Summary of Hayden Lake Water Quality Monitoring

Introduction: The purpose of this summary is to give any individual an understanding of the types of water quality monitoring that have been conducted on Hayden Lake. There are six distinct monitoring efforts on the lake's water quality and one on its near shore septic systems ranging over a period from 1972 through 2006. This summary will attempt to report the approaches taken, the data developed, and, as important, how the approach did not reveal the entire picture. Any opinion stated is that of one professional with many years of water quality experience and might be disputed by another's opinion. This document is a summary. The actual reports on which it is based are linked to the report at the appropriate location so those wishing more in depth information may consult the report.

National Eutrophication Study: The National Eutrophication Study was conducted in 1975 and published by the U. S. Environmental Protection Agency (EPA) in 1977. Thirteen lakes in Idaho, among them Coeur d'Alene Lake, Hayden Lake, and Twin Lakes, were visited by a pontoon equipped Huey helicopter during the spring, summer, and fall seasons. Integrated samples from the surface to the bottom of the lake were taken at three stations on Hayden Lake: a mid-lake station midway between the country club and Cooper Bay, a mid-lake station just south of the lake's northern arm, and a station well within the northern arm near Sportsman's Access.

Water samples demonstrated that Hayden Lake was one of the clearest lakes sampled within the State. Physical measurements were within the ranges expected for a Northern Idaho lake. Chlorophyll a levels of 2-4.6 micrograms per liter indicate that the lake was in an area of algal growth that was tending towards deteriorating water quality (early mesotrophy). Primary production potential from algal growth was rated moderately low in the spring and high in the fall. Of the thirteen Idaho lakes sampled, 11 had higher total phosphorous and all others had higher orthophosphate than Hayden Lake. These plant growth nutrients were shown to be limiting algae growth in the spring and fall periods for Hayden Lake. Nitrogen plant growth nutrients were assayed as limiting in the summer samples. The study observations did not report any problematic conditions during visits of technicians to the lake. A crude plant growth nutrient loading analysis of the lake was made for the study, as was an assessment of point and nonpoint sources of pollution. No known point sources (pollution from a discrete source such as a pipe) were reported, while forestry, agriculture, and septic systems were assigned nutrient loads. A large part of the nonpoint source phosphorous was not accounted for by the modeling.

The National Eutrophication Study was, by its design, a very quick (one spring, summer, and fall) snapshot of the lake's water quality. This study lends itself to criticism for viewing the lake as a single unit. The three water quality stations were deemed equal, with two in rather deep water and the third being well within the Northern Arm which is an artifact of impoundment of the lake in 1911. The northern arm's physical conditions, depth, temperature, and plant growth are quite different than the other two sampling sites. Mixing of the water quality data collected at the northern arm station with that of the main lake by mathematical average, does bias the overall quality of the main lake with data from an area expected to have different water quality

because of its very different conditions. The plant growth nutrient loading estimates are fairly crude models based on an insufficient amount of stream discharge modeling. Even with these faults however, it did suggest some nutrient loading factor was missed.

Water Quality Summary; Hayden Lake 1977: The summary report includes data collected by the Division of Environmental Quality; Department of Health & Welfare (DEQ) between 1972 and 1976, preliminary data from EPA's National Eutrophication Study (NES), some physical and chemical data collected by Idaho Departments of Fish & Game and Water Resources back to 1948, and bacteriological surveys made by the Panhandle Health District (PHD) in the mid-1970s. The report was compiled by a DEQ water quality analyst.

The summarized data demonstrate that the lake was generally low in plant growth nutrients, phosphorous, and nitrogen (oligotrophic) in its main deep water pool. The summary notes that certain shallow bays, notably Mokins and O'Rourke, and the shallow northern arm, ranged from moderate to high plant growth nutrient (mestotrophic to eutrophic) conditions. The shallow northern arm, which is 6 feet is deep, was noted to be an artifact of the 1911 impoundment of the lake. Prior to this time, it was a pasture along the edge of Hayden Creek. Hayden Creek entered the lake near Henry's Point. Aquatic weed growth was noted as heavy in the shallow bays and the northern arm. Algal growth potential studies made by EPA in the NES and by DEQ during the same time period, demonstrated the lake to be limited by the phosphorous compound orthophosphate necessary for algal (plant) growth. Nitrogen is also necessary for plant growth. Nitrogen was not found to limit plant growth, except in one case during the early spring. The nitrate form of nitrogen was found to be very low in lake waters at all times, while the ammonia form was found on occasion at levels of concern in areas of heavy residential use. These ammonia results suggest impacts of human sewage on the lakeshore. Dissolved oxygen concentrations collected over the history of lake monitoring indicated no limitations.

Assessment of nonpoint sources of water contaminates were made. These sources included domestic habitations, recreation, agriculture, mining, and timber harvest, and the road development necessary to support these activities. A shoreline wastewater treatment assessment made by PHD found 584 individual subsurface wastewater disposal systems of various types. These systems were located an average of 115 feet from the lake. Fifty-nine percent of survey lots were found to have bedrock at six feet or less from the surface. Shallow soils of this type are regarded as poorly suited for most on-site wastewater treatment and disposal systems. Based on the assessment, total phosphorous and nitrogen loading to the lake from these sources was estimated at 12% and 10.9% respectively. Phosphorous and nitrogen loading, as the result of housing, roads, agriculture, and logging, was estimated at 24.1% and 22.7% respectively. The report did note that a cattle ranch at the north end of the lake routinely discharged manure into the lake. The practice was ended in 1973 by PHD.

The summarized data included bacteriological survey results completed by DEQ and PHD jointly. The lake did not exceed the class A bacteria standard supportive of recreational use at any time, although one health warning at Honeysuckle Beach occurred during a high temperature period. A targeted bacteriological study conducted during July 1975 was designed

to detect bacteria increases as recreational cabin use increased. The study did reveal a bacterial increase trend in shoreline waters adjacent to dense recreational home and cabin development on the south shore to the vicinity of Sandy Bay, and the west shore and northwest shore to the vicinity of Cramp's Bay. Although high total coliform bacteria counts were observed in these high development areas, seldom were fecal coliforms detected.

The results summarized in 1977 provide the initial overall view of Hayden Lake's water quality. These results constitute an initial baseline, created after development of the lakeshore was well established for at least fifty years. The ammonia, nitrogen, and bacterial results point to a concern that improper wastewater treatment and disposal was affecting near shore waters in areas of residential and recreational cabin development. The subsurface wastewater disposal systems survey completed by PHD demonstrated the problems with this treatment approach and the estimated loading for phosphorous and nitrogen plant growth nutrients. The summary report does provide estimates of plant growth nutrient loadings, but these are not sufficiently comprehensive to support a protective lake management strategy. Improved measurement of watershed inputs and the fate of nutrients once carried into the lake would be required for these estimates.

Water Quality Study of Hayden Lake 1985: The assessment of Hayden Lake's water quality and the resulting report was commissioned by the group, Save Hayden Lake, a group of citizens concerned that the lake's water quality was deteriorating. The study was conducted by an Eastern Washington University limnologist and his graduate students. The study is the most in-depth into the quality of Hayden Lake's water, biota, and the loading of the plant (algae) growth nutrients from tributary sources made to the date of the study or afterwards. The objective of the study was to develop a water quality baseline of the current water quality including the loading of algae growth nutrients. Based on this baseline, the effect of activities in the watershed could be predicted.

The study collected samples from April through December 1985. Physical measurements and samples were collected at four stations on the lake through the water column. Additional samples were collected from the zone penetrated by light (euphotic zone). Several physical measurements were collected while samples were analyzed for an array of chemical constituents, algae, and zooplankton content. The majority of the tributary streams were monitored with physical measurements including water discharge into the lake and sampled to measure chemical constituents of the water. From the discharge measurement and the concentration of plant growth nutrients (nitrogen and phosphorous), the load of these constituents entering the lake was calculated. The plant growth nutrient load from septic system discharge was estimated. The discharge from the lake as it flows over the dike or discharge to the Rathdrum Prairie Aquifer was measured and estimated.

The study documented the bicarbonate water of Hayden Lake to be high in clarity, low in mineral content, and low in plant growth nutrient concentrations. The lake developed strong thermal stratification during the summer months with a relatively thin layer of warm surface water (epilimnion) and a large pool of cold water at depth (hypolimnion). The lake was well

oxygenated, but exhibited some oxygen depletion to 4.4 milligrams per liter at depth near the bottom in early fall months. The chlorophyll concentration, a measure of algae (plant) abundance, was low, 2.04 milligrams per cubic meter as was the primary productivity, the amount of carbon fixed by photosynthesis, 0.202 grams carbon per square meter per day. Based on the nutrient concentration, chlorophyll content and primary productivity, the lake was classified as oligotrophic, but bordering on mesotrophic. Oligotrophy is a condition of low nutrients and low algae growth resulting in very clear water, while mesotrophy is characterized by higher plant growth nutrients, more plant (algae) growth, and lower clarity. Assessment of the algae present through the year and the zooplankton feeding on it, supported the oligotrophic classification, but presence of one group of zooplankton could suggest trends towards mesotrophy. Sampling for bacteria documented that none were measured in the open water of the lake and very few were present in the shoreline waters except for one sample taken at Honeysuckle Beach during a period of high use by swimmers. Calculations of the ratio of nitrogen to phosphorous present in the lake water provided evidence that phosphorous is the plant growth nutrient limiting algae growth.

Nutrient loading estimates demonstrated that 69% of the phosphorous present in the lake came from the tributaries draining the watershed, while an estimated 5% had its origin from septic tanks. An estimated 26% of the phosphorous came from atmospheric fallout. Given the phosphorous loading sources, the study indicated that management of the lake's watershed was the key to managing the lake's water quality. Since the U. S. Forest Service managed 63% of the watershed, its actions were most important. The study cautioned that if the Forest Service continued to harvest the forests of the watershed for a target of a 100 year rotation of the trees, the cutting rate would adversely affect the lake's water quality.

The study outlined a very thorough sampling of the lake and most of its tributaries waters through the seasons. The study remains the best characterization of the lake's water quality to date. Although all of the major tributary streams to the lake were flow gaged, and water quality characterized, many small tributaries that are located in more densely populated areas of the watershed, as on the lake's south shore, were not characterized. Since most of these tributaries are intermittent, flowing only during snow melt or significant precipitation events, gaging their discharge and sampling them was problematic at the time of the study. If it had been possible for the study to document these streams, it is likely that another major source of phosphorous loading to the lake that would have been recognized: storm water. The study did not document the influence of storm water discharge to the lake as a major source of phosphorous and one directly related to human activity in the watershed. Careful reading of the text indicates the phosphorous mass balance developed from the data collected was lacking. Sediment uptake and release of phosphorous was invoked to achieve the balance. It is likely the actual difficulty had its roots in the fact that the storm water source was not recognized. The study focused most of its efforts in lake water quality sampling on four stations in the lake. Three of these are mid-lake stations, while the fourth was in the transition zone between the deep open lake and the shallow northern arm of the lake. The only samples collected near shore or in bays were grab samples tested for bacteria. Although this design is preferred to assess the water quality health of a lake, it ignores the fact that degradation of

water quality typically begins in the bay areas and is only detectable at mid-lake stations after degradation is well advanced. A water quality monitoring scheme likely to identify water quality degradation early requires a strong component examining the most vulnerable bays.

Hayden Lake Shoreline Survey 1986: The shoreline survey of septic systems completed by the Panhandle Health District in 1986 updated the shoreline survey completed in 1976. The survey divided the lake shore into the eleven zones used in the 1976 survey. The physical characteristics of each zone's shoreline were documented as were the soil types. The numbers of new and upgraded septic systems since the 1976 survey were noted. The efficiency of the soils in the removal of septage contaminants and nutrients was estimated for each zone. Any restrictions on the use of on-site wastewater drain fields were noted.

The survey found 653 septic systems on the shoreline. Sixty-six (66) were new construction since 1976; forty-three (43) had been repaired or renovated, while 544 remained essentially as they were in 1976. The average separation of drain fields from the lake increased to 125 feet. This report, like its predecessor, noted serious problems with application of wastewater into the clay soils generated from the basalt on the southwest, west, and northwest shore of the lake. The survey noted specific areas beyond these where drain field treatment and disposal of wastewater was restricted or closely regulated. The survey demonstrated that the average distance of drain fields from the lake was increasing in all zones primarily due to the requirement of greater separation distances required by the newer regulations. Most existing lots did not have the depth to achieve the separation distances required by the updated septic system regulations. Many systems that were replaced could not find the proper separation on the property in question, and drain fields were removed to the furthest point feasible. New systems were required to obtain easements for drain fields on property adjacent to the lot but further removed from the lake to meet the increased separation regulations. The report pointed out that shoreline areas one, two, and three (Honeysuckle Bay to Cramps Bay and most of area 11 Windy Bay to Honeysuckle Bay) were scheduled for sewage collector system installation by the Hayden Lake Recreational Water & Sewer District in the following two years. The shoreline survey update was preparatory to the sewage collector installation on the south shore to Sandy Bay, and along the west and northwest shores to Cramps Bay, that the 1977 bacteria assessment and the 1985 water quality study indicated was necessary to protect the lake.

Water Quality Assessment 1987: The 1987 water quality assessment was compiled by DEQ and released in 1990. The report primarily restates many of the conclusions of the water quality assessment report of 1985, but does add some information from water quality monitoring completed at the mid-lake stations in 1986 and later the Citizens' Volunteer Monitoring Program (CVMP) completed between 1987 and 1990. The methods for both the DEQ monitoring and CVMP are provided. The parameters measured are scaled back as are some parts of the water column sampled, but the methods are similar to those used in the 1985 study. Although attempts were made to use the same sampling locations as the 1985 study, the report indicates this goal was not achieved. Results of monitoring on Hayden Creek are cited that verify the phosphorous load estimates made in 1985, but indicate that grazing in

Lancaster Creek, one of Hayden Creek's tributaries contributes significantly to the phosphorous load. The report addresses the phosphorous balance issue. Based on additional years of nitrogen and phosphorous data, the report suggests a concentration increase of phosphorous in the hypolimnion, even though the 1985 study did not measure a phosphorous concentration increase. It is difficult to assess from the data, but such observations may have been symptomatic of the failure to recognize the storm water source from heavily developed slopes adjacent to the lake.

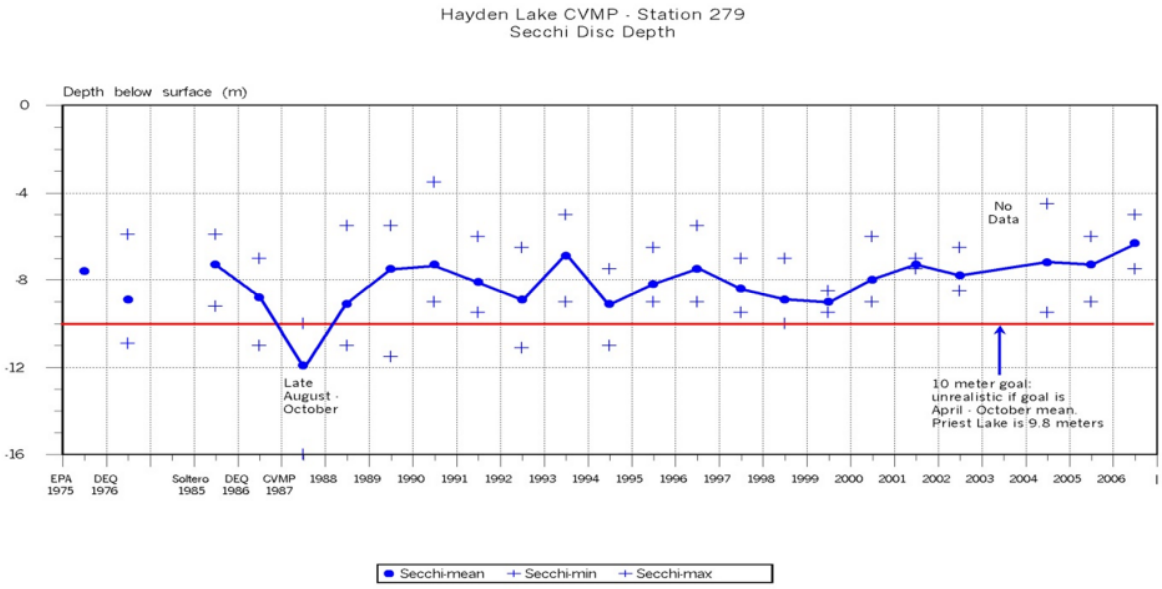
The report largely restates the earlier work of the 1985 study and makes recommendations based on the data. The report does provide the first three years of the CVMP results and the methods used. The CVMP results are given in greater detail below. Although minimal in scope as compared to the 1985 study, the CVMP data gathered over a sixteen year period links the 1985 results to subsequent monitoring completed in 2005 and 2006.

Citizens Volunteer Monitoring: The Citizens Volunteer Monitoring Program (CVMP) was a program operated by DEQ for many years from the late 1980s through 2007, when funding for the program was cut. Interested citizens were trained by DEQ personnel to collect water quality data and samples from key waterbodies across the state. As a volunteer effort, many data sets were developed by several individuals on several lakes, but the records were broken due to the lack of volunteers in some years. In the case of Hayden Lake, a continuous sixteen year record of data and sample collection exists. The vast majority of these data and the samples were collected by a single dedicated individual, Robert (Bob) Black. Thanks to the efforts of Bob Black, a chain of data exists between the in-depth 1985 study completed by Eastern Washington University limnologists and the most recent work on the lake.

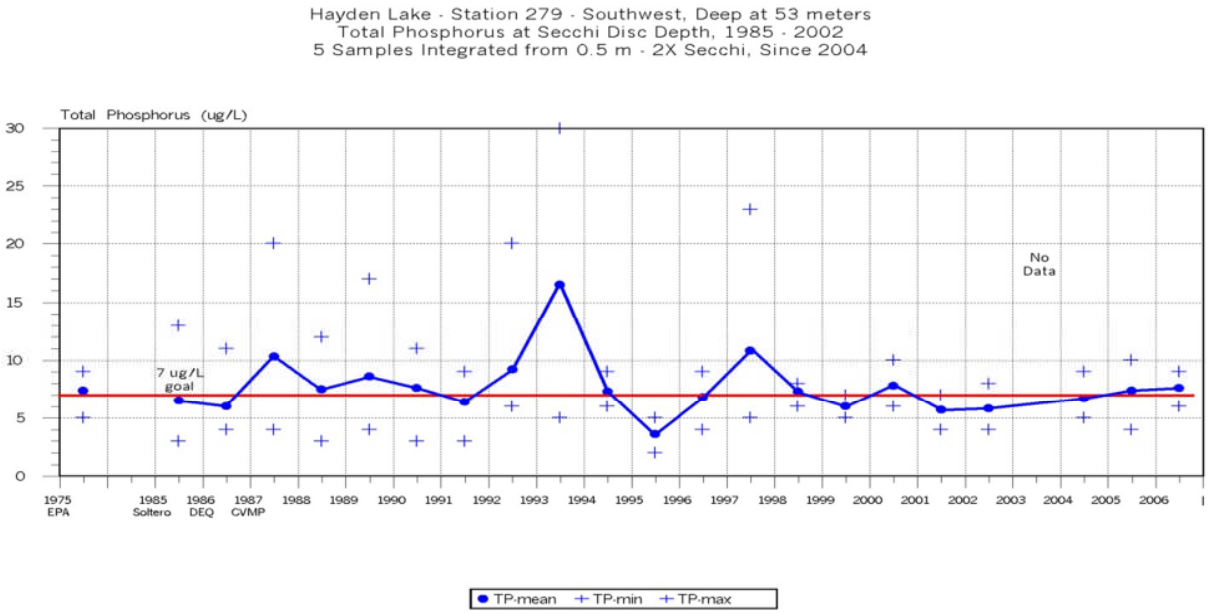
The CVMP monitoring consisted of samples collected at the four mid-lake stations established in the 1985 study and used by DEQ in its 1986 sampling. Sampling was conducted five times between August and November of each year. Water clarity was established with a Secchi disc. Samples were then collected at the Secchi depth (how deep the Secchi disc can be seen) and from one meter off the bottom with a polyethylene Kemmerer sampling bottle. Temperature and oxygen of the upper and near bottom samples were measured. Three one liter samples were collected at the Secchi depth while two were collected near the bottom. A sample from each stratum was preserved with acid while the other was not. The third sample from the upper strata was wrapped in foil to protect against degradation of chlorophyll. The samples were analyzed for different chemical forms of the plant growth nutrients--phosphorous and nitrogen, while the third foil wrapped sample from the upper level was analyzed for chlorophyll a.

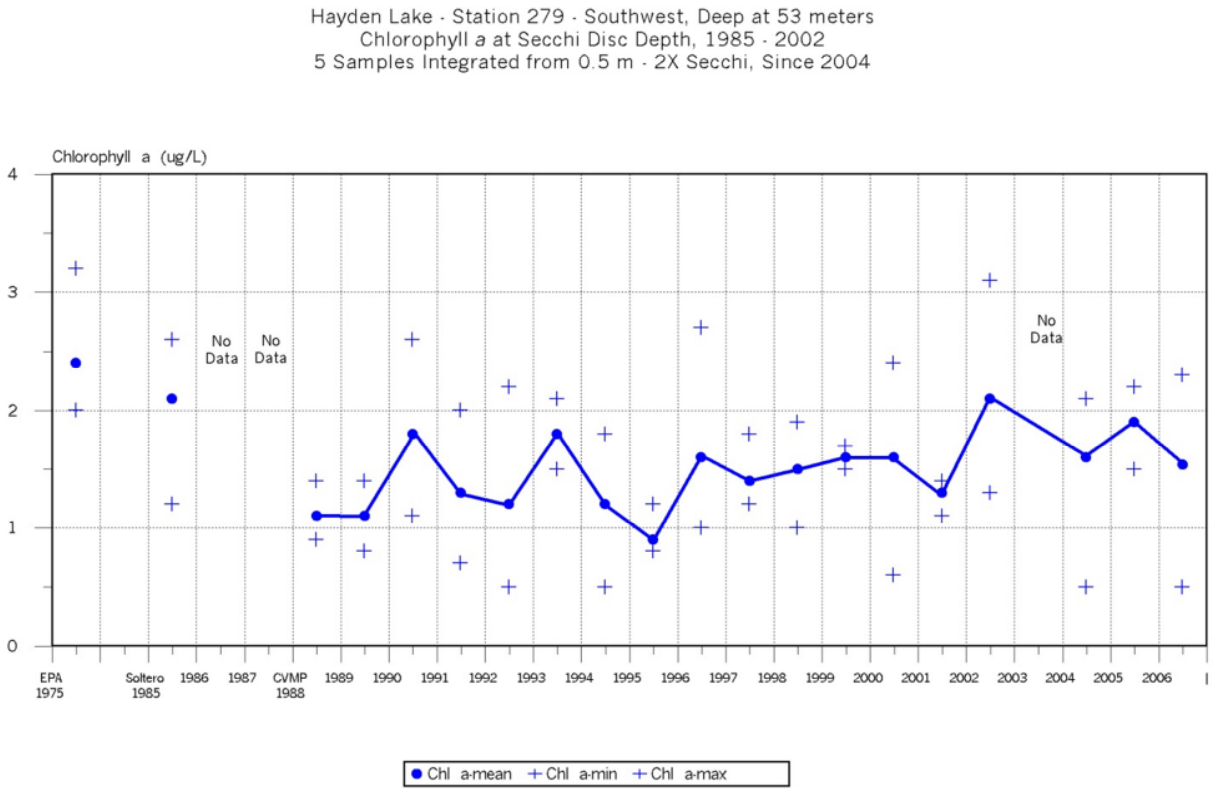
The three most critical values collected by the CVMP work were the clarity measure in Secchi depth in meters, and the total phosphorous and the chlorophyll a concentration. Phosphorous is the nutrient limiting plant (algae) growth, while chlorophyll a is a measure of the amount of algae present in the upper (illuminated) part of the water column. The three graphs that follow show the mean and range of these values over the sixteen year period for a mid-lake station. Data are missing for some years. For reference, the mean and range values collected in the

1985 study and DEQ's 1986 measurements are shown as are values collected in a later monitoring effort (2005-2006). Where applicable, the goal of the Hayden lake Management Plan is marked on the graph.



Note: 1 meter = 3.28 feet





The data collected in the CVMP effort provides a long term sixteen year assessment of three critical parameters of Hayden Lake's water quality. Clarity averaged around eight meters during the summer and fall months varying a meter above or below this average. The 12 meter measurement is believed to be an error as stated in the 1987 Assessment. Based on the long term record, a clarity goal of 10 meters may be overly ambitious. Total phosphorous averages around 7.5 micrograms per liter with departures well over 10 micrograms per liter and as low as 3 micrograms per liter. The departures upward are accompanied by wide ranges in data points suggesting potential contamination issues. The ten year average does not meet the management plan goal of 7 micrograms per liter phosphorous. Chlorophyll a data indicate the lake, throughout the period, maintained the low productivity typical of an oligotrophic waterbody, less than 2 micrograms per liter. All chlorophyll a averages were below those collected in the 1985 study or by DEQ a year later.

The CVMP data is a vital link, but the sampling locations were roughly those used earlier in the 1985 study and suffer the same flaw. Three of these are mid-lake stations, while the fourth was in the transition zone between the deep open lake and the shallow northern arm of the lake. The data collected over the sixteen years does not indicate the status of water quality in the much shallower bays of Hayden Lake.

Water Quality Monitoring 2005 -2006: Water quality monitoring was completed in 2005 by the Hayden Lake Watershed Advisory Group. By 2006, the group had re-organized as the original Hayden Lake Watershed Association. The Association requested the Hayden Lake Recreational Water & Sewer District to hire a lake manager who assisted with the work. The monitoring was completed as part of DEQ's CVMP. However, the monitoring plan was altered dramatically to assess the water quality of one bay and a station near the northern arm of the lake, and limit the mid-lake stations that provide redundant data in previous monitoring to one station. Three lake stations were monitored: a mid-lake station in the deep pool of the lake, a station in Berven Bay and a station near the lake's northern arm. Berven Bay was monitored because development in the bay's watershed was accelerating. The northern arm station was monitored because prior to the impoundment of the lake by the dike, this area was a meadow that was seasonally flooded. Inundation of the meadow created a shallow, less than 2 meters deep, area of the lake with abundant aquatic weed growth and higher primary productivity. The northern arm station was situated just to the south of the shallow area. The monitoring plan also incorporated monitoring of the discharge and plant growth nutrient content of Hayden Creek and new methods to assess changes occurring in the water quality of the lake's bays.

Each lake station was sampled five times between April and October. Clarity was measured with a Secchi disc. Temperature, conductivity and dissolved oxygen were measured through the entire lake water column. An integrated sample of the water column that receives sunlight (euphotic zone) was analyzed for total phosphorous and chlorophyll a. The Forest Service operated the gaging station on Hayden Creek to measure discharge while DEQ collected water quality samples to measure the plant growth nutrients. Chlorophyll fluorescence was measured across the length of bays (transects) and the northern arm to assess chlorophyll concentration trends. These data were verified in 2005 by collecting samples and measuring chlorophyll a across the same transect in the northern arm.

Results of the 2005 and 2006 monitoring mirrored those of earlier CVMP monitoring for the mid-lake, Berven Bay, and northern arm stations. The lake's clarity exceeded 7 meters (23 feet) on average, total phosphorous was slightly higher than 7 micrograms per liter, and chlorophyll a concentrations were in the range from 1.5 to 2 micrograms per liter. Berven Bay was similar to the mid-lake station because it is a very deep bay (17 meters) very close to shore. The results from the northern arm station indicated it was more like an open lake station with little impact to the water quality from the shallow high primary productivity just to the north. Although Hayden Creek discharge was measured for a year by the U. S. Forest Service, funding and personnel changes in DEQ precluded follow through on the nutrient monitoring. Both chlorophyll fluorescence and actual chlorophyll a measurements were made on a transect from north to south across the northern arm of the lake. Chlorophyll a concentration was nearly 13 micrograms per liter at the northern end near Sportsmen's Access, peaked to the south at 17 micrograms per liter and then declined to 1.9 micrograms per liter as the transect reached the station located near the northern arm. The chlorophyll fluorescence mirrored this pattern across the transect. These results demonstrate the high primary productivity of the shallow areas of the lake. In 2006, chlorophyll fluorescence transects were completed on the northern

arm and on a few other bays (Berven, O'Rourke and Windy) of the lake. Transect data were collected with global positioning satellite (GPS) data identifying the location of each specific location. This allows the absolute location of these transects to be compared with any subsequent transects collected.

A gradient of primary productivity as measured either as chlorophyll a concentration or fluorescence is expected from the shallow waters of a bay into the deep waters of an oligotrophic (low nutrient, low primary productivity) lake. The general trend of water quality is assessed by if and how that gradient changes over time. No change indicates a static condition in the lake. Since few natural systems are static, this outcome is unexpected. Migration of higher chlorophyll values (concentration or fluorescence) out towards the general lake waters is a strong indication of water quality degradation, especially if this migration outward is progressive and persistent. Migration of the gradient towards shore would indicate improvement in a bay's water quality and a general improvement in lake water quality.

The 2005-2006 monitoring effort on Hayden Lake was cut short by funding cuts at DEQ that ended the CVMP program. The monitoring effort laid a chlorophyll fluorescence baseline for the northern arm and a few bays of the lake. However, subsequent transects require collection before any conclusions could be drawn concerning the water quality trend in the bays of Hayden Lake. The baseline data is geo-referenced with GPS so subsequently collected data could be compared based on the absolute position of the data. The failure to collect the tributary plant growth nutrient data also limited information gathered by the monitoring effort. This failure points out the very real fact the government agencies are in a persistent cycle of budget cuts making them far less likely to take on such projects and programs. It will likely fall to private groups or districts dedicated to a single lake resource to complete this necessary monitoring.

Final remarks:

A monitoring effort was launched by the University of Idaho in cooperation with the HLWAI and Coeur d'Alene High School. Data were collected over the summer of 2010, however, those data were not placed in any report released to the public. Loss of the faculty position which carried out this work essentially terminated the program.