that lake water quality is likely at risk, and the drivers of changes in water quality should continue to be investigated.

5.3 Groundwater Restoration

The Seeley Lake Sewer District has been monitoring chloride, nitrate, nitrite and total Kjeldahl nitrogen in roughly ten monitoring wells since 2022. This monitoring will continue in addition to investigations of surface water and groundwater interactions. Surface water and groundwater interact where the elevation of groundwater (the potentiometric surface) intersects surface water at the same elevation. The potentiometric surface was constructed as part of a groundwater evaluation study (Norbeck and McDonald, 1999) and should be updated to reflect the additional wells completed since that time. A more accurate potentiometric surface may help inform the analysis of surface water/groundwater interactions. The connection between the groundwater and Seeley Lake should also be evaluated using synthetic DNA as a tracer (Georgakakos et al. 2019). This approach was successfully used on Whitefish Lake in 2022 to assess the connection between septic leachate and surface water. Public outreach regarding best practices for septic maintenance should also be considered, similar to those ongoing in the Flathead basin.

5.4 Climate Change Actions

Actions outlined in the 2017 Montana Nonpoint Source Management Plan which aim to mitigate the effects of climate change while addressing some of the causes include the following (refer to the original report for the complete list, only those that are relevant to the Clearwater Valley and our restoration goals are included here):

1. Supporting local planning efforts that address water quality impacts associated with climate change
2. Supporting temperature and flow monitoring efforts in Montana watersheds
3. Protecting and restoring riparian areas with native vegetation, which provides shade and stabilizes banks
4. Reconnecting rivers with their floodplains, providing additional groundwater storage
5. Protecting and restoring wetland areas with natural vegetation, providing water storage, wildlife habitat, pollution attenuation and contributing to groundwater recharge to streams and rivers
6. Protecting and restoring cold-water refuges, including deep pool habitat and cool spring and groundwater return flows to rivers and streams
7. Encouraging development of long-term strategies for water use, water conservation, and water lease agreements to maintain optimal flows for desirable temperature aquatic habitat
8. Supporting local and statewide efforts to increase drought resiliency
9. Increasing public awareness of water quality problems associated with climate change

6.0 Monitoring Recommendations

The overall goal of monitoring going forward should be the development of a nutrient budget to estimate the nutrient load entering and leaving the chain of lakes. This requires monitoring of both discharge and nutrients in streams and rivers entering and flowing out of the major lakes.

6.1 Surface Water: Streams

The major contributors to nutrient loading identified in earlier monitoring (Deer Creek, Seeley Creek, Rice Creek) should be monitored for turbidity, TN, and TP and discharge should be measured. Morrell Creek should continue to be monitored for nutrients and discharge both above the town of Seeley Lake and at its confluence with the Clearwater River. The Clearwater River should continue to be monitored above Seeley Lake and at the downstream monitoring location below Seeley Lake. Discharge data on the Clearwater River and Owl Creek should also be collected, and the locations and timing of dewatering should be documented.

Citizen science was used in previous monitoring and could be re-started for public involvement, and could be expanded to include macroinvertebrate monitoring in streams and lakes. This could be an excellent volunteer program to engage interested members of the public to learn more about aquatic ecology.

6.2 Surface Water: Lakes

The six primary lakes in the Valley should continue to be monitored, at both pelagic and littoral zones. Measurements should include Secchi depth, temperature and DO profiles, and concentrations of TN, TP, and chlorophyll a. These measures should be taken monthly starting at lake turnover in the spring and continuing until early fall. Minimum sample collection for each lake should include surface water samples at the inlet and outlet of each lake as well as a surface and deep-water sample from at the deepest location of each lake. Additional “deep” water samples should be added at selected locations along shorelines where streams or suspected groundwater inlets may occur. Nutrient samples from Emerald Lake would also be informative, as this lake is similar to Big Sky Lake as it has houses on its shores with well drained soils.

Hypsometric data should be generated for each lake, and the nutrient data for each lake analyzed relative to depths and total water volumes. This is especially true for Big Sky Lake where very high levels of nutrients have been found in the deepest part of the lake. AHOD should continue to be calculated for each lake, and each lake analyzed for trends in its trophic status.

E. coli should be sampled at selected locations throughout the Valley. Possible sampling sites include the outlets of Seeley Lake at the Riverview Bridge as well as in the south bay of Seeley Lake, the outlet of Placid Lake, the outlet of Big Sky Lake, and the outlet of Salmon Lake. Additional locations where suspected mixing with contaminated groundwater could be added.

6.3 Groundwater

The 1999 groundwater evaluation should be updated to include available information on new wells completed in the area and monitoring well data collected by the Seeley Lake Sewer District. The areas of groundwater recharge and discharge should be better defined.

The Missoula County Department of Ecology has expressed an interest in better understanding the interaction between the groundwater and the surface water bodies in the Seeley Lake area and how these may impact accelerated growth of aquatic vegetation along the shorelines of Seeley Lake and the Clearwater River. Also of interest was frequency of harmful algal blooms, the potential impact to the community economy should the lake quality degrade significantly and projected future impacts of continued nutrient loading on Seeley Lake, especially through the lens of climate change. The feasibility of synthetic DNA tracers such as demonstrated on Whitefish Lake should be evaluated. CRC sampled for whitening agents in Seeley Lake in 2022 and found no positive results. However, this or other targeted methods could be applied to specific locations where septic leachate and suspected groundwater mixing to surface waters may be occurring to more efficiently determine if this is occurring or not.

6.4 AIS

Aquatic invasive species should continue to be monitored. Veliger monitoring for mussels should continue to check for their possible introduction into any of the lakes. Aquatic macrophytes should be periodically surveyed to determine if any new invasive species have entered the watershed. The locations and spread of fragrant water-lily should also be periodically mapped to determine its status in the Valley.

Any observed algal blooms in the Valley should be documented, and samples collected to determine the type of algae present. If feasible, water samples should be taken from the same location at the time of the outbreak so that possible causative factors can be investigated.

Monitoring should continue for the presence of northern pike in Placid Lake via reports from anglers. If pike are caught, MT FWP should be supported in developing a response plan.

Other data gaps that could be addressed in the future include:

a. Research if a thermal barrier exists for different fish species, does stream warming affect the invasion rates and potential of species like brook trout?
b. Determine minimum instream flows for aquatic organisms.
c. Conduct a survey to see if Placid Lake homeowners irrigate their lawns, disseminate education resources about the dewatering issue, and how refraining from irrigating during droughts could ameliorate water depletion issues.

d. Pursue grants for septic maintenance/replacement particularly in areas where any form of sewer system is not contemplated. DEQ has 319 funding for septic maintenance and broader education and outreach campaign. Monies may also come through DNRC, which has an individual grant program (RRG) for landowners which could be used for upgrades.

7.0 Community Engagement

A number of public meetings were held to engage the community of Seeley Lake in the preparation of this Plan. In addition, a survey was conducted (see below) to assess the community's level of interest in various natural resource issues or concerns and their engagement if various natural resource related activities.

A public meeting is scheduled to occur in early 2024 to present the results and recommendations contained in this Plan. Public outreach and education will be an essential component for implementation of a restoration plan. The public needs to be provided with all available data on surface and groundwater conditions including an unbiased interpretation of what the data mean. CRC is positioned to assist with outreach and education in support of this Plan. CRC has been the lead organization for compiling information on water quality in the Valley and has been a primary advocate to actions needed to maintain and improve water quality.

In April of 2021, a virtual survey was conducted to assess community priorities as they related to the overall watershed planning process. The main survey questions and responses are summarized below (Figures 60-64).

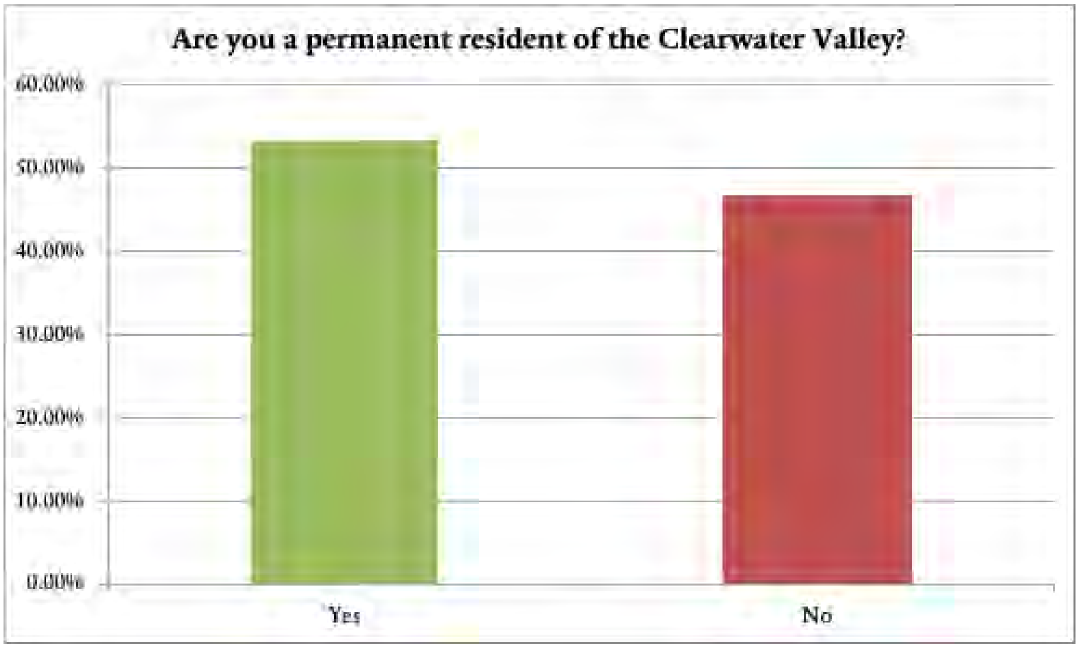


Figure 60. Are you a permanent resident of the Clearwater Valley?

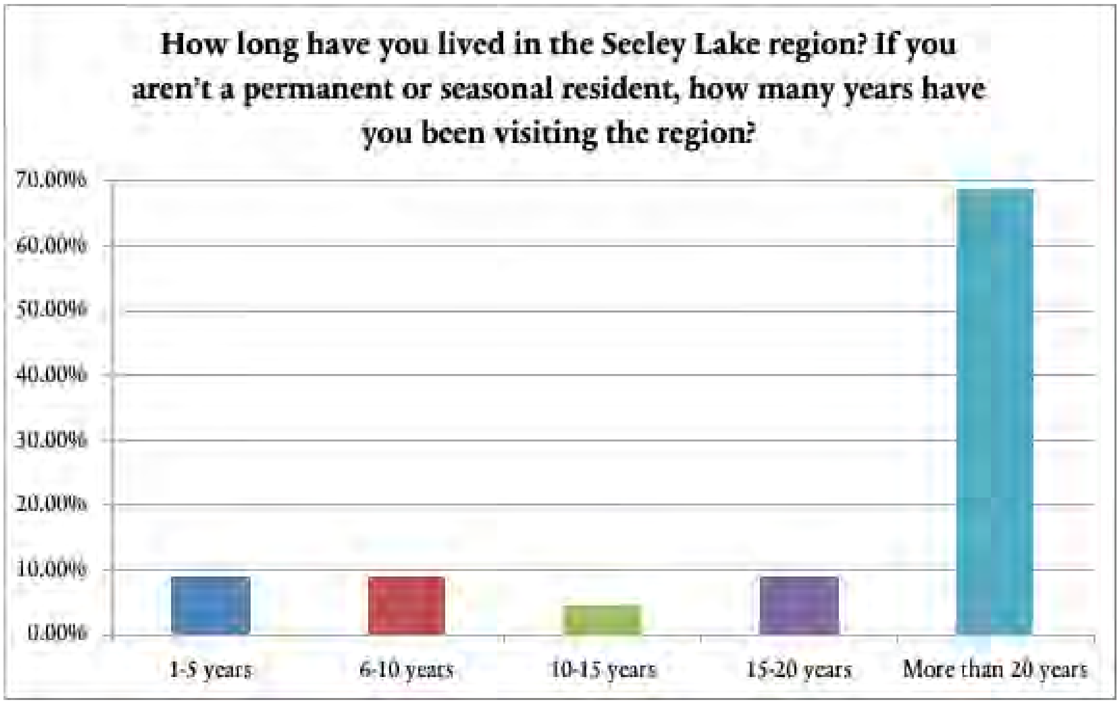


Figure 61. How long have you lived in the Seeley Lake region? If you aren't a permanent or seasonal resident, how many years have you been visiting the region?

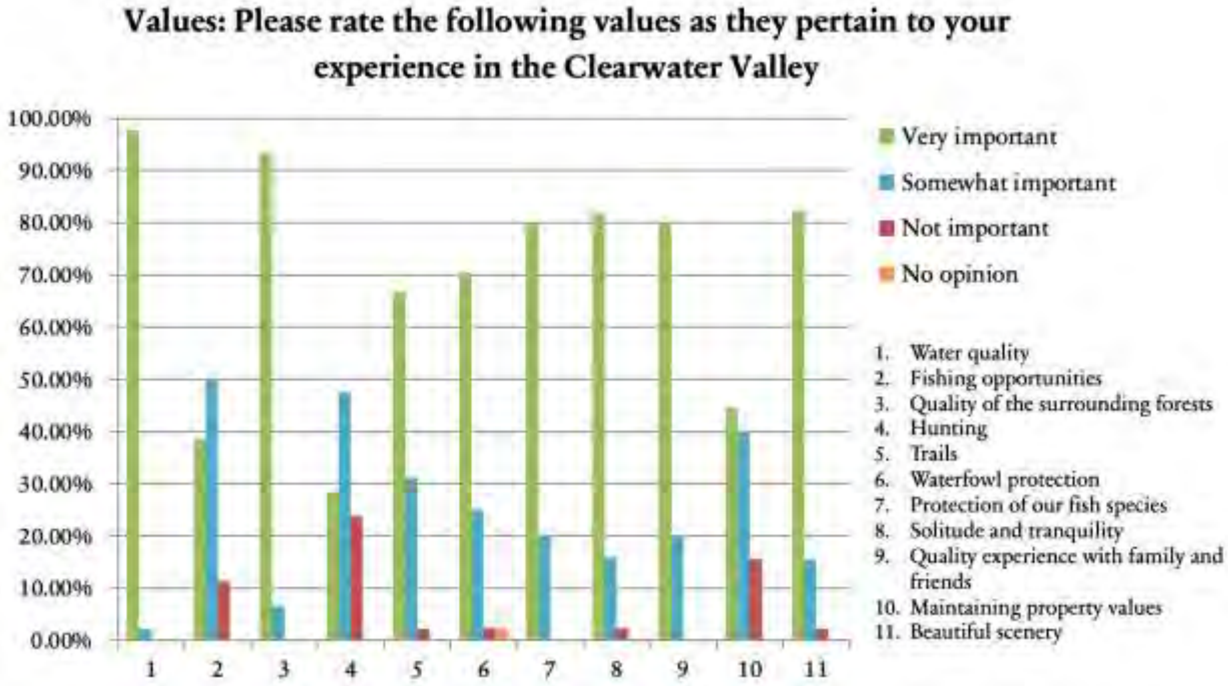


Figure 62. Values: please rate the following values as they pertain to your experience in the Clearwater Valley.

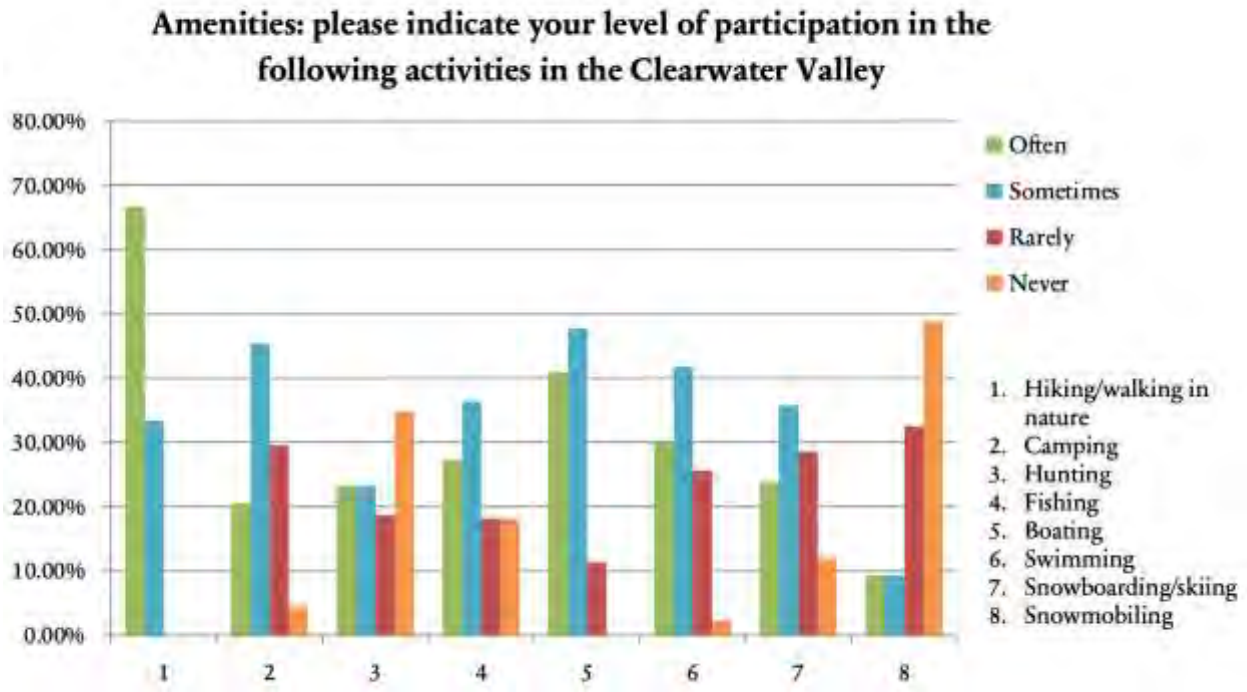


Figure 63 Amenities: please indicate your level of participation in the following activities in the Clearwater Valley.

Eighteen additional activities were listed by survey respondents; the most popular of which included: biking/mountain biking (8 respondents), bird watching (3 respondents), non-motorized boating (3 respondents), berry picking (3 respondents), and horseback riding (3 respondents). Other activities mentioned included: ice skating, mushroom gathering, wildlife watching, cultural events, botany, model aircraft flying, motorcycling, backpacking, native plant and pollinator studying, and aquatic life form studying.

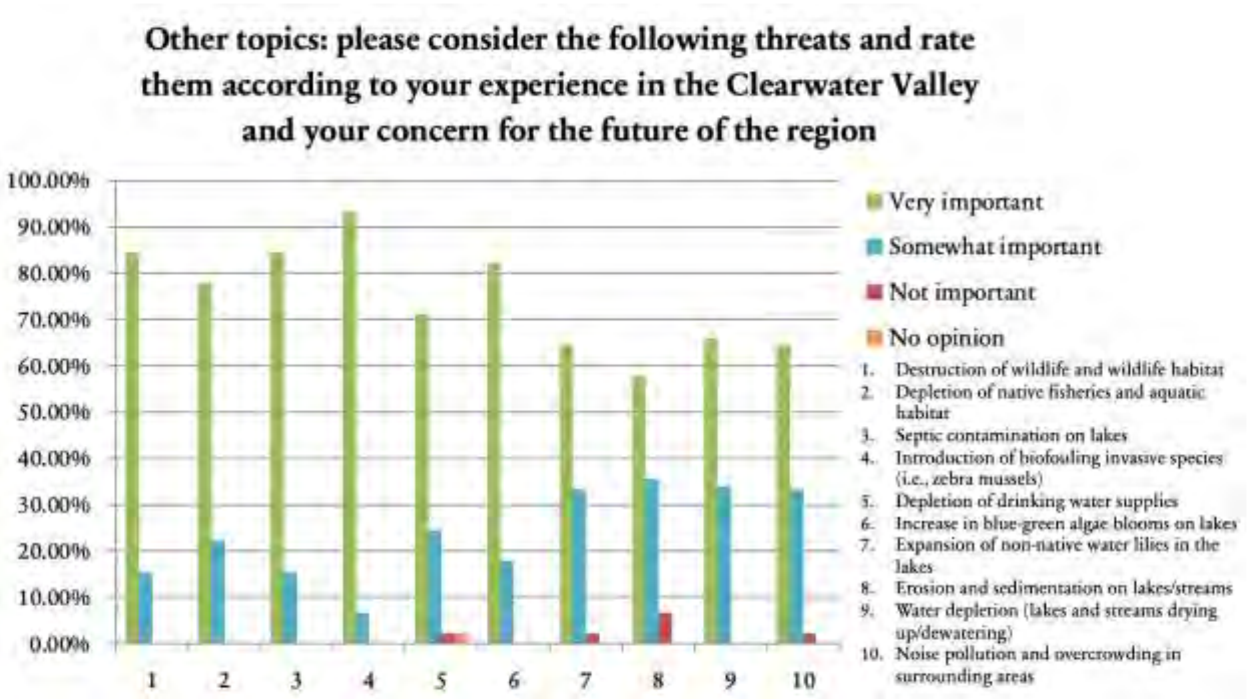


Figure 64. Other topics: please consider the following threats and rate them according to your experience in the Clearwater Valley and your concern for the future of the region.

Seventeen additional threats of concern were listed by survey respondents; the most popular of which included: overcrowding of recreational areas (3 respondents), forest fires (2 respondents), development (2 respondents) and boat wakes (2 respondents). Other threats mentioned included: forest access, invasive weeds, road salt pollution, light pollution, bear/human conflict, lack of camping access, air pollution, lack of forest management, sewer system, lack of access to public lands, lack of data, protection of marshes, and protection of beaver habitats.

8.0 EPA Required Elements

The nine minimum elements to be included in section 319-funded watershed plans for threatened and impaired waters are summarized below.

8.1 Identify causes and sources of impairment.

The following causes and likely sources of impairment were identified and discussed in the Plan:

Sediment from the outlying road system.

Septic leachate in groundwater around Seeley Lake.

Potential mixing of contaminated groundwater with surface water around the town of Seeley Lake, around Big Sky Lake, and at the outlet of Seeley Lake.

Nutrient loading of Seeley Creek, Rice Creek, Deer Creek, and Morrell Creek around the developed area surrounding the community of Seeley Lake.

Nutrient and potential *E. coli* contamination of the outlet of Seeley Lake above the Riverview Road bridge.

Presence and spread of invasive fragrant water-lilies.

8.2 Estimate load reductions expected through management measures.

The following load reductions are described and recommended in the Plan:

Nutrient levels in Deer Creek should continue to be reduced with an objective of a 10% reduction from current levels.

Nutrient levels in Seeley Creek, especially TP, should be reduced by 33%.

Nutrient levels in Morrell Creek below town (at the confluence of Morrell Creek at the Clearwater River) should be no higher than 10% above levels found at Cottonwood Lake Road. Continue load reductions of 10% should be the objective for Morrell Creek at Cottonwood Lake Road.

Rice Creek should have load reductions of TN and TP of 10%.

Nutrient loadings and *E. coli* at the outlet of Seeley Lake at the Riverview Bridge should be no higher than the levels of nutrients and *E. coli* found in surface water samples from the lake proper.

Nutrient levels in Big Sky Lake (TN and TP) should be reduced to 50% of their current levels for both surface and deep waters.

Groundwater under the town of Seeley Lake should have load reductions determined through an evaluation conducted and approved by the Sewer Board, Missoula County, and DEQ.

8.3 Describe the non-point source pollutant management measures.

Non-point source pollutant management efforts discussed in the Plan include the following:

Continue to address roads as a source of sediment and nutrients to streams and lakes. The top 30 road segments estimated to be contributing pollutants are listed in the report, and can be targeted for increased application of BMP's, or targeted for decommissioning, if appropriate.

Groundwater contamination under the town of Seeley Lake is targeted for corrective actions. Appropriate actions to address septic leachate need to be determined by agencies responsible for addressing this issue.

Testing of potential groundwater contamination to surface waters in Big Sky Lake and the outlet of Seeley Lake is needed to identify sources, likely septic leachate, and plan corrective actions.

Intensified testing of waters along Morrell Creek as it crosses through the developed area of Seeley Lake is needed to identify sources of nutrient loading with follow up actions to reduce these sources.

8.4 Estimate technical and financial assistance needed.

Enhanced technical support for conducting more advanced water quality monitoring is needed to identify potential but suspected sources of pollutants to surface waters. Methods such as testing for whitening agents and use of synthetic DNA or other markers are needed to determine if and where septic leachates are entering surface waters. Additional analysis and evaluation of compiled water quality information involving agency experts is desired to better quantify current status and trends of water quality in the Valley.

Financial assistance is needed to conduct pollutant management measures as well as to conduct continuing and expanded water quality and AIS monitoring. Road improvements in outlying areas to reduce sediments and nutrient input to streams can easily consume $4-5 million, particularly for replacing inadequate culverts, rerouting roads in inappropriate locations, and applying BMP's to road surfaces. As discussed, continued and enhanced monitoring of surface waters is needed. This could cost from $30,000- $100,000/yr depending on the methods used and intensity of sampling. Continued AIS monitoring is estimated to cost $15-20,000/yr.

Addressing the issue of groundwater contamination will require significant financial support. Estimates of needed financial assistance should be developed by the responsible agencies. Financial assistance to homeowners with old or inadequate septic systems should be considered as part of this determination of financial need.

8.5 Describe information and education activities for public involvement

Outreach and education activities will be a critical component for obtaining the local support to fully implement an effective Plan. The public needs to be informed about available data on water quality, with an unbiased interpretation of those data. This will be an on-going process as additional monitoring is conducted and new data that identifies sources of pollutants is produced. Landowners surrounding each lake (Big Sky Lake, Seeley Lake, Salmon Lake, Placid Lake, Lake Inez, and Emerald Lake) should be encouraged to understand the status of their lake and needed actions to keep each lake in a desirable condition.

CRC is positioned to be highly engaged in community and public outreach and education on water quality issues. CRC has been the lead organization for water quality monitoring and in advocating for actions to address identified water quality concerns for many years. Continued outreach is planned, with public presentations on water quality status, availability of reports on water quality through CRC's website, videos, and articles in the local paper, CRC will continue its outreach and education efforts. CRC will also help with outreach to individual lake homeowner organizations to help address challenges specific to each lake.

8.6 Outline schedule for implementing non-point source pollutant management measures.

Continued monitoring of water quality should continue each year. For lakes, this should begin with lake turnover in the spring and continue each year until cooling temperatures in the fall. Stream sampling for streams of concern should occur during peak runoff and into the summer.

Road improvements could be implemented as soon as funding sources are identified to conduct these improvements. As most roads to be treated are on public lands, this work will first require planning and environmental review, which can take several months or more to complete.

8.7 Describe interim, measurable milestones.

As described, water quality and AIS monitoring should be conducted in lakes and streams each year with specific milestones for timing and reporting on these actions. Milestones can also be set for reporting on the findings each year. Holding a public meeting with remote access to present annual findings such as the meeting scheduled for January 2024 is recommended. Milestones for additional public outreach and engagement such as meetings with lake homeowner groups can also be set.

Other milestones are more difficult to set, as all require funding to implement. Annual milestones for applying for funding sources can be set, but given the uncertainty in obtaining needed funding or the timing of its attainment makes setting measurable milestones for restoration activities difficult.

8.8 Establish criteria for determining whether loading reductions are being achieved over time.

The identified desired reductions in loadings discussed above form the basis for determining whether or not loading reductions are being achieved. With proposed annual monitoring of the streams and lakes where loading reductions are recommended, trends in nutrients or other targets can be identified, and evaluations of whether desired changes are occurring will be produced.

8.9 Define monitoring plan.

Desired monitoring going forward is one of the primary outputs discussed in this Plan. This continued and enhanced monitoring efforts described in the Plan are essential to better define sources of pollutants and needed restoration actions.

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Appendices

Recommended Actions from Blackfoot Watershed Plan

Blanchard Creek

Recommended Conservation Practices/BMPs

Ongoing efforts by DNRC on Blanchard Creek include riparian fencing, bank shaping, and willow planting. According to the Fish and Wildlife Service, a water lease arrangement has been made on lower Blanchard Creek in which diversions are stopped when Blanchard Creek reaches 3 cfs. "Fish-friendly" diversion structures were constructed in 1993, and the culvert under Highway 200 was also modified to facilitate fish passage. Improved grazing management in the riparian corridor has been initiated by Plum Creek Timber Company and the Department of Natural Resource Conservation. Additional opportunities for improvement of water quality conditions in Blanchard Creek are described below.

The management of fine sediment on Blanchard Creek can be best achieved by first addressing those sources with the largest portion of controllable sediment by volume on an average annual basis. These sources include roads and upland areas.

Road-derived sediment is a likely contributor to habitat degradation along much of the creek. In 2005, 3 road crossings were assessed in lower Blanchard Creek. BMP status at these sites ranged from full to lacking and the potential for additional BMPs was noted at each crossing (RDG, 2006). None of these sites were identified as fish passage barriers or at risk for fill failure. An analysis of potential culvert fill failure did however estimate that 112 tons of sediment could be delivered to the stream in a given year as a result of culvert failure. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the Best Management Practices for Forestry in Montana (MT DNRC/BMP Work Group, January 2006) and the Montana Streamside Management Zone (SMZ) Law. Reference these documents and the *Middle Blackfoot-Nevada TMDL and Water Quality Improvement Plan* for the BMPs, which should be applied to road crossings where reduction of sediment delivery is possible, where culvert failure is of concern, and where the stream is adversely affected by roads. The main access road up Blanchard Creek closely follows the creek on much of its length. Due to the extent of roads and the proximity of roads to the stream in the Blanchard Creek basin, vegetation enhancement on cut slopes, fill slopes, and where the road prism impinges on the active floodplain and channel margin would increase sediment trapping capabilities. Road closure or road obliterations could be considered in areas that are least used for vehicles or travel.

Much of the listed segment of Blanchard Creek flows through a confined valley that is bordered by fairly steep hill slopes that have been historically logged. Recommended conservation measures on Blanchard Creek include reducing sediment sourcing from these hill slopes through the application of Upland BMPs to reduce sediment production from historic timber harvesting activities. Any future logging-related land management should include Forestry BMPs such as SMZ practices, as well as the voluntary practices developed by the 2006 BMP working group.

On lowermost Blanchard Creek, corrals that abut the stream corridor are another likely source of upland sediment. The application of Upland and Riparian Area BMPs adjacent to the corrals would help reduce upland sediment delivery to the stream and also reduce the potential for excessive nutrient loading to Blanchard Creek and the Clearwater River. Grazing BMPs in upland areas are also recommended to promote vegetative filtering capacity which will reduce sediment delivery.

Improving the extent of woody bankline vegetation throughout the Blanchard Creek stream corridor will improve habitat conditions and reduce sediment delivery from streambank erosion and other sources. Currently, the extent of woody vegetation on the banks of Blanchard Creek is on the order of 42%, whereas the target value for this parameter is over 84%. The degradation of this woody vegetation in the stream corridor is likely primarily associated with riparian grazing, timber harvesting, dewatering, and road encroachment. Riparian Area BMP treatments, Grazing BMPs, and Water Conservation BMPs would improve woody vegetation extent along the stream bank, reduce streambank erosion through bank stabilization, and reduce sediment delivery from uplands through increased filtering capacity. Improvement of woody riparian vegetation conditions will also provide preventative measures with respect to temperature and nutrient loading.

Much of the substrate on Blanchard Creek consists of coarse armor that appears largely immobile under current flow conditions. Because of its armored nature, rates of natural bed scour on Blanchard Creek appear low. Bedform diversity is very limited, and the channel typically consists of a very coarse bed that forms long, relatively straight run environments. In order to create more habitat complexity, active restoration techniques targeting habitat enhancement (pool excavation, bar construction, riparian planting, and low flow sinuosity creation) would greatly improve fish habitat within the reach. However, these improvements should be implemented only in conjunction with the maintenance of sufficient flows to provide habitat for identified target life stages.

“Flow alterations from water diversions” is included as a source of impairment on the 2006 303(d) List. Field observations indicate significant dewatering on the lower reaches of Blanchard Creek. This loss of low flows during the irrigation season likely contributes to fine sediment accumulations as well as loss of riparian vigor. Opportunities to increase minimum flow rates in Blanchard Creek may include Water Banking, Water Rights Leasing, and Water Rights Conversions to In-Stream Flows (Appendix H). Irrigation System Management, including efficiency improvements and application management may also be designed to reduce low flow depletions on the river. Any flow management scheme should consider the preservation of channel forming (bank full) flows in the reach to promote local scour and associated pool formation and maintenance.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in Appendix H to avoid exacerbating existing sediment, habitat, and low flow conditions or creating additional water quality concerns related to nutrients, temperature, or metals in Blanchard Creek.

Buck Creek

Table 20. Summary of identified problems and applicable treatments, Buck Creek

Water Quality Component	**Limiting Factors/ Indicators**	**Suspected Sources**	**Applicable Treatments**
Sediment	None	Roads (5 tons/yr)	Road BMPs
Habitat	Woody vegetation extent, surface flow expression	Valley bottom disturbance	Stream BMPs
		Riparian degradation	Forestry BMPs, Riparian Area BMPs
Nutrients	None		Preventative
Temperature	None identified		Preventative
Metals	None identified		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Buck Creek (Blackfoot Challenge, 2005).

The primary issue with regard to habitat integrity on Buck Creek is the disturbed valley bottom and riparian zone. In 2004, field crews noted a recovering riparian area following logging and in the long-term, these impacts will likely be remedied by this natural process. This recovery will include reestablishment of conifers in the valley bottom and soils development in the riparian corridor. In the short-term, however, habitat will be limited to substrate condition and associated flow infiltration.

If aquatic habitat within Buck Creek is deemed to be of priority, then active restoration of the stream corridor would accelerate the natural recovery process. This restoration would include reconstruction of the channel using a well-graded substrate that reduces the permeability of the channel bed, as well as extensive revegetation along the stream bank. These treatments would fall under the category of Stream BMPs. It should be noted, however, that channel reconstruction in the reach will result in the removal of existing dense woody vegetation, which is dominated by shrubs.

Of the 15 tons of sediment delivered from road crossings each year, 4.5 tons is considered controllable through the implementation of BMPs. Plum Creek has surveyed 11 of the 12 road crossings in the basin. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the Best Management Practices for Forestry in Montana and the Montana Streamside Management Zone (SMZ) Law. In 2004, field crews noted the presence of weeds (knapweed and oxeye daisy) on and along road surfaces. Weed Management activities described in Appendix H of the *Middle Blackfoot-Nevada TMDL and Water Quality Improvement Plan* are recommended.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in Appendix H to avoid exacerbating existing habitat and low flow conditions or creating additional water quality concerns related to sediment, nutrients, temperature, or metals in Buck Creek.

Monitoring Needs

No sediment related impairments have been identified and it is believed that Buck Creek is capable of supporting all beneficial uses. Due to dry channel conditions, chemical and biological samplings have not been conducted and the stream remains listed as not assessed. Chemical and biological samplings under wet channel conditions are recommended to confirm beneficial use support. Monitoring the effects of recent fires in the Buck Creek watershed is also recommended.

Richmond Creek

Table 21. Summary of identified problems and applicable treatments, Richmond Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess fine sediment	Stream bank sediment (1 ton/year)	Riparian Area BMPs, Forestry BMPs
		Road sediment (33 tons/year)	Roads BMPs

		Hill slope sediment (40 tons/yr)	Riparian Area BMPs, Upland BMPs, Forestry BMPs
Habitat	None		Preventative
Nutrients	None		Preventative
Temperature	None		Preventative
Metals	None		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Richmond Creek (Blackfoot Challenge, 2005).

Recommended conservation objectives for Richmond Creek are to reduce sediment sourcing from hill slopes and roads, and to reduce the delivery of that sediment to the creek. Roads currently cross and closely follow the channel in several places. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (Appendix H). Locally, where access points cross the channel, woody riparian vegetation has been cleared. These areas would benefit from Upland BMPs to restore cover against the valley bottom.

On timber harvested hill slopes, Forestry BMPs identified in the Streamside Management Zone (SMZ) guidelines, as well as the voluntary practices developed by the 2006 BMP working group are recommended as appropriate measures to reduce sediment production and delivery rates (Appendix H).

An evaluation of four culverts on Richmond Creek in 2002 indicated that all four are likely barriers to fish passage (Cahoon, 2005). The majority of the barriers are due to the culvert slope, as well as the water depth at low flow. If habitat connectivity is deemed a priority in the watershed, the removal of these barriers is recommended as a primary conservation measure in Richmond Creek.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in Appendix H to avoid exacerbating existing sediment conditions or creating additional water quality concerns related to habitat, low flows, nutrients, temperature, or metals in Richmond Creek.

Monitoring Needs

Comments received during the public review period suggest that further nutrient monitoring in Richmond Creek (particularly the lower portion) may be needed.

West Fork Clearwater River

Table 22. Summary of identified problems and applicable treatments, West Fork Clearwater River.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess fine sediment	Stream bank sediment (15 tons/year)	Forestry BMPs, Riparian Areas BMPs
		Road sediment (13 tons/yr)	Roads BMPs
		Hill slope sediment (40 tons/yr)	Riparian Areas BMPs, Forestry BMPs
Habitat	None		Preventative
Nutrients	None		Preventative
Temperature	None		Preventative
Metals	None		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration projects have been documented in the West Fork Clearwater River. Recommended conservation objectives for the West Fork Clearwater River are to reduce sediment sourcing from hill slopes, streambanks, and roads, and to reduce the delivery of that sediment to the river.

No data was collected on individual road crossings in the West Fork Clearwater River drainage making it difficult to determine the status of Road BMPs or specific sediment reduction measures that are needed. An assessment of road crossings in the West Fork Clearwater drainage is recommended to determine potential sediment reduction activities from this source through the implementation of Roads BMPs developed by the Montana DNRC/BMP Work Group in January 2006 (Appendix H).

On timber harvested hill slopes, Forestry BMPs identified in the Streamside Management Zone (SMZ) guidelines, as well as the voluntary practices developed by the 2006 BMP working group are recommended as appropriate measures to reduce sediment production and delivery rates (Appendix H). These practices can be augmented with Riparian BMPs to reduce sediment delivery to the channel.

The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in Appendix H to avoid exacerbating existing sediment conditions or creating additional water quality concerns related to habitat, low flows, nutrients, temperature, or metals in the West Fork Clearwater River.

Monitoring Needs

Comments received during the public review period suggest that further nutrient and temperature monitoring in the lower reaches of the West Fork Clearwater River may be needed.

Deer Creek

Table 23. Summary of identified problems and applicable treatments, Deer Creek.

Water Quality Component	Limiting Factors/ Indicators	Suspected Sources	Applicable Treatments
Sediment	Excess fine sediment	Stream bank sediment (38 tons/year)	Riparian Area BMPs, Forestry BMPs
		Road sediment (53 tons/year)	Roads BMPs
		Hill slope sediment (868 tons/yr)	Upland BMPs, Forestry BMPs
Habitat	Pool quality (suspected)	Riparian degradation	Stream BMPs, Riparian Area BMPs
Nutrients	None identified		Preventative
Temperature	None identified		Preventative

Metals	None identified		Preventative

Recommended Conservation Practices/BMPs

No water quality or fisheries restoration related projects have been documented in Deer Creek (Blackfoot Challenge, 2005).

Recommend conservation measures on Deer Creek include reducing sediment sourcing from hill slopes and roads. On timber harvested hill slopes, Upland BMPs will help reduce sediment production, and Riparian Area BMPs will help reduce sediment delivery to the stream. Any future logging-related land management should include Forestry BMPs such as SMZ practices, as well as the voluntary practices developed by the 2006 BMP working group (Appendix H).

Road-derived sediment is a likely contributor to habitat degradation along lower Deer Creek. Of the 68 possible crossings in Deer Creek, 48 have been assessed by Plum Creek Timber Company. In 2005, two road crossings were assessed on Deer Creek as part of TMDL efforts. One site was noted as having partial BMPs while the other site was noted as lacking BMPs. The site where BMPs were lacking was also identified as a potential fish passage barrier. Opportunities for reducing sediment delivery from these crossings are described in RDG, 2006. The management of sediment derived from roads can be best achieved by Roads BMPs that are outlined in the BMP document developed by the Montana DNRC/BMP Work Group in January 2006 (Appendix H).

The lack of woody debris that has been described on Deer Creek by project stakeholders can be addressed by revegetation of the channel margins, as well as by selective placement of LWD in the channel to promote local scour and improve overall habitat complexity. As such, the Stream BMPs that improve in-stream habitat complexity would be applicable on Deer Creek.

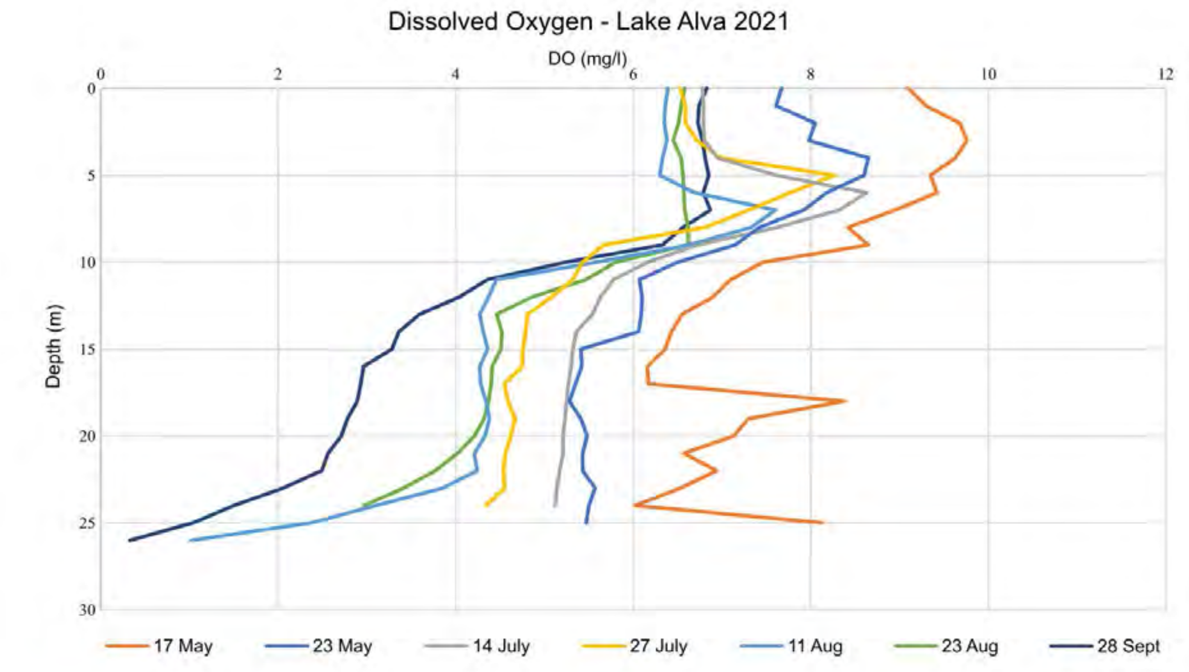
The recommended conservation practices and BMPs described above apply primarily to remediation of water quality issues related to current and historic land uses. Future land uses should also consider implementation of applicable BMPs described in Appendix H to avoid exacerbating existing sediment and habitat conditions or creating additional water quality concerns related to low flows, nutrients, temperature, or metals in Deer Creek.

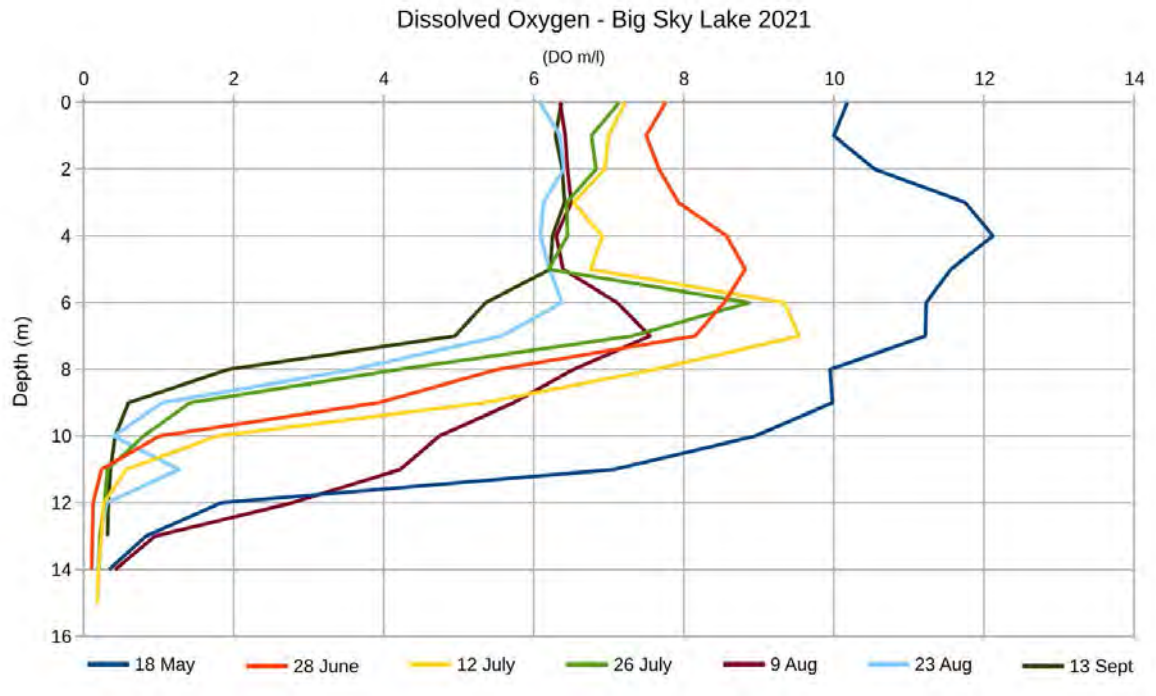
Monitoring Needs

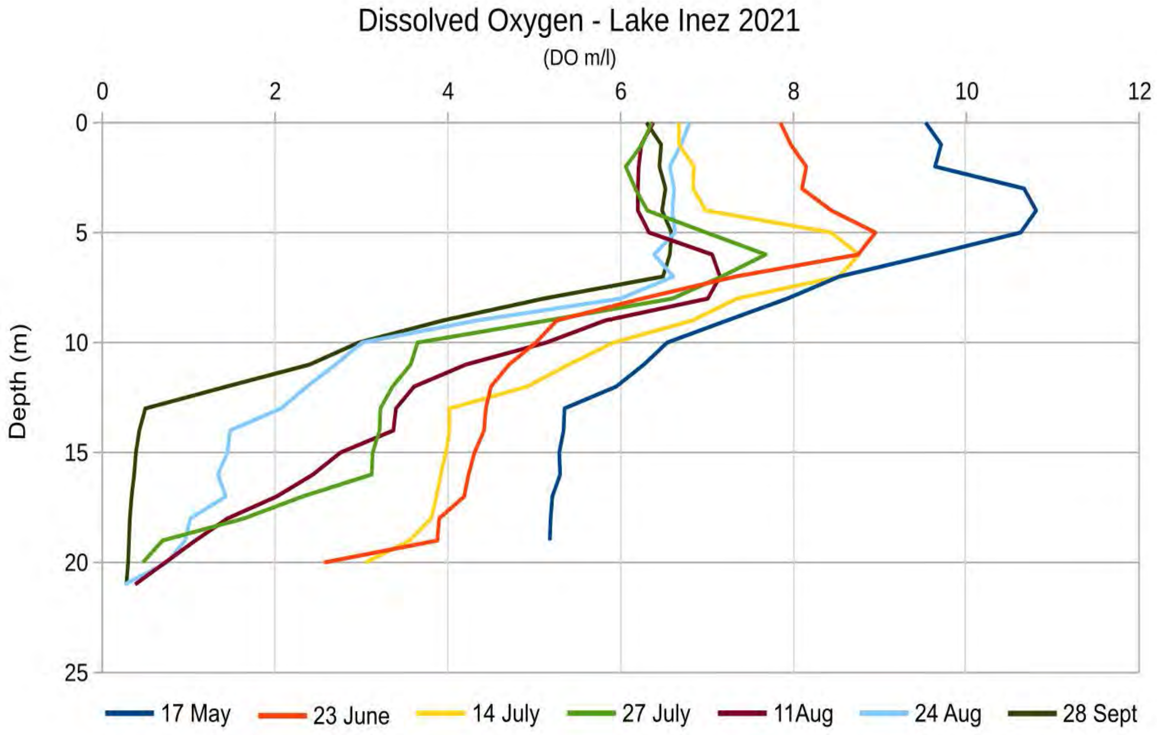
Aquatic habitat conditions have not been documented in Deer Creek. As pool quality is suspected as a limiting factor to water quality based upon the reported lack of woody debris in the channel, aquatic habitat conditions should be assessed to determine if concerns are warranted. Comments received during the public review period suggest further nutrient sampling in Deer Creek (particularly in the lower portion) may be needed.

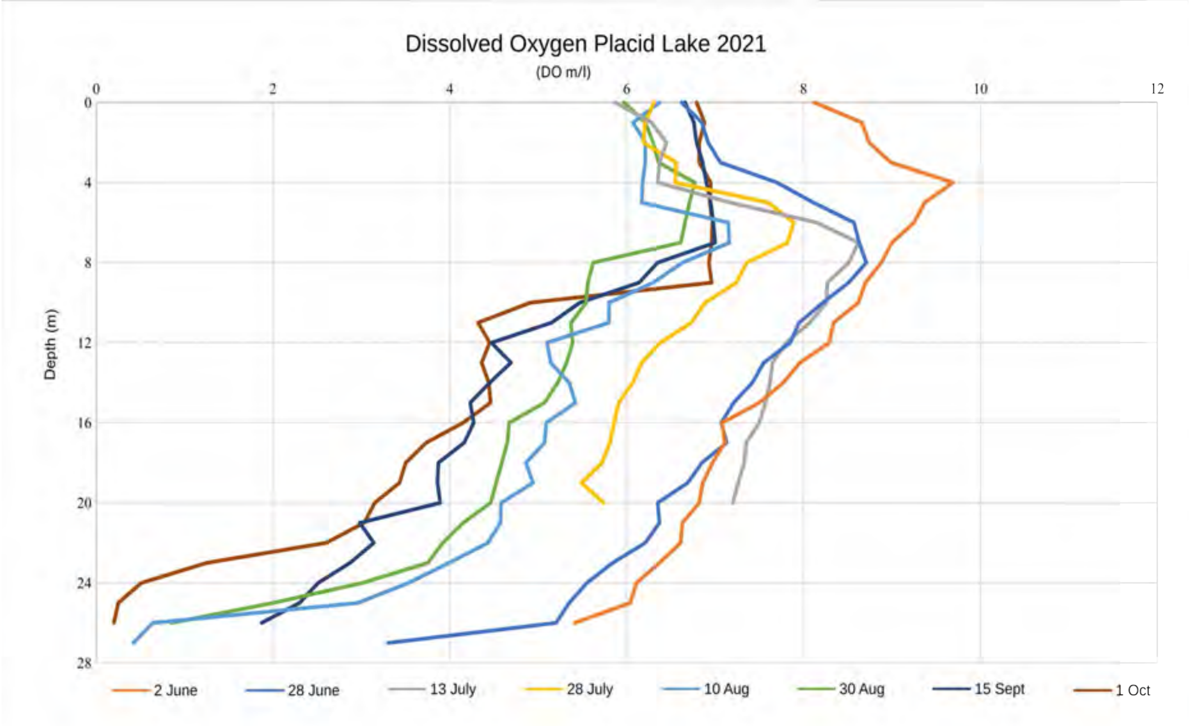
Graphs of Nutrient Sampling Results for Clearwater Valley Lakes

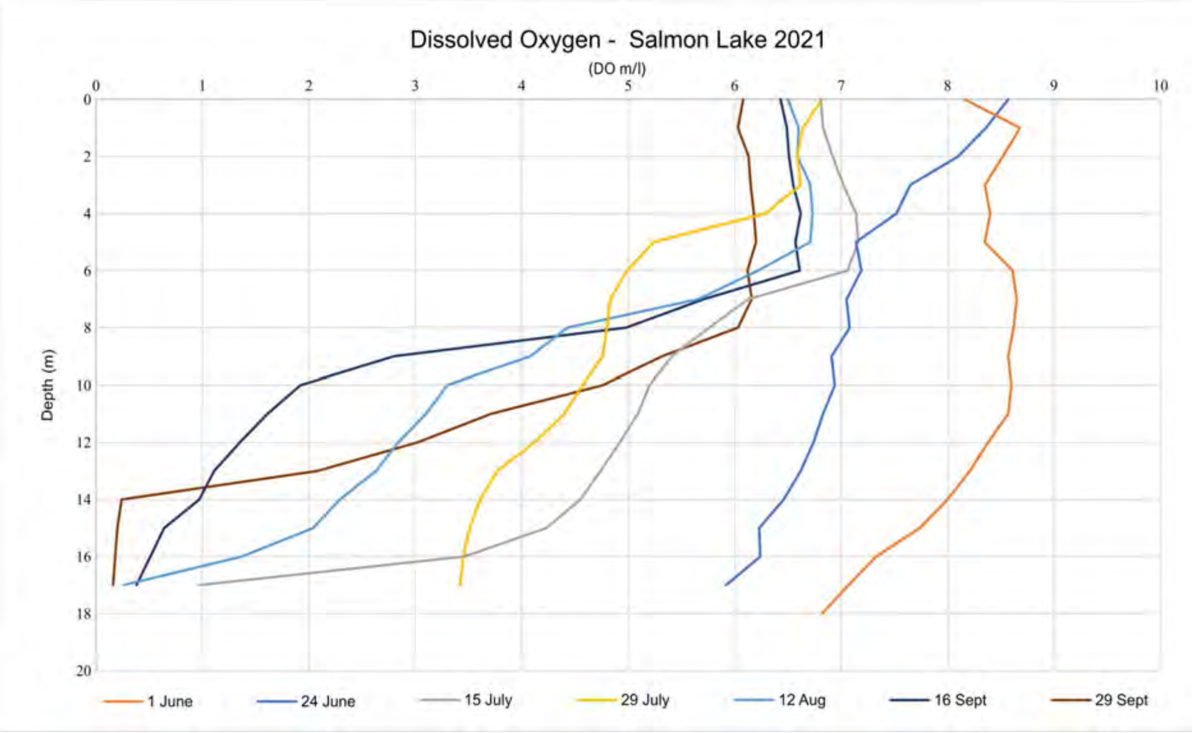
Dissolved oxygen (DO) 2021






Dissolved Oxygen - Lake Inez 2021
(DO m/l)
0
2
4
6
8
10
12
0
5
10
15
20
25
Depth (m)
17 May
23 June
14 July
27 July
11Aug
24 Aug
28 Sept


Dissolved Oxygen Placid Lake 2021
(DO m/l)
0
2
4
6
8
10
12
0
4
8
12
16
20
24
28
Depth (m)
2 June
28 June
13 July
28 July
10 Aug
30 Aug
15 Sept
1 Oct


Dissolved Oxygen - Salmon Lake 2021
(DO m/l)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
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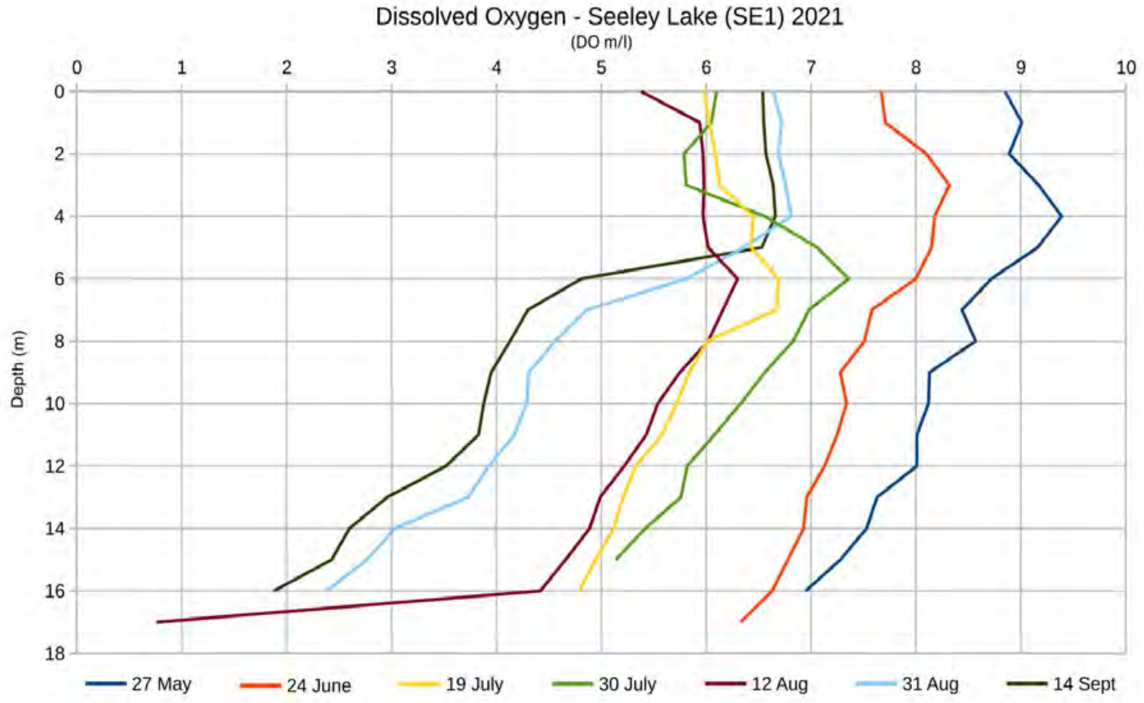
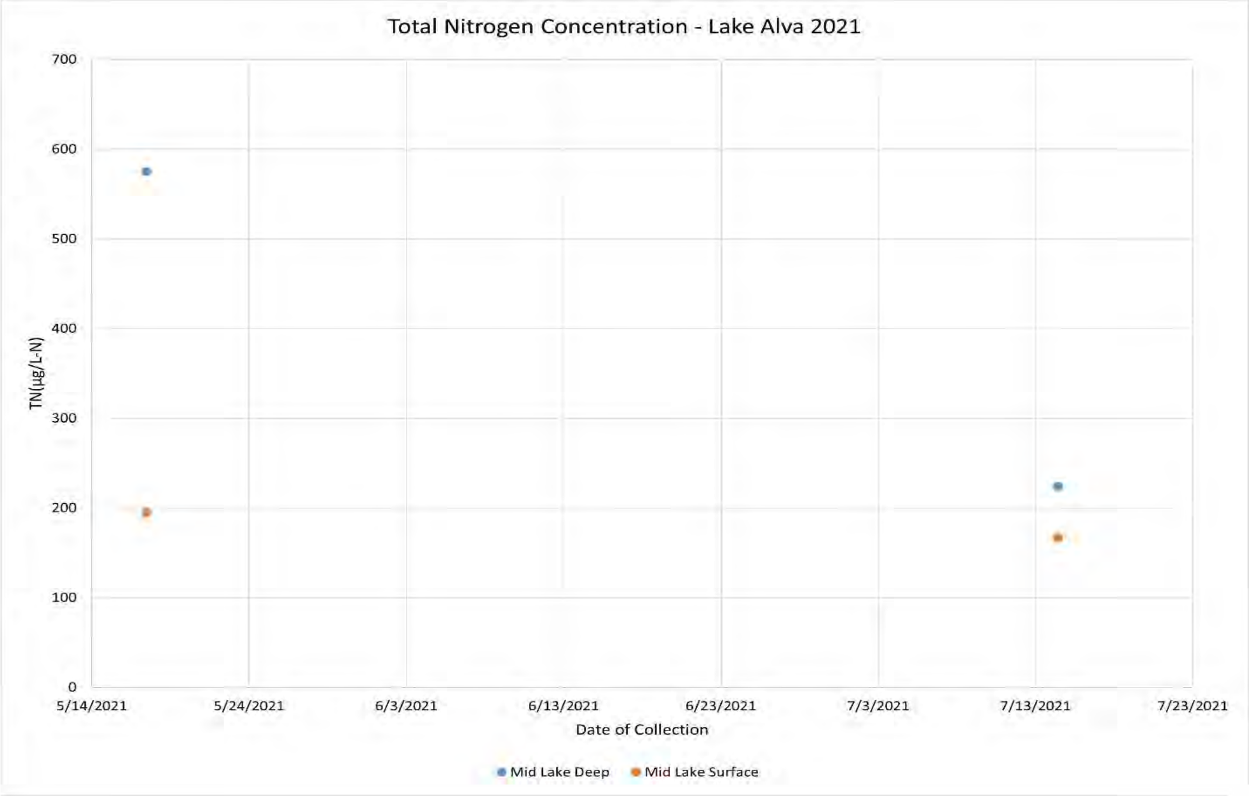
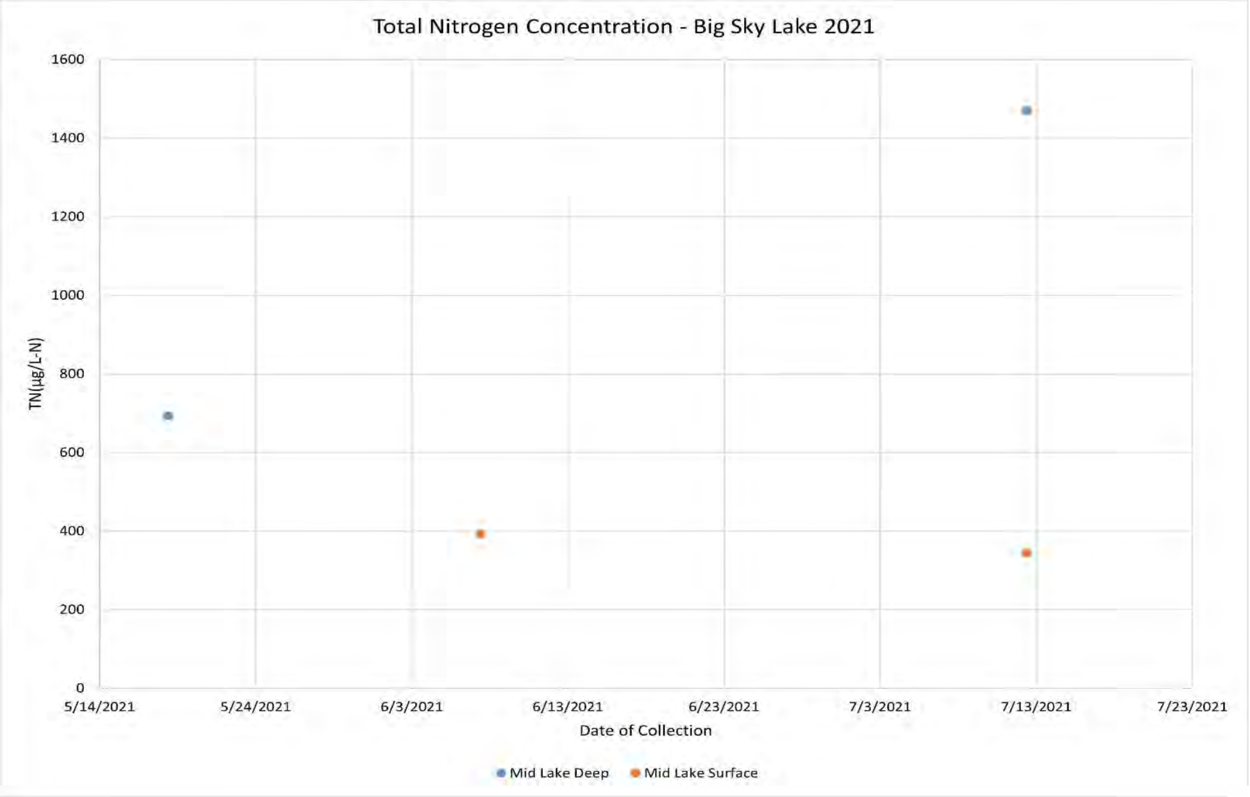
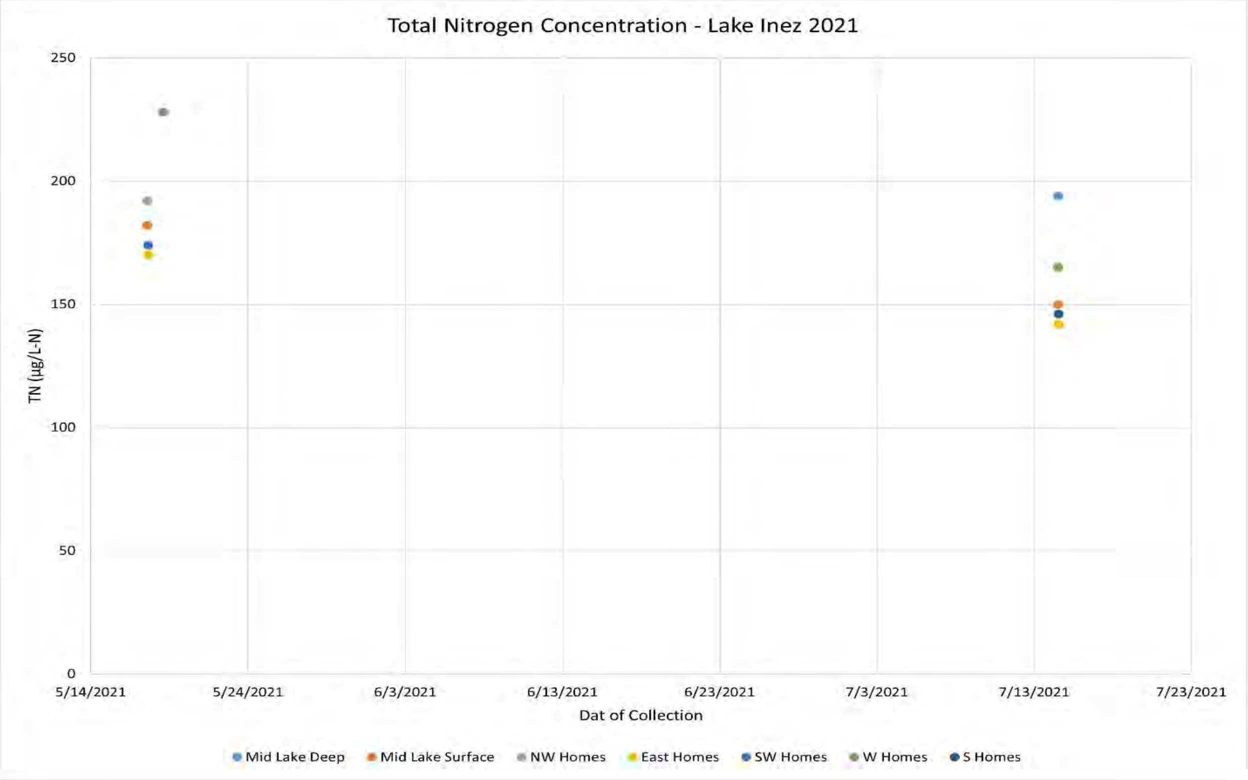
15 July
29 July
12 Aug
16 Sept
29 Sept

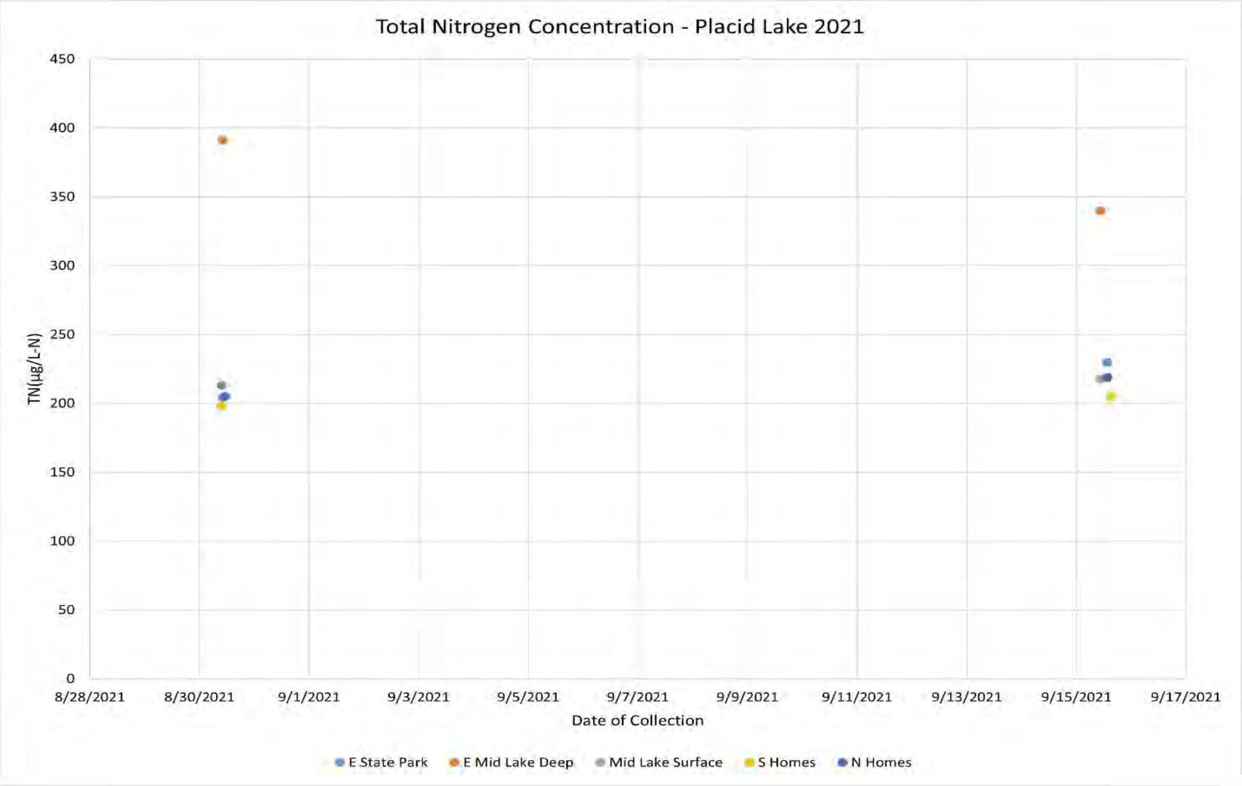

Dissolved Oxygen - Seeley Lake (SE1) 2021
(DO m/l)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
12
14
16
18
27 May
24 June
19 July
30 July
12 Aug
31 Aug
14 Sept

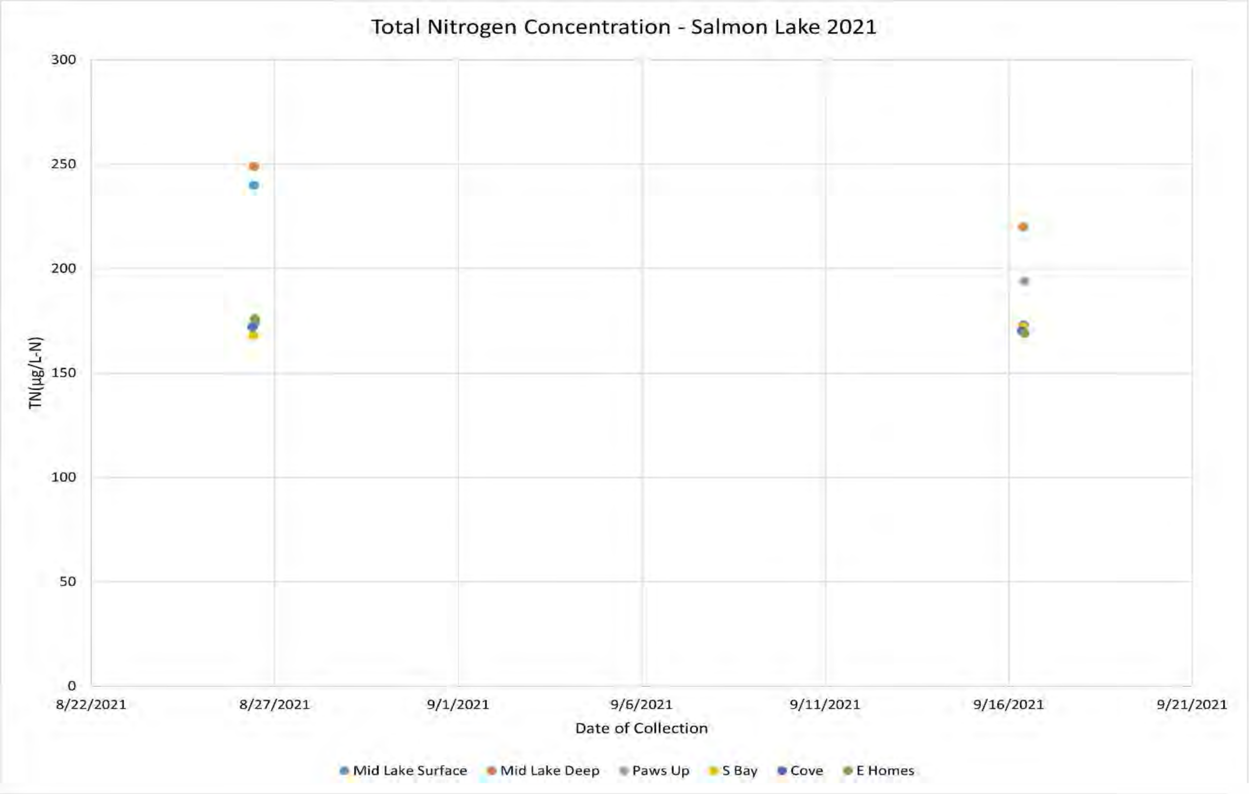
Total Nitrogen (TN) 2021

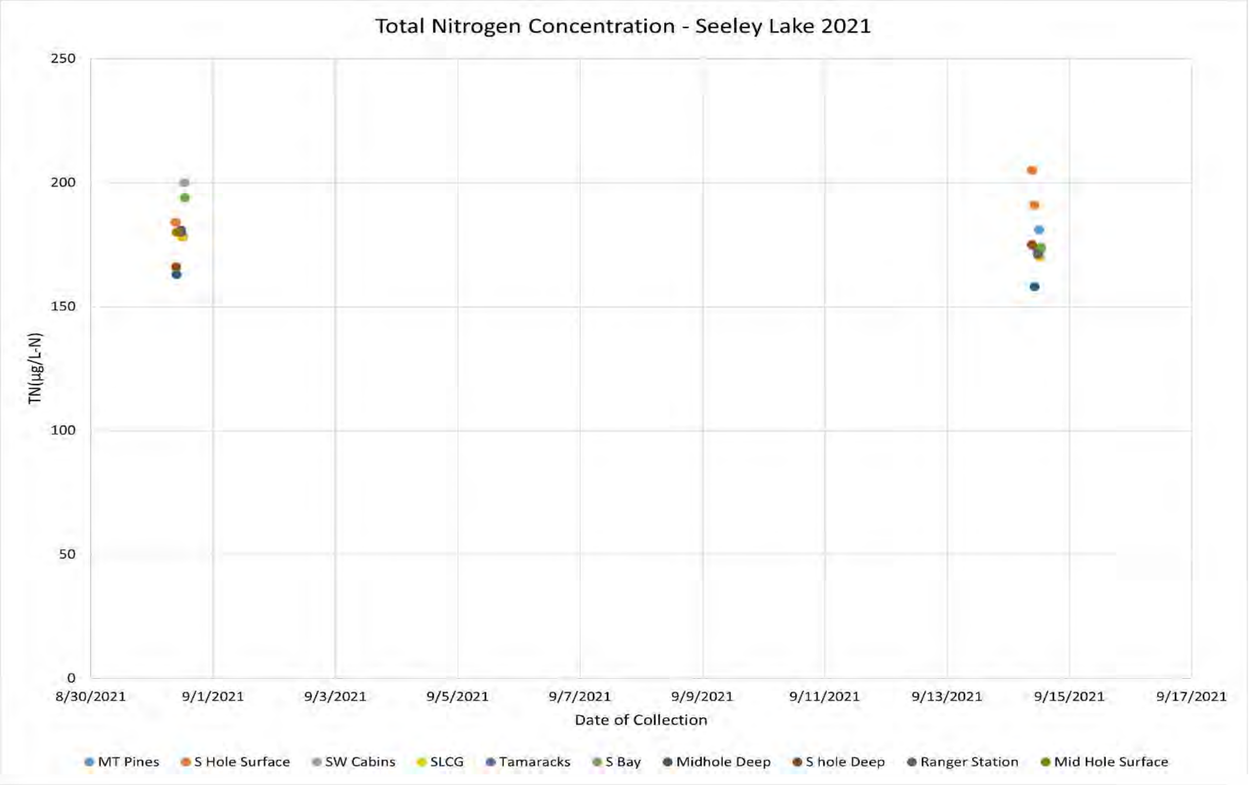




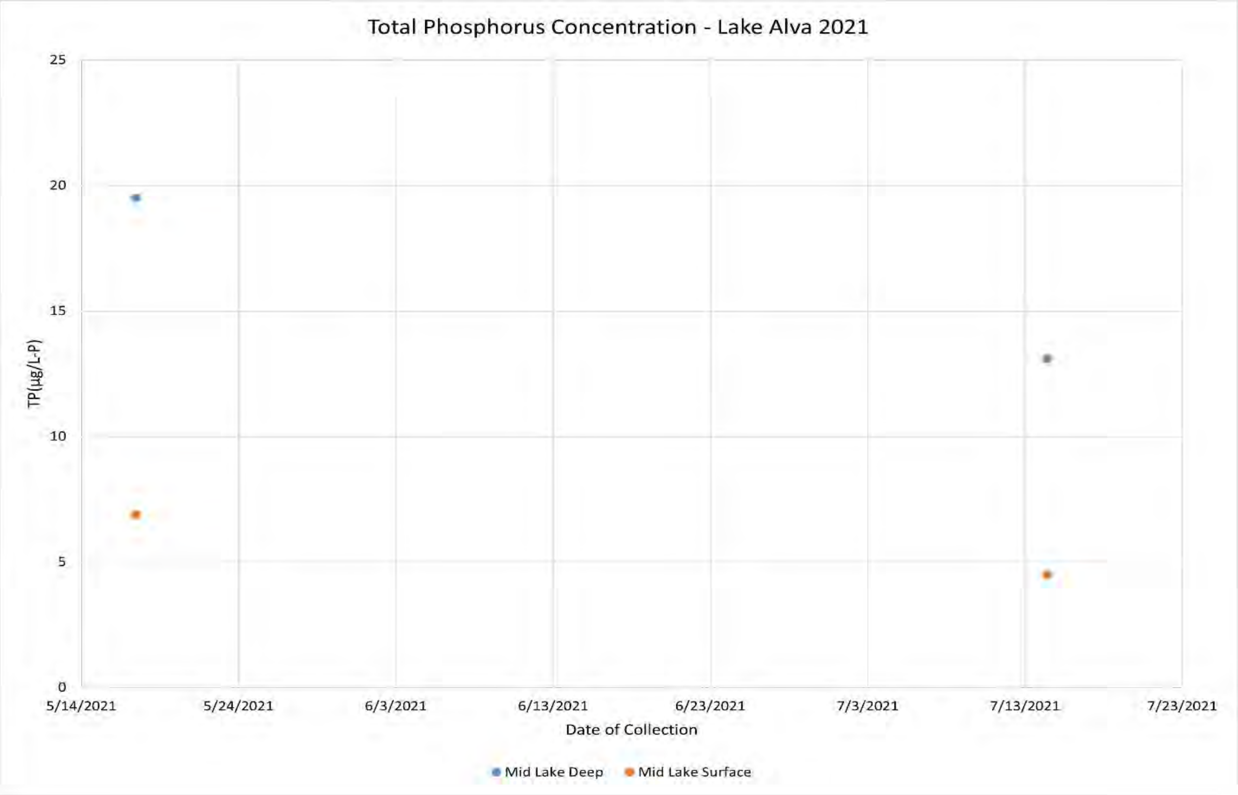

Total Nitrogen Concentration - Lake Inez 2021
250
200
150
100
50
0
TN (µg/L-N)
5/14/2021
5/24/2021
6/3/2021
6/13/2021
6/23/2021
7/3/2021
7/13/2021
7/23/2021
Dat of Collection
● Mid Lake Deep
● Mid Lake Surface
● NW Homes
● East Homes
● SW Homes
● W Homes
● S Homes

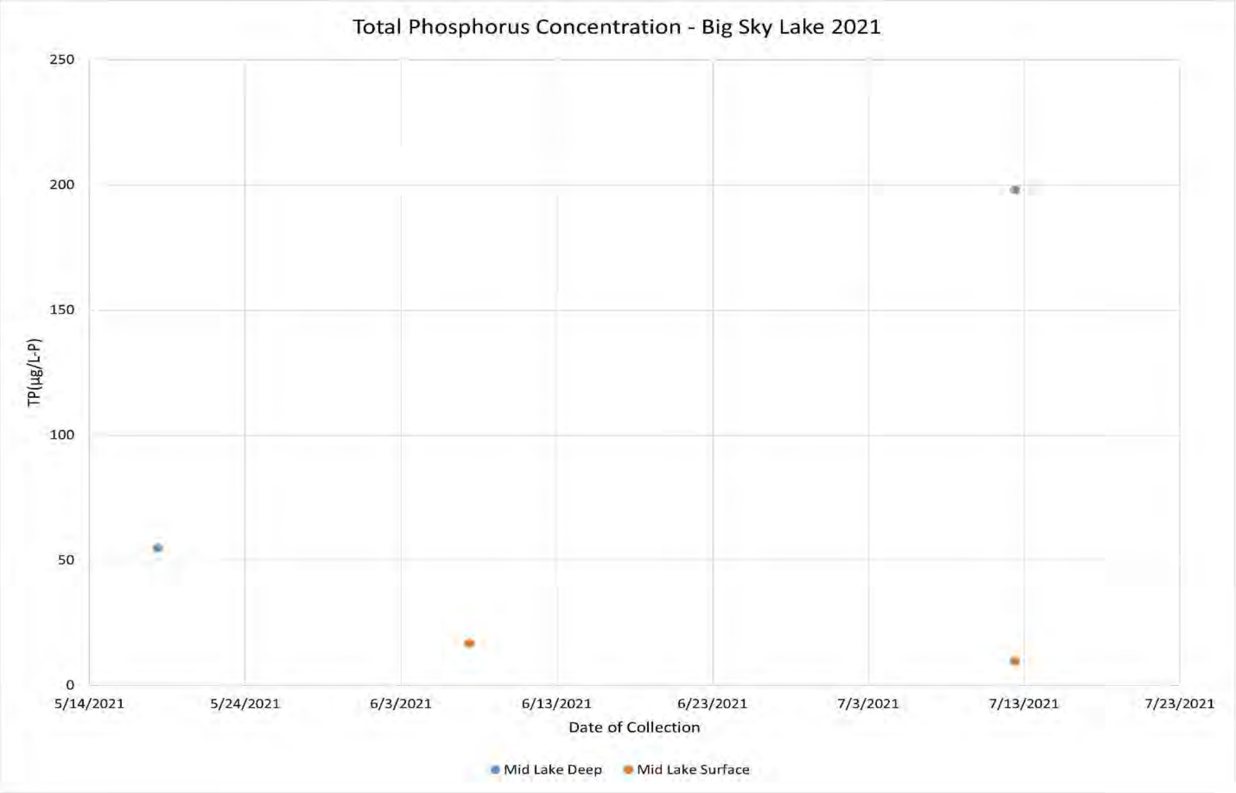

Total Nitrogen Concentration - Placid Lake 2021
450
400
350
300
250
200
150
100
50
0
TN(µg/L-N)
8/28/2021
8/30/2021
9/1/2021
9/3/2021
9/5/2021
9/7/2021
9/9/2021
9/11/2021
9/13/2021
9/15/2021
9/17/2021
Date of Collection
● E State Park
● E Mid Lake Deep
● Mid Lake Surface
● S Homes
● N Homes

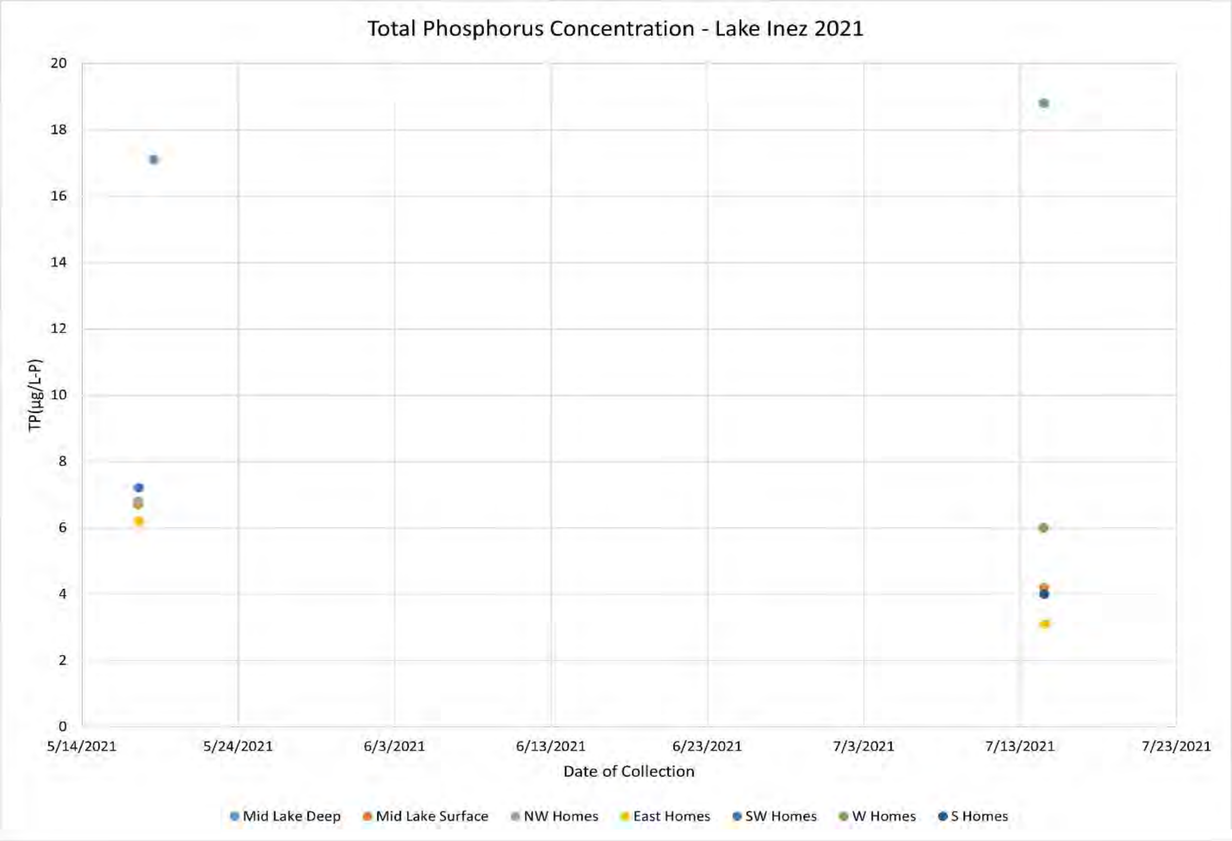

Total Nitrogen Concentration - Salmon Lake 2021
TN(µg/L-N)
300
250
200
150
100
50
0
8/22/2021
8/27/2021
9/1/2021
9/6/2021
9/11/2021
9/16/2021
9/21/2021
Date of Collection
Mid Lake Surface
Mid Lake Deep
Paws Up
S Bay
Cove
E Homes

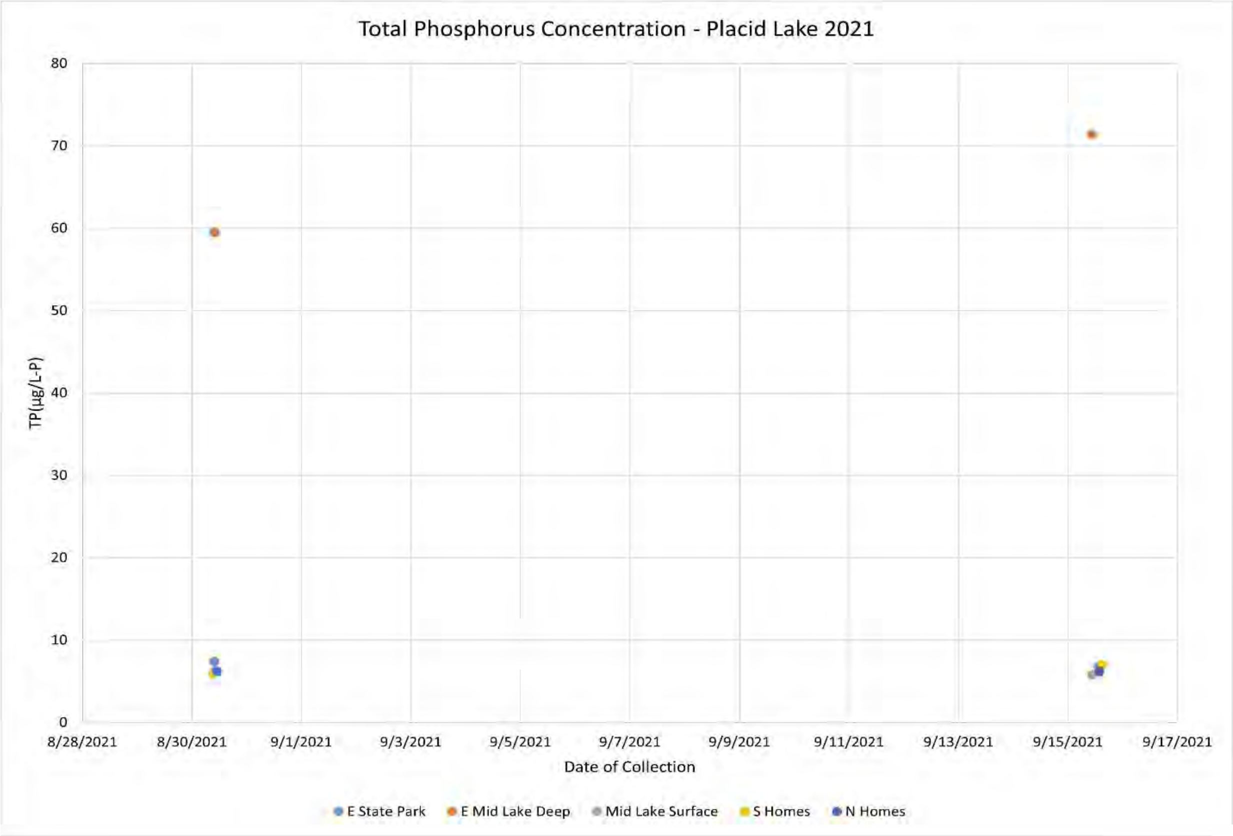

Total Nitrogen Concentration - Seeley Lake 2021
TN(µg/L-N)
250
200
150
100
50
0
8/30/2021
9/1/2021
9/3/2021
9/5/2021
9/7/2021
9/9/2021
9/11/2021
9/13/2021
9/15/2021
9/17/2021
Date of Collection
MT Pines
S Hole Surface
SW Cabins
SLCG
Tamaracks
S Bay
Midhole Deep
S hole Deep
Ranger Station
Mid Hole Surface

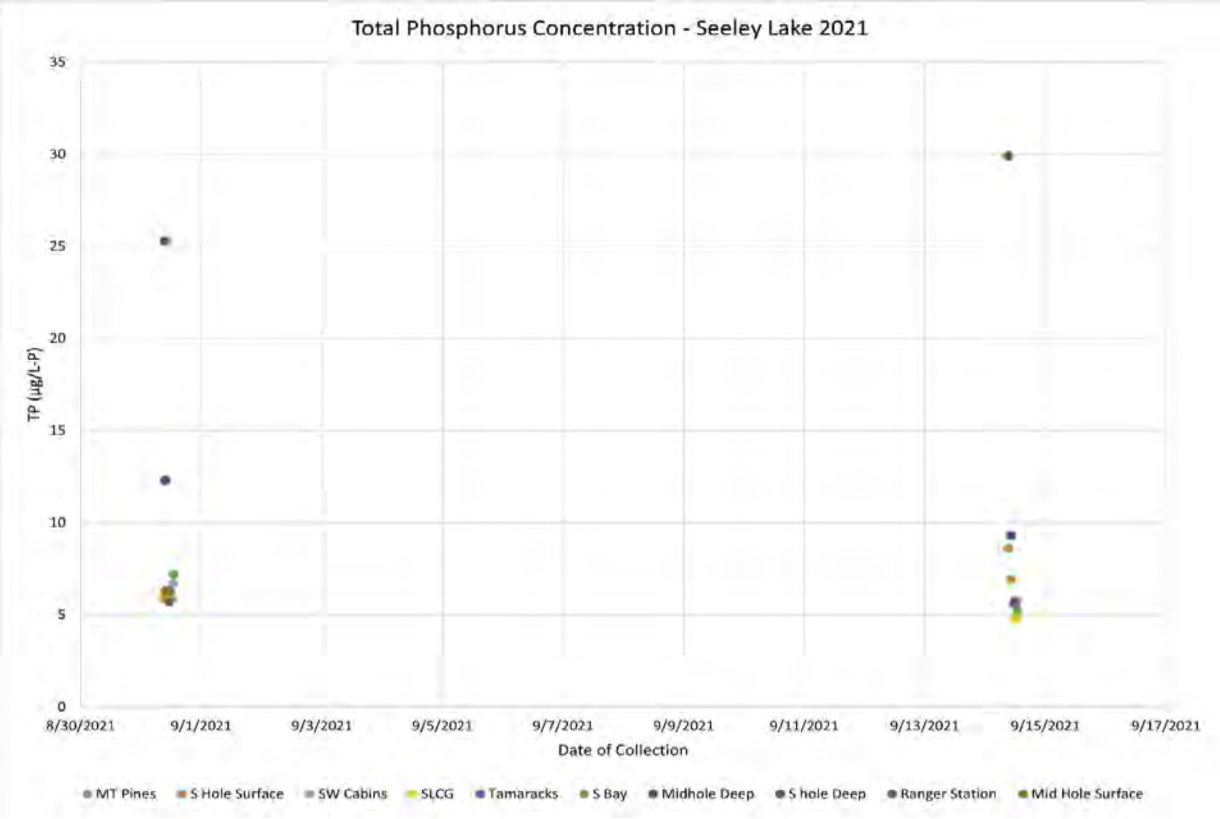
Total Phosphorus (TP) 2021

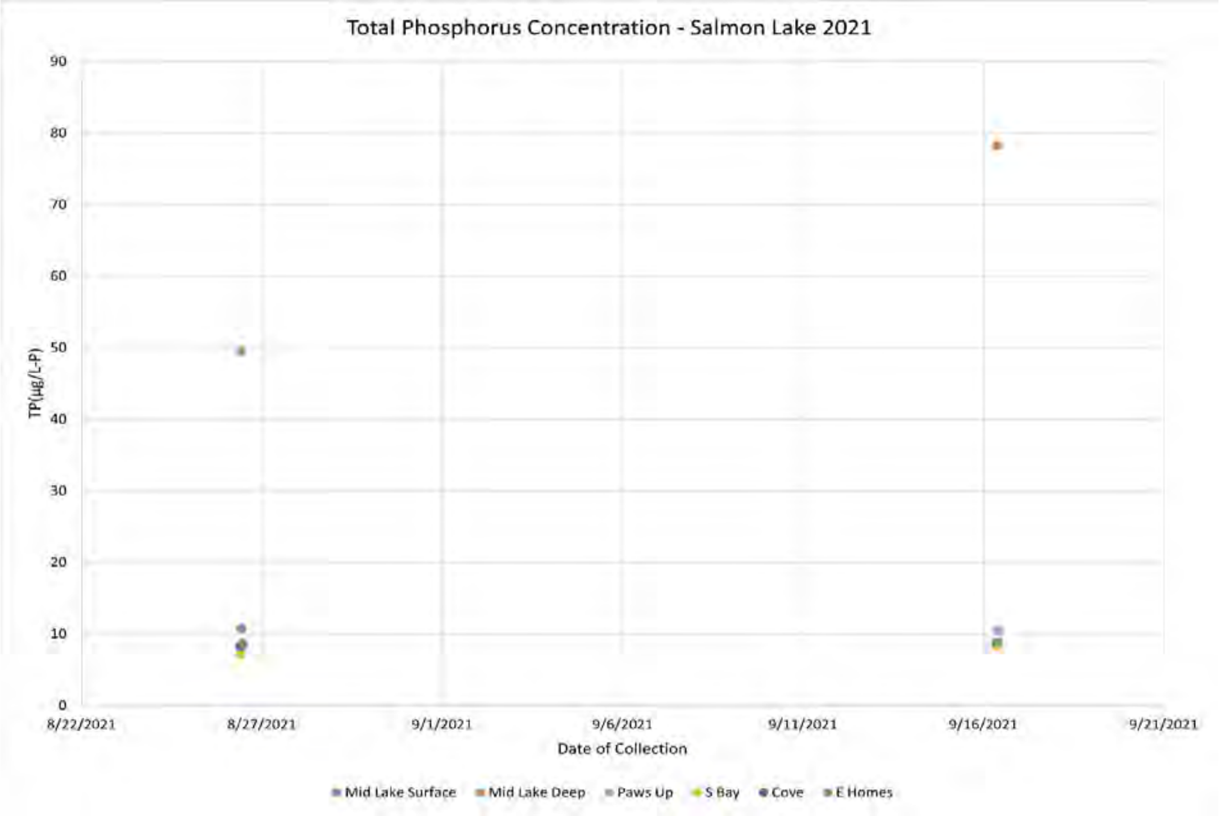




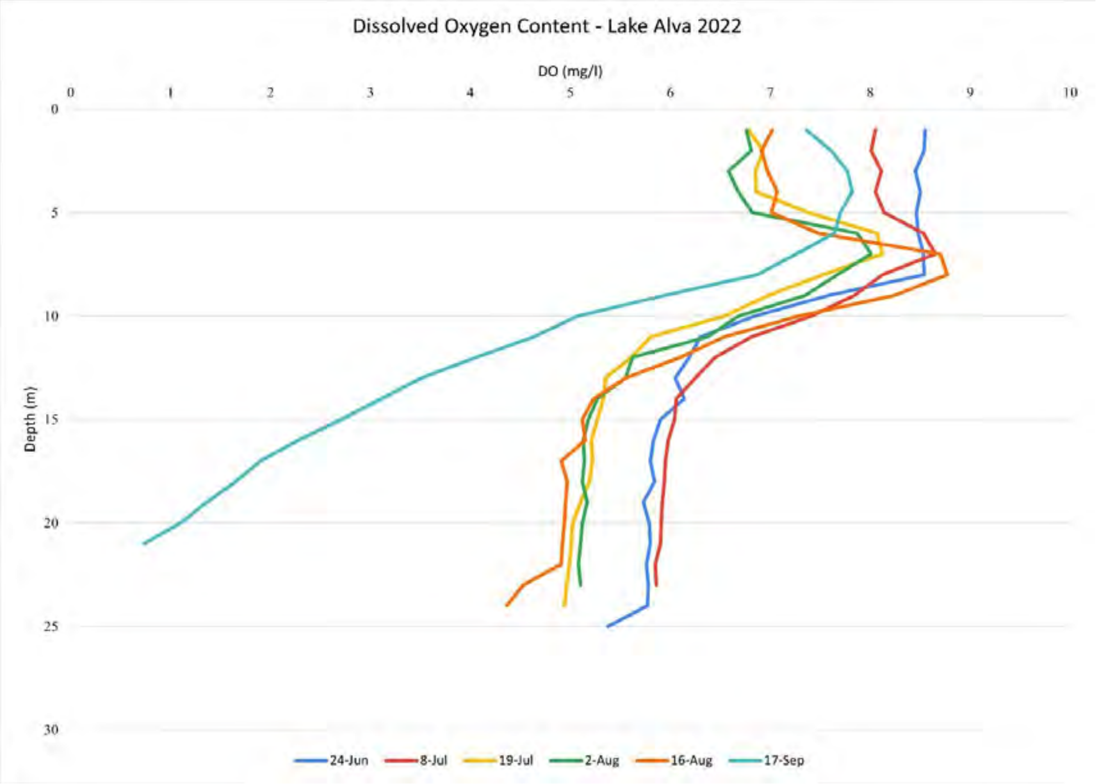

Total Phosphorus Concentration - Lake Inez 2021
TP(µg/L-P)
20
18
16
14
12
10
8
6
4
2
0
5/14/2021
5/24/2021
6/3/2021
6/13/2021
6/23/2021
7/3/2021
7/13/2021
7/23/2021
Date of Collection
● Mid Lake Deep
● Mid Lake Surface
● NW Homes
● East Homes
● SW Homes
● W Homes
● S Homes

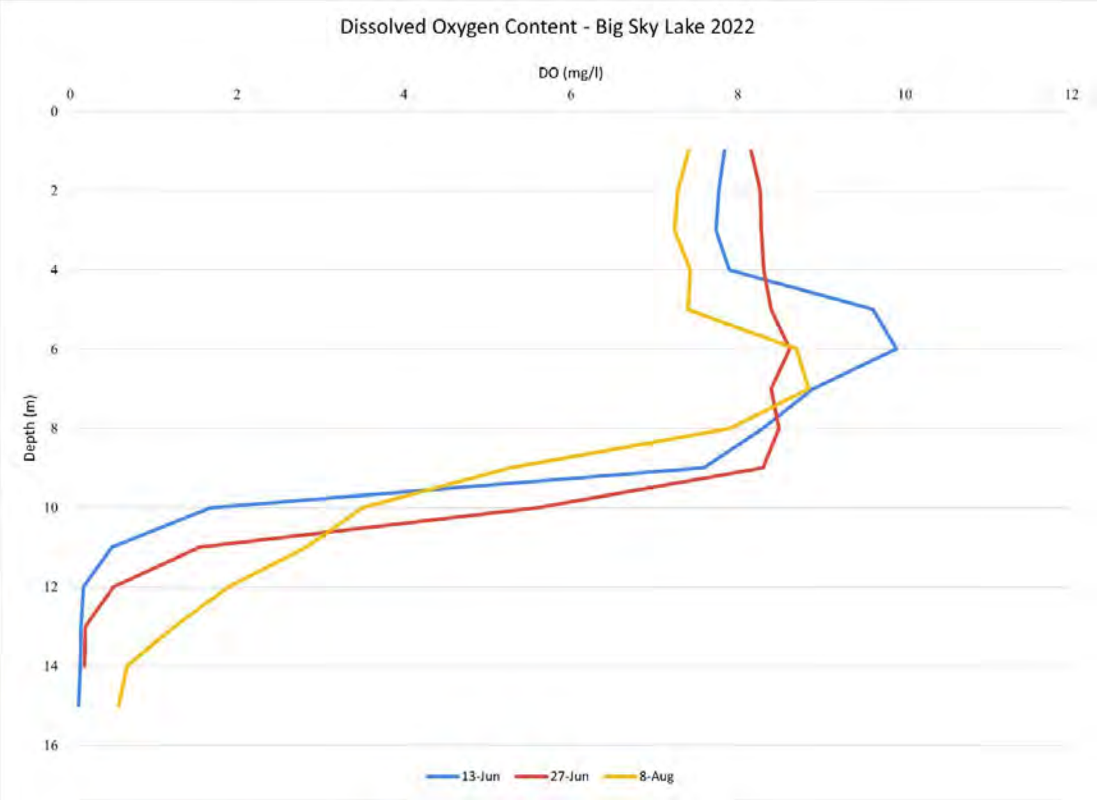

Total Phosphorus Concentration - Placid Lake 2021
TP(µg/L-P)
80
70
60
50
40
30
20
10
0
8/28/2021
8/30/2021
9/1/2021
9/3/2021
9/5/2021
9/7/2021
9/9/2021
9/11/2021
9/13/2021
9/15/2021
9/17/2021
Date of Collection
● E State Park
● E Mid Lake Deep
● Mid Lake Surface
● S Homes
● N Homes

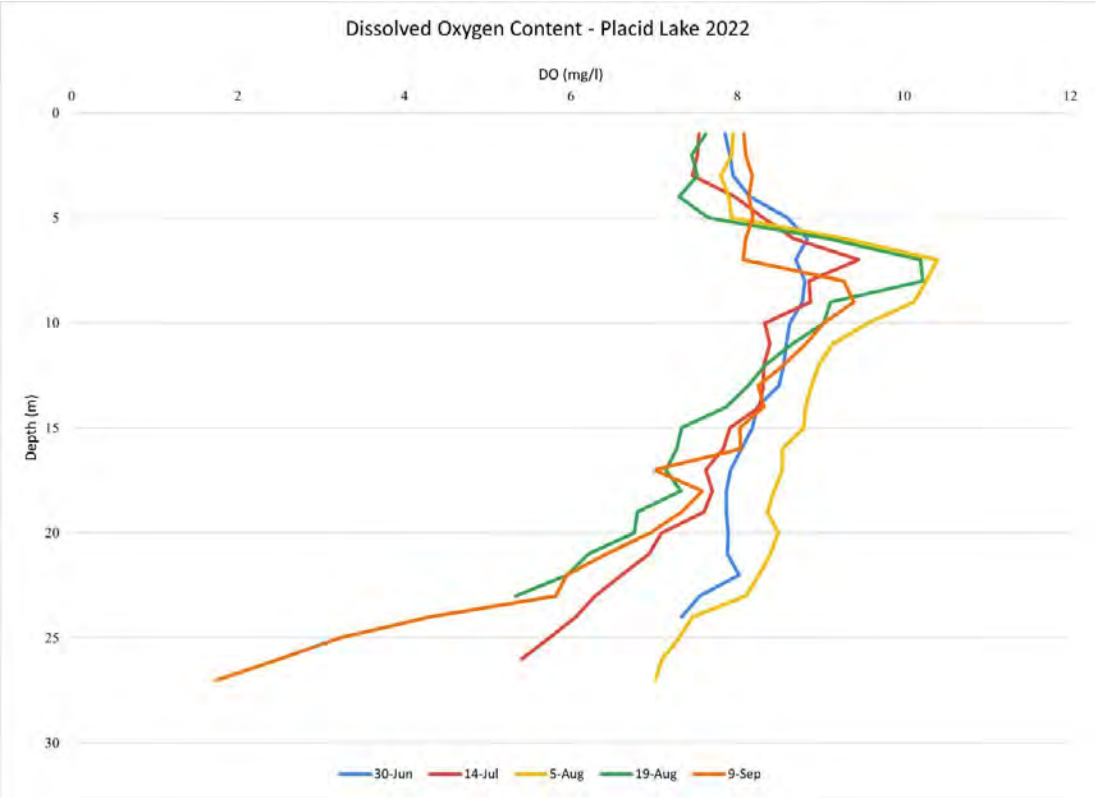

Total Phosphorus Concentration - Seeley Lake 2021
TP (µg/L-P)
0
5
10
15
20
25
30
35
8/30/2021
9/1/2021
9/3/2021
9/5/2021
9/7/2021
9/9/2021
9/11/2021
9/13/2021
9/15/2021
9/17/2021
Date of Collection
MT Pines
S Hole Surface
SW Cabins
SLCG
Tamaracks
S Bay
Midhole Deep
S hole Deep
Ranger Station
Mid Hole Surface

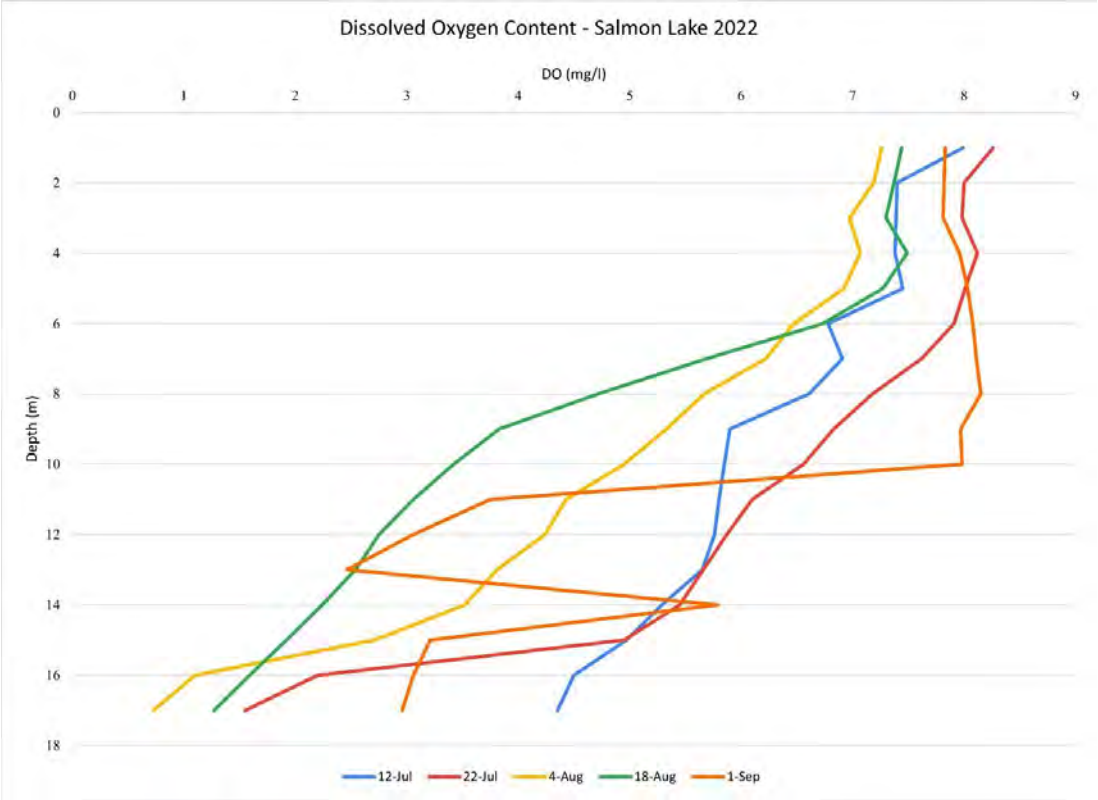

Total Phosphorus Concentration - Salmon Lake 2021
TP(µg/L-P)
0
10
20
30
40
50
60
70
80
90
8/22/2021
8/27/2021
9/1/2021
9/6/2021
9/11/2021
9/16/2021
9/21/2021
Date of Collection
Mid Lake Surface
Mid Lake Deep
Paws Up
S Bay
Cove
E Homes

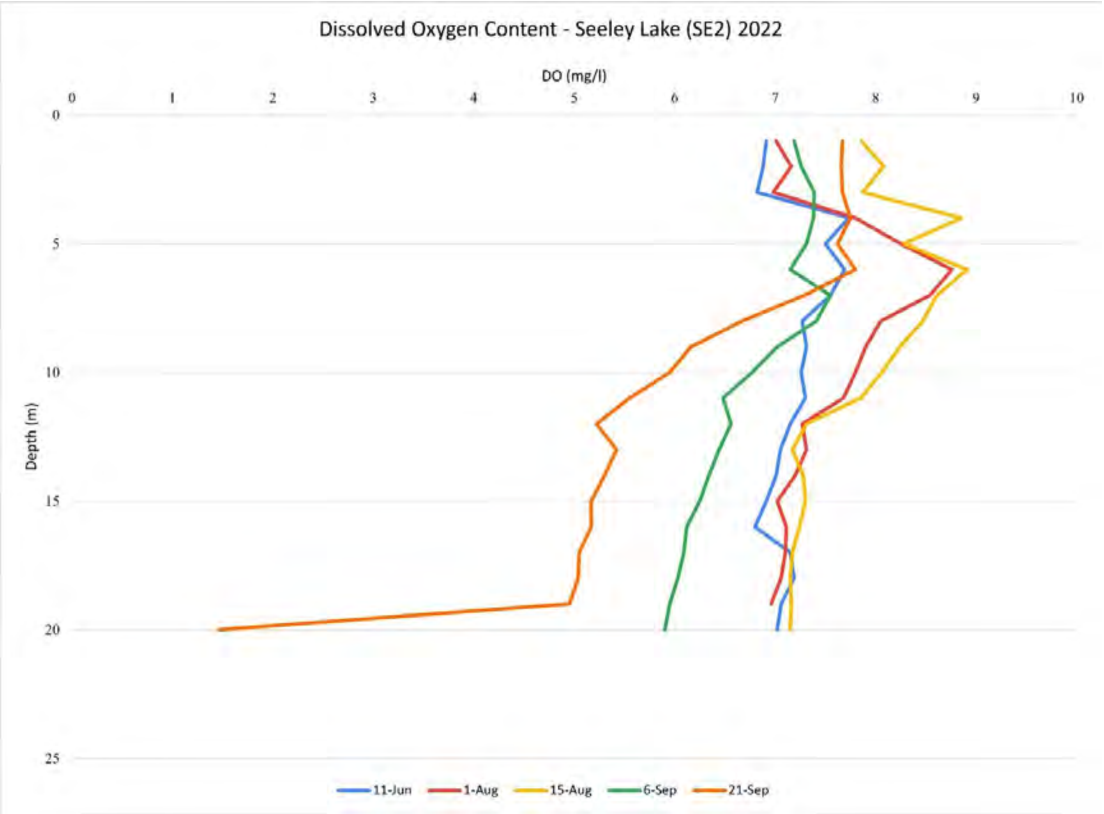
Dissolved oxygen (DO) 2022



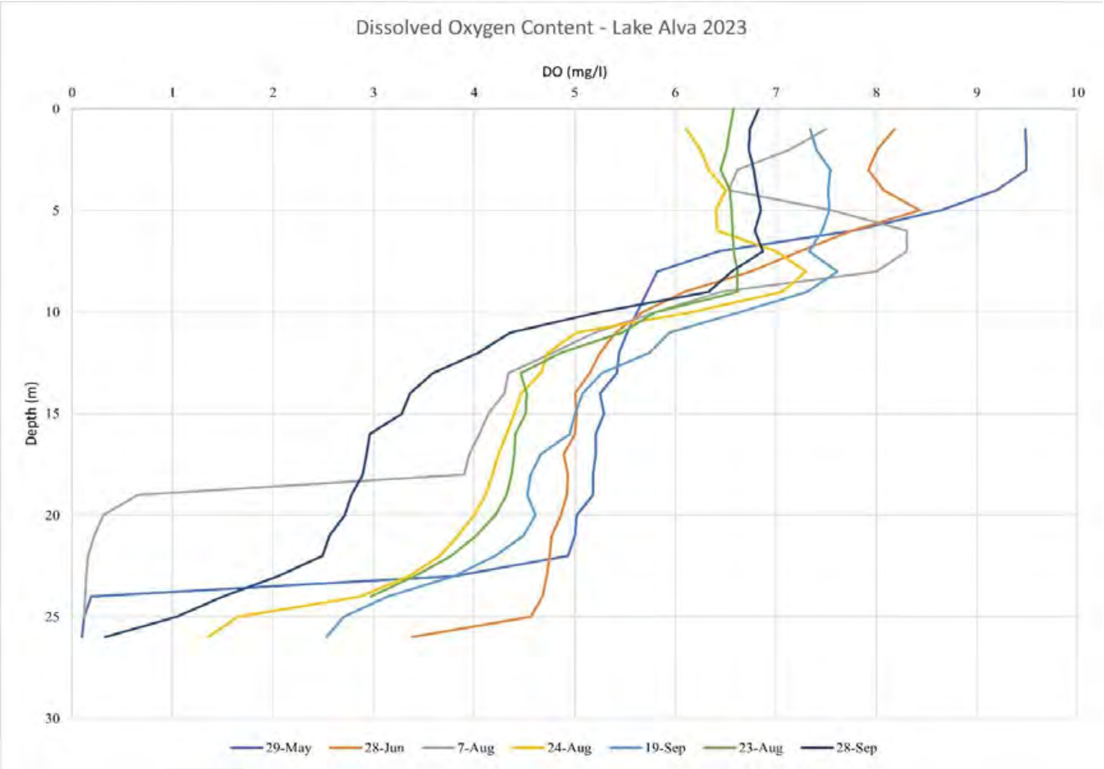


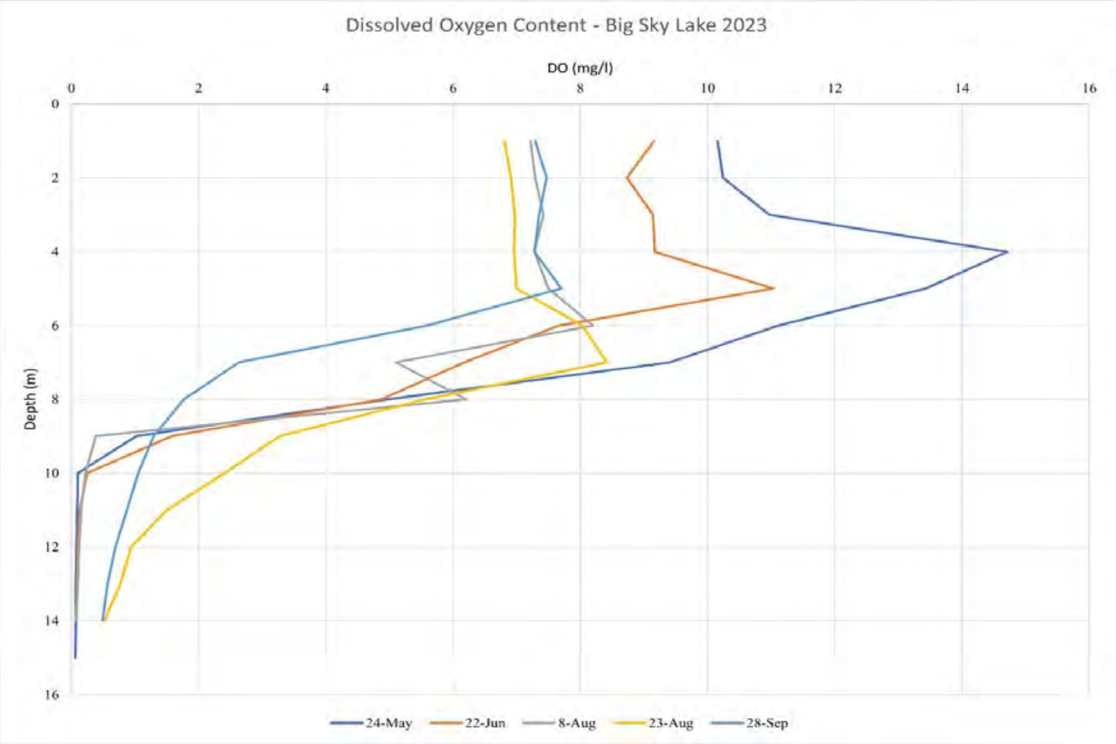

Dissolved Oxygen Content - Placid Lake 2022
DO (mg/l)
0
2
4
6
8
10
12
Depth (m)
0
5
10
15
20
25
30
30-Jun
14-Jul
5-Aug
19-Aug
9-Sep


Dissolved Oxygen Content - Salmon Lake 2022
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
Depth (m)
0
2
4
6
8
10
12
14
16
18
12-Jul
22-Jul
4-Aug
18-Aug
1-Sep

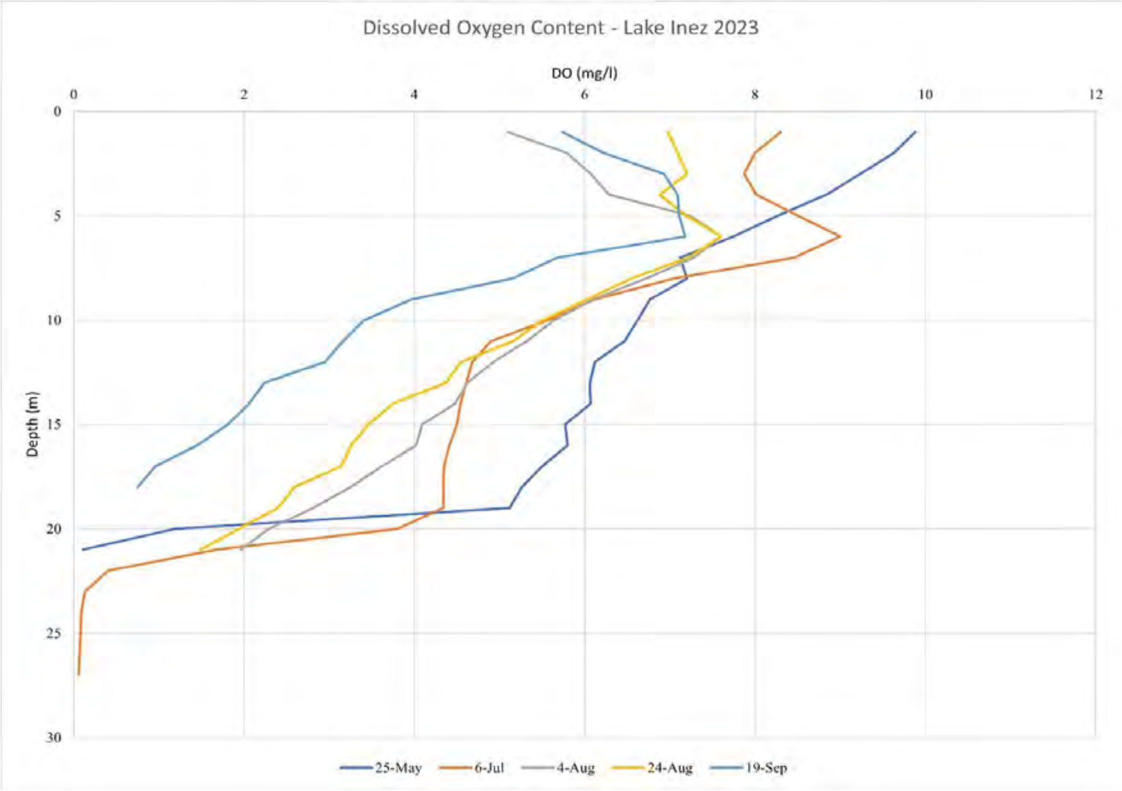


Dissolved oxygen (DO) 2023

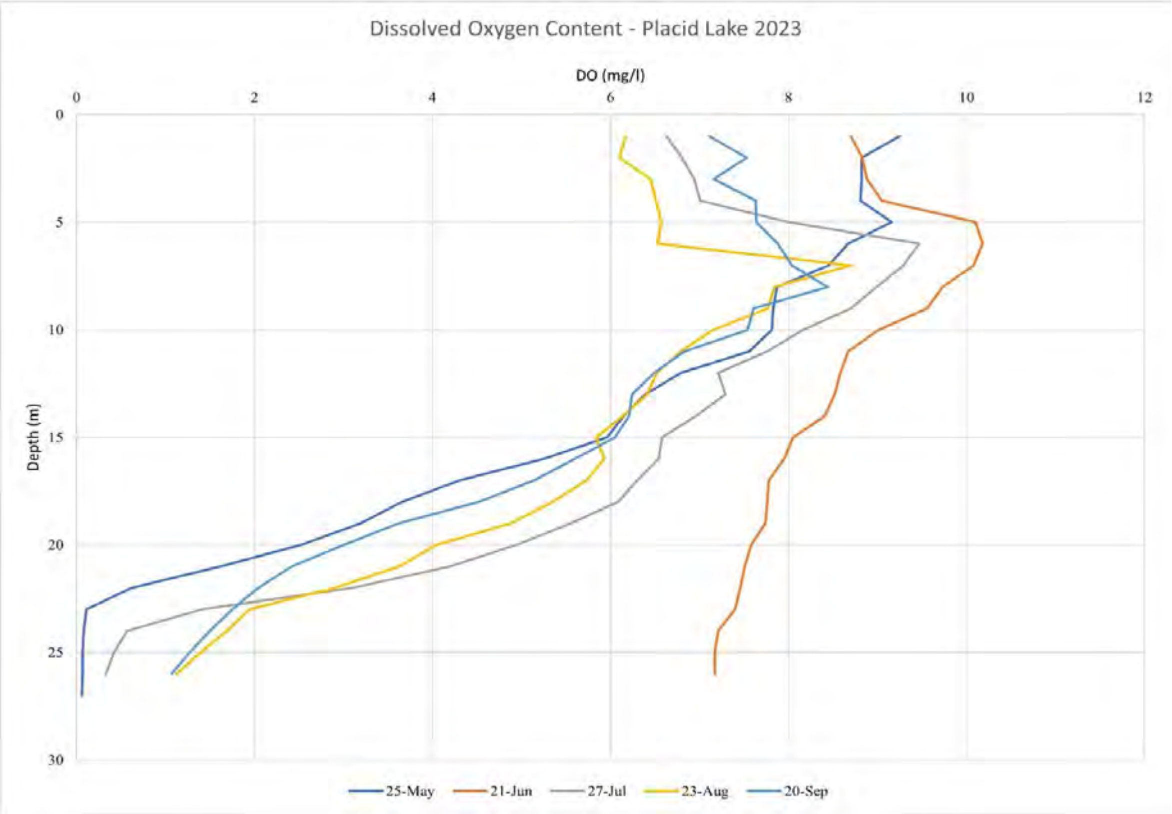


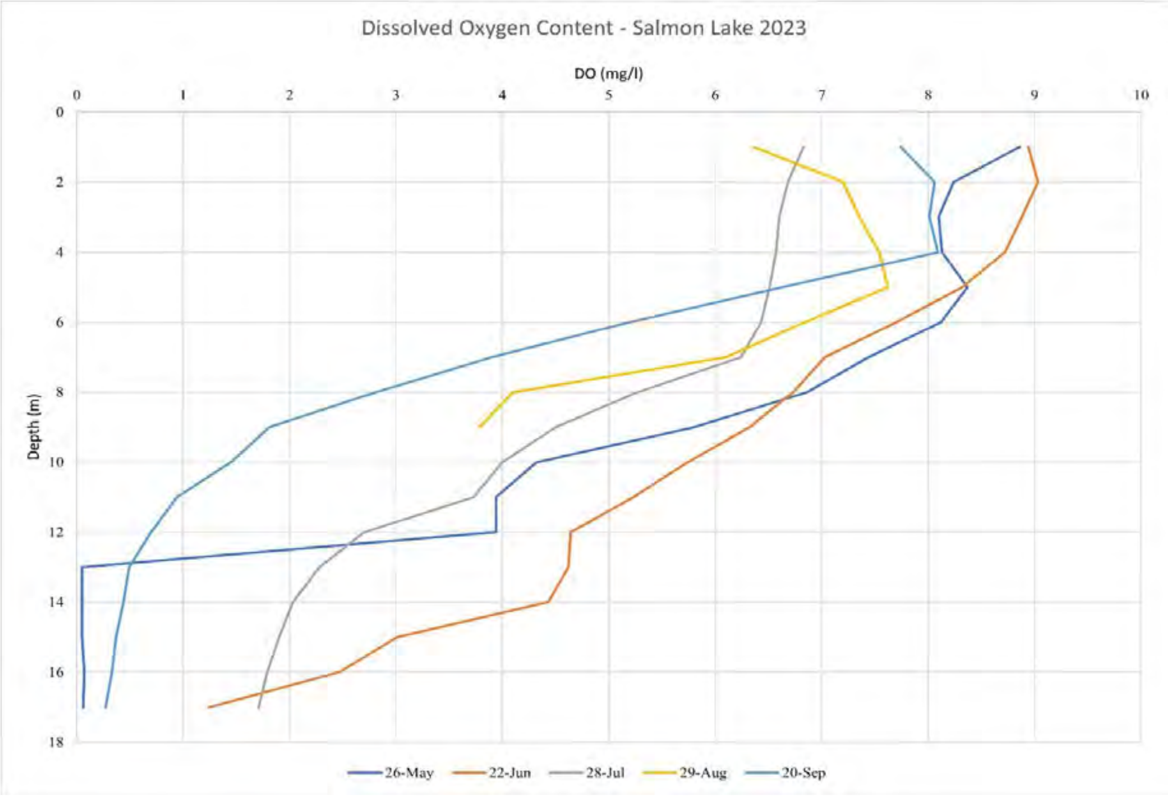


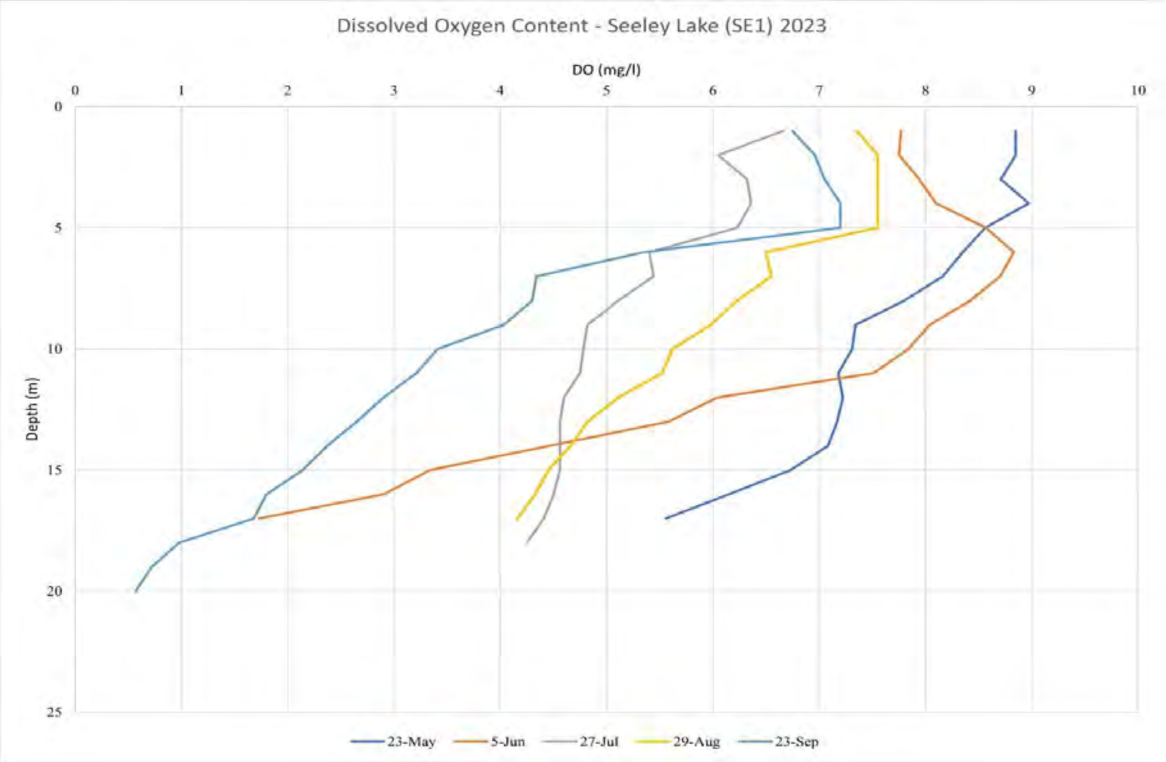
Dissolved Oxygen Content - Big Sky Lake 2023
DO (mg/l)
0
2
4
6
8
10
12
14
16
Depth (m)
0
2
4
6
8
10
12
14
16
24-May
22-Jun
8-Aug
23-Aug
28-Sep

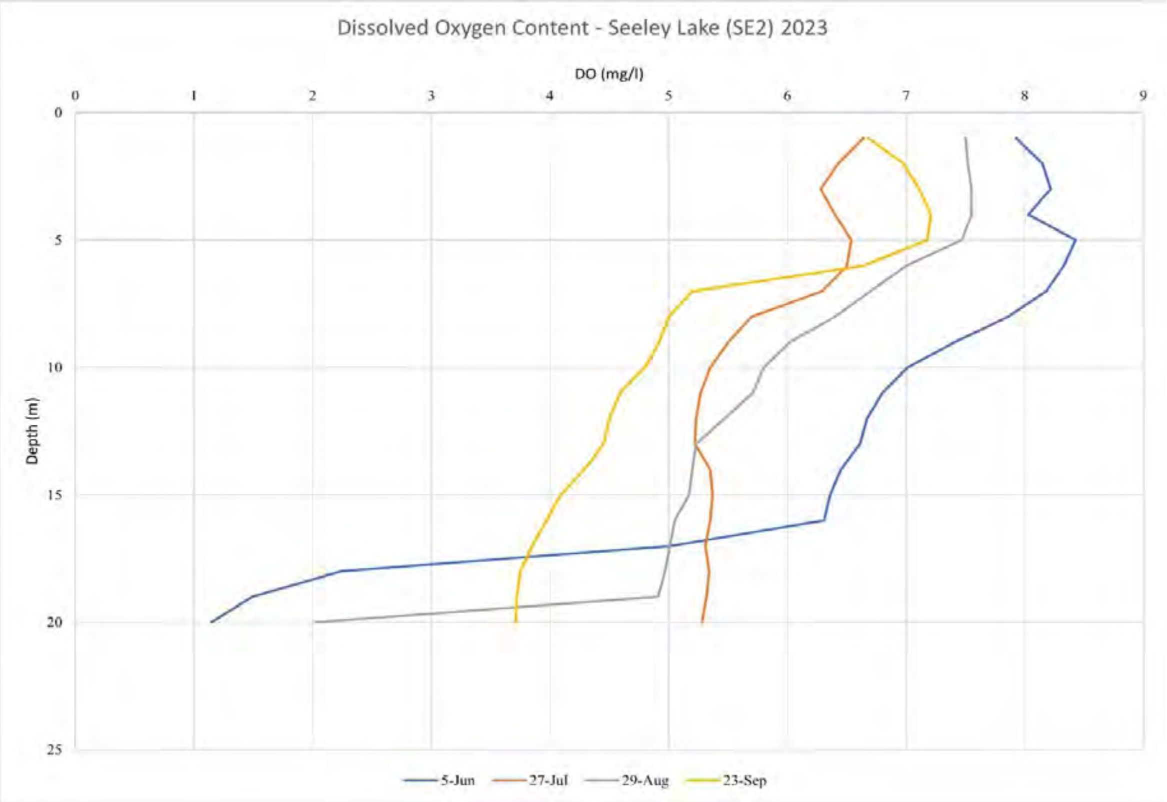


Dissolved Oxygen Content - Lake Inez 2023
DO (mg/l)
0
2
4
6
8
10
12
Depth (m)
0
5
10
15
20
25
30
25-May
6-Jul
4-Aug
24-Aug
19-Sep

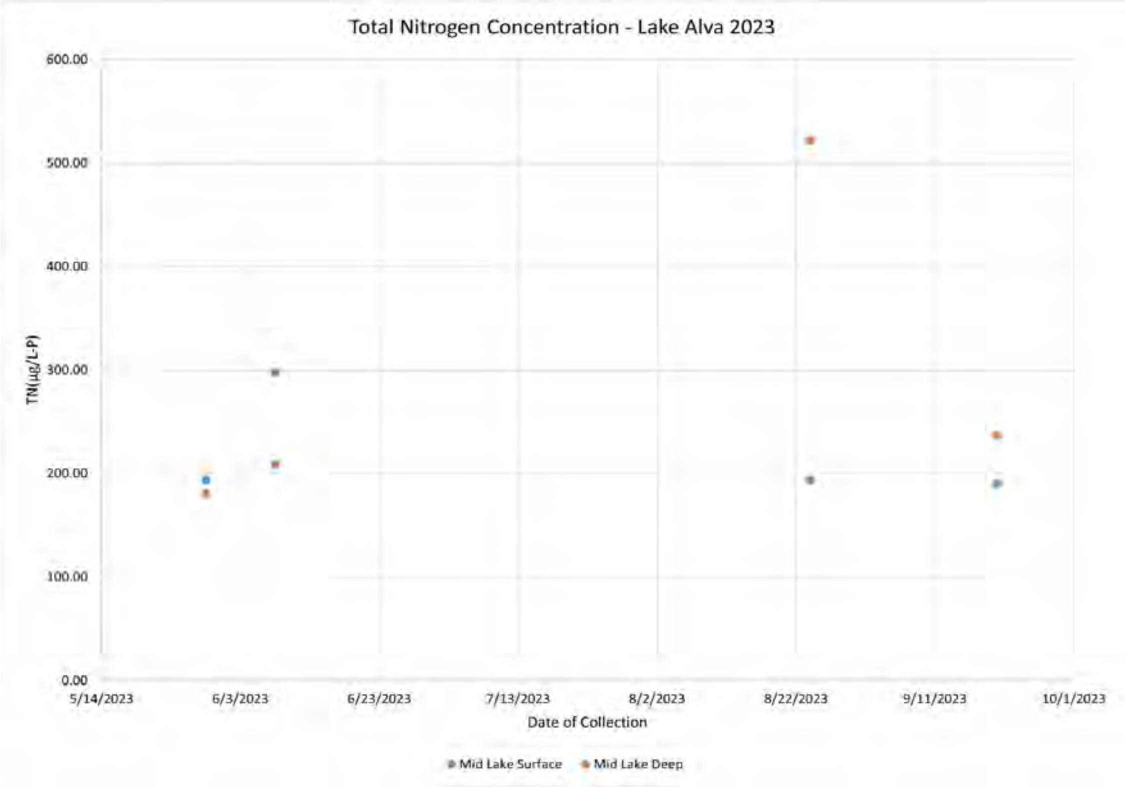

Dissolved Oxygen Content - Placid Lake 2023
DO (mg/l)
0
2
4
6
8
10
12
Depth (m)
0
5
10
15
20
25
30
25-May
21-Jun
27-Jul
23-Aug
20-Sep

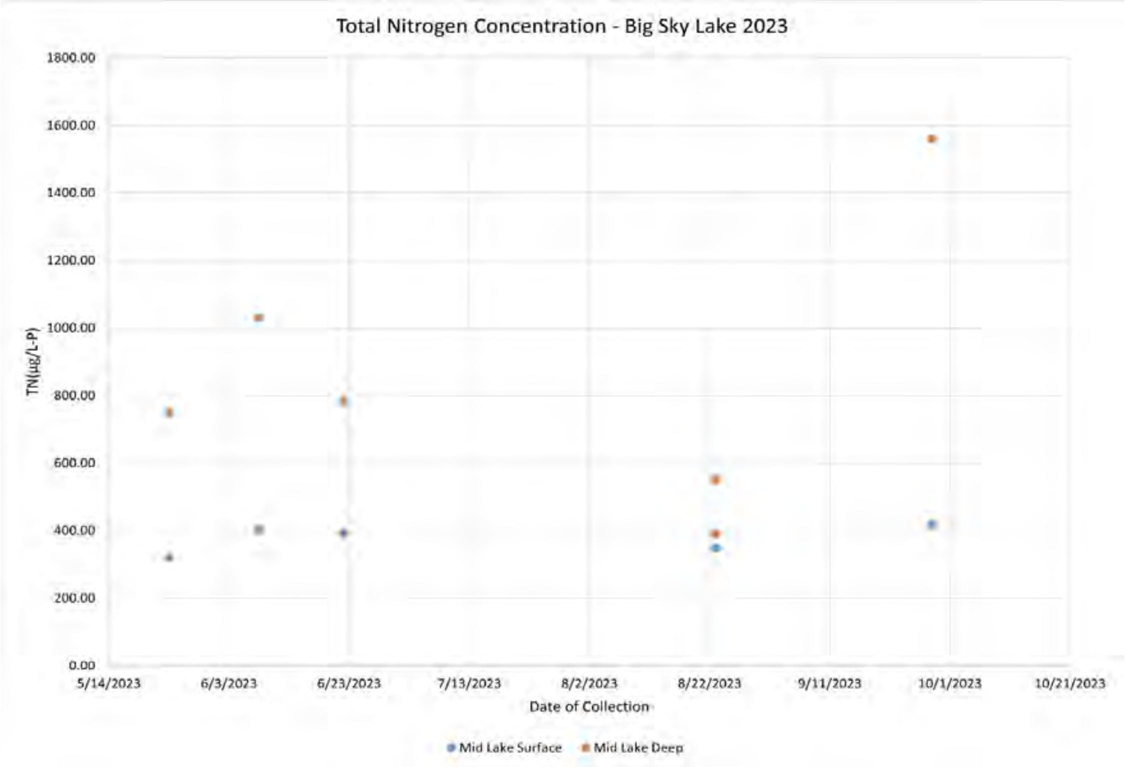

Dissolved Oxygen Content - Salmon Lake 2023
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
2
4
6
8
10
12
14
16
18
26-May
22-Jun
28-Jul
29-Aug
20-Sep

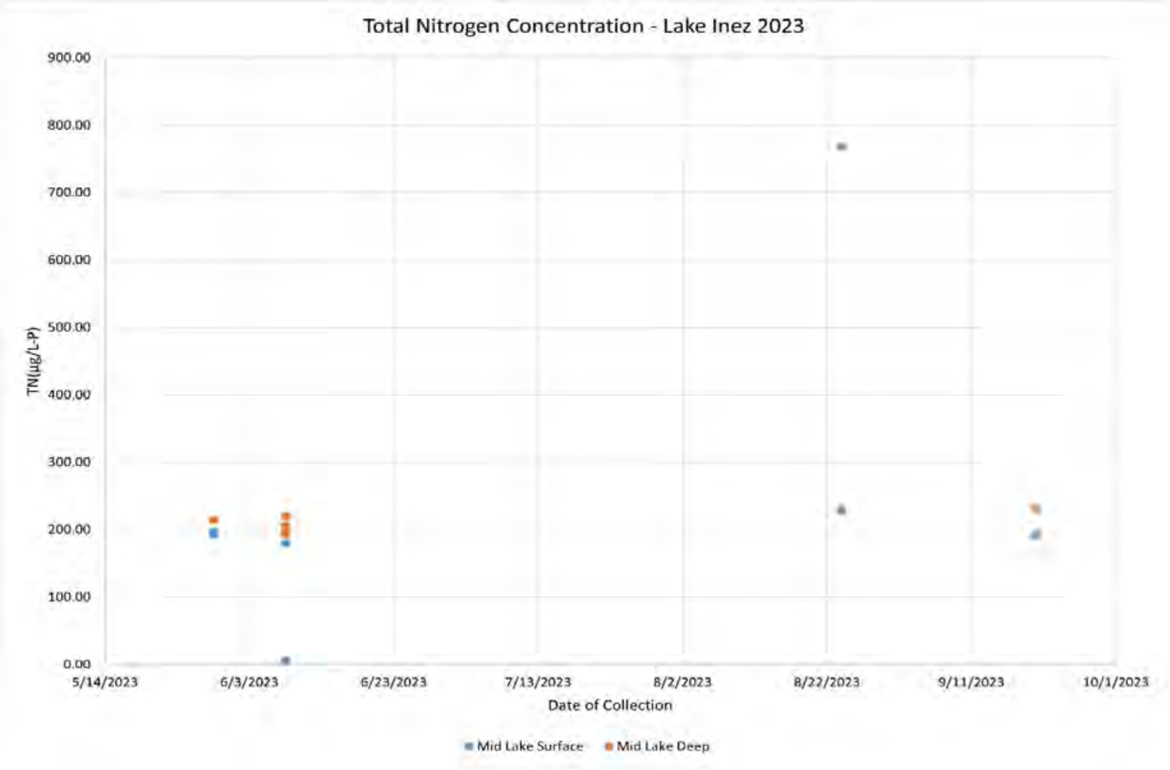

Dissolved Oxygen Content - Seeley Lake (SE1) 2023
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0
5
10
15
20
25
23-May
5-Jun
27-Jul
29-Aug
23-Sep

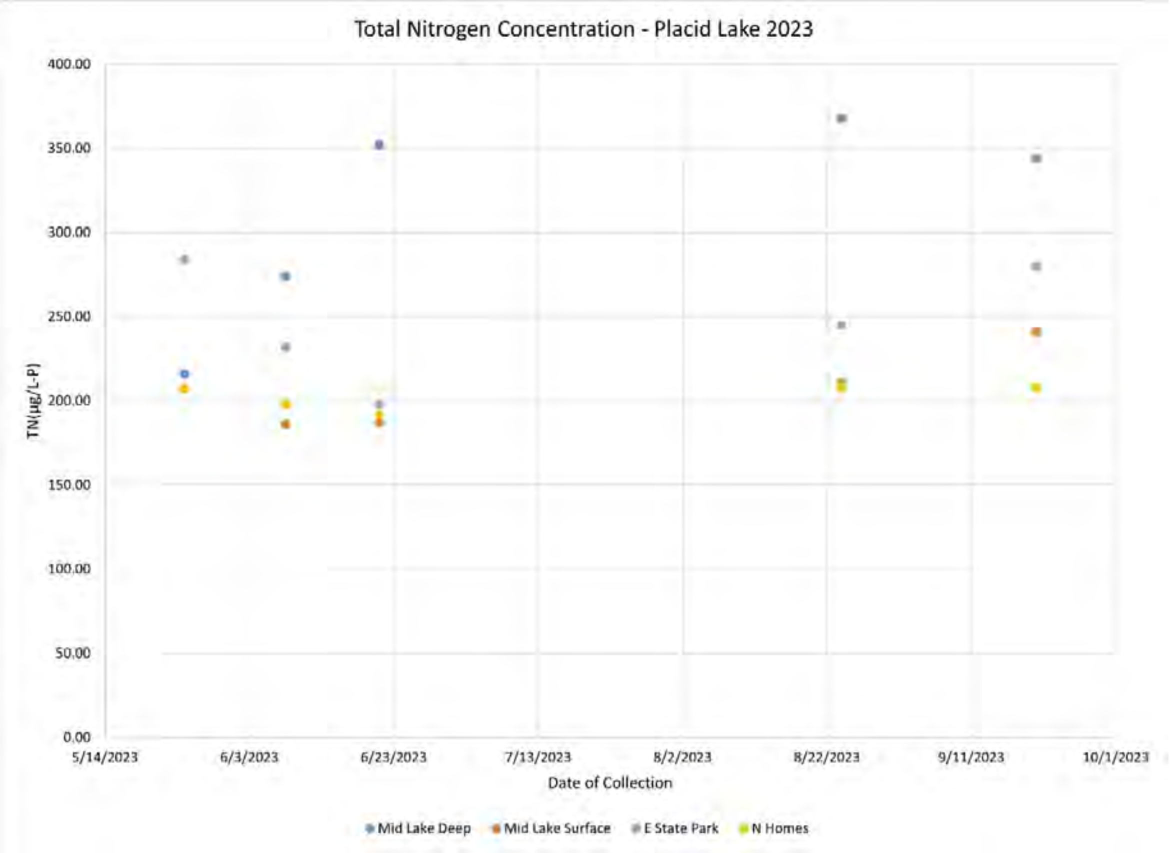

Dissolved Oxygen Content - Seeley Lake (SE2) 2023
DO (mg/l)
0
1
2
3
4
5
6
7
8
9
Depth (m)
0
5
10
15
20
25
5-Jun
27-Jul
29-Aug
23-Sep

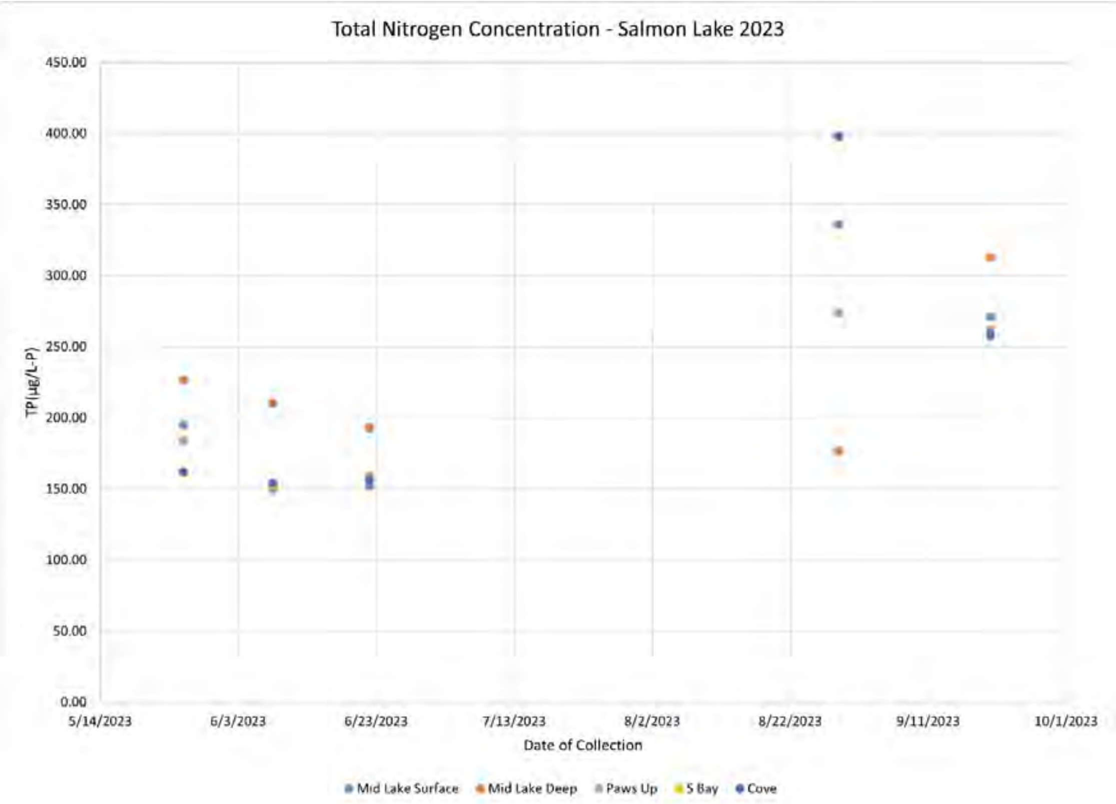
Total Nitrogen (TN) 2023

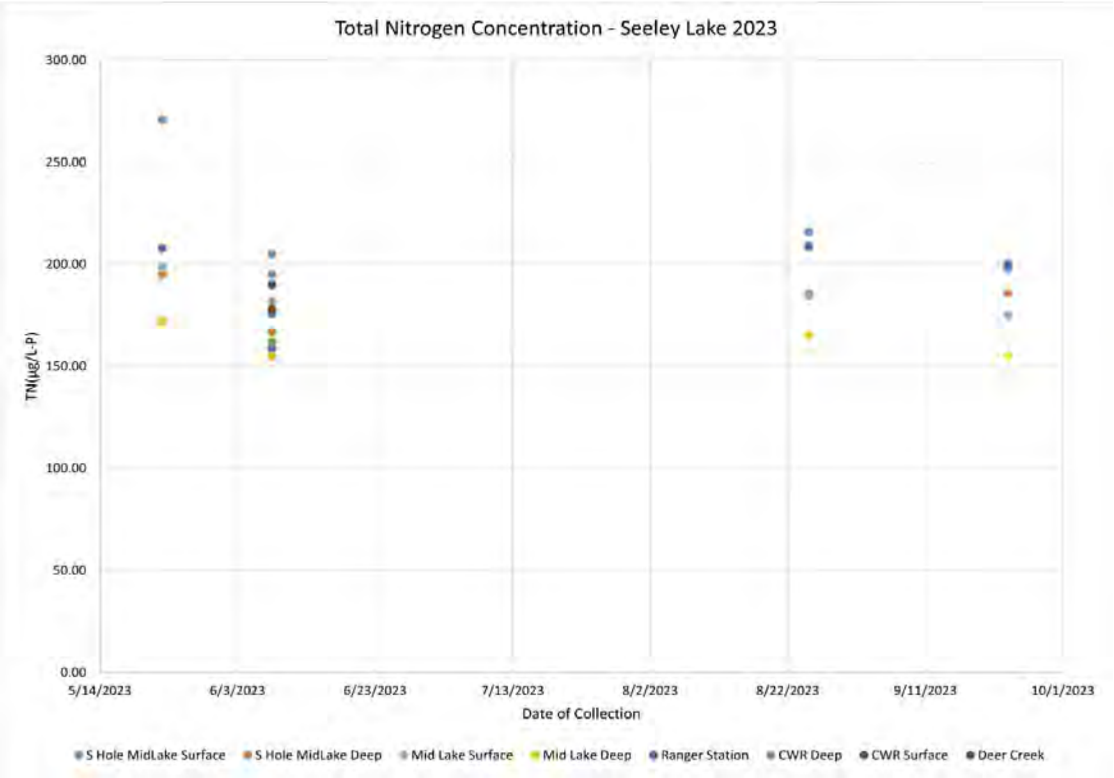




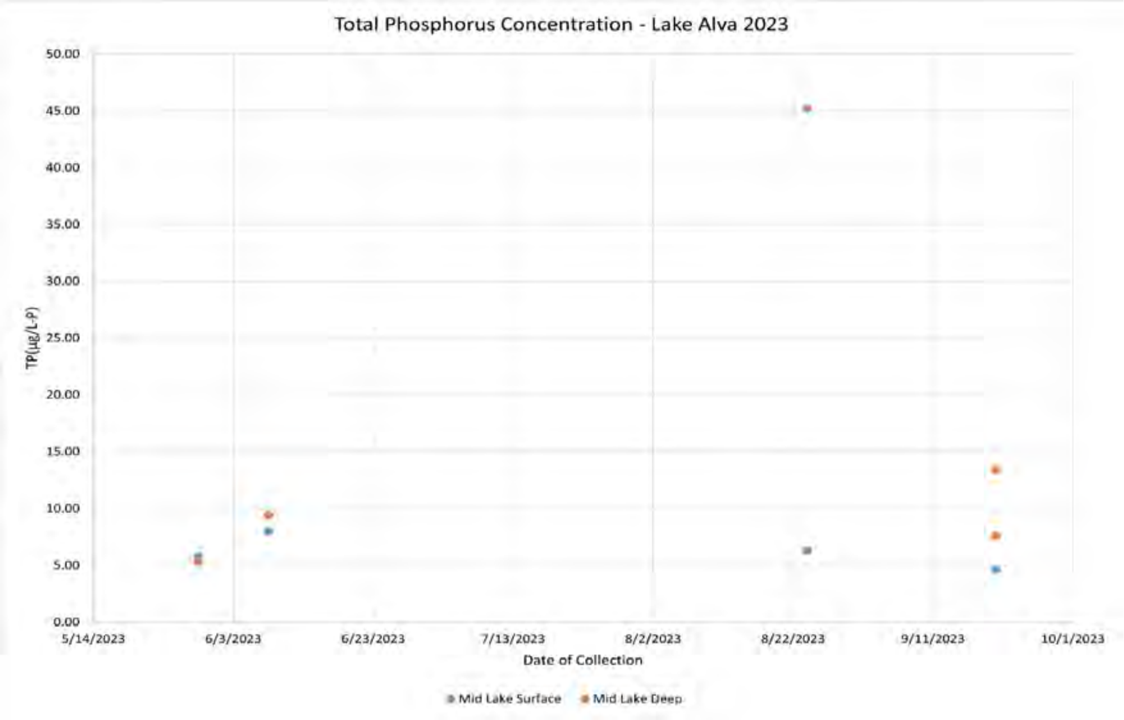

Total Nitrogen Concentration - Lake Inez 2023
TN(µg/L-P)
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
Mid Lake Surface
Mid Lake Deep

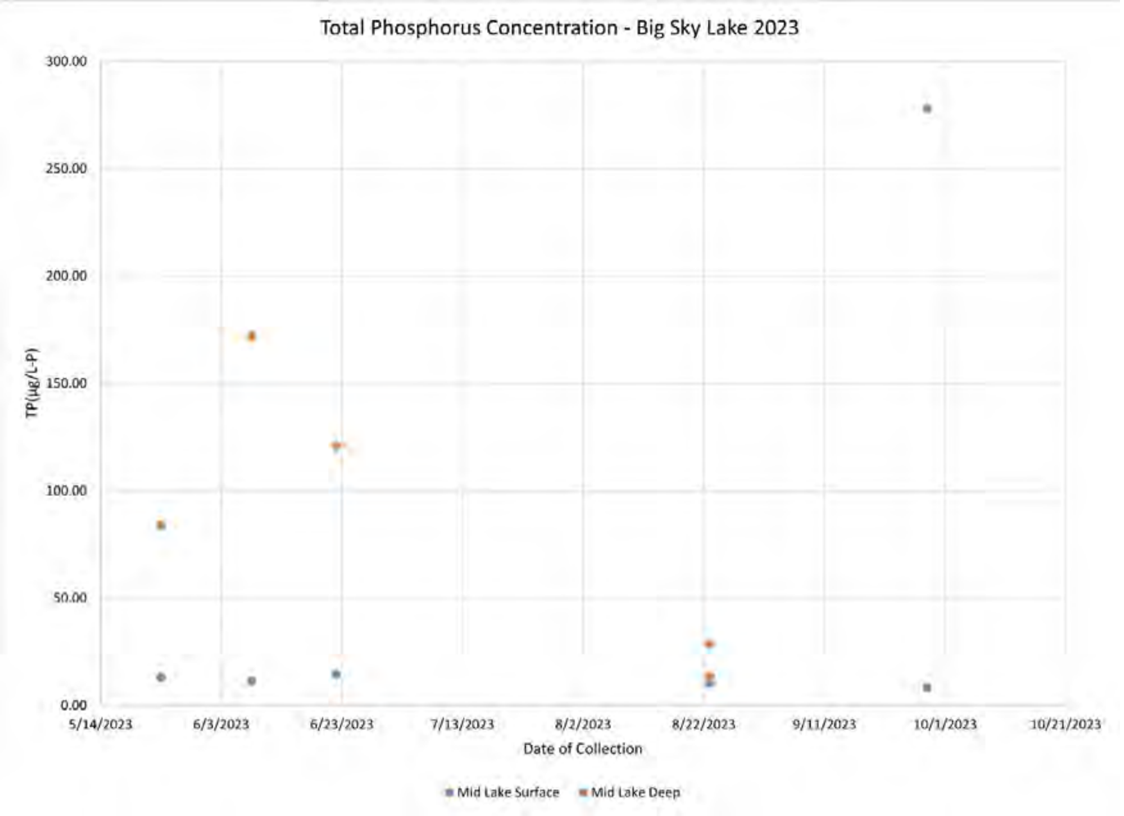

Total Nitrogen Concentration - Placid Lake 2023
TN(µg/L-P)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
Mid Lake Deep
Mid Lake Surface
E State Park
N Homes

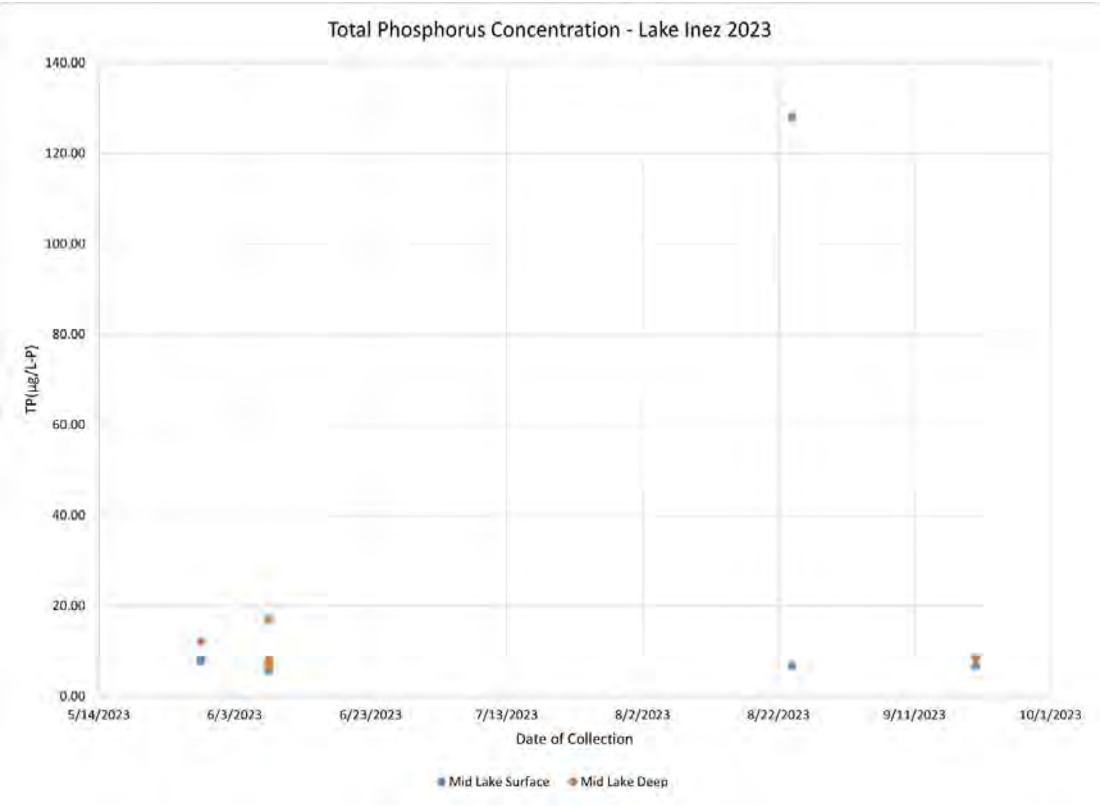

Total Nitrogen Concentration - Salmon Lake 2023
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
TP(µg/L-P)
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
Mid Lake Surface
Mid Lake Deep
Paws Up
S Bay
Cove

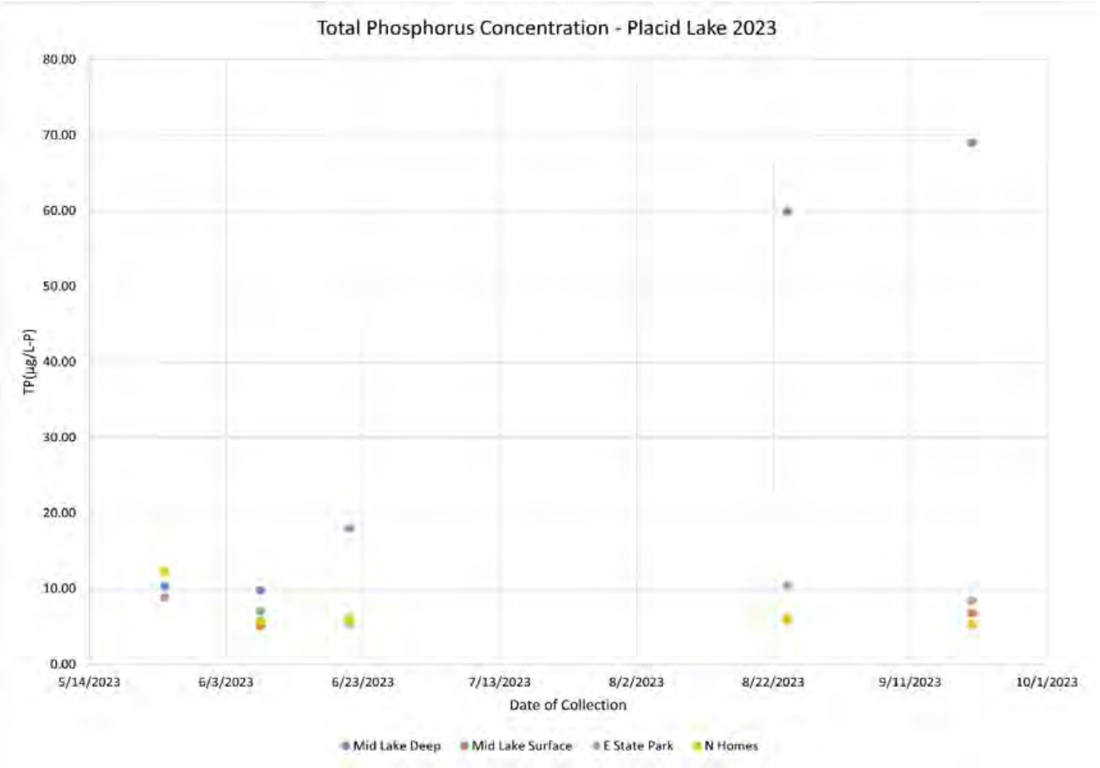

Total Nitrogen Concentration - Seeley Lake 2023
300.00
250.00
200.00
150.00
100.00
50.00
0.00
TN(µg/L-P)
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
S Hole MidLake Surface
S Hole MidLake Deep
Mid Lake Surface
Mid Lake Deep
Ranger Station
CWR Deep
CWR Surface
Deer Creek

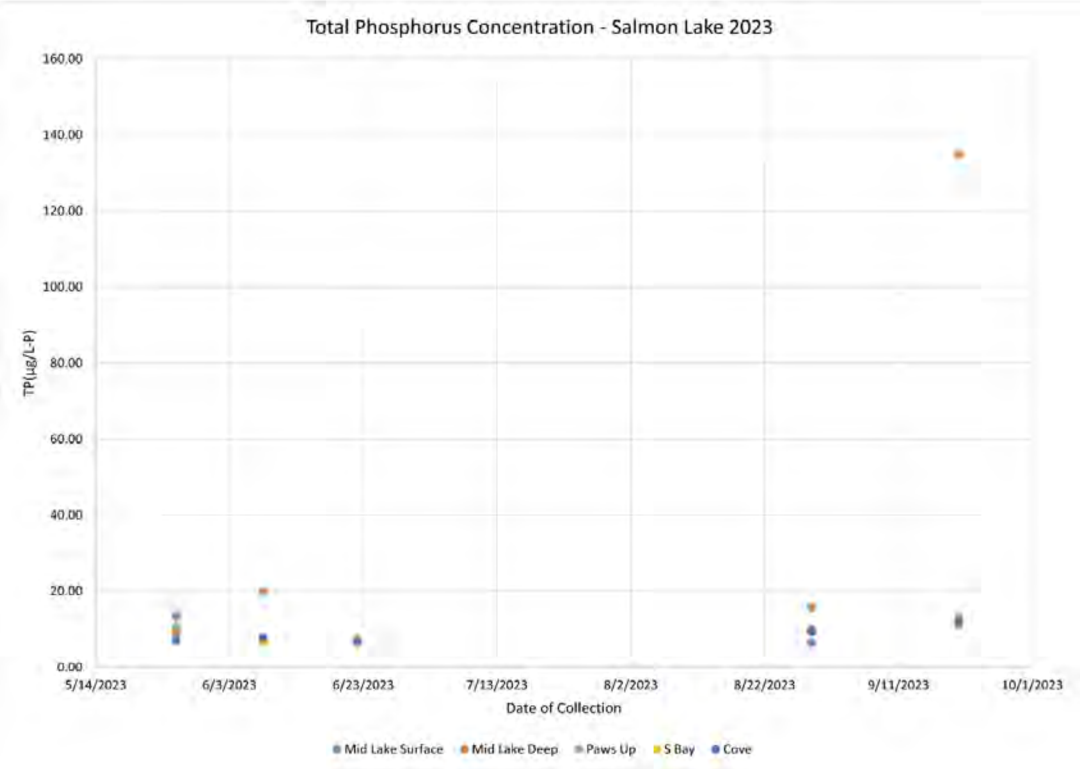
Total Phosphorus (TP) 2023

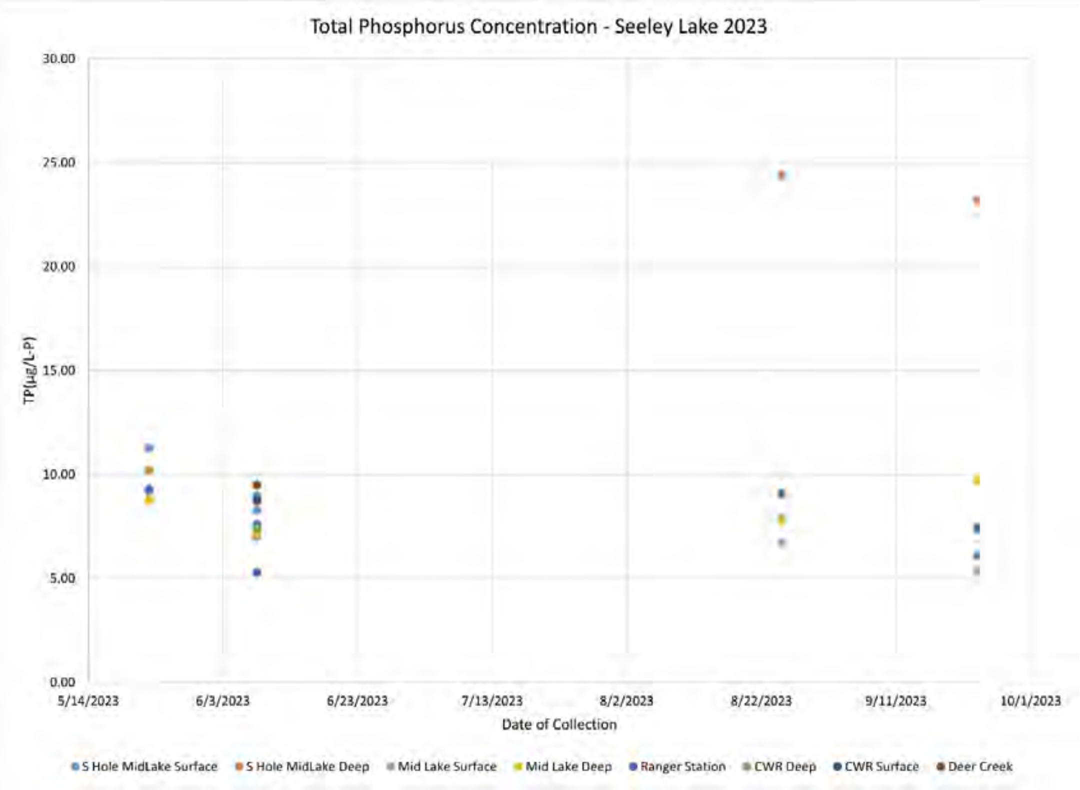





Total Phosphorus Concentration - Lake Inez 2023
TP(µg/L-P)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
Mid Lake Surface
Mid Lake Deep


Total Phosphorus Concentration - Placid Lake 2023
TP(µg/L-P)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
Mid Lake Deep
Mid Lake Surface
E State Park
N Homes


Total Phosphorus Concentration - Salmon Lake 2023
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
TP(µg/L-P)
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
Mid Lake Surface
Mid Lake Deep
Paws Up
S Bay
Cove


Total Phosphorus Concentration - Seeley Lake 2023
30.00
25.00
20.00
15.00
10.00
5.00
0.00
TP(µg/L-P)
5/14/2023
6/3/2023
6/23/2023
7/13/2023
8/2/2023
8/22/2023
9/11/2023
10/1/2023
Date of Collection
S Hole MidLake Surface
S Hole MidLake Deep
Mid Lake Surface
Mid Lake Deep
Ranger Station
CWR Deep
CWR Surface
Deer Creek