IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY AND THE COCOLALLA LAKE ASSOCIATION

Cocolalla Lake TMDL 5-Year Review

Summary from Pend Oreille Lake and Pend Oreille River Tributaries TMDL 5-Year Review

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Review of Cocolalla Lake watershed characteristics, Citizens Volunteer Monitoring data report, bathymetric characterization, implementation projects completed, educational programs ongoing, road crossing assessment, geomorphic risk sediment source assessment, and periphyton assessment.

Acknowledgments

I am pleased and grateful to acknowledge the assistance that I received from Janet Conlin and her son Sean for their help collecting Citizens Volunteer Monitoring Program (CVMP) Data, assisting with collection of periphyton samples and helping to set, manage and recover artificial substrates for measurement of productivity in Lake Cocolalla. I am also grateful to the Cocolalla Lake Association for all the work that is done to be vigilant over the Lake by inspecting roads and culverts on Fish Creek as part of a §319 water quality grant, organizing lake clean-up, providing an Annual Meeting Forum to solicit concerns and information on watershed conditions and being exemplary Lake Stewards. I would also like to express appreciation to Cary Poston and Chuck Gladish for collecting quality historic water quality data through the CVMP effort.

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Executive Summary

Cocolalla Lake (assessment unit ID17010214PN013L_0L) and its tributaries

The Cocolalla Lake watershed includes the lake and the following tributaries: Cocolalla Creek headwaters with 1st and 2nd-order tributaries (ID17010214PN014_02); Cocolalla Creek (ID17010214PN012_02), (ID17010214PN014_03) and (ID17010214PN013L_0L), Fish Creek (ID17010214PN014_03), Butler Creek (ID17010214PN014_02), Johnson Creek (ID17010214PN013_02), and Westmond Creek (ID17010214PN013_2a, and Cocolalla Lake (ID17010214PN013L_0L). Intermittent streams include lower Butler, Westmond, lower Fish Creek, and Johnson Creek.

TMDL Implementation Projects Completed: Implementation Activities on Cocolalla Creek above the highway 95 crossing between 2007 and 2015 include agricultural pasture management with offsite watering; over two miles of fence constructed to partition pastures and protect riparian areas, vegetation enhancement, 761 acres of forest stand improvement, and development of a Forest Management Plan. Clean Water Act §319 grants have been implemented for improved drainage and management for Fish Creek Road and there is a nutrient management habitat enhancement project on the IDFG Wildlife Management Area that captures nutrients from Fish Creek and improves channel condition and habitat for fish passage and spawning habitat. Numerous outreach and education projects are focused on the watershed including the Pend Oreille Water Festival Environmental Education Program, Idaho State Forestry Contest, Stormwater Erosion Education Program, Lake*A*Syst (lakeshore resident assistance) and ongoing outreach and education provided by the Cocolalla Lake Association (CLA) with monthly and annual meetings for interested residents. The CLA has been actively working with Idaho Department of Fish and Game to provide oversight of the boat launch and to provide inspections of boats going in to Lake Cocolalla for the presence of aquatic invasive species including curly leaf pondweed, Eurasian water milfoil, and invasive zebra and quagga mussels. There is still a developed campground at the Fish and Game Boat Launch that requires oversight and management to prevent contamination of the Lake by unlawful dumping and refuse.

Evidence of Beneficial Use Support: Trophic conditions in Cocolalla Lake are improving, and many nutrient sources have reduced and stabilized. Hypolimnetic anoxia is less common in frequency and duration. Nutrient Targets are not yet being met in Lake Cocolalla which is the sentinel target for tributary implementation of nutrient and sediment reductions.

TMDL 5-Year Review Recommendations: Revegetation of historic timber harvests and succession of plant species has reduced the aerial loading rate of nutrients to tributaries and the Lake. Road management continues to be very important and a number of maintenance deficiencies exist on residential roads near the lake that are privately maintained as well as collector roads managed by the County. Road culvert drainage and stream crossings are particularly important to implement maintenance and prevent erosion and culvert failure. Education programs should be maintained for residents to provide guidance and assistance with management of lakeshore and near-lake residences. Ultimately a centralized sewer system around the lake would reduce nutrient loading over time as would septic and drain field maintenance and management. While there has been a good effort at nutrient reduction implementation projects, additional nutrient and sediment efforts are needed.

Cocolalla Lake Background

In northern Idaho, Cocolalla Lake (Assessment Unit ID17010214PN013L_0L) is an important resource for recreation, fisheries, wildlife, residential and economic development, and agriculture and serves as a transportation corridor. Historically, the lake was an important source of ice for shipping and storage by rail and local residents, and much of the watershed is managed for timber harvest on private land. Development has increased around the lake and the lakeshore is developed on the western and northern shores. The south shore is under IDFG management as a Wildlife Management Area that provides limited mitigation for loss of habitat due to the impoundment of Pend Oreille River and Lake Pend Oreille from Albeni Falls Dam operations. Water quality impacts from Albeni Falls Dam operations have never been mitigated. The eastern shore of Lake Cocolalla is bordered by the Burlington Northern–Santa Fe rail line. While this shore is essentially undeveloped, the shore is altered by hydrologic modifications resulting from the proximity of the rail line and State Highway 95. The lake is popular for day use by recreational boaters, campers, and fishers. Currently, no developed campgrounds are in use around the lake. A public access boat ramp on the north shore accommodates small boats. Larger boats lose the ability to launch by midsummer as lake levels drop from reduced inflow. A private unregulated boat ramp is located south of Johnson Creek on the western middle part of the lake. Major tributaries in order of discharge are Cocolalla, Fish, Westmond, Johnson, and Butler Creeks.

Cocolalla Lake was listed as impaired due to unspecified “pollutants,” nutrients, and DO on Idaho’s 1996 §303(d) list. The lake is listed in Idaho’s 2012 Integrated Report as impaired due to DO and total phosphorus.

Changes to Subbasin Characteristics

Pollutant loads have not significantly increased since the 2001 TMDL. Improved land management continues as historic timber harvests have demonstrated ground cover regrowth, and replacement stands of timber have developed. Population growth has generally occurred in areas with existing infrastructure, rather than extensive new projects in undeveloped areas, which has reduced nonpoint source nutrient loading. Agriculture remains oriented toward the broader valley along approximately 5.5 miles of southern Blacktail Road adjacent to the lower gradient reach of Cocolalla Creek from the southern Blacktail Road culvert to the Highway 95 Bridge. Residences are interspersed within the agricultural areas along Cocolalla Creek with properties of varying sizes from a few acres to 10–15 acres, often referred to as ranchettes. Riparian buffers exist and continue to grow, increasing shade and nutrient buffers and reducing streambank erosion.

Within the watershed, no centralized sewer system exists, and there are no point source discharges requiring EPA permits. Two large soil absorption systems (LSAS) are in use upland of the northwest area of the lake and most residences have individual drain fields.

Road density has not significantly increased, although road maintenance practices have been variable. Road erosion continues to be a maintenance challenge because many of the roads in the watershed were initially built to facilitate timber harvest specifications. After significant harvests within the watershed were completed, many private parcels were developed for residences along these roads. County maintenance has been counterproductive in reducing roadbed erosion at times due to inadequate maintenance practices. A practice employed for snow management called “daylighting” is intended to increase melting of plowed snow over a wider right-of-way. This practice involves physical destruction of shrubs and recruiting trees along ditches but leaves organic debris in place to clog ditches and culverts, which in turn fills ditches and forces water carrying sediment and nutrients to flow down roadways, increasing delivery to surface waters. Sediment deposition, observed accumulating along Loop Road and residential roads closer to the water, is transported into creeks and seeps to the lake. During high flow events there have been numerous undersize culverts block with debris, resulting in water impoundment and then catastrophic failure releasing road bed, twisted culvert, and even old car bodies used as fill material. This happened in 2012 on the south Loop Road. In 2017 a blowout occurred on Irish Road over lower Cocolalla Creek. The road crossings on lower Blacktail Road is significant source of sediment and road material from snow removal and dumping gravel to fill continual erosion around the culvert. On the Creek above this crossing there are numerous residential road crossings facilitated by culverts that are placed shallow and poorly maintained that could isolate numerous residents after a failure.

Highway 95 is the primary transportation corridor along the eastern side of the lake with the Burlington Northern- Santa Fe Railroad between the highway and lake. The railbed material directly interfaces with the lake over several hundred yards along the northeastern region of the lake. Metal retaining walls are flimsy and failing in several spots resulting in cobble-sized materials along the edge of the lake. Roadbed material erodes along rail line service roads adjacent to the rail line and is transported by Butler Creek to Cocolalla Creek in significant amounts and ultimately has to be dredged to not erode the footings of the rail trestle where Cocolalla Creek makes its southern crossing to carry the eroded fine sediment to the lake.

Highway is undergoing an extensive widening to accommodate increased traffic. Along Cocolalla Lake this project is slated to continue and will likely impinge on perched wetlands along this route from Southern Blacktail Road to beyond the Westmond Creek crossing. It will be very important, in combination with the expansion of rail lines in this area to provide mitigation, protection, and enhancement of wetlands to protect lake water quality. Stormwater management will also be extremely important here.

Transport of hazardous materials and nutrient-rich materials is increasing along Highway 95 and the rail line including crude oil, coal, ammonium nitrate, acids, industrial chemicals, and raw materials. For example, in 2014 a tandem trailer transporting explosive-grade ammonium nitrate overturned just above Cocolalla Lake along Cocolalla Creek. Twelve hundred gallons of liquid fertilizer used in Canadian mines for its explosive properties spilled into roadside ditches and entered drainage ditches leading to Cocolalla Creek. Containment involved plugging ditches and pumping surface water and contaminant, but nutrients seeped into the creek and subsequently the lake. Most of the product was contained, although significant amounts penetrated soil, entered wetlands, and overtime, released to the lake. Nitrogen levels were not noted to increase in surface waters, and lake monitoring did not identify increased nitrogen in the lake. The risk, however, was made clear in the confusion that occurred between emergency services, contracted removal efforts, and company personnel in relation to stopping the leak, quantifying the spill, and monitoring the dispersal.

Physical and Biological Characteristics

The Cocolalla Lake watershed has the following physical and biological characteristics:

Drainage area: 66.3 mi^2

Percentage covered by forest: 71%

Average basin elevation: 2,820 feet

Mean annual precipitation: 27.3 inches

Mean basin slope (from 10 meter DEM): 18%

Area with slopes greater than 30%: 18%

Agricultural land as a percentage of drainage area: 6.1%

Developed land as a percentage of drainage area: 2.1%

Percentage of lakes and ponds as a percentage of drainage area: 2.2%

Percentage of drainage area as surficial volcanic rocks: 33.2%

Percentage of drainage area as impervious: 0.5%

Hydrology

Flow in Cocolalla Creek is snowmelt-dominated with base flow influenced by springs and seeps. No USGS streamflow gages exist in the watershed. During extreme drought conditions in 2015, many of the tributaries were dry at the confluence with the lake or Cocolalla Creek including Fish, Johnson, Westmond, and Butler Creeks. Base flow in Cocolalla Creek was less than average, though flow was continuous from the headwaters reach supplied by springs and seeps to the confluence with Cocolalla Lake. Cocolalla Creek flows out of Cocolalla Lake on the northwest corner of the lake and flows into Round Lake 2.8 miles below the outlet of Cocolalla Lake. Cocolalla Creek flows out of Round Lake at a fish barrier weir that was installed in the 1950s. Cocolalla Creek enters slack water in the unnamed slough (referred to locally as Cocolalla Slough) formed by the impoundment created by Albeni Falls Dam on the Pend Oreille River and the historic course of Cocolalla Creek. There is significant sediment deposition in Cocolalla Slough from widely fluctuating water levels in the backwaters formed by impoundment of the Pend Oreille River. Significant erosion along the Pend Oreille River creates a large deltaic deposition at the confluence of Cocolalla Creek with the Pend Oreille River. This creates a favorable environment for colonization by nuisance and aquatic invasive species that have been proliferating along the Pend Oreille River. Water quality has never been mitigated for the impacts of Albini Falls Dam, only lost wildlife habitat has been mitigated through IDFG.

The StreamStats USGS Watershed Model shows the following flow parameters at the inlet to the lake:

Mean estimated annual flow of Cocolalla Creek: 49.1 cfs

Estimated peak flow, April 20: 153 cfs

Estimated peak flow, May 20: 137 cfs

Peak flows observed during rain-on-snow events can easily exceed the estimated peak flows for April and May. These events often occur in February and March such as in 2008 and 2017 resulting in extensive lake flooding, creek flooding, culvert blowout, landslides, and damage to homes and drain fields

Lake Characteristics

Cocolalla Lake has a surface area of approximately 840 acres (3.3 km^2) and a mean depth of 25.9 feet with the maximum depth of 44.6 feet. It is a glacial scour lake that lies in the Purcell Trench, a land feature created by successive glacial activity oriented north to south, beginning in Canada and extending to the Rathdrum Prairie. Successive glacial pulses have alternately scoured the lake and created the terminal moraine at the southern end of the lake where Cocolalla Creek enters the lake after receiving flow from Fish and Butler Creeks. The bathymetry of Cocolalla Lake is shown in **Figure 1**. Bottom structure is uniformly flat with moderately sloped sides. Bottom composition varies from fractured boulders and glacial rubble to cobble and gravel. A significant portion of the lake is composed of organic sediment and soft materials that contribute to internal nutrient load. The southern end of the lake becomes shallow over the lower one fifth of the lake to where Cocolalla Creek enters.

Cocolalla Creek is the northwestern outlet of the lake between Westmond and Johnson Creeks that flows to Round Lake. Cocolalla Creek is the outlet of Round Lake that is impounded above a fish barrier weir and then flows to Mortenson Slough, which discharges to the Pend Oreille River.

The 2001 TMDL estimated internal loading to be the most significant source of nutrients to the lake followed by sediment delivered to the lake from bank and road erosion. Sediment is fairly well distributed through the deeper areas of the lake with the southern portion of the lake having a more organic substrate due to extensive aquatic macrophyte growth that accumulates seasonally and combines with deposition from Cocolalla Creek. Invasive aquatic plants have been established in the southern area of the lake for years as Eurasian water milfoil and curly leaf pondweed stands have increased in area and distribution. Stands of high-stem density invasive species increase organic deposition and nutrification in shallow areas where sunlight penetrates to the substrate. Internal loading occurs primarily under ice cover when anoxia at the sediment-water interface releases nutrients stored in the sediment. Softer substrate indicates potential areas of increased nutrient release to the water column. Relative bottom hardness is shown in **Figure 2**.

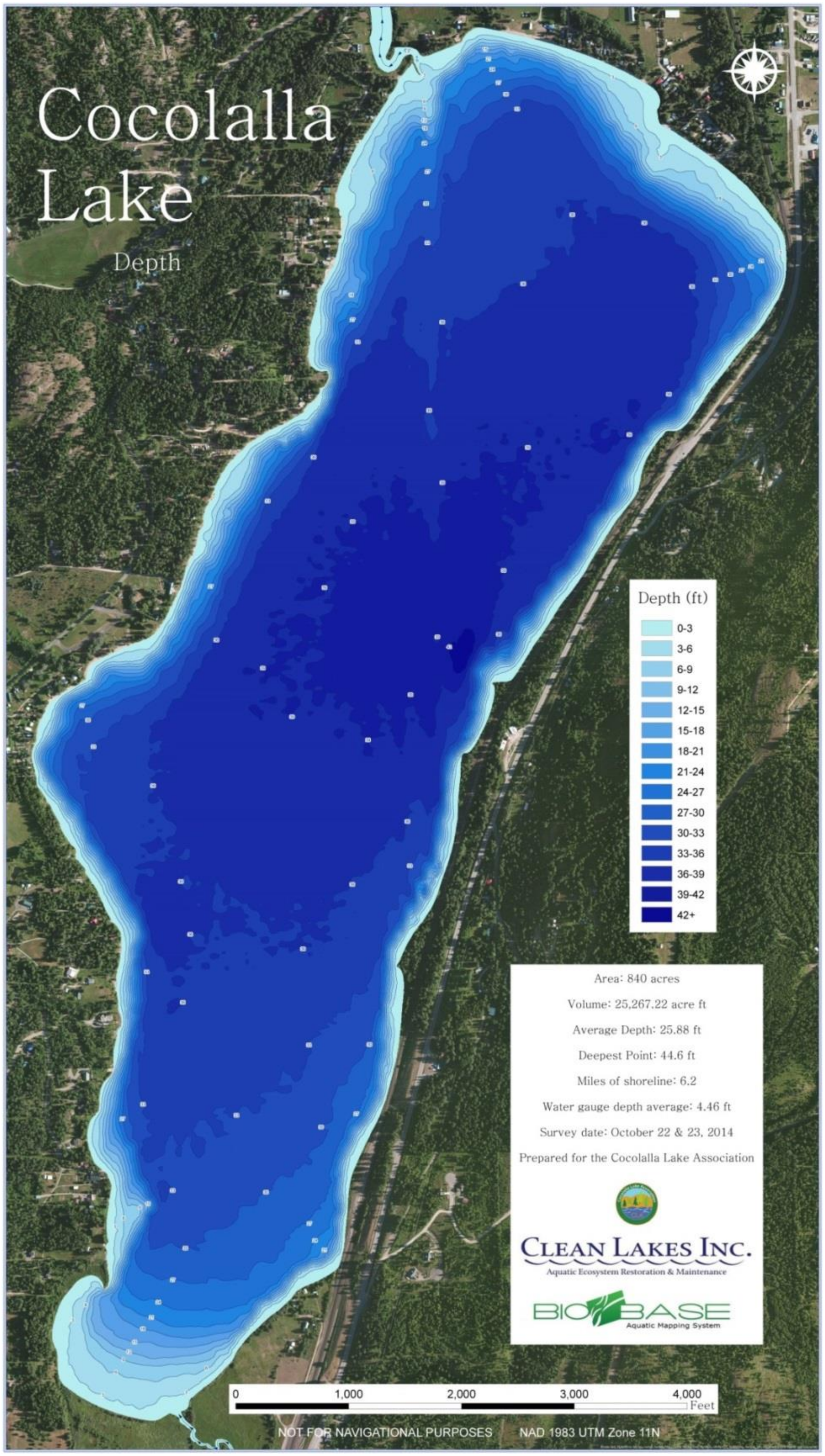

Figure 1. Cocolalla Lake bathymetry map.

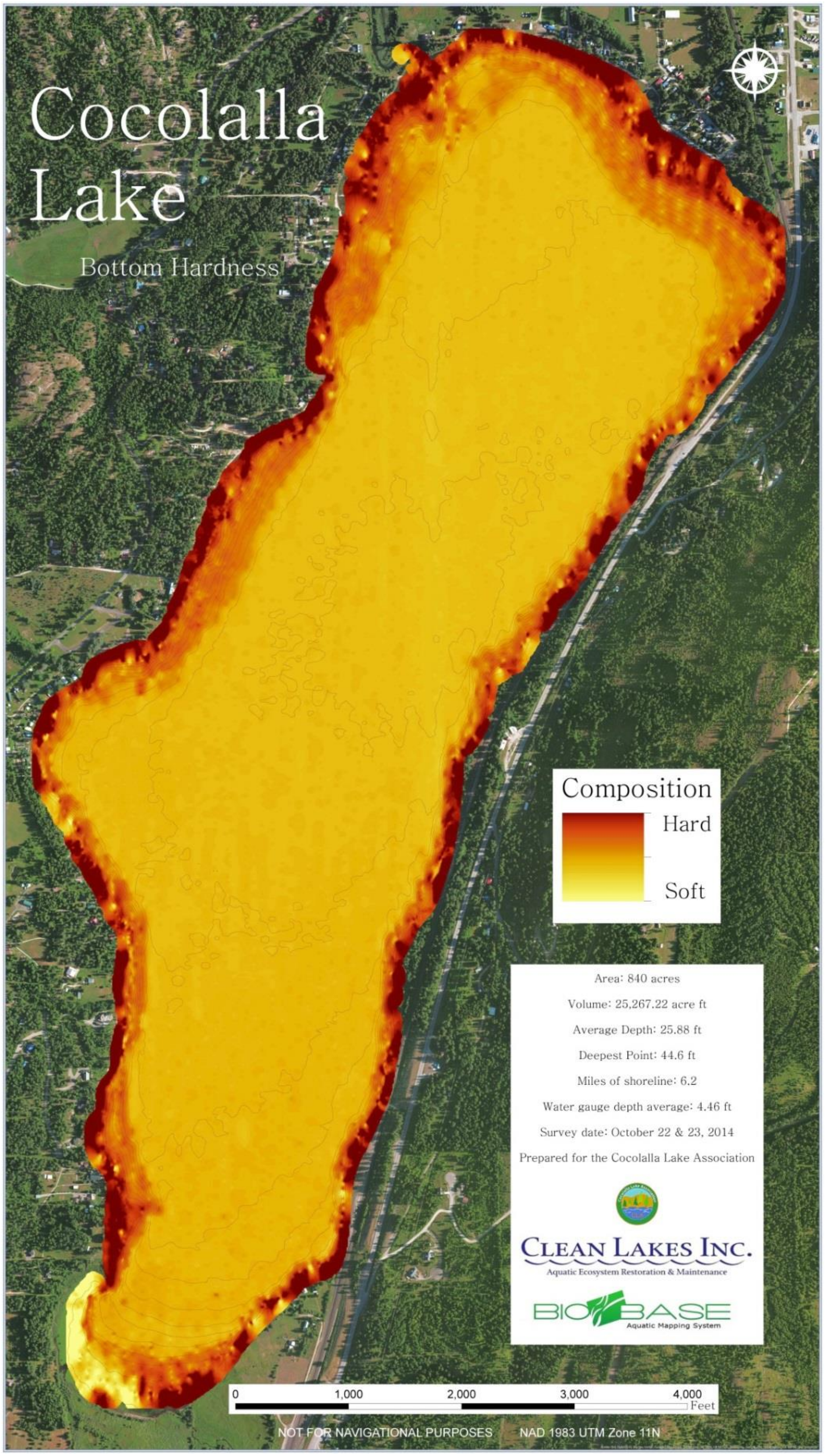

Figure 2. Cocolalla Lake hardness map.

Fisheries

Cocolalla Lake is a multifaceted warm- and cool-water fishery. Natural production of Westslope cutthroat trout, brook trout, and brown trout inhabit perennial tributaries including Cocolalla, Fish, and Butler Creeks. Rainbow trout are stocked into Cocolalla Creek. Butler Creek is isolated by a dry channel that consistently forms during base-flow periods due to infiltration into valley fill material just above Highway 95. This isolation may protect this population from hybridization, though brook trout are present in this watershed.

Cocolalla Creek has a self-sustaining population of brown trout that tolerate the warmer waters and impacted habitat in the valley reach of Cocolalla Creek along Highway 95. Headwaters of Cocolalla Creek and upper tributaries have remnant populations of Westslope cutthroat trout, but are largely composed of brook trout. Higher gradient reaches of Cocolalla Creek and its tributaries are perennial and may have a greater component of Westslope cutthroat trout. It is possible that Fish Creek tributaries that are isolated by fish barrier culverts may have Westslope cutthroat trout present in upper reaches. These reaches should be surveyed.

Cocolalla Lake has been characterized as having high densities of channel catfish that can grow to over 60 cm. Brown bullheads are also present. Self-sustaining populations of largemouth bass, smallmouth bass, perch, and bluegill are popular with anglers. Round Lake receives inflow from Cocolalla Creek and has an outlet that is impounded by a fish weir that was installed in the 1950s to protect native Westslope Cutthroat Trout. Unlawful introductions of fish and incidental stocking introductions likely account for today's population diversity. The fish population seems stable and productive. No indications exist of winter or summer kill impacting fish abundance or diversity. The fishery in Cocolalla Lake is important to the local economy and anglers come from neighboring states and Canada to fish.

Geomorphic Risk Assessment

A geomorphic risk assessment for the watershed was developed using GIS software to identify drainage density, subwatershed soil types, stream slope, and relative length of source, transport, and response reaches of streams in watersheds for Cocolalla, Fish, Butler, Johnson, and Westmond Creeks. The geomorphic Risk Assessment identifies watershed characteristics that result in higher erosion, increased transport and deposition due to valley and hillside slope and soil type. Vulnerable areas exhibit steep slopes, highly erodible soils, high road density, and extensive response reaches that can accumulate sediment that results in bank erosion or steep channel reaches that contribute sediment and adsorbed nutrients to the lake. Areas of concern that are identified in the evaluation include Butler, Cocolalla, Fish, and Johnson Creeks. The Fish Creek subwatershed has high stream density (a significant number of contributing smaller streams), high gradient, moderate road density, and historic high sediment loads. Cocolalla Creek exhibits a large watershed area with areas of steep gradient channel and high road density. Butler Creek flows adjacent to forest roads and has a steep canyon section and steep channel slope over much of its course. The Johnson Creek watershed has a high drainage density and road density. The combination of high stream gradient, high road density and numerous road crossings increase sediment load and transport capability. Road maintenance practices have featured poor drainage, improperly sized culverts, and hanging culverts that cause headcuts and downcuts and create fish barriers.

Summary and Analysis of Current Water Quality Data

Water quality data have been collected fairly consistently since 1987 (Falter and Good 1987). At that time, concern over water quality had mounted regarding increasing frequency and severity of blue-green algal blooms thought to be related to increased developmental pressure and historic nonpoint source pollution sources including lakeside-improvised septic systems, road erosion, and land management practices in the watershed. These concerns ultimately led to listing the lake for nutrients and developing a TMDL that captured existing data up to 2001 (DEQ 2001).

Citizen's Volunteer Monitoring Program

Since 1987, water quality data have been collected by the CVMP except from 2009 through 2011, when the recession limited DEQ funding for monitoring. CVMP data consist of temperature and oxygen profiles and samples for total phosphorus, total nitrogen (a recent addition to the sample plan) and chlorophyll-a analysis. Temperature and oxygen profiles are collected at 1 meter intervals from 0.1 meter to 1 meter off the bottom. Depth varies with lake level but is generally 11 meters at the sampling location, which is in the deepest area of the lake. Total phosphorus is collected at two depths, the Secchi depth and 1 meter above the bottom. A chlorophyll-a sample and a total nitrogen sample are also collected at the Secchi depth. The combined samples from the Secchi depth are collected using a Van Dorn or Kemmerer bottle. Sample water is alternately placed from both depths in a mixing churn and samples are drawn from the spigot. Total phosphorus and total nitrogen samples are preserved and chilled for transport to the lab.

Total Phosphorus

Total phosphorus can be partitioned between the epilimnion and hypolimnion in stratified lakes. During the summer months, Cocolalla Lake regularly stratifies by depth and temperature with warmer waters above cooler water; however, it often mixes after sustained wind events and restratifies. The lower boundary layer of the hypolimnion, the sediment/water interface, produces phosphorus that diffuses from anaerobic activity in the sediment to the water column above the sediment to the confining layer of the thermocline or metalimnion. Phosphorus can diffuse through the hypolimnion and then, when the thermal resistance to mixing is eliminated in a wind event, the phosphorus mixes throughout the water column. When the water restratifies, within days, the epilimnetic phosphorus concentration can increase and the hypolimnetic phosphorus concentration can decrease in relation to premixing conditions. Epilimnetic total phosphorus generally ranges between less than 10 µg/L and 60 µg/L. Hypolimnetic total phosphorus can range between 20 µg/L to over 200 µg/L. Epilimnion values from 60 to 100 µg/L may indicate wind mixing events that pulse phosphorus from sediments (also referred to as internal loading).

Dissolved Oxygen

DO content in Cocolalla Lake is determined by water temperature at depth, wind mixing and aeration and the sum of oxygen demand from respiration and decomposition. DO in the epilimnion decreases as waters warm above the thermocline and can range from 5 mg/L during the warm season of the year to 12 mg/L. Generally, epilimnetic DO stays above 6 mg/L throughout the summer months and is not stressful to fish. Thermocline DO decreases through the warm season of the year from near saturation values in May to around 2 mg/L in the warm season between July and September. Historically, DO levels in the hypolimnion also follow this pattern between saturation at around 12 mg/L in the early season and less than 1 mg/L during the warm season.

An evaluation of DO trend data in Cocolalla Lake shows that in recent years, incidents of hypolimnetic anoxia and hypoxia are less frequent and shorter than in previous years. Anoxic hypolimnion conditions in Cocolalla Lake seem to manifest during periods of warm weather, bright sunlight, and reduced wind for mixing and circulation. These conditions often precede conditions that facilitate blue-green algae blooms. The lake oxygenates during occasional wind events that mix waters over all but the deepest areas of the lake. DO is plotted from 1989 to present with time trend data showing improvement in hypolimnetic DO. Data represented are based on seasonal data and associated residuals to show overall improving trends (**Figure 3**).

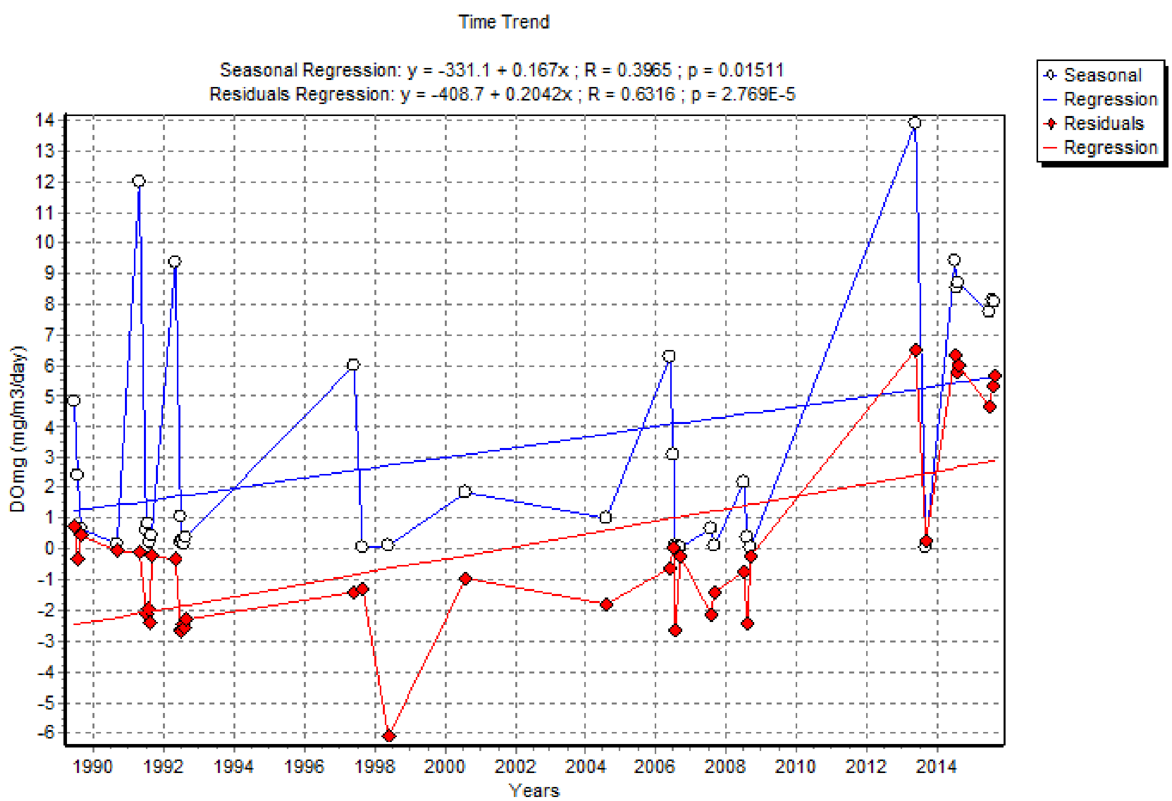

Figure 3. Hypolimnion dissolved oxygen regressions for data from 1989 through the 2015 field season.

Trophic State Analysis

Trophic Level Index values and trends are a good indicator of improved water quality based on reduced nutrient inputs and improved land and residence management. Water quality data from the period of record was evaluated for trophic conditions in the lake using a limnological assessment software called LakeWatch. Trends include trophic indices calculated independently for total phosphorus, Secchi depth, chlorophyll-a, and total nitrogen. The software generates both Carlson and Burns Trophic Level Index values, index scores, and trends analysis based on nutrient concentrations and water clarity. LakeWatch reports generated from the accumulated data show improving trophic state trends in Cocolalla Lake. Both reports summarize trophic values and base index scores to identify the trophic level as eutrophic and the trend as "improvement probable."

Data throughout the evaluation period show slight improvement of epilimnion total phosphorus, although wind mixing can periodically break down stratification and increase variability of total phosphorus concentrations. Regression of seasonal and associated residuals shows phosphorus concentrations may be decreasing slightly though the trend indicator for calculation with residuals is more static though lower values. Epilimnion total phosphorus over time is shown in **Figure 4**.

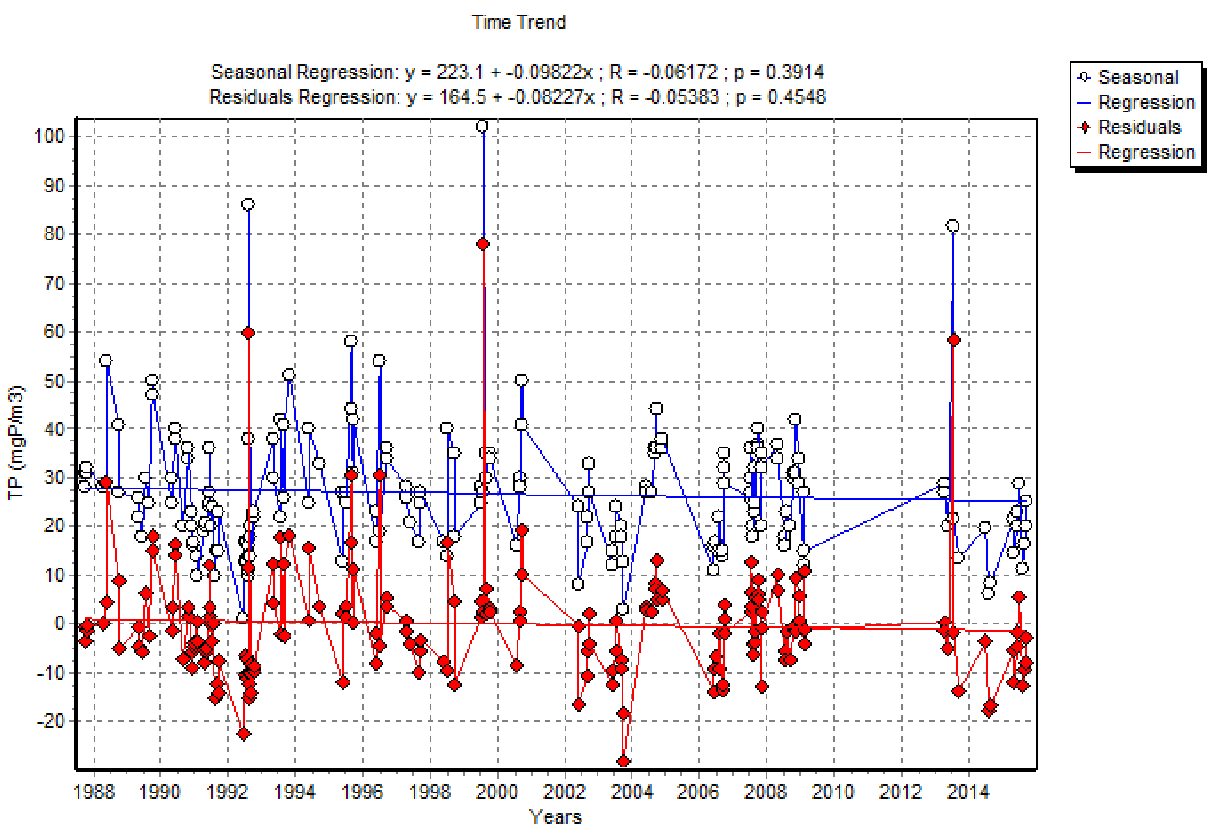

Figure 4. Epilimnion total phosphorus regressions for data from 1988 through the 2015 field season.

Trophic State Index calculations are based on Secchi disk depth as well as nutrient and chlorophyll-a data. While the long-term trend analysis does not show a significant decrease in chlorophyll-a since 1987, chlorophyll-a concentrations do seem to be lower in the last 3 years (**Figure 5**). The long-term trend data show increasing water clarity as evidenced by increasing Secchi depth readings (**Figure 6**).

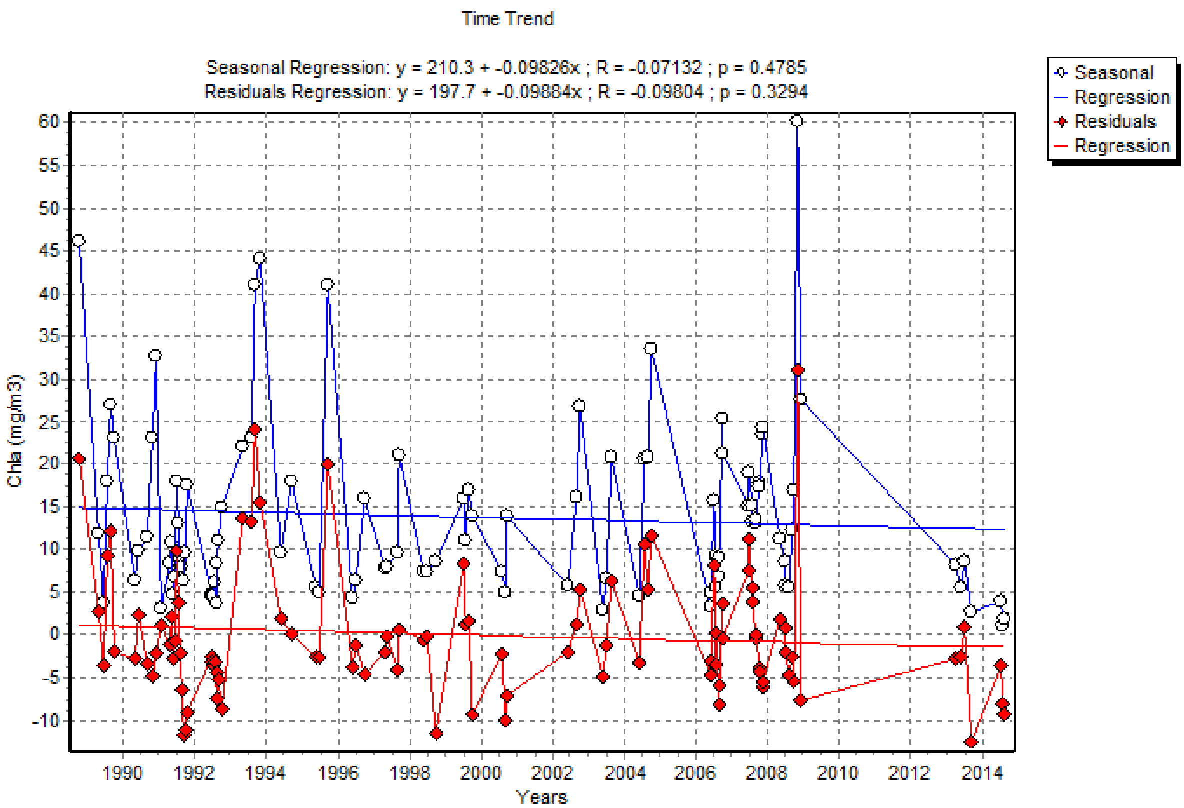

Figure 5. Chlorophyll-a regressions for data from 1988 through the 2015 field season.

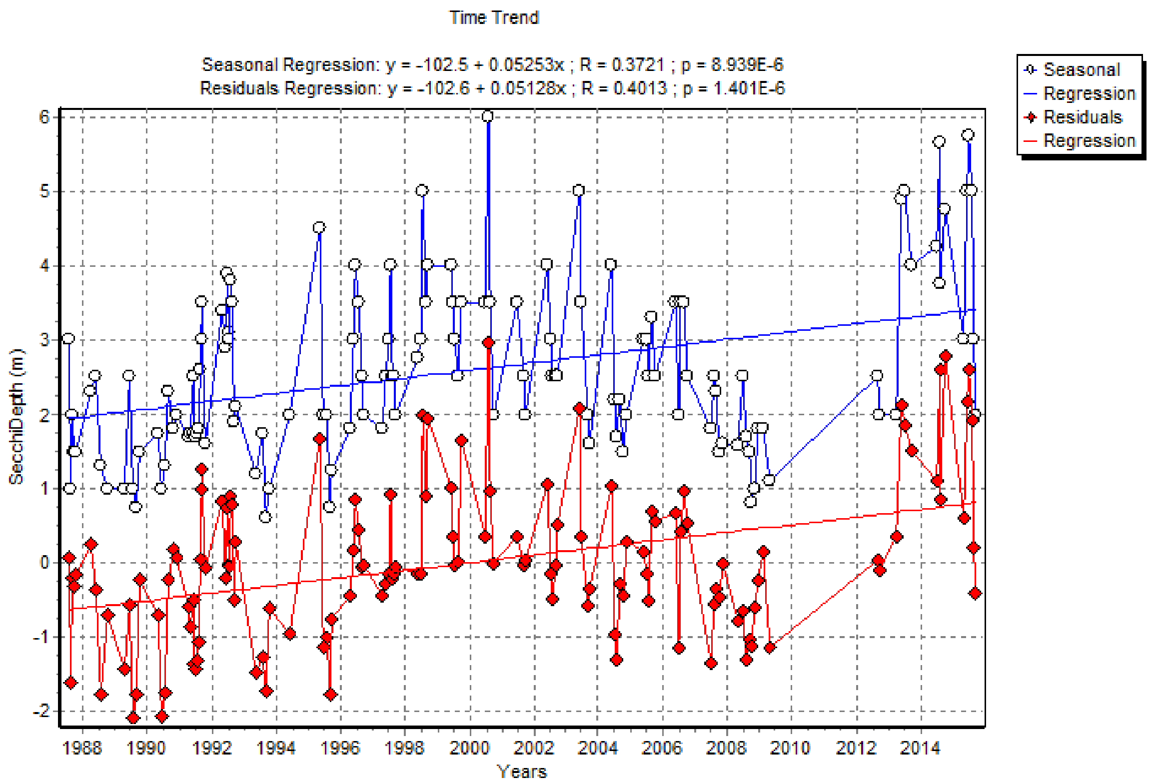

Figure 6. Secchi depth regressions for data from 1988 through the 2015 field season.

Blue-Green Algae

An anecdotal indicator of trophic condition includes trends for noxious algal blooms. Over the previous 3 years; 2014 through 2016, there have been significant blue-green algae blooms though the only blooms to trigger a health district advisory were fall of 2009 and 2016. The 2009 bloom was primarily *Gloetrichia* sp. A bloom during September and October 2009 occurred that required an advisory warning against contact, or consumption of waters visibly affected by an algal bloom. During August, September, and October 2015, a lower intensity bloom of *Aphanizomenon flos-aqua* and *Anabaena* sp. occurred but did not warrant an advisory. The 2016 bloom began in mid-July as evidenced by decreasing Secchi depth measurements and microscopic examination by staff. The advisory was placed in effect on November 21st and remained in effect through ice formation on December 15th 2016 when the advisory was lifted. Throughout the lake, algal densities were below toxin-producing concentrations described by World Health Organization standards. Concentrations that triggered advisories were primarily along shorelines from wind-blown algae accumulations. Blooms were nearly annual at the time that the TMDL was developed and the frequency of blue-green algal blooms has reduced but bloom severity seems to remain significant.

Summary and Analysis of Periphyton Productivity

Chlorophyll-a concentrations, periphyton cell identification and enumeration (counts), relative temperature, and relative light measures were collected from artificial substrates to characterize productivity measures to accompany routine trophic monitoring. Artificial substrates are styrene 1 ft^2 squares glued to inert pavers to provide a substrate that measures increases in periphyton at weekly intervals to plot a growth rate dependent on bioavailable phosphorus and nitrogen.

Productivity monitoring was focused on the organisms living on the surfaces (periphyton) of the bottom (benthos) of the lake in the nearshore zone. Periphyton is representative of lake productivity because it remains in place (relatively nonmotile), is relatively easily sampled, and integrates a number of biotic and abiotic factors.

Artificial substrates were deployed at three nearshore locations during the week of August 9, 2015, and were visited weekly for the following 6 weeks (**Table 1**, **Figure 7**). The substrates were retrieved the first week of October. Periphyton samples were collected and analyzed for chlorophyll-a concentrations each week. Analysis of chlorophyll-a in the periphyton was used to determine a growth rate and a relative measure of productivity. During the retrieval, an additional periphyton sample was taken for periphyton taxa identification and enumeration.

Table 1. Productivity monitoring stations on Cocolalla Lake.

Station Name	Latitude[a]	Longitude[a]
Southwest	W 116° 37.5495”	N 48° 06.8879”
North	W 116° 37.0785”	N 48° 07.9414”
Southeast	W 116° 37.0906”	N 48°06.7003”

[a] Datum WGS84

Figure 7. Location of 2015 periphyton sampling sites on Cocolalla Lake.

Chlorophyll Growth Rate

Figure 8 through **Figure 10** illustrates chlorophyll-a growth rates at the three sites. All graphs show good regressions for biologic measures. The study should have run longer to capture a leveling off of the growth rate, where the periphyton is fully stocked and additional growth is limited by space. The average chlorophyll-a growth rate for both the northern and southeastern sites were above 600 µg/m^2/day. The southwestern site had a lower growth rate of 346 µg/m^2/day. The southeastern site had a growth rate of 625 µg/m^2/day. The chlorophyll-a data suggest that water column nutrients in the northern portion of the lake support higher periphyton productivity than do the nutrients in the southern portion of the lake. This higher productivity may be partially due to prevailing winds from the southwest and potential accumulation of nutrients from lakeshore residences. It can also be due to in-lake productivity of localized substrate and accumulation of internal nutrient loading from biological processes.

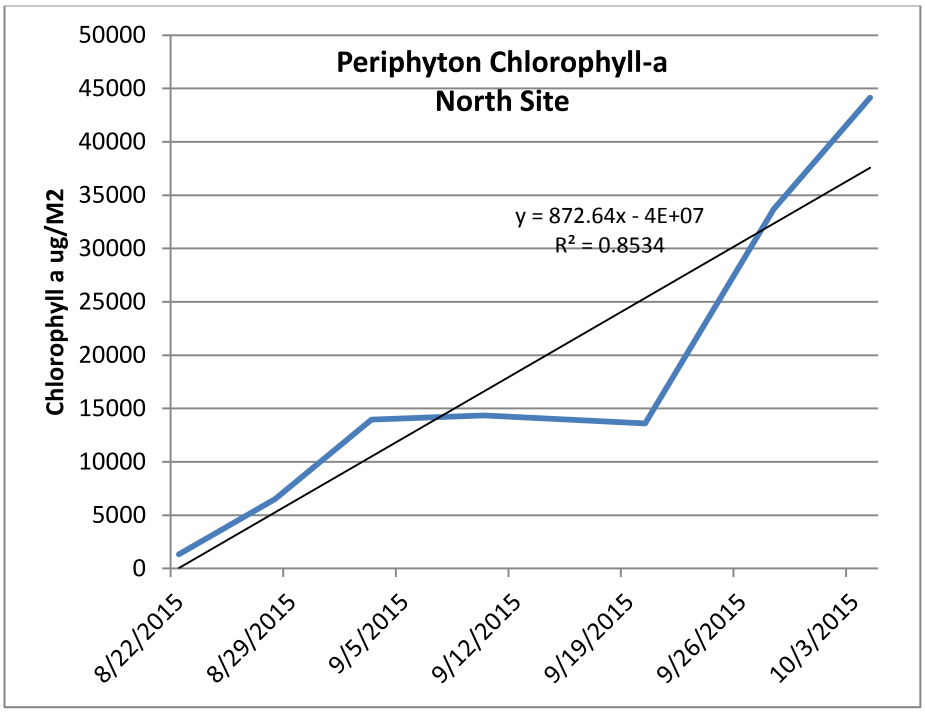

Figure 8. Periphyton chlorophyll-a growth rate, north site.

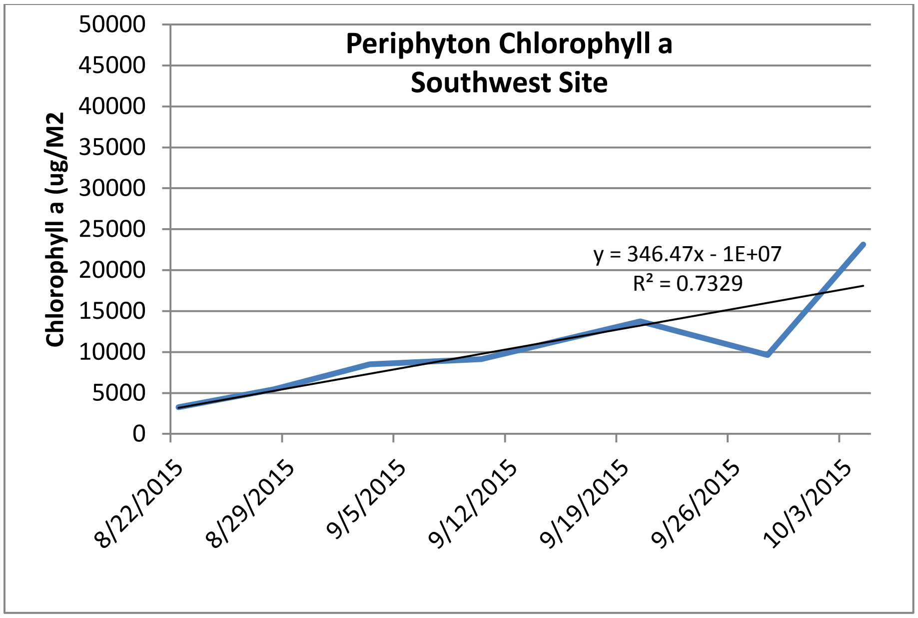

Figure 9. Periphyton chlorophyll-a growth rate, southwest site.

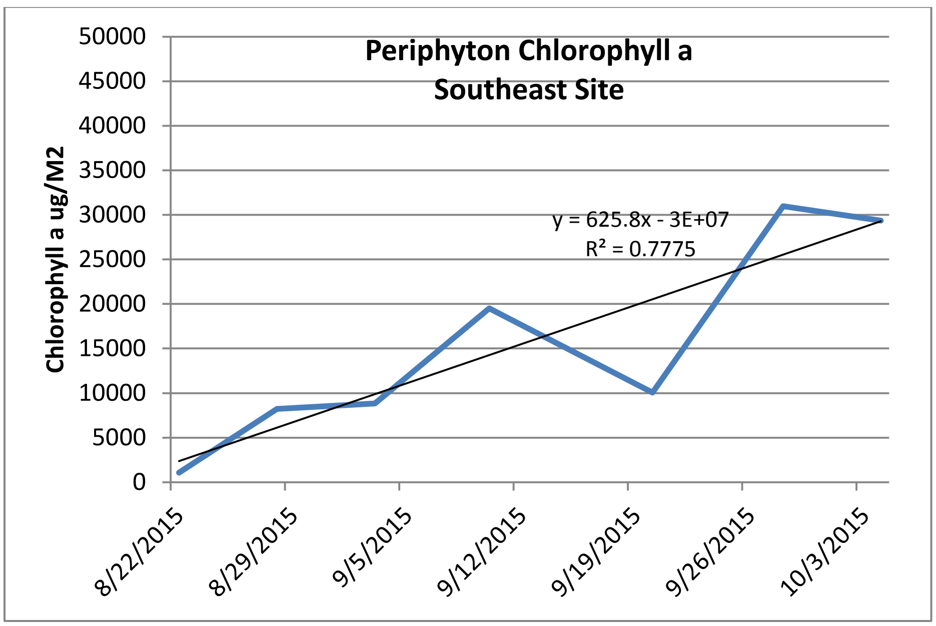

Figure 10. Periphyton chlorophyll-a growth rate, southeast site.

Comparison of Chlorophyll-a Growth Rates with Nearshore Sites on Lake Pend Oreille

Chlorophyll growth was compared to oligotrophic bays in Lake Pend Oreille in 2014. Artificial substrates were deployed in 14 stations in nearshore waters of Lake Pend Oreille. It was determined in the study that water column nutrients in the northern portion of Lake Pend Oreille support higher periphyton productivity than do the nutrients in the mid/southern portion of the lake. Two bays in the higher-production northern portion of the lake (Ellisport and Kootenai Bays) and one bay in the low-production southern portion of the lake (Idelwilde Bay) were chosen for this comparison. Chlorophyll growth rate in Ellisport and Kootenai Bays were approximately 535 µg/m^2/day (**Figure 11** and **Figure 12**). The chlorophyll growth rate in Idelwilde Bay was 134 µg/m^2/day (**Figure 13**). Both the northern and southeastern locations on Cocolalla Lake exceeded the rates in the northern bays of Lake Pend Oreille. A comparison of water column concentrations of total phosphorus in Cocolalla Lake and Lake Pend Oreille suggest periphyton productivity in Cocolalla Lake is a result of the higher nutrient concentrations. As stated earlier, epilimnetic total phosphorus in Cocolalla Lake generally ranges between less than 10 µg/L and 60µg/L. However, higher epilimnion values from 60 to 100 60µg/L are observed, likely a result of wind mixing events with the higher-concentration hypolimnion. During 2006–2015, mean total phosphorus concentrations in Ellisport, Kootenai, and Idelwilde Bays were all below 8 µg/L.

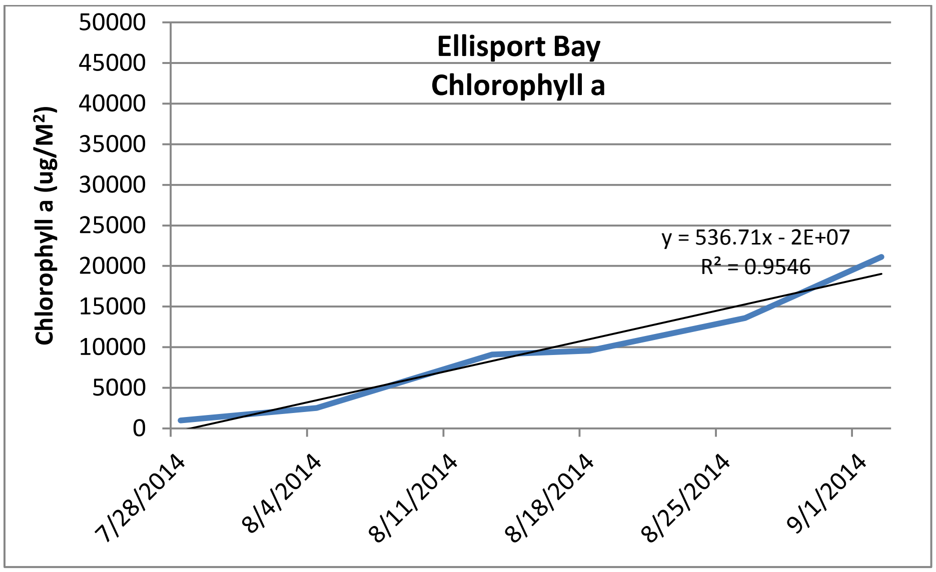

Figure 11. Periphyton chlorophyll-a growth rate, Ellisport Bay, Lake Pend Oreille.

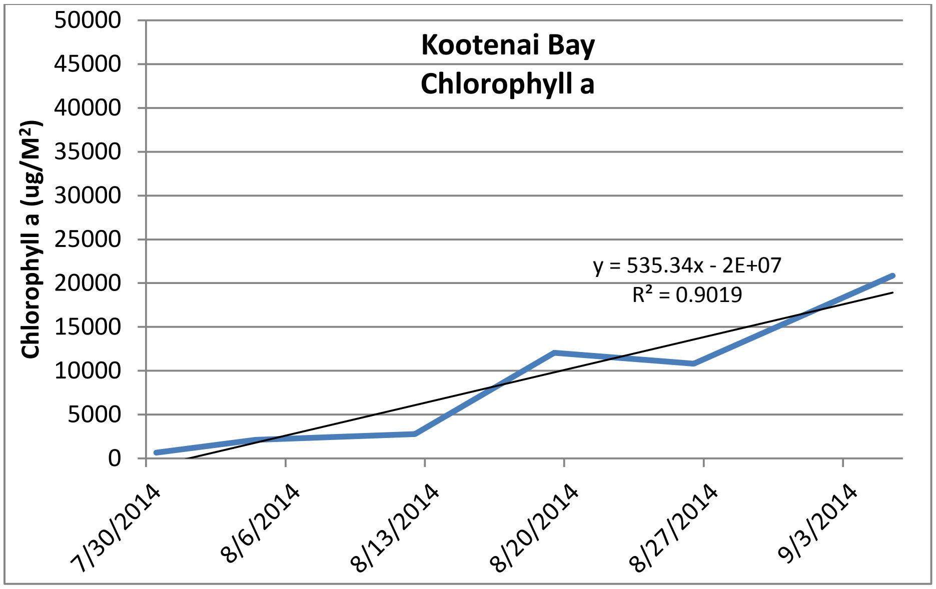

Figure 12. Periphyton chlorophyll-a growth rate, Kootenai Bay, Lake Pend Oreille.

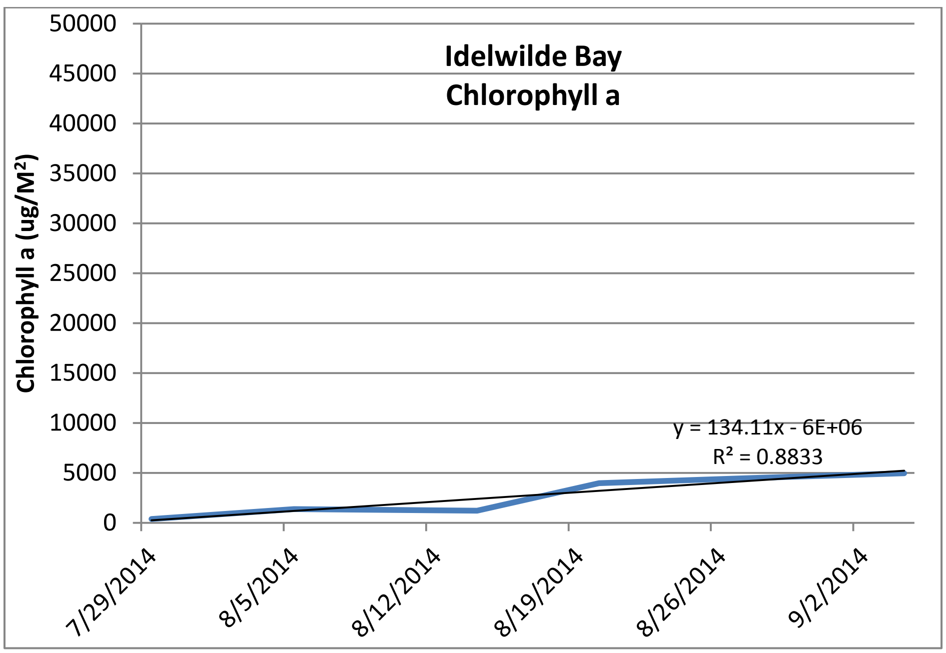

Figure 13. Periphyton chlorophyll-a growth rate, Idelwilde Bay, Lake Pend Oreille.

Periphyton Communities

Periphyton community structure and abundance provide an additional line of evidence that the stations in the northern portion of the lake support higher periphyton productivity than do the stations in the mid/southern portion of the lake. Appendix A includes the identification (taxa) and enumeration (cell counts) of the organisms from samples taken during the last week (week 6). The results indicate 17 individual taxa were identified from three separate classes:

Bacillariophyte, commonly known as diatoms

Chlorophyceae (coccoid greens and desmids), commonly known as green algae

Cyanophyceae (colonial and filamentous blue-greens), commonly known as cyanobacteria

While many of the taxa were benthic organisms and attached to the substrate, some were free floating or swimming planktonic organisms and part of the periphyton community. Appendix A includes a relative taxa frequency for each taxa present.

An additional line of evidence that the northern region of the lake has higher productivity than other regions of the lake is the dominate periphyton taxa, which were *Ulothrix,* a green algae, (4.6 million cells/m^2) and *Aulacoseira,* a diatom (2.6 million cells/m^2). Other chlorophyll-a-producing taxa at the northern location were *Anabaena,* a cyanobacteria, (180,000 cells/m^2) and *Mougeotia,* a green algae (180,000 cells/m^2). The sum of these taxa is four times the abundance in the southern sites.

Dominate periphyton taxa collected in the southeastern region of the lake were *Aulacoseira*, a diatom, (2.0 million cells/m^2) and *Anabaena*, a cyanobacteria (1.2 million cells/m^2). Other chlorophyll-a-producing taxa in the southwestern location were *Staurastrum*, a green algae (49,000 cells/m^2).

Dominate periphyton taxa collected in the southwestern region of the lake were *Mougeotia,* a green algae, (980,000 cells/m^2) and *Aulacoseira,* a diatom (850,000 cells/m^2). Other chlorophyll-a-producing taxa in the southwestern location were *Anabaena*, a cyanobacteria, (370,000 cells/m^2).

2015 Road Crossing Inventory

In 2015, DEQ conducted a survey of 12 stream crossing conditions within the Cocolalla Lake watershed (**Table 2**). Eight of the crossings had erosion issues. One crossing over Westmond Creek had severe erosion at the outlet of the culvert, which was exacerbated by cattle grazing (**Figure 14**). Three crossings had road fill erosion into the creek at the crossing (**Figure 15** and **Figure 16**). A bridge at the outlet of Cocolalla Lake was undersized with two overflow culverts that were rusted out (**Figure 17** and **Figure 18**).

Table 2. Stream crossing condition, Cocolalla Lake watershed.

Type of Crossing	Location	Lat/Long	Erosion Severity	Overall Condition	Fish Barrier?
Culvert: round corrugated steel	Westmond Creek crossing	N 48.150546 W 116.	Medium: water backs up at inlet	Good	No
Culvert: round corrugated steel	Upper Cocolalla Lake	N 48.074093 W 116.596290	High: cattle grazing	Fair	No

	tributary				
Culvert: arched corrugated steel	Upper Cocolalla Lake	N 48.047913 W 116.628502	Medium: road fill eroding	Good	No
Culvert: squashed corrugated steel	Upper Cocolalla Lake	N 48.049862 W 116.588013	Medium: road fill eroding	New	No
Culvert: squashed corrugated steel	Fish Creek at Loop Road	N 48.099870 W 116.672729	Low	Excellent	No (fish ladder)
Two culverts: round corrugated steel	Fish Creek	N 48.099897 W 116.660655	Medium: road fill eroding	Good	No
Culvert	Cocolalla Lake unnamed tributary	N 48.114409 W 116.633380	Low	Good	No
Culvert: round corrugated steel	Cocolalla Lake unnamed tributary	N 48.137128 W 116.622473	Low	Good	No
Culvert: round corrugated steel	Cocolalla Lake unnamed tributary	N 48.138929 W 116.612795	Medium at outlet	Good	No
Bridge: timber	Cocolalla Creek at outlet of lake	N 48.143247 W 116.615173	Low/medium bridge undersized	Fair	No
Culvert: round corrugated steel	Butler Creek	N 48.138905 W 116.615173	Low/poor alignment	Good	No
Culvert: round corrugated steel	Butler Creek	Unknown	Low	Good	No

Figure 14. Erosion at outlet of upper Cocolalla Creek crossing.

Figure 15. Road fill erosion into upper Cocolalla Creek.

Figure 16. Road fill erosion into Fish Creek.

Figure 17. Undersized bridge at outlet of Cocolalla Lake.

Figure 18. Rusted-out, overflow culvert at outlet of Cocolalla Lake.

Review of Implementation Plan and Activities

Upon approval of the TMDL for Cocolalla Lake, implementation plans were developed for Cocolalla Lake and its tributaries by the Bonner Soil and Water Conservation District and HDR Engineering for DEQ. Implementation projects are considered voluntary and cooperative on private lands and include mitigation for the impacts of Albeni Falls Dam, §319 implementation grant projects, application of Idaho Forest Practices Act standards, outreach and education projects, and individual residence practices guided by Lake*A*Syst and county ordinances that protect lakeshore zones with setbacks and disturbance ordinances. Implementation projects recommended in the implementation plans are summarized below:

1. Work with the Idaho Transportation Department for mitigation land at the southern end of Cocolalla Lake and determine a restoration plan for wetlands.

Increase water quality monitoring to include winter months and research use of more precise instrumentation.

Obtain lake-level monitoring equipment that will not be damaged by ice and current.

Work with the Idaho Association of Soil Conservation Districts to assist in implementing its agriculture plan for the Cocolalla Lake watershed.

Encourage formation of sewer district around Cocolalla Lake.

Reduce sediment in Fish Creek through road improvements and bank stabilization.

Encourage county to be consistent with watershed goals to reduce pollution to Cocolalla Lake on the Westmond area county-owned property of more than 400 acres as well as oversight of developments on the southeastern shore of the lake governed by county ordinance for disturbance, setback and planning.

Clean up beach at railroad access sites—provide trash receptacles.

Fund additional inventories of plants, sediment nutrient levels, habitat, and BURP monitoring.

The implementation projects provided below have been completed by agency partners since the TMDL was approved.

Agency Partner Implementation Projects

The NRCS and agency partners have conducted the following projects in the Cocolalla Lake watershed dated between 2007 and 2015:

Fencing	10,881 feet
Pest management	56.2 acres
Watering facilities	2
Critical area planting	1 acre
Pipeline	802 feet
Pasture/hay/biomass	109.1 acres
Use exclusion	23 acres
Stream crossing	2
Tree/shrub establishment	30.7 acres
Technical assistance	1
Forest stand improvement	761.3 acres
Prescribed burn	3 acres
Slash treatment	79.4 acres
Prescribed grazing	76.2 acres
Conservation cover	2.1 acres
Forest management plan	1
Tree pruning	8 acres

Herbaceous weed control	3.6 acres
Seasonal high tunnel	1,337.5 feet
Irrigation system	1 acre
Tree/shrub site prep	20 acres
Range planting	20 acres

Education Projects

Education and outreach projects include educating youth about land management and watershed management to improve water quality. The Pend Oreille Water Festival, an annual comprehensive environmental education program for all fifth graders in the area, includes stations that children progress through that identify sources of pollutants, BMPs to reduce pollutants, and management strategies for streams, lake shorelines, wetlands, and riparian areas to reduce nutrient and sediment inputs. The Idaho State Forestry Contest is held in the Cocolalla watershed to educate high school students about good forestry practices to reduce erosion and nutrient inputs from timber harvest, roads, and regrowth strategies to improve water quality.

A Stormwater Erosion Education Program helps local developers and landscapers improve their knowledge and implementation of BMPs to reduce sediment and nutrients from entering surface waters.

The Lake*A*Syst program is directed toward lake residents to improve shoreline management, property erosion, nutrient management, and littoral zone vegetation to enhance water quality and fish habitat and reduce pollutant inputs to surface water. These projects have increased awareness among citizens and developers to provide water quality improvements over time. These programs are available to citizens, lake residents, and the development sector year-round and have greatly improved construction and residence management to reduce pollutants.

Another important outreach and education forum is the monthly meetings of the Cocolalla Lake Association. Various speakers with IDFG, DEQ, Bonner Road and Bridge, Emergency Management, BNSF Rail, the soil and water conservation district, and nationally recognized invasive species experts make presentations at association meetings to educate residents and answer questions to improve land management in the watershed.

Citizen Monitoring

Citizen monitoring is an important facet of awareness and implementation in the watershed. It is primarily an outreach and education function, although voluntary monitoring data can facilitate DEQ awareness and planning. The Cocolalla Lake Association provides volunteers to collect water quality data from May through September on the lake and as needed in the winter through the ice. The sampling protocol is identified in the Citizen’s Volunteer Monitoring Manual and the LakeWatch Sampling and

Data Management Manual to ensure good technique and quality control of monthly monitoring for dissolved oxygen and temperature profiles, Secchi depth, chlorophyll-a, and total phosphorus from the photic depth and 1 meter above the bottom. Data are submitted to a local credible laboratory and managed through LakeWatch, which is a software product geared to data management and reporting for lake monitoring.

The University of Idaho also provides a framework for stream monitoring through the Master Water Stewards Program to monitor fine sediment, turbidity, total nutrients, discharge, basic insect presence, and *E. coli* levels. Monitoring has been conducted on Westmond Creek, an ephemeral creek on the northern part of the lake, and Johnson's Creek, an ephemeral stream entering the lake on the eastern shore.

Invasive Species

Invasive aquatic plants have been a concern in Lake Cocolalla since the June 2009 discovery of Eurasian water milfoil (EWM) on the south end of the lake. Initially the Cocolalla Lake Association gained approval to fund treatment of EWM by private consultants. The Idaho State Department of Agriculture began oversight of aquatic invasive species in 2011. Hybrid strains of EWM are increasingly resistant to conventional treatment and have proliferated to several new areas along the western shore of the lake. Fragmentation from boat propellers and ambient wind direction are consistent forces that move species from the southern end of the lake where Cocolalla Creek enters the lake. There may be a reservoir of EWM in some slack reaches of the creek that will effect recolonization of the lake after apparent eradication.

Cocolalla Lake is moderately productive and this equates to a vigorous fishery featuring quick growth and good survival. Infestation by zebra or quagga mussels would certainly impact the lake, which has suitable habitat with light penetration to bottom layers over much of the lake. Invasive mussels drastically change the cycling of nutrients and impact the aquatic food chain to greatly reduce the number of fish with life stages dependent on phytoplankton and zooplankton and the forage fish that depend on primary and secondary producers. Such a change would increase water clarity but would also facilitate the spread of invasive species to deeper habitats.

Vigilance over invasive species continues with the implementation of a boat washing station funded by the Cocolalla Lake Association and the Idaho State Department of Agriculture to remove invasive species on boats and trailers before they get into Cocolalla Lake. Facilities are provided through cooperative efforts at the IDFG boat ramp on the north end of the lake. Annual surveys for aquatic invasive species are now conducted by the Idaho State Department of Agriculture Invasive Species Program. The lake generally requires annual treatment due to proliferation of EWM hybrid plants that resist control by aquatic herbicides. Curley leaf pondweed is also increasing its distribution and density and requires increasing treatment. The Cocolalla Lake Association continues to be the prime force in oversight of lake management, invasive species vigilance, water quality data collection, and outreach and education.

Fish Creek Road Sediment Reduction Project

The Cocolalla Lake Association sponsored a §319 grant valued at $180,000 in 2009 to provide improvements to Fish Creek Road, a major sediment and nutrient source to the lake. The project improved 15 culverts and installed 9 new culverts. The project also graded roads, improved ditches, identified erosion reduction measures, and improved road drainage. Private driveways were evaluated for improvements (culverts, ditch work, etc.). Hydro seeding revegetation was also done. An agreement was made through the Cocolalla Lake Association memorandum of understanding that the association would inspect and cleanout as necessary (twice each spring and once each fall) 20 culverts in this program. The project required some application refinement and was ultimately awarded to Bonner Road and Bridge through the Bonner Soil and Water Conservation District.

Idaho Department of Fish and Game Wetland Restoration Project

In 2014, the IDFG—in collaboration with the Bonneville Power Administration, DEQ, the NRCS, Ducks Unlimited, and the Cocolalla Lake Association—completed a wetland enhancement project on the south end of the lake adjacent to Fish Creek. The project restored wetland function across 90 acres of property and restored more than 700 feet of Fish Creek with diversion into historic sinuous channels. This project will significantly reduce the sediment, nutrient, and temperature load coming from Fish Creek into the lake, and it has improved habitat to enhance fish passage, spawning, and bank stability.

Cocolalla Lake Association

The Cocolalla Lake Association continues to hold monthly meetings that are informational with guest speakers and agency updates. The Cocolalla Lake Association is instrumental in facilitating coordination and communication between agencies, rail industry representatives, Bonner County Emergency Services, and the interested public. Meeting discussions range from aquatic invasive species survey results, treatment reports, and distribution changes to emergency response for transportation corridor spills that may affect water quality. Members provide updates on lake level, fishing reports, and volunteer water quality monitoring updates. The association has been a long-term advocate of wetlands enhancement and mitigation as well as promoting BMPs to improve and protect water quality. The association is often called on to express preference for water quality related issues and wetland mitigation from Idaho Transportation Department and BNSF rail activities. Recreation management, boat inspections, boating safety issues, and invasive species issue updates are regular topics of discussion.

Outreach and education has been facilitated by the Cocolalla Lake Association, which gives presentations on BMPs for reducing nutrient loading to the lake and describing Lake*A*Syst techniques for reducing nutrient loading by eliminating lawn fertilization, improving riparian buffer strips, controlling erosion in disturbed areas, and maintaining septic tanks.

The Cocolalla Lake Association formed an Algae Reduction Committee in 2009 to evaluate ways of limiting internal cycling of nutrients from sediments to curb harmful algal blooms. External loading of sediment and nutrients has been reduced but remains to the extent that layering phosphorus absorbing materials on the substrate of the lake would be nullified by loading from tributaries. Disturbance of substrate by bottom dwelling fish would also likely reduce the efficacy of an alum or Phoslock (brand) treatment, rendering the cost estimate of $1.2 million for a single Phoslock treatment that would only last a few years as not cost effective.

The Cocolalla Lake Association organizes a lake clean-up annually and members provide boats and individuals to pick up garbage and debris around the lake and in areas along railroad tracks and the wildlife management area on the southern shore of the lake. Members, during the annual fall east shore clean-up, have seen increasing amounts and size of coal chips along the shore line particularly at the southeast end of the lake just north of the Weatherly home site. This phenomenon is a concern among those in the Lake Association as the likelihood rises of adding track along the Lake to increase train traffic, which is significantly composed of coal trains passing the lake.

TMDL Discussion

Modeling done in the early 1990s demonstrated that a phosphorus reduction of 39% would result in an epilimnetic phosphorus concentration of 16 µg/L, a chlorophyll-a concentration of 8.5 µg/L, and a Secchi depth of 10 feet. These conditions were determined to support beneficial uses. Data showed that meeting the phosphorus reductions necessary to meet the 16 µg/L target would not achieve dissolved oxygen conditions that meet Idaho's water quality standard of 6 mg/L. During the 2001 TMDL development process, it was thought that a reduction to 10 µg/L would move the trophic level of the lake to a state where there is no internal nutrient cycling, and the dissolved oxygen standard would be met. However, the TMDL added at 20% margin of safety, which translated to a TMDL target of 8 µg/L total phosphorus in the lake and a load reduction requirement of 89% (DEQ 2001). The target identified in the TMDL was determined to be adequate to show that reduced nutrient loading was required to improve conditions in the lake and to restore full support of beneficial uses.

Water quality and trophic state is improving in Cocolalla Lake. Water quality data shows slight improvement of water clarity and improvement of epilimnetic total phosphorus concentrations. More recent epilimnetic total phosphorus concentrations have generally been observed in a range of <10 µg/L to 30 µg/L. However, wind mixing can periodically break down stratification and increase the variability of total phosphorus concentrations. Nevertheless, total phosphorus concentrations are still above the TMDL target, and nutrient loads to Cocolalla Lake still need to be reduced.

DO data in Cocolalla Lake show that epilimnetic DO generally stays above 6 mg/L throughout the summer months and is not stressful to fish. In recent years, incidents of hypolimnetic anoxia and hypoxia are less frequent and shorter duration than in previous years. Aggressive aquatic nuisance species management by the Cocolalla Lake Association has reduced DO demand by reducing biomass and plant decay.

Many TMDL projects have been implemented to reduce nutrients and sediment-bound nutrients into Cocolalla Lake. Agency partners and willing landowners have installed a number of projects on private property. Education and outreach efforts have targeted audiences from lakeshore owners, to contractors, to school-aged children. The Cocolalla Lake Association has been active in monitoring and facilitating coordination and communication between agencies, rail industry representatives, Bonner County Emergency Services, and the interested public. It is also active in recreation management, boat inspections, invasive species management, and in finding innovative ways to reduce internal cycling. Road improvements have been made along Fish Creek and other roads. A project on IDFG property on the southern end of the lake restored wetland function across over 90 acres of property and restored more than 700 feet of Fish Creek, which will significantly reduce the sediment, nutrient, and temperature load into the lake.

In summary, trophic conditions are improving, and many nutrient sources have reduced and stabilized. Hypolimnetic anoxia is less common in frequency and duration. Since the 1980s, numerous implementation projects have been completed, land management practices have improved, development pressure has subsided, and regrowth of over-harvested timber lands has occurred. A large condominium development was cancelled that was planned on the eastern part of the lake known as Sandy Shores, where Johnson Creek makes its confluence with the lake. This project would have been the first commercial residential development that would have had a soil absorption system that would likely have negatively impacted water quality in an area with a high water table.

While nutrient reduction projects have been successful, there continues to be a need for nutrient and sediment reduction where opportunities exist. A geomorphic risk assessment for the watershed identified areas of concern in the Butler, Cocolalla, Fish, and Johnson Creek watersheds. In addition to the steep gradient of these watersheds, high road density and numerous road crossings were a concern for increased sediment load and transport capability. Continued improvement of road drainage, erosion control, and culverts needs to occur. In addition, continued assistance to lakeshore residents using the Lake*A*Syst program is needed for improved lakeshore habitat and reduced nutrient and sediment introduction from runoff to the lake.

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Appendix A. Periphyton Community Structure and Abundance for Cocolalla Lake

Location	Sample Date	Group	Taxa	Cells/m^2
Southeast	10/4/2015	Diatoms	Aulacoseira sp. :	2,000,602,000
Southeast	10/4/2015	Blue Greens	Anabaena sp. (CELLS):	1,219,880,000
Southeast	10/4/2015	Diatoms	Fragilaria sp. :	878,313,000
Southeast	10/4/2015	Diatoms	Cyclotella sp. :	113,855,000
Southeast	10/4/2015	Diatoms	Achnanthes	65,060,000
Southeast	10/4/2015	Diatoms	Cymbella (SM):	48,795,000
Southeast	10/4/2015	Diatoms	Pinnularia sp.(SM):	48,795,000
Southeast	10/4/2015	Greens	Staurastrum sp. (SMALL):	48,795,000
Southeast	10/4/2015	Diatoms	Caloneis sp. :	16,265,000
Southeast	10/4/2015	Diatoms	Gomphonema sp.(LG):	16,265,000
Southeast	10/4/2015	Diatoms	Rhopalodia gibba:	16,265,000
Southeast	10/4/2015	Diatoms	Synedra sp. :	16,265,000
North	10/4/2015	Greens	Ulothrix (CELLS):	4,574,754,000
North	10/4/2015	Diatoms	Aulacoseira sp. :	2,622,859,000
North	10/4/2015	Diatoms	Cyclotella sp. :	579,469,000
North	10/4/2015	Diatoms	Fragilaria sp. :	396,479,000
North	10/4/2015	Diatoms	Frustulia sp.(SM):	243,987,000
North	10/4/2015	Blue Greens	Anabaena sp. (CELLS):	182,990,000
North	10/4/2015	Greens	Mougeotia (MEDIUM-CELLS):	182,990,000
North	10/4/2015	Diatoms	Epithemia sp. :	121,993,000
North	10/4/2015	Diatoms	Cymbella (LG):	30,498,000
North	10/4/2015	Diatoms	Cymbella (SM):	30,498,000

Location	Sample Date	Group	Taxa	Cells/m^2
North	10/4/2015	Diatoms	Tabellaria fenestrata:	30,498,000
Southwest	10/4/2015	Greens	Mougeotia (MEDIUM-CELLS):	975,904,000
Southwest	10/4/2015	Diatoms	Aulacoseira sp. :	853,916,000
Southwest	10/4/2015	Diatoms	Cyclotella sp. :	414,841,000
Southwest	10/4/2015	Blue Greens	Anabaena sp. (CELLS):	365,964,000
Southwest	10/4/2015	Diatoms	Fragilaria sp. :	365,964,000
Southwest	10/4/2015	Diatoms	Achnanthes	170,865,000
Southwest	10/4/2015	Diatoms	Epithemia sp. :	48,467,000
Southwest	10/4/2015	Diatoms	Frustulia sp.(SM):	48,467,000
Southwest	10/4/2015	Diatoms	Cymbella (SM):	24,233,000
Southwest	10/4/2015	Diatoms	Navicula sp.(SM):	24,233,000
Southwest	10/4/2015	Diatoms	Pinnularia sp.(SM):	24,233,000
Southwest	10/4/2015	Diatoms	Synedra sp. :	24,233,000