TOTAL MAXIMUM DAILY LOAD EVALUATION OF pH FOR RESERVOIRS IN THE BLACK HILLS PLATEAU ECOREGION OF CUSTER AND PENNINGTON COUNTIES, SOUTH DAKOTA

South Dakota Department of
Environment and Natural Resources

Protecting South Dakota's Tomorrow ... Today

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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Acknowledgements

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1.0 Total Maximum Daily Load Summary

Center Lake Phosphorus Total Maximum Daily Load Summary Table

Entity ID:	SD-CH-L-CENTER_01
Location:	HUC Code: 10120109
Size of Watershed:	6,070 acres
Waterbody Type:	Reservoir
303(d) Listing Parameter:	pH
Initial Listing date:	1998
TMDL Priority Ranking:	1
Listed Lake Acres:	22.7
Designated Use of Concern:	Coldwater Permanent Fish Life Propagation
Analytical Approach:	***BATHTUB, FLUX***
Target:	Meet all applicable water quality standards, and a pH < 9.0
Indicators:	pH
WLA:	***0***
LA:	***0.31 kg/Day total phosphorus***
MOS:	***Implicit***
TMDL:	***0.31 kg/Day total phosphorus***

Legion Lake Phosphorus Total Maximum Daily Load Summary Table

Entity ID:	SD-CH-L-LEGION_01
Location:	HUC Code: 10120109
Size of Watershed:	1,510 acres
Waterbody Type:	Reservoir
303(d) Listing Parameter:	pH and DO
Initial Listing date:	1998
TMDL Priority Ranking:	1
Listed Lake Acres:	5.4
Designated Use of Concern:	Coldwater Marginal Fish Life Propagation
Analytical Approach:	***BATHTUB, FLUX***
Target:	Meet all applicable water quality standards, and a pH < 9.0
Indicators:	pH and Dissolved Oxygen Concentrations
WLA:	***0***
LA:	***0.022 kg/Day total phosphorus***
MOS:	***Implicit***
TMDL:	***0.022 kg/Day total phosphorus***

Horse Thief Lake Phosphorus Total Maximum Daily Load Summary Table

Entity ID:	SD-CH-L-HORSETHIEF_01
Location:	HUC Code: 10120109
Size of Watershed:	1,842 acres
Waterbody Type:	Reservoir
303(d) Listing Parameter:	pH
Initial Listing date:	2006
TMDL Priority Ranking:	1
Listed Lake Acres:	15.1
Designated Use of Concern:	Coldwater Permanent Fish Life Propagation
Analytical Approach:	***BATHTUB, FLUX***
Target:	Meet all applicable water quality standards, and a pH < 9.0
Indicators:	pH
WLA:	***0***
LA:	***0. 11 kg/Day total phosphorus***
MOS:	***Implicit***
TMDL:	***0. 11 kg/Day total phosphorus***

2.0 Introduction

The intent of this document is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA. This TMDL document addresses the pH impairments in ecoregion 17b, the Black Hills Plateau, as well as the specific TMDL components of three pH impaired assessment units, SD-CH-L-CENTER_01, SD-CH-L-HORSETHIEF_01, and SD-CH-L-LEGION_01.

1.1 Study Area Characteristics

The 2010 South Dakota Integrated Report lists 19 lakes and reservoirs as violating the pH standard defined by their beneficial uses. Three of these 19 waterbodies are located in ecoregion 17b, the Black Hills Plateau. The three impaired reservoirs are separated by less than 10 miles. The similarities between these reservoirs were a primary consideration in the decision to consolidate them into a single evaluation.

In addition to the three lakes that are listed as impaired for high pH readings, six other reservoirs located within the ecoregion were also included in the evaluation. Including all of these reservoirs provided an ecoregion approach which created a more robust dataset from which to derive the cause of the pH impairments. Table 1 includes descriptive statistics and the coldwater fishery designations of the reservoirs evaluated. The pH standard was exceeded in at least one sample from each of the nine waterbodies with the exception of Pactola. Future listings in this ecoregion may utilize this evaluation as an aid in waterbody specific TMDL development.

Table 1. Ecoregion 17b (Black Hills Plateau) Reservoir Data

Lake ID	Lake Name	pH Listing	Coldwater Fishery	Max Depth (ft)	Size (acres)	Drainage Area (acres)
2102	Lakota	No	Marginal	21	9.9	8060
2103	Bismark	No	Marginal	26	23.0	2508
2105	Center	Yes	Permanent	40	22.7	6070
2107	Legion	Yes	Marginal	20	5.4	1510
2110	Stockade	No	Marginal	42	113.7	49345
2111	Sylvan	No	Permanent	36	13.3	572
9213	Horse Thief	Yes	Permanent	35	15.1	1842
9223	Pactola	No	Permanent	99	822.1	206586
9233	Sheridan	No	Permanent	96	367.9	93125

Ecoregion 17b is an unglaciated plateau in the mid elevations of the Black Hills in Western South Dakota (Figure 1). Its extents reach 80 miles north to south and 40 miles east to west. It includes areas of sharply tilted metamorphic rock and lower elevation granite outcrops. Areas of limestone are characterized by caves, springs, and consistent yearly stream flow. Ponderosa pine forest is the dominant vegetation, however areas of aspen, paper birch, and spruce may be found in drainages and wet meadows. (Omernik, 1996)

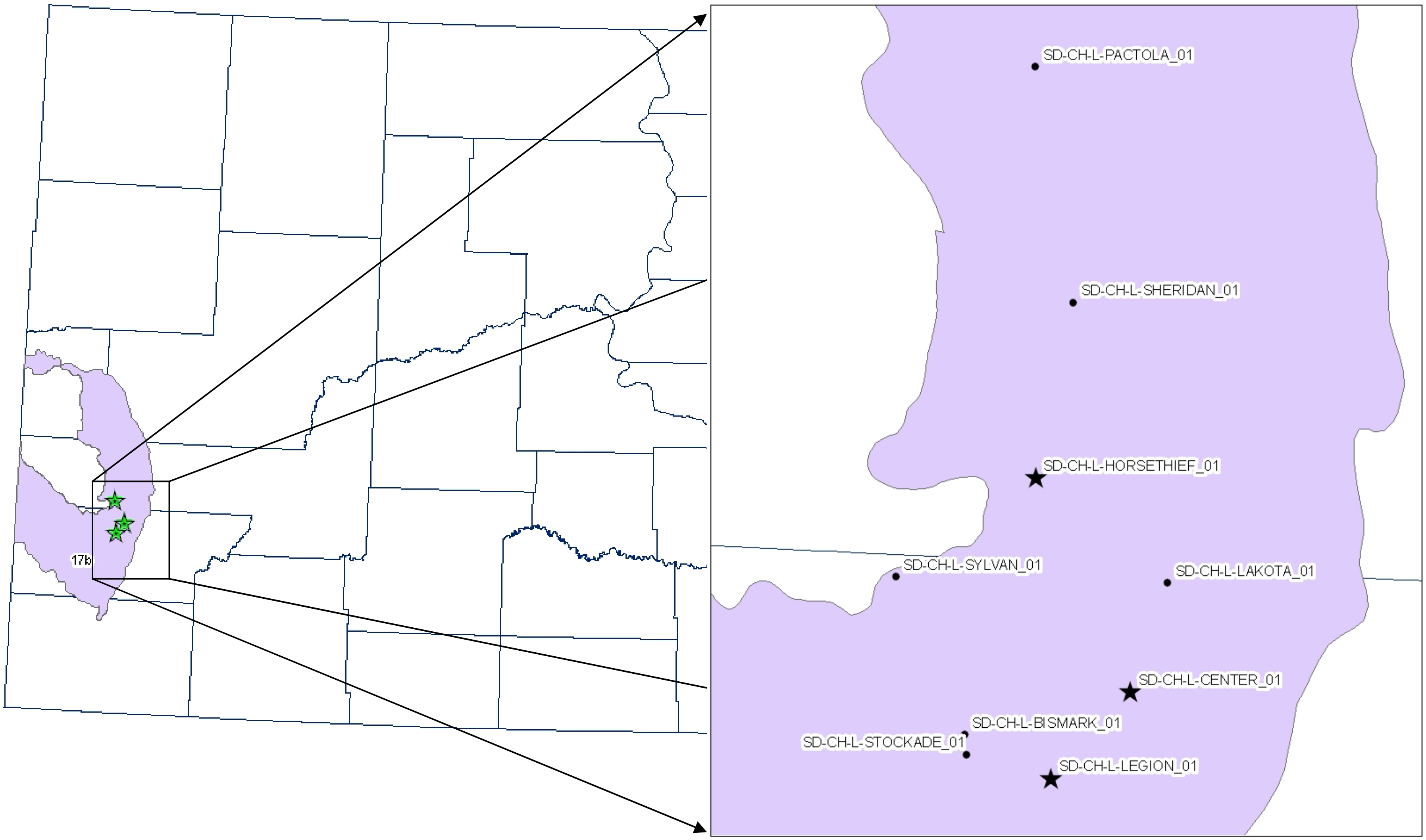

Figure 1. Black Hills Plateau and Assessment Unit Locations in South Dakota

The data included in this report represents the entire ecoregion, but the distribution of reservoirs and their drainage areas is limited to a 150,000 acre region along the eastern edge of the ecoregion (Figure 2). The reservoirs are divided among seven 12 digit Hydrologic Units (HUC). Included among these are Iron Creek (101201090803), Stockade Lakes-French Creek (101201090603), Pactola Reservoir-Rapid Creek (101201100201), Sheridan Lake-Spring Creek (101201090905), Newton Fork-Spring Creek (101201090904), Grizzley Bear Creek-Battle Creek (101201090802), and Upper Grace Coolidge Creek (101201090805).

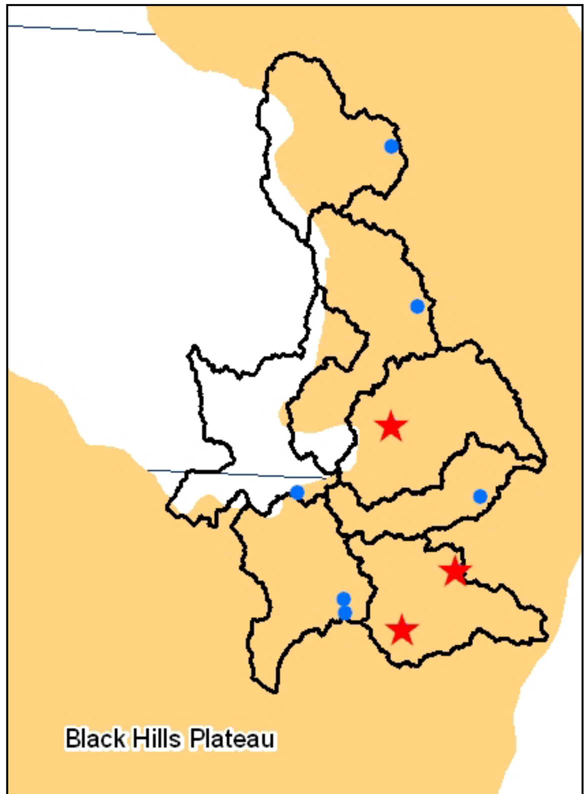

Figure 2. Twelve Digit Hydrologic Units Associated with Black Hills Plateau Reservoirs

A large portion of the Newton Fork-Spring Creek HUC is located within ecoregion 17c (Black Hills Core Highland). This HUC contains the Sylvan Lake drainage and eventually reaches Sheridan Lake.

Primary soils include; Bullflat-Cordeston silt loams (BsB), Buska-Mocmont-Rock outcrop (BtE/BuE), Buska-Virkula loams (BvC), Cordeston loam (CvB), Cordeston-Marshbrook loams (CwB), Hilger-Virkula (HoD), Pactola-Virkula Rock outcrop (PaE), Rock outcrop-Mocmont (RkG), Rock outcrop-Pactola (RIG), and Virkula-Pactola (VpC). (USDA, 1990) Many of these soils have a significant portion that is characterized by unweathered rock outcroppings. These predominantly granite soils are carbonate-poor, which results in runoff waters that have relatively low alkalinities (in comparison with many prairie watersheds in South Dakota).

The watershed climate is characterized by warm summers and cold winters. Precipitation falls primarily as rainfall with the heaviest accumulations during late spring and early summer. Annual snowfall rates average between 39 and 45 inches. Thunderstorms are frequent, typically occurring approximately 42 days each year. (USDA, 1990)

The largest communities in the drainage basins are Custer, Hill City, and Keystone. The population is estimated to be approximately 3,800 people with the majority living in or near the communities of Hill City and Custer.

The Black Hills Plateau covers 962,000 acres of the Black Hills. Public lands compose 795,000 acres or 83% of the ecoregion. The largest component of the public land is the Black Hills National Forest, accounting for over 640,000 acres. State lands such as

Custer State Park cover approximately 65,000 acres. Remaining public acres are divided among Bureau of Land Management, National Park Service, and other public lands.

Landuse in the ecoregion is broken down in Table 2. Over 97% of the ecoregion remains in native vegetation, which is predominately a ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, but the predominant form of agriculture is livestock grazing.

Table 2. Landuse in Ecoregion 17b

Landuse	Percentage
NLCD - Evergreen Forest	62%
NLCD - Grassland Herbaceous	30%
NLCD - Shrubland	5%
NLCD - Developed	1%
NLCD - Cropland	1%
Other	1%

3.0 Significant Sources

3.1 Point Sources

There are no point source discharge permits located in the drainage for any of the lake TMDLs addressed in this report; Center, Legion, or Horse Thief.

3.2 Non Point Sources

3.2.1 Center Lake

The source of phosphorus loading from the Center Lake watershed is a combination of septic system failure, recreational uses, vehicle traffic, as well as natural background sources (i.e. wildlife, weathering, etc.). However, degraded water quality in Center Lake is primarily attributed to recreational activity within the watershed. Approximately 90% of the watershed land area is managed by the SD Department of Game, Fish and Parks (Custer State Park), while the remaining 10% is managed by the US Forest Service. Although much of the watershed remains in its natural state, the intense usage of recreational facilities within Custer State Park has degraded the watershed condition.

Additional restroom facilities, waste receptacles, and fish-cleaning stations are recommended for the Center Lake recreational area to reduce the litter and human waste associated with the recreational use of Center Lake. Park managers should also consider alternative wastewater treatment options to replace or enhance the current septic system servicing the Center Lake recreational area.

Roadways near Center Lake and streams contributing to Center Lake should be inspected for erosion and excess weathering. Identified erosional areas should be repaired or stabilized to prevent further erosion. Stream bank and shoreline protection and enhancement are also recommended to allow sediment and nutrient loads to be filtered and reduced before reaching the lake.

Implementation of the management practices recommended above should result in a 70% reduction of the total phosphorus load to Center Lake, which is required to achieve the TMDL target of a median chlorophyll and Secchi depth TSI $\leq$48.

3.2.2 Legion Lake

Since phosphorus was identified as a limiting nutrient for algae growth, watershed or external phosphorus loads should be maintained or reduced using management practices recommended in the assessment report. External loads could be reduced with the implementation of riparian zone management and construction of wetlands on the inlet stream.

Non-point sources of phosphorus from the watershed (external load) are only a portion of the total phosphorus load to Legion Lake. Internal phosphorus loading from lake bottom sediment is another source of phosphorus and can also be controlled. Alum treatment and aeration/ circulation methods are recommended to remove phosphorus from the lake water column.

The TMDL target can be maintained with the implementation of the above recommended management practices.

3.2.3 Horse Thief Lake

Nonpoint sources of pollution in the Horse Thief Lake Watershed have been mitigated through numerous changes in the watershed as well as through BMP installation by the US Forest Service. To fully understand the impacts to the lake over time, knowledge of the areas settlement and history is of importance.

Beginning with the discovery of gold in French Creek in 1874, the Black Hills began to experience an immediate in migration of prospectors and settlers. By the turn of the century, logging and prospecting were primary occupations in the area. Evidence of each of these activities is still visible within the Pine Creek drainage today.

After the turn of the century, numerous roads were carved throughout the Black Hills and were constructed without consideration for environmental impacts. Many of these roadways experienced significant erosion. Often located along drainages, stream yields would have been significant. Documentation for the construction and life use of the these roadways is non existent, and many were used for short time periods, however their impacts persisted for years after abandonment.

Beginning in 1920, the watershed received its first level of protection from Congress through the establishment of the 35,000 acre Norbeck Wildlife Preserve. Through its establishment, all motorized and wheeled traffic was eliminated, insuring that additional road use and construction would halt.

On July 3, 1932, a portion of the Pine Creek watershed was designated as a Research Natural Area (RNA). Existing documentation states that at this point, no roads or trails existed in this portion of the watershed. Its establishment was to provide an area of "virgin or unmodified condition" for "preservation for present and future generations". While no maps of this area will be included, it is important to note that the RNA covers about 460 acres of the Horse Thief Watershed.

In 1980, the Black Elk Wilderness was established which covered a majority of the watershed. This designation further restricted use of the trails eliminating bicycles and large groups as well as adding further protection to aquatic resources.

The final aid to the watershed occurred on September 23rd, 1993 with the establishment of the Peter Norbeck Scenic Byway which includes Highway 244 which crosses the dam. Grants from Department of Transportation byway funds have been used by the Forest service to complete many of the erosion control projects found near the lake and throughout the watershed. These activities are detailed in section 8.3 of this document.

4.0 Technical Analysis

4.1 Data Collection and Methods

Data in ecoregion 17b was collected through numerous sources including ambient monitoring programs such as the SD DENR Statewide Lake Assessment Project as well as individual projects such as the Custer State Park Lakes assessment. Samples included in the analysis were limited with respect to their completeness of measurements. To prevent bias associated with partial samples, only those that included all of the following parameters were included; pH, chlorophyll a, phosphorus, and nitrogen. Data were not excluded based on the age of the sample. The resulting dataset consisted of 94 samples from the nine reservoirs. The omission of partial samples results in a dataset that may not be used to determine support status for any given waterbody.

All modeling analysis was completed according to the most recent version of the Water Quality Modeling in South Dakota document (SDDENR, 2009), except where noted.

Table 3 includes a general overview of the water chemistry of each waterbody evaluated for comparison. These concentrations were developed by averaging the surface samples utilized in this analysis. Phosphorus and nitrogen concentrations were rounded to the nearest 10 ppb.

Table 3. General Chemistry of Ecoregion 17b Reservoirs

Lake ID	Lake Name	pH Listing	Coldwater Fishery	Alkalinity (PPM)	Phosphorus (PPB)	Chlorophyll *a* (PPB)	Nitrogen (PPB)
2102	Lakota	No	Marginal	40	90	15	620
2103	Bismark	No	Marginal	59	200	13	1370
2105	Center	Yes	Permanent	46	50	15	680
2107	Legion	Yes	Marginal	66	60	10	1010
2110	Stockade	No	Marginal	119	340	13	1750
2111	Sylvan	No	Permanent	39	120	44	1080
9213	Horse Thief	Yes	Permanent	33	130	23	1030
9223	Pactola	No	Permanent	150	20	2	260
9233	Sheridan	No	Permanent	122	60	8	670

4.2 Hydroxide

Pure water dissociates weakly into H^+ and OH^- ions. The dissociation constant is very small (10^{-14}), however, and the amounts of H^+ and OH- present are 10^{-7}g-ions per liter. Impurities in natural waters such as acids, bases, and salts affect the concentration of these ions. It is measured as pH and defined as the logarithm of the reciprocal of the free hydrogen ions. (Wetzel, 2001)

A pH of 7 is considered neutral, at which point there is a balance of H^+ and OH^- ions. An increase in either of these ions results in an equivalent decrease in the other ion. In the case of the Ecoregion 17b reservoirs, the pH is frequently too high, which may be described as an absence of H^+ ions or an excess of OH^- ions. A pH of 9 representing 10^{-9} H^+ ions per liter may also be described accurately as a pOH of 5, representing 10^{-5} OH^- ions per liter.

A review of the effects of pH on freshwater fish has been published by the European Inland Fisheries Advisory Commission (EIFAC, 1969). The Commission concluded: “There is no definite pH range within which a fishery is unharmed and outside which it is damaged, but rather, there is a gradual deterioration as the pH values are further removed from the normal range. The pH range which is not directly lethal to fish is 5-9; however, the toxicity of several common pollutants is markedly affected by pH changes within this range, and increasing acidity or alkalinity may make these poisons more toxic. Also, an acid discharge may liberate sufficient CO_2 from bicarbonate in the water either to be directly toxic, or to cause the pH range 5-6 to become lethal.” (USEPA, 1976)

When the pH of freshwater becomes too high (> 9.6), the effects on fish may include: death, damage to outer surfaces like gills, eyes, and skin and an inability to dispose of metabolic wastes. High pH may also increase the toxicity of other substances. For example, the toxicity of ammonia is ten times more severe at a pH of 8 than it is at pH 7. It is directly toxic to aquatic life when it appears in alkaline conditions.

pH and pOH values cannot be averaged arithmetically, so the average must be estimated from the logarithm of the reciprocals. The pH values for each of the reservoirs were converted to pOH (14 – pH = pOH). The log of the reciprocals was used to create the chart in Figure 3. Lakes in this ecoregion are impacted by alkaline conditions that result in elevated pH values, as a result, the OH^- ions were chosen over the H^+ ions to generate a positive response in the calculations and graphics.

Figure 3 presents the hydroxide ion concentrations for the various lakes evaluated in the ecoregion. The line drawn at a concentration of 0.00001 represents a pH of 9.0, the upper boundary of the states water quality standards.

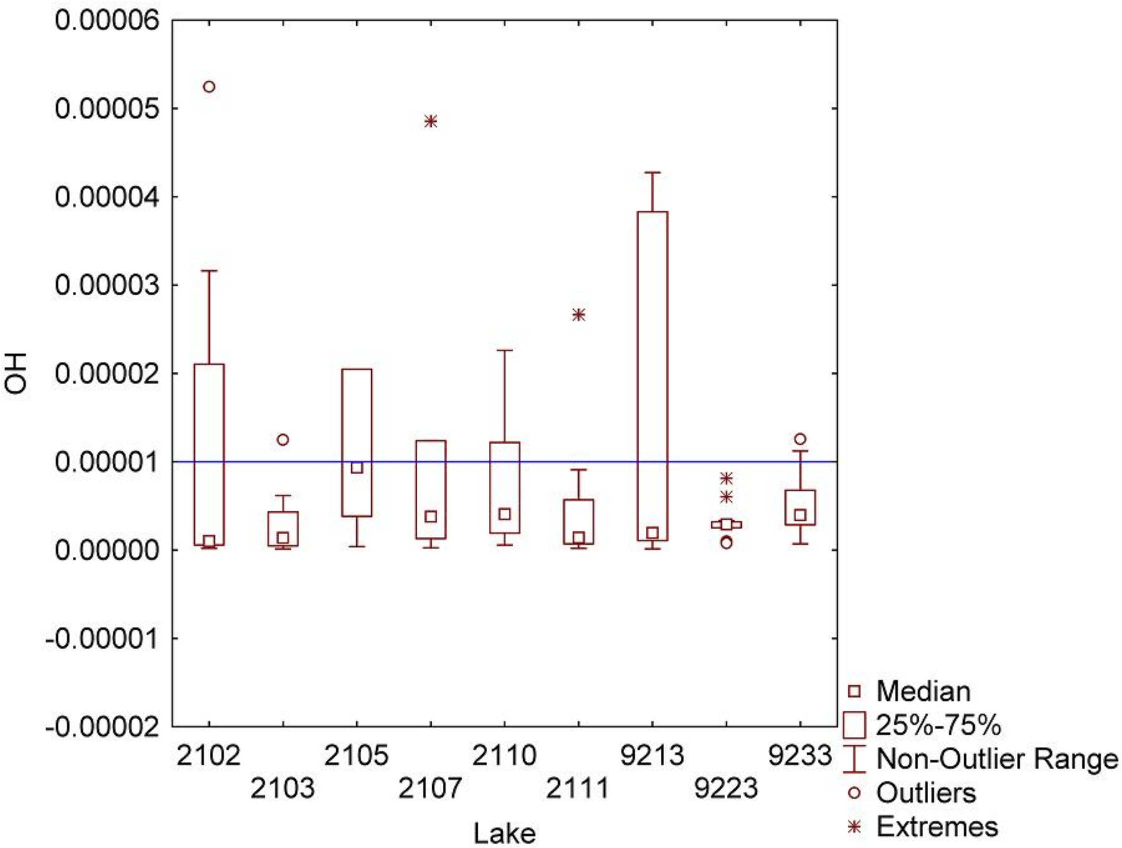

Figure 3. Hydroxide Ion Concentrations for Ecoregion 17b Reservoirs

Horse Thief Reservoir (9213) experiences the greatest variability in measured pH values. This reservoir also has the lowest alkalinity concentrations, which would normally act as a buffer to these wide variations.

Center and Legion Reservoirs (2105 and 2107 respectively) appear to be very similar to both Lakota and Stockade (2102 and 2110 respectively). The median value for Center Lake is quite obviously higher than any of the other waterbodies, and is very near to the threshold value of 9.0.

Legion (2107), Lakota (2102), and Stockade (2110) each have similar median values and distributions. Although Legion Lake is the only one of these waterbodies that is currently listed as impaired, the similarities between these waterbodies suggest the potential for impairment in the other two. Continued long term monitoring as a part of South Dakotas statewide lakes assessment project will help define the need for TMDL development for Lakota and Stockade. If impairment is determined, this document may be utilized to help develop the TMDL as well as remediation plans.

4.3 Alkalinity

Alkalinity is a term that refers to the buffering ability of the carbonate system in water. The term is also used interchangeably with 'acid neutralizing capacity' (ANC), which is the capacity to neutralize strong inorganic acids (Wetzel, 2001). Alkalinity is a product of geological setting. Soils rich in carbonate rock, such as limestone, provide a source of high alkalinity (Monson, 2000). In general, increased alkalinity inhibits drastic pH changes. Alkalinity typically ranges from 20 to 200 mg/L in natural environments (Lind, 1985). The alkalinities of the reservoirs in this ecoregion are generally quite low, particularly when compared to measurements made in prairie systems in South Dakota, Figure 4.

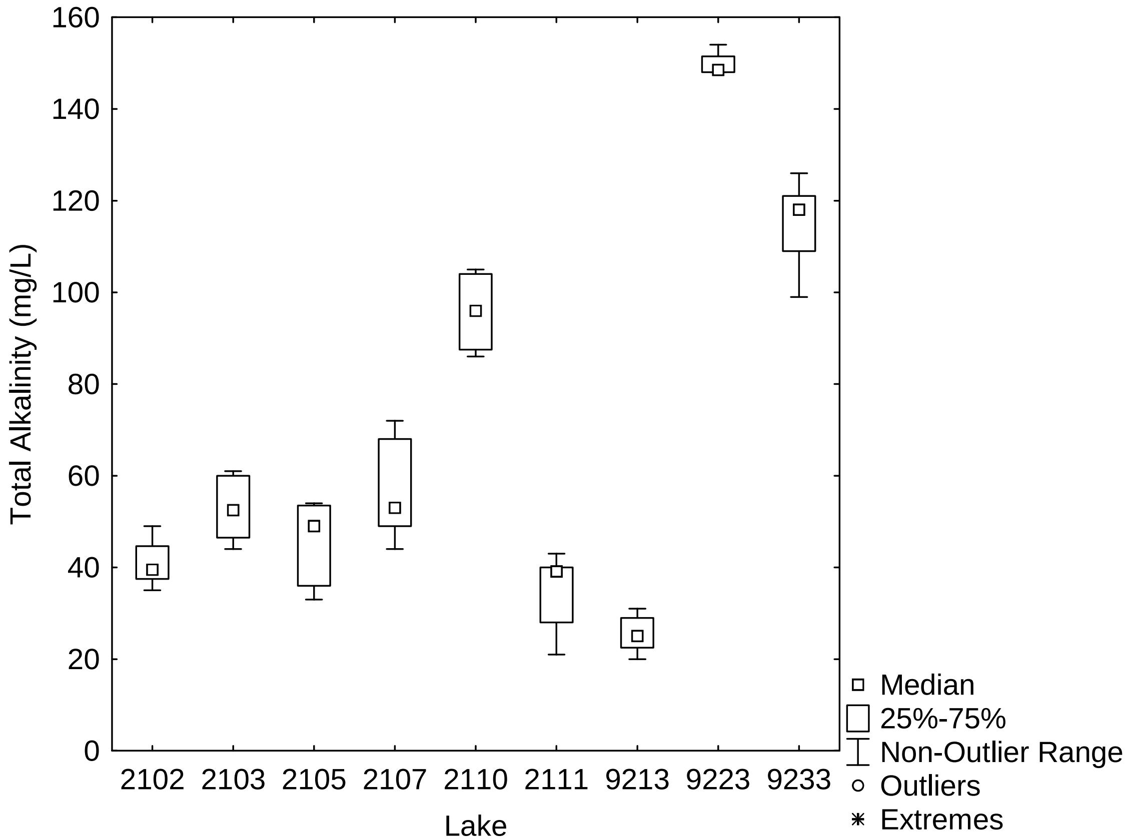

Figure 4. Alkalinity Concentrations for Ecoregion 17b Reservoirs

The reservoirs with larger drainage areas tended to have higher alkalinities than those with relatively small drainages. As water percolates through soil of a drainage basin, it becomes enriched with CO2 from plant and microbial respiration. The carbonic acid that forms solubilizes limestone of calcium-enriched rock formations and produces calcium bicarbonate, which is relatively soluble in water, and increases the amount of ionized Ca^{++} and HCO^{3-} of the water. (Wetzel, 2001)

Horse Thief Reservoir (9213) has a particularly low alkalinity which makes it the most susceptible to changes in pH and can be attributed to the wide range of pH values measured.

4.4 Phosphorus and Nitrogen

Phosphorus and nitrogen are nutrients that are essential to plant growth. While not directly linked to elevated pH concentrations, increased concentrations of either nutrient can result in excessive macrophyte and algae growth in the waterbody. Increased respiration from excessive macrophyte and algae growth results in processes that elevate the pH.

The ratio of nitrogen to phosphorus (N:P) considered optimal for plant growth is commonly accepted to be approximately 10:1. The ecoregion 17b reservoirs had an average N:P ratio of 17:1, suggesting that the limiting nutrient is phosphorus. Reducing the phosphorus entering the reservoirs is expected to result in a reduction of aquatic biomass.

Nutrient concentrations in this ecoregion are some of the lowest measured in South Dakota. Pactola reservoir (9223) has the lowest measured nutrient concentrations in the state and at times approaches conditions that would be classified as oligotrophic on the Carlson TSI Scale (Figures 5 and 6).

Pactola has significantly lower nutrient concentrations than the remaining lakes in the ecoregion. The remaining lakes show no clear pattern linking the concentrations of either nitrogen or phosphorus to elevated pH values. The more important link is that Pactola has not been measured over the standard while all of the remaining lakes have at least 1 sample that exceeds the standard. This reinforces that nutrient reductions that result in lower lake productivity levels will result in fewer pH violations.

The allowable nutrient concentration for each lake will be slightly different as a result of factors (including but not limited to) lake depth, alkalinity, and surface area. Bismark (2103) Reservoir has the highest nitrogen and phosphorus concentrations but an alkalinity that is very similar to Center (2105) and Legion (2107). The pH measured in Bismark is consistently some of the lowest values recorded.

This suggests that a single nutrient value for the entire ecoregion would be inappropriate. Concentrations found in Bismark are high enough to cause impairment in most, if not all of the remaining reservoirs. Concentrations found in Pactola would be unnecessarily restrictive, as Bismark is currently fully supporting its uses. Lake specific TMDLs will be developed utilizing the ecoregion as a guide to help define each lakes specific needs.

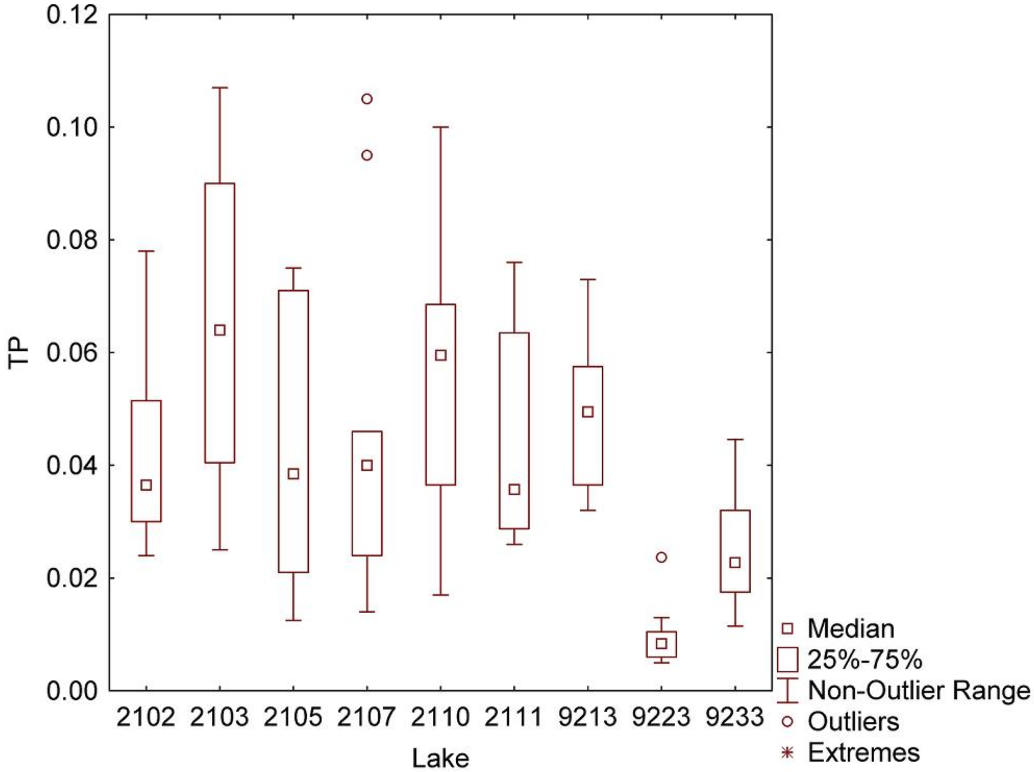

Figure 5. Total Phosphorus Concentrations for Ecoregion 17b Reservoirs

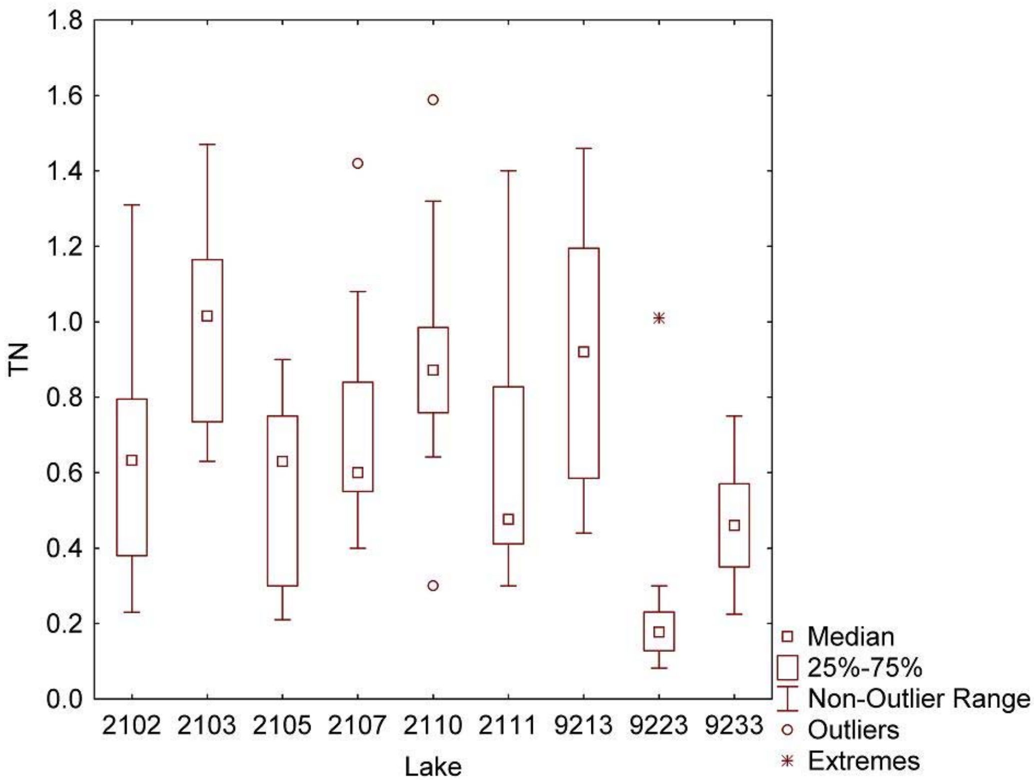

Figure 6. Total Nitrogen Concentrations for Ecoregion 17b Reservoirs

4.5 Chlorophyll a

Chlorophyll *a* is the green pigment found in algae and is commonly used as an estimate of biomass. Variability is introduced to estimates through algal cells within the water column that are in various stages of decomposition. Correcting for degradation products improves these estimates.

Chlorophyll *a* data that was not corrected for degradation products was selected for this report. This results in slightly higher biomass estimates and additional variability in regression analysis. The method used to correct for degradation products was modified in 2000 to improve accuracy and consistency, however the method used for the uncorrected data remained the same. Due to the large amount of data that was collected prior to the method modification, the uncorrected data were selected to eliminate lab bias. The underlying assumption is that many of the concentrations were sufficiently low and lab bias would be greater than the bias introduced by including degradation products.

Figure 7 depicts the variability among reservoirs in the ecoregion. As with the other parameters, Pactola emerged as a potential outlier representing a condition that is exceedingly low in primary productivity. This reference condition is not necessarily the condition the other reservoirs need to attain full support their beneficial uses, but simply acts as evidence that nutrient reductions are the appropriate approach to achieving reduced pH values.

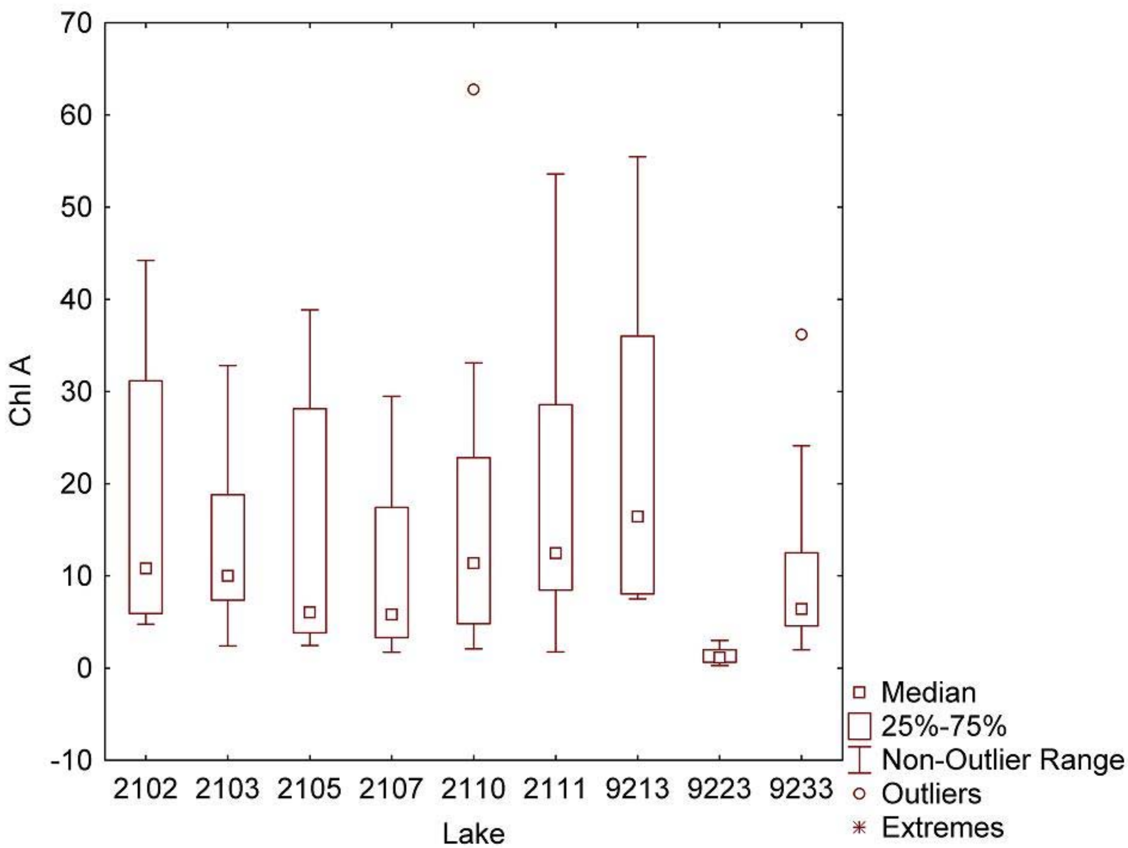

Figure 7. Chlorophyll *a* Concentrations for Ecoregion 17b Reservoirs

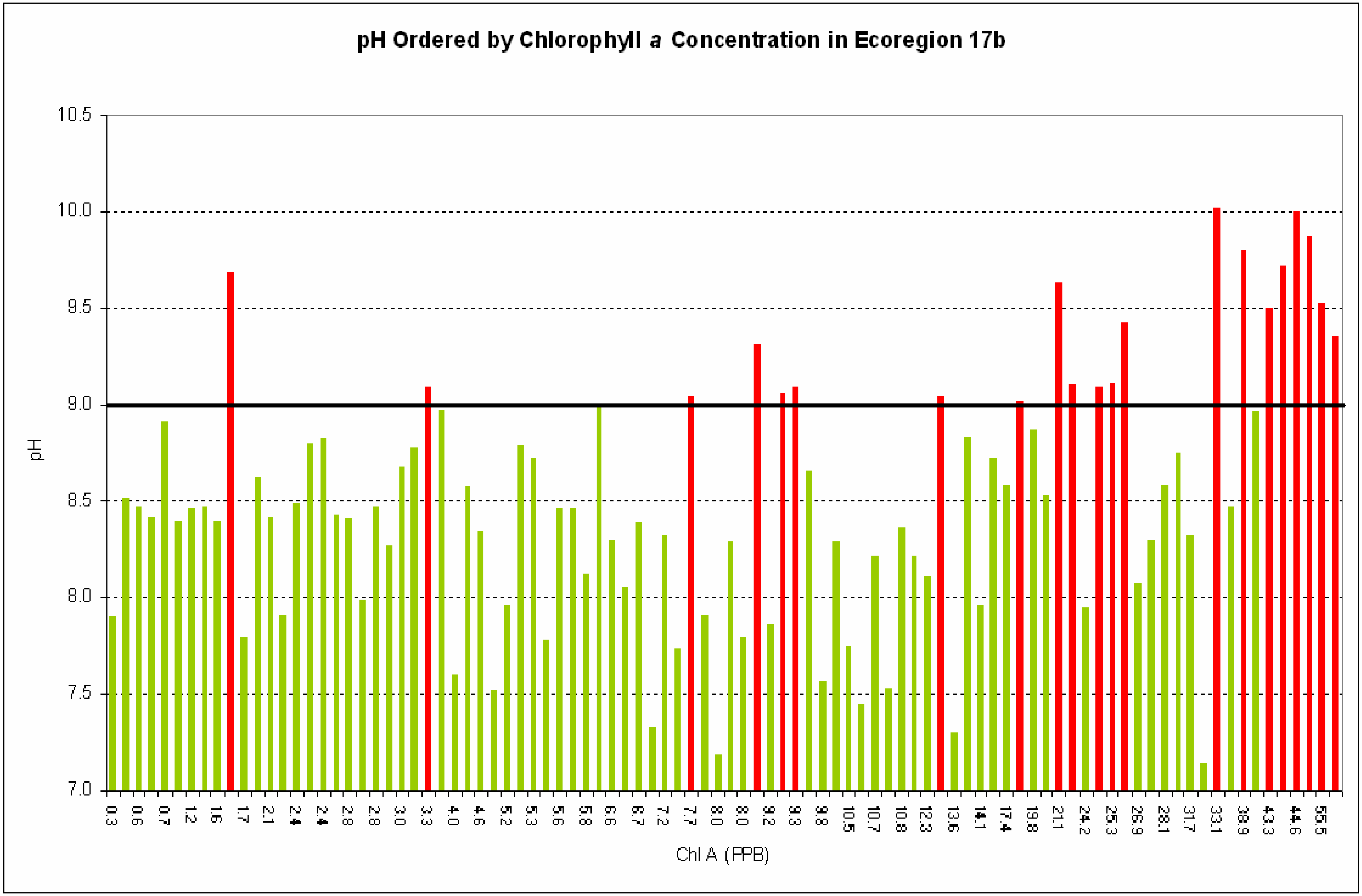

Figure 8. pH Ordered by Chlorophyll *a* Concentration in Ecoregion 17b

Figure 8 breaks down the pH data into individual samples from all of the reservoirs, rank ordered by increasing chlorophyll *a* concentrations. It is evident that as chlorophyll concentrations increase, the number of samples that exceed the pH standard of 9.0 also increases.

Figure 9 plots the same data as Figure 8 utilizing a different method. It depicts the percentage of samples below a given chlorophyll concentration that exceed the water quality standard. To account for variability, listing methodology used in South Dakotas Integrated Report allows for up to 10% of the data to exceed the standard. The trend line in figure 9 crosses the 10^{th} percentile at 11.5 ppb chlorophyll a. Variability in the data suggests that acceptable values may range from 9 to 12.5 ppb depending on the individual waterbody. Any additional reductions beyond this may be considered a margin of safety.

Sections 5.1 through 5.3 of this document will address the necessary reductions in phosphorus to achieve chlorophyll a concentrations necessary for full support of the beneficial uses in each lake.

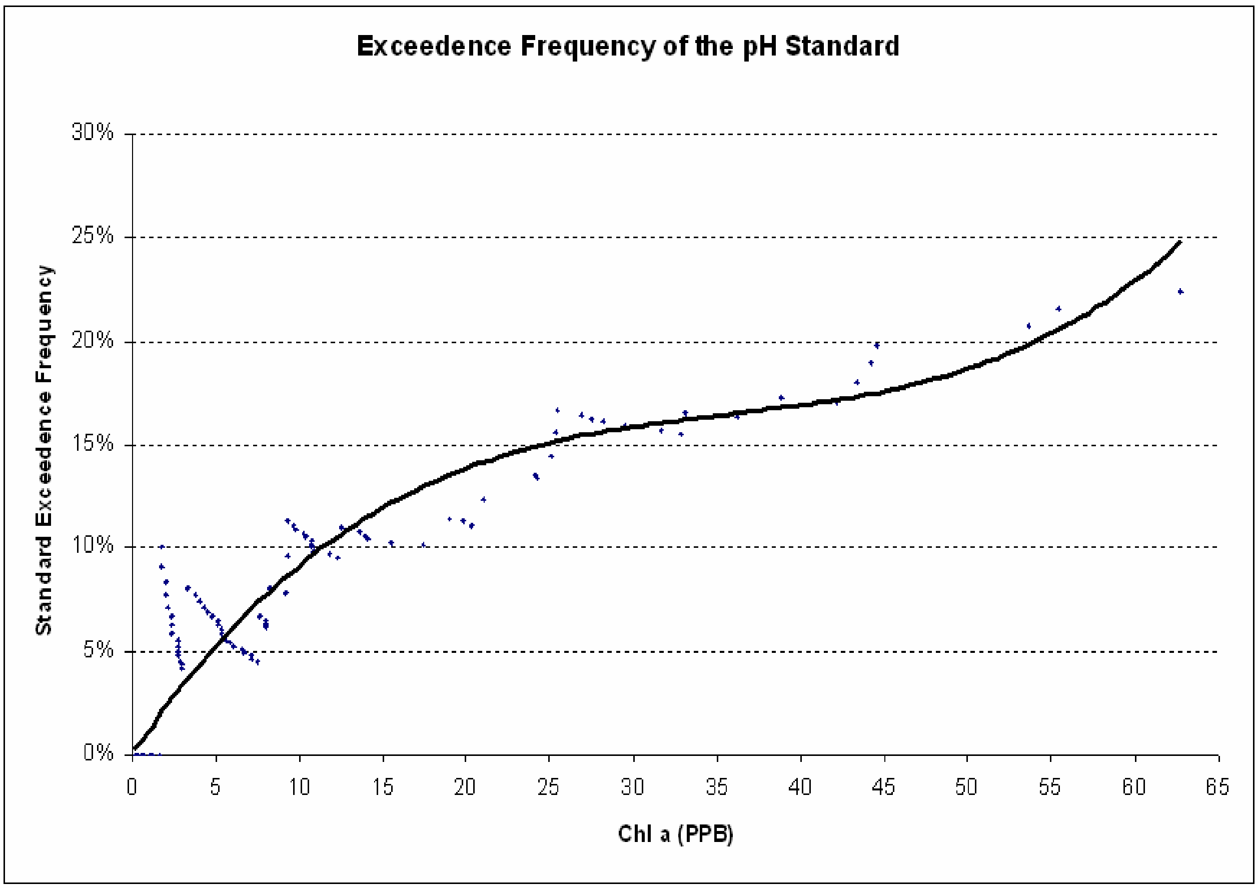

Figure 9. Exceedence Frequency of the pH Standard Related to Chlorophyll a

5.0 Total Maximum Daily Loads

The three waterbodies listed in South Dakotas 2010 Integrated Report will each be evaluated individually taking into consideration the information found in section 4.0 of this report.

Center and Legion Lakes have existing phosphorus TMDLs that did not address the pH impairments. In each of these cases, this report will evaluate the phosphorus goals set in the approved TMDL and determine if they are sufficient to obtain the pH standard. Portions of the TMDLs and final reports will be replicated within this document to facilitate an understanding of the waterbody without requiring the reader to reference the original document(s).

As a result of variability in datasets (inclusion of newer data and omission of incomplete samples) between section 4.0 and the replicated sections of these reports, some difference in calculated values will be observed. The values in the replicated sections were not adjusted unless necessary in order to maintain consistency between this and the original documents.

Horse Thief Reservoir does not have a phosphorus TMDL. This report will establish a phosphorus limit for this waterbody based on the ecoregion data evaluated in section 4.0.

5.1 Center Lake (2105)

5.1.1 Watershed Description

The Center Lake watershed is approximately 6,270 acres and is located in the north half of Custer State Park. The Center Lake watershed contains heavily forested areas with several campgrounds, day use facilities, the Black Hills Playhouse complex, and beach area facilities in close proximity to the lake and its associated tributaries. The watershed and the sampling locations are shown in Figure 10. Average annual precipitation is approximately 25.4 inches. Approximately 73 % of the precipitation occurs during the months of April through September. In the summer, the average temperature is 65 degrees F. During the winter, the average temperature is 31 degrees F.

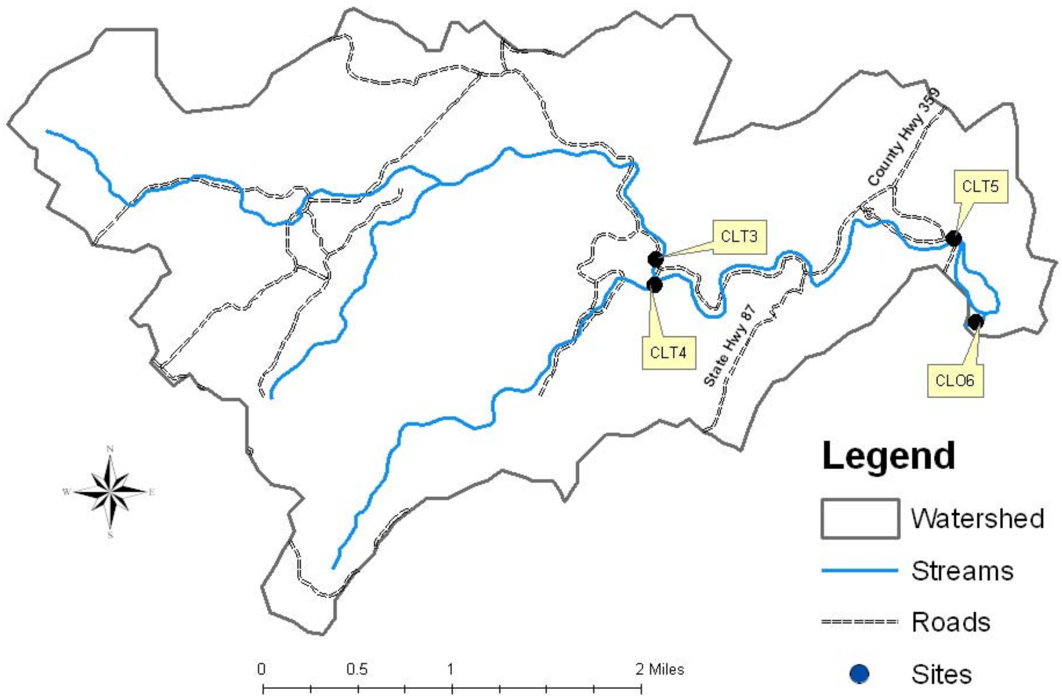

Figure 10. Center Lake Watershed and Tributary Sites, Custer County, SD.

The primary landuses in the watershed are forestry and recreational. The streams in this watershed drain predominantly forested land and receive runoff from relatively undisturbed lands. The major soil association found in the Center Lake watershed is Buska-Mocmont-Rock outcrop, defined as follows: Rock outcrop and deep, well drained, gently sloping to very steep, loamy soils formed in material weathered from micaceous schist and granite; on mountains.

The primary inflow to Center Lake is Grace Coolidge Creek, draining approximately 6,270 acres. The outlet for Center Lake is also Grace Coolidge Creek. The entire Center Lake watershed is in Custer County, which has a population of 7,275 residents as recorded in the year 2000 census.

5.1.2 Beneficial Use Assignment and Water Quality Standards

Each waterbody within South Dakota is assigned beneficial uses. All waters (both lakes and streams) are designated the use of fish and wildlife propagation, recreation and stock watering. All streams are assigned the use of irrigation. Additional uses may be assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in South Dakota state statutes in support of these uses. These standards consist of suites of numeric criteria that provide physical and chemical benchmarks from which management decisions can be developed.

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the states water quality standards, this is the method used in the states Integrated Water Quality Report (IR) as well as in permit development.

Additional “narrative” standards that may apply can be found in the “Administrative rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09”. These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The following beneficial uses have been assigned to Center Lake: (1) coldwater permanent fish propagation, (2) immersion recreation, (3) limited contact recreation, and (4) wildlife propagation, recreation and livestock watering. Table 4 lists the criteria that must be met to maintain the above beneficial uses. When multiple standards exist for a particular parameter, the most stringent standard is used.

Table 4. Surface water quality standards for Center Lake

Parameters	Criteria	Unit of Measure	Beneficial Use Requiring this Standard
Total ammonia nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A of Surface Water Quality Standards	mg/L 30 average	Coldwater Permanent Fish Propagation
	Equal to or less than the result from Equation 1 in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Chlorides	<100	mg/L 30-day average	Coldwater Permanent Fish Propagation
	<175	mg/L Dailey Maximum	
Dissolved Oxygen	>6.0	mg/L Dailey Maximum	Coldwater Permanent Fish Propagation
	>7.0	Mg/L in spawning areas during the spawning season	
Undisassociated hydrogen sulfide	<0.002	mg/L Dailey Maximum	Coldwater Permanent Fish Propagation
pH (standard units)	>6.5 to <9.0	units	Coldwater Permanent Fish Propagation
Total Suspended Solids	<30 (30 day average) <53 (single sample)	mg/L	Coldwater Permanent Fish Propagation
Temperature	<18.3	°C	Coldwater Permanent Fish Propagation
Fecal Coliform Bacteria (May 1- Sept 30)	<200 (geometric mean) <400 (single sample)	count/100 mL	Immersion Recreation
Escherichia Coli Bacteria (May 1- Sept 30)	<126 (geometric mean) <235 (single sample)	count/100 mL	Immersion Recreation
Alkalinity ($CaCO_3$)	<750 (mean) <1,313 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Nitrogen, nitrate as N	<50 (mean) <88 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Solids, total dissolved	<2,500 (mean) <4,375 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon	<10	mg/L	Wildlife Propagation and Stock Watering

5.1.3 Tributary Hydrology and Chemistry

Hydrology of Grace Coolidge Creek

Hydrologic and constituent loads were estimated from sample data and instantaneous flow measurements using the FLUX model in order to develop nutrient and hydrologic budgets for Center Lake. Approximately 447 acre-ft of water flowed into Center Lake from the gauged watershed during the project period. The amount of water delivered per acre for the gauged watershed was 0.07 acre-ft/year. Total flow volume and mean flow rate for each site are listed in Table 5.

Table 5. Hydrologic Loads Delivered from the Center Lake Watershed.

Site	Flow Duration (project period)	Total Flow Volume (hm^3)	Mean Flow Rate (hm^3/yr)	Mean Flow Rate (cfs)
CLT-3	365 days	0.145	0.145	0.147
CLT-4	365 days	0.061	0.061	0.077
CLT-5	365 days	0.552	0.552	0.631
CLO-6	365 days	0.401	0.401	0.439

Note: 1 hm3 = 1,000,000 m3 and 1m3 ≈ 35.3 ft3

Seasonal Loadings

Seasonal and annual loads for each measured parameter (nutrients and solids) were also calculated using the FLUX model (Table 6). Seasonal constituent loads were derived in the following manner: winter is the sum of December, January and February loads; spring is the sum of March, April and May loads; summer is the sum of June, July and August loads; and fall is the sum of September, October and November loads. Relatively consistent loading occurred throughout the study period, with slightly higher loading occurring in the spring due to snowmelt runoff and rain events. Figure 11 and Figure 12 are graphical representations of seasonal annual loading for the nutrients total nitrogen and total phosphorus, respectively.

Table 6. Seasonal and Annual Loads (kg) Delivered from the Center Lake Watershed.

Parameter	Spring	Summer	Fall	Winter	Annual
Total Nitrogen	40.2	39.4	36.3	35.5	151.4
Ammonia	7.3	7.1	6.6	6.5	27.5
Nitrate+Nitrite	3.8	3.6	3.2	3.2	13.8
Total Kjeldahl Nitrogen	36.5	35.8	33	32.3	137.6
Organic Nitrogen	29.2	28.6	26.5	25.8	110.1
Total Phosphorus	12	12	11.9	11.8	47.7
Total Dissolved Phosphorus	9.3	9.2	9.1	9	36.6
Alkalinity	7,052	6,930	6,390	6,329	26,702
Total Solids	11,730	11,527	10,629	10,527	44,414
Total Dissolved Solids	11,127	10,934	10,082	9,986	42,129
Total Suspended Solids	11,127	10,934	10,082	9,986	42,129
Inorganic Nitrogen	10.9	10.8	9.9	9.7	41.3

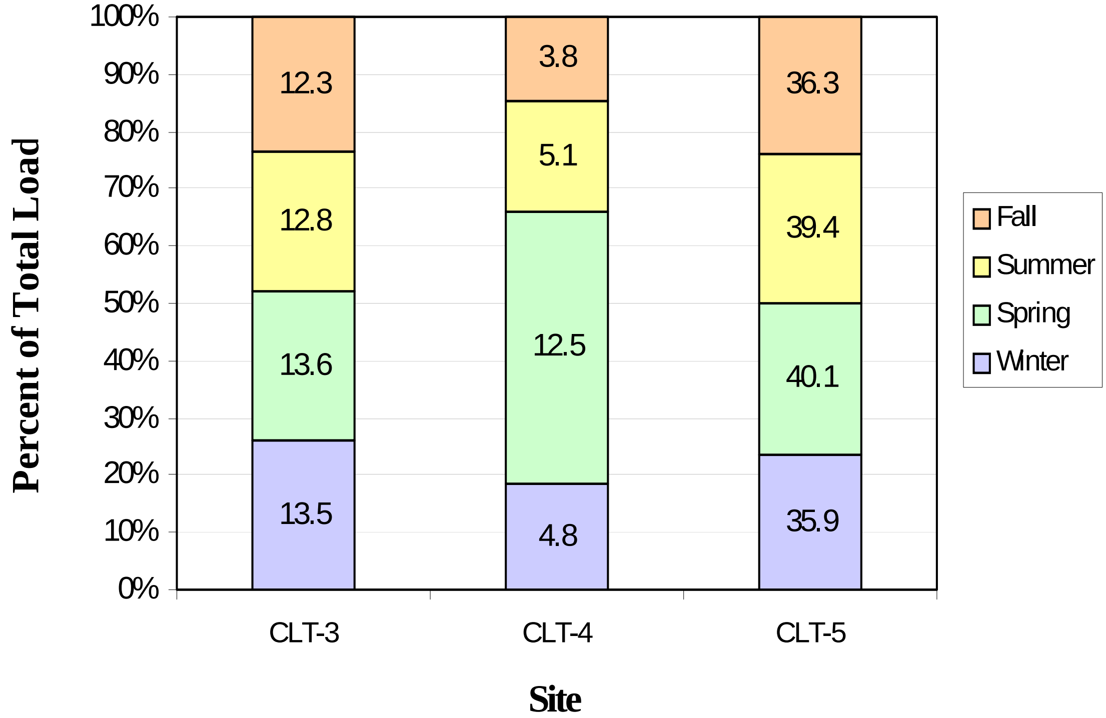

Figure 11. Seasonal Loading of Total Nitrogen (kg) by Tributary Site

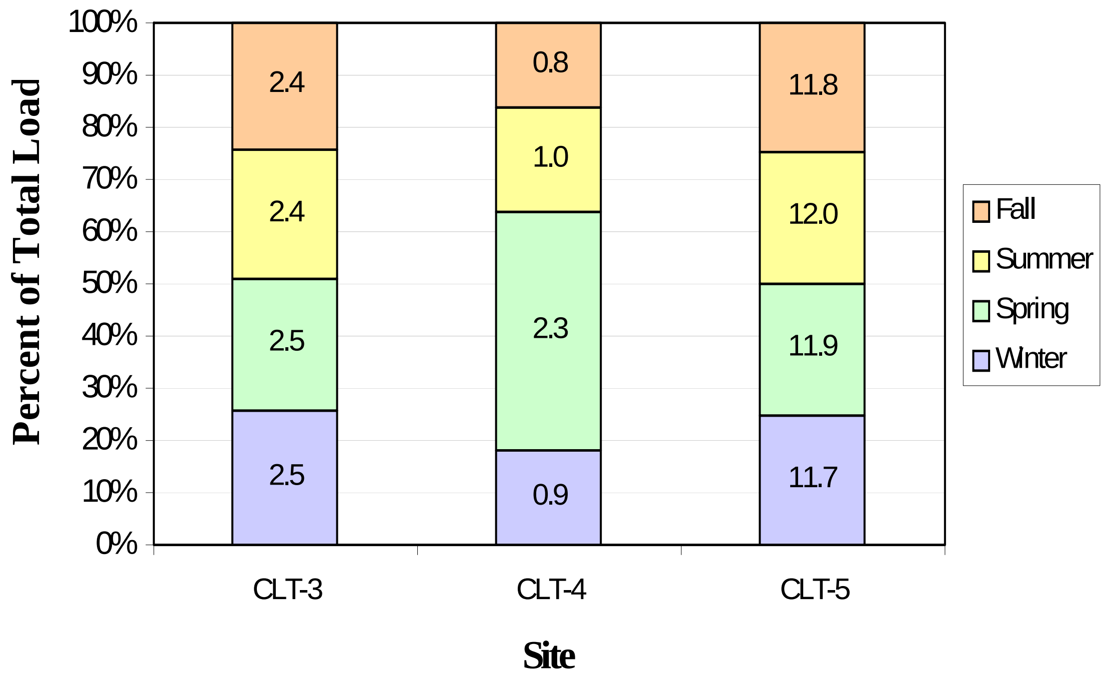

Figure 12. Seasonal Loading of Total Phosphorus (kg) for Tributary Site

Export Coefficients

Export coefficient values were used to make comparisons between subwatersheds CLT-3 and CLT-4, and the total watershed, CLT-5. The CLT-3 subwatershed had higher total solids, higher total dissolved solids and higher alkalinity than subwatershed CLT-4 (Table 7). CLT-4 had higher ammonia, total nitrogen and total phosphorus than CLT-3. The inlet site (CLT-5) represents the whole watershed. CLT-5 exhibited higher export coefficient values than CLT-3 and CLT-4, including total phosphorus export coefficients (Figure 13). These higher total export coefficient values for the inlet indicate a source of nutrients exists in some area of the watershed below CLT-3 and CLT-4.

Table 7. Export Coefficient Values for Each Parameter for all Tributary Sites (kg/acre/yr).

Parameter	**CLT-3**	**CLT-4**	**CLT-5**
Alkalinity	1.60664	0.89747	4.25879
TKN	0.01373	0.01361	0.02199
Nitrite+Nitrate	0.00154	0.00119	0.00219
Ammonia	0.00228	0.00238	0.00440
Organic Nitrogen	0.01139	0.01576	0.01759
Inorganic Nitrogen	0.00389	0.00357	0.00662
Total Nitrogen	0.01611	0.01948	0.02419
Total Phosphorus	0.00302	0.00372	0.00756
Total Dissolved Phosphorus	0.00204	0.00223	0.00582
Total Suspended Solids	0.12657	0.12312	0.36654
Total Dissolved Solids	3.25623	2.78922	6.71925
Total Solids	3.38312	2.92662	7.08367

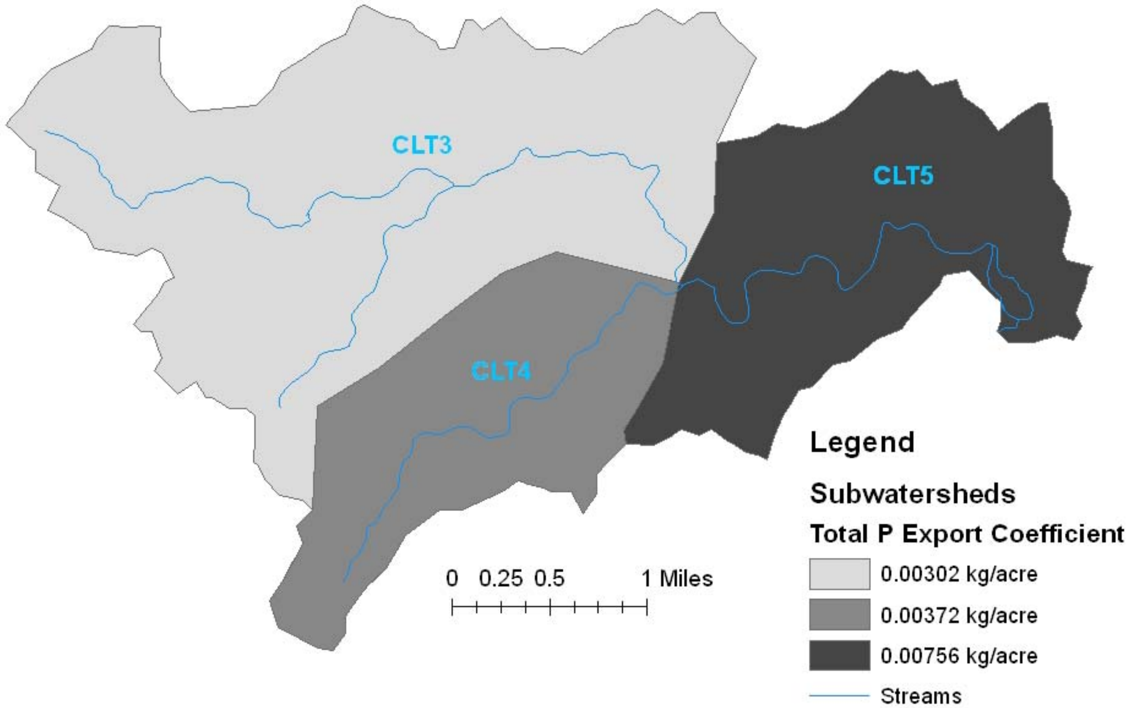

Figure 13. Center Lake Subwatersheds Showing Total Phosphorus Export Coefficients ***(Darker color indicates higher phosphorus delivery)***

Phosphorus

Phosphorus is present in all aquatic systems. Its natural sources include the leaching of phosphate-bearing rocks and organic matter decomposition. Other potential sources of phosphorus include man-made fertilizers, runoff from roadway maintenance operations, leaking and/or otherwise faulty septic systems, animal waste, and runoff from burned areas.

Outlet total phosphorus concentrations are slightly higher than inlet total phosphorus concentrations (Table 8 and Figure 14). Total phosphorus concentrations at the inlet ranged from 0.03 to 0.15 mg/L (mean = 0.09), while concentrations at the outlet ranged from 0.07 to 0.28 mg/L (mean = 0.16) (Table 19). FLUX model output indicated total phosphorus concentration at the inlet was 0.0857 mg/L. FLUX estimated total phosphorus annual load was 47.40 kg, equivalent to 7.6 grams per watershed acre.

Table 8. Descriptive Statistics of Total Phosphorus (mg/L) for Tributary Samples.

Site	Mean	Median	Minimum	Maximum	Standard Deviation
CLT-3	0.070	0.060	0.040	0.130	0.034
CLT-4	0.080	0.090	0.050	0.120	0.030
CLT-5	0.090	0.095	0.030	0.150	0.037
CLO-6	0.164	0.160	0.070	0.280	0.061

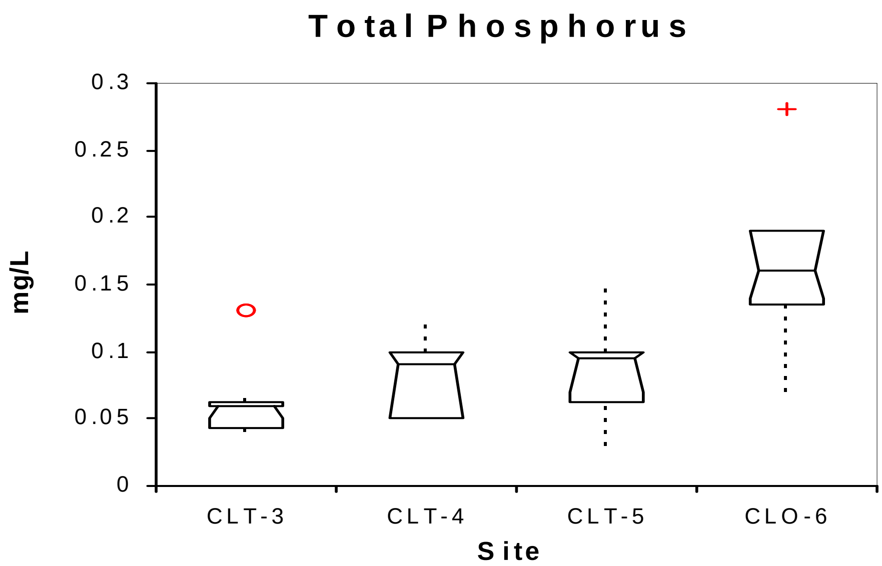

Figure 14. Box Plot of Total Phosphorus for Tributary Sites.

Total dissolved phosphorus (TDP) concentrations at the inlet (CLT-5) ranged from 0.02 to 0.12 mg/L (mean = 0.07), while concentrations at the outlet ranged from 0.01 to 0.11 mg/L (mean = 0.06) (Table 20). TDP concentrations at the inlet and outlet were higher as well as more variable than concentrations at the other two sites (Figure 14). FLUX model output indicated TDP concentration at the inlet was 0.0660 mg/L. FLUX estimated TDP annual load was 36.5 kg, which is equivalent to 5.8 grams per watershed acre.

5.1.4 Reservoir Chemistry

Acidification and Alkalinity

In Center Lake, pH values ranged from 6.7 to 9.7 (Figure 15). Many measurements (40%) at both sites and both depths exceeded the upper limit of the water quality criterion, which requires pH values to fall within a range of 6.5 to 9.0 for cold water permanent fish propagation (Figure 15). Because greater than 10% of the pH measurements exceeded the criterion, a pH TMDL is required for Center Lake.

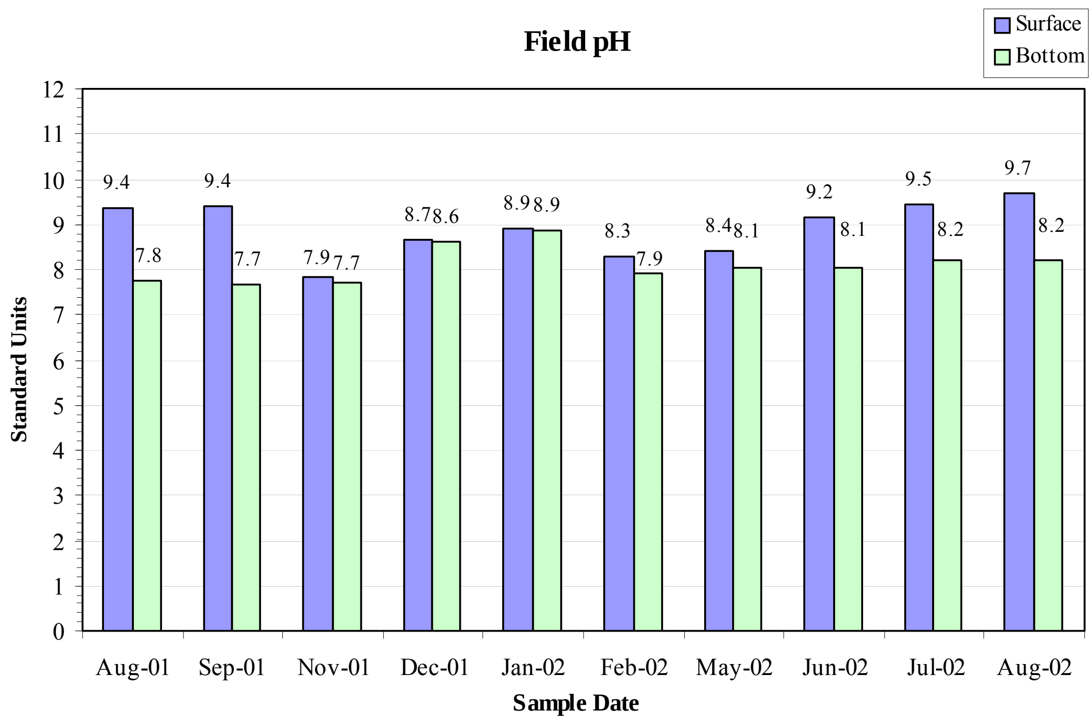

Figure 15. Average Surface and Bottom pH by Sample Date for Center Lake

Where igneous rocks and carbonate-poor soils are predominant, waters will have low alkalinity. Considering the geology of the Center Lake watershed (predominantly granite and quartzite) and low alkalinity concentrations observed during this assessment, erosion and natural weathering of the drainage area are not likely sources of the high pH.

The eutrophication of Center Lake is believed to be the largest cause of high pH. The vertical distribution of pH in Center Lake is strongly influenced by the photosynthetic utilization of carbon dioxide in the trophogenic zone (the lighted zone where organic matter is synthesized and oxygen generated), which tends to reduce carbon dioxide content and increase pH. Therefore, management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Center Lake.

Alkalinity is a measure of the buffering capacity of a waterbody. Alkalinity measurements in Center Lake were fairly consistent throughout the sampling period, ranging on average from 45.7 to 49.1 mg/L (Table 9). The alkalinity standard for Center Lake is ≤ 1313 mg/L. All sample measurements for Center Lake were far below the state standard (Figure 16).

Table 9. Descriptive Statistics of Alkalinity (mg/L) for Center Lake Sites.

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	45.7	46	30	56	5.362
Bottom	49.1	48	42	86	9.095

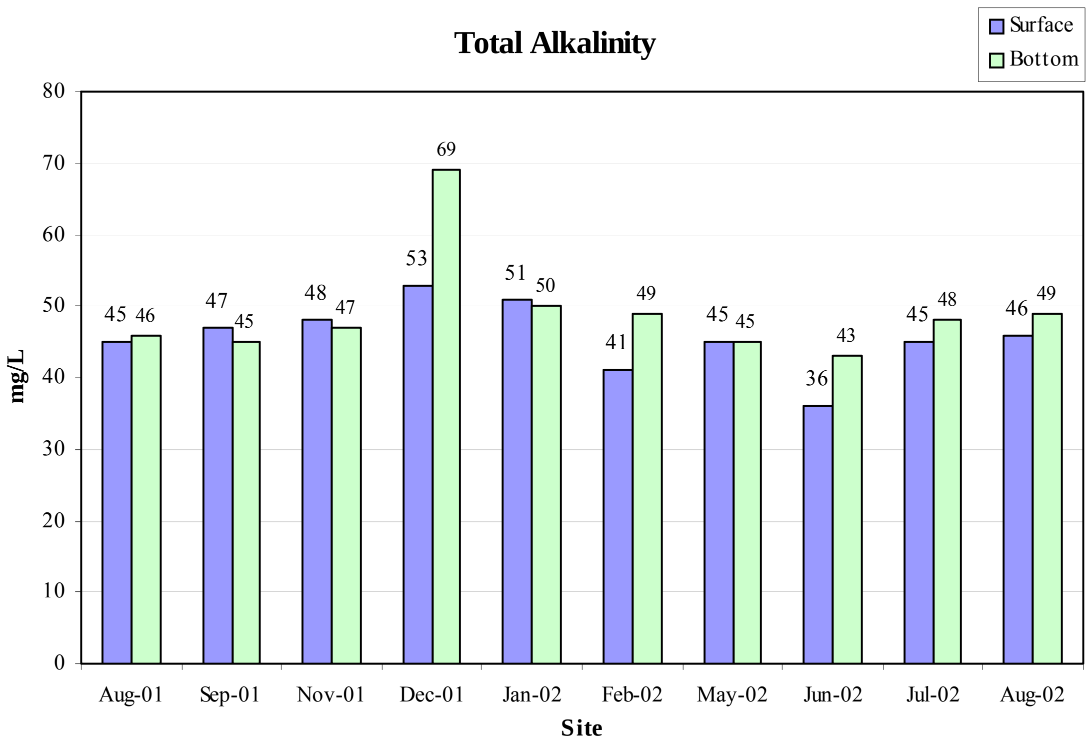

Figure 16. Average Alkalinity of Surface and Bottom Samples by Sampling Date for Center Lake

Nitrogen

Several forms of nitrogen can be found in a waterbody. Natural sources of nitrogen include precipitation, biological processes (i.e. nitrogen fixation), and surface and groundwater drainage. Anthropogenic nitrogen sources include sewage inputs of organic nitrogen and fertilizer applications.

Total Kjeldahl Nitrogen (TKN) is a measure of organic nitrogen plus ammonia. Therefore, organic nitrogen can be calculated by subtracting ammonia from TKN. In Center Lake, the amount of organic nitrogen far exceeded inorganic forms. The calculated average organic nitrogen concentration was 4.89×10^{-4} mg/L. Average inorganic nitrogen (ammonia and nitrate/nitrite) concentration was 1.84×10^{-4} mg/L.

Ammonia is the nitrogen end product of bacterial decomposition of organic matter. This form of nitrogen is most readily available to algae and aquatic plants for uptake and growth. Sources of ammonia may include animal wastes, decayed organic matter, or bacterial conversion of other nitrogen compounds.

For this study, when samples were analyzed for total ammonia, 0.10 mg/L was designated as the detection limit. Total ammonia levels were below the detection limit in 60% of the samples collected in Center Lake. Inorganic forms of nitrogen, including ammonia and nitrate, are quickly consumed by aquatic plants and algae, and can become the limiting factor for growth. Samples with total ammonia levels below the detection limit were assigned values of half the detection limit (0.05 mg/L), assuming that a trace amount was present.

Total ammonia concentrations ranged from less than detection limits to 0.6 mg/L (Table 10). Maximum ammonia concentrations were observed in samples collected in July and August, 2002 (Figure 17). State water quality standards contain total ammonia criteria for the protection of waters classified as fisheries. This criterion is dependent on the pH of the water sample at the time the sample was collected. All ammonia samples were evaluated using the criteria shown in Table 3, and no samples exceeded the total ammonia criteria.

Table 10. Descriptive Statistics of Ammonia (mg/L) for Center Lake Sites. ***(Minimum values represent half of the detection limit of 0.1 mg/L)***

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	0.065	0.05	0.05	0.2	0.046
Bottom	0.13	0.05	0.05	0.6	0.144

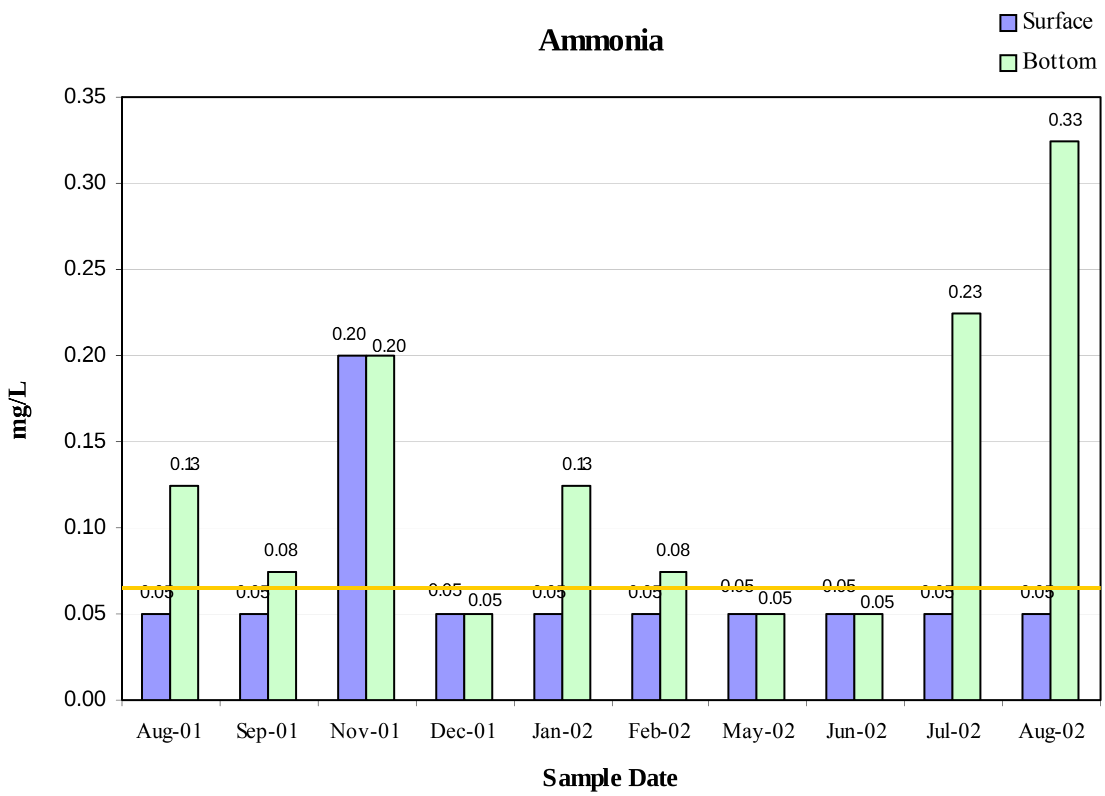

Figure 17. Average Surface and Bottom Concentrations of Total Ammonia by Sample Date for Center Lake. ***(Horizontal line indicates the detection limit of 0.10 mg/L)***

Nitrate + nitrite concentrations ranged from less than the detection limit to 0.6 mg/L (Table 11). The majority of the samples fell below the detection limit of 0.05 mg/L. Maximum concentrations were observed in samples collected in December, 2001.

Table 11. Descriptive Statistics of Nitrate + Nitrite (mg/L) for Center Lake Sites ***(Minimum values represent half of the detection limit of 0.05 mg/L)***

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	0.02675	0.025	0.025	0.06	0.007826
Bottom	0.0275	0.025	0.025	0.05	0.007695

Total nitrogen can be calculated by adding TKN and nitrate/nitrite concentrations. Total nitrogen values were used to determine whether nitrogen is a limiting nutrient in Center Lake (see limiting nutrient section). Total nitrogen in Center Lake ranged from 0.0825 to 1.525 mg/L (Table 12). Average surface and bottom concentrations of total nitrogen by sample date can be seen in Figure 34, with the concentrations averaged for the two sites.

Table 12. Descriptive Statistics of Total Nitrogen (mg/L) for Center Lake Sites.

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	0.63975	0.625	0.085	1.525	0.368887
Bottom	0.7325	0.825	0.275	1.225	0.282854

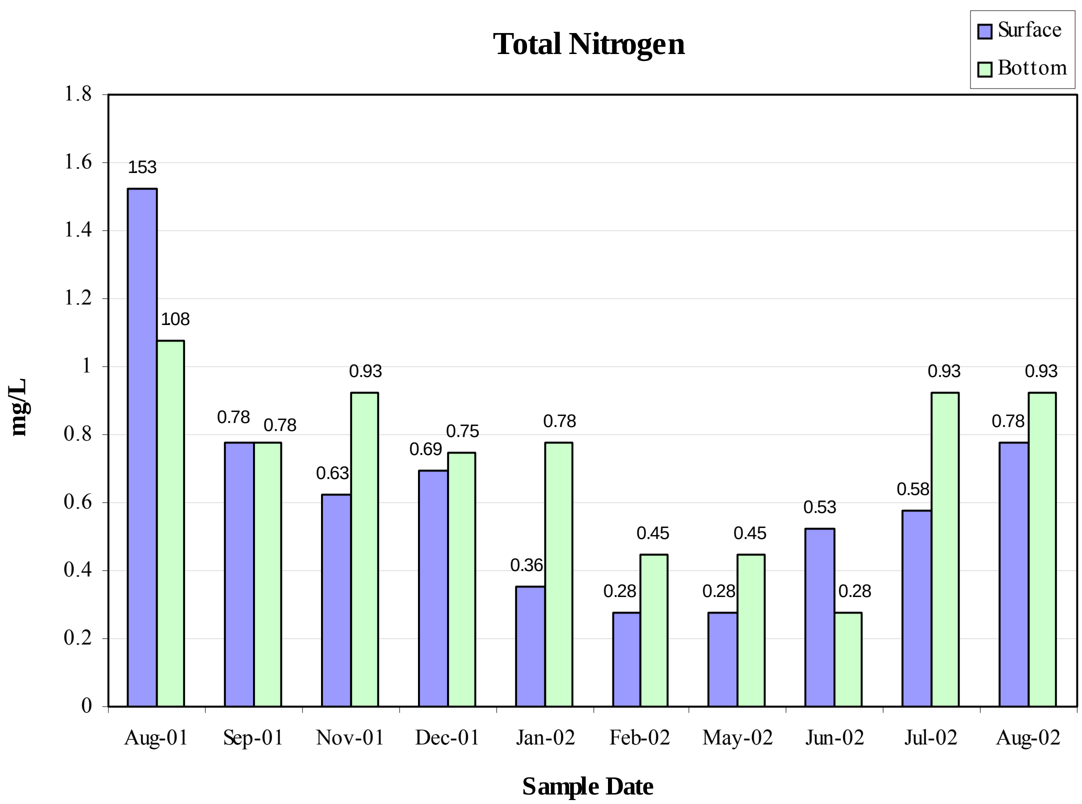

Figure 18. Average Surface and Bottom Concentrations of Total Nitrogen by sample date for Center Lake.

Phosphorus

Like nitrogen, phosphorus is a biologically active element. It cycles through different states in the aquatic environment, and its concentration in any one state depends on the degree of biological assimilation or decomposition occurring in that system. The predominant inorganic form of phosphorus in lake systems is orthophosphate. Due to difficulties of meeting holding times for orthophosphate analysis, total dissolved phosphorus (TDP) concentrations were used as an alternate in this study.

Total phosphorus concentrations of non-polluted waters are usually less than 0.1 mg/L (Lind, 1985). Total phosphorus values in Center Lake ranged from 0.01 to 0.13 mg/L (Table 13). Maximum concentrations of phosphorus were observed in August and September, possibly following a large rain event (Figure 19). Besides rain events, natural erosion as well as runoff from road maintenance activities may contribute to the phosphorus loads. Internal loading may also be contributing, as sediment is disturbed during storm events, which may redistribute phosphorus into the water column as the water becomes more mixed.

Table 13. Descriptive Statistics of Total Phosphorus (mg/L) for Center Lake Sites.

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	0.031	0.030	0.010	0.060	0.0135
Bottom	0.049	0.040	0.030	0.130	0.0245

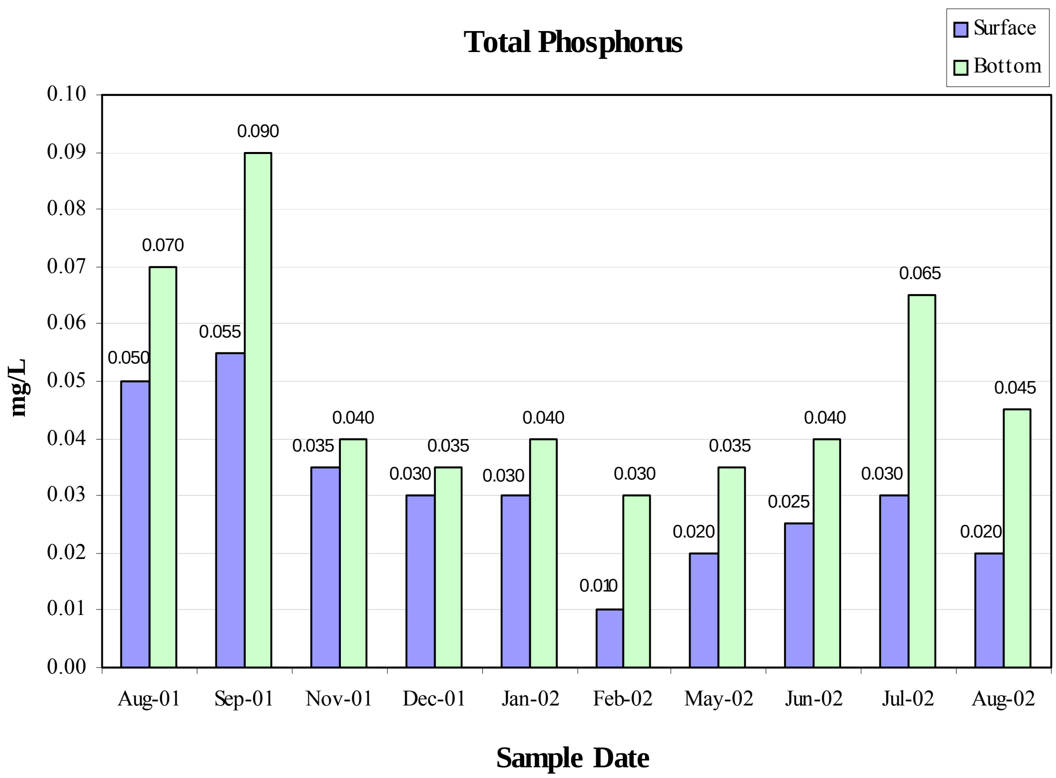

Figure 19. Average Surface and Bottom Concentrations of Total Phosphorus by Sample Date for Center Lake.

Phosphorus is often a limiting nutrient to algae and macrophyte production within many aquatic systems. Loading of this nutrient allows for increased eutrophication (primary production). TDP is the portion of total phosphorus that is readily available for aquatic plant or algae utilization. TDP concentrations of non-polluted waters are usually less than 0.01 mg/L (Lind, 1985). TDP concentrations in Center Lake ranged from no detection (< 0.01) to 0.04 mg/L (Table 14). On several sample dates, concentrations exceeded the minimum amount for rapid algal growth, which requires only 0.02 mg/L (Figure 20).

Table 14. Descriptive Statistics of Total Dissolved Phosphorus (mg/L) for Center Lake Sites.

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	0.0120	0.0075	0.005	0.030	0.0088
Bottom	0.0125	0.0075	0.005	0.040	0.0101

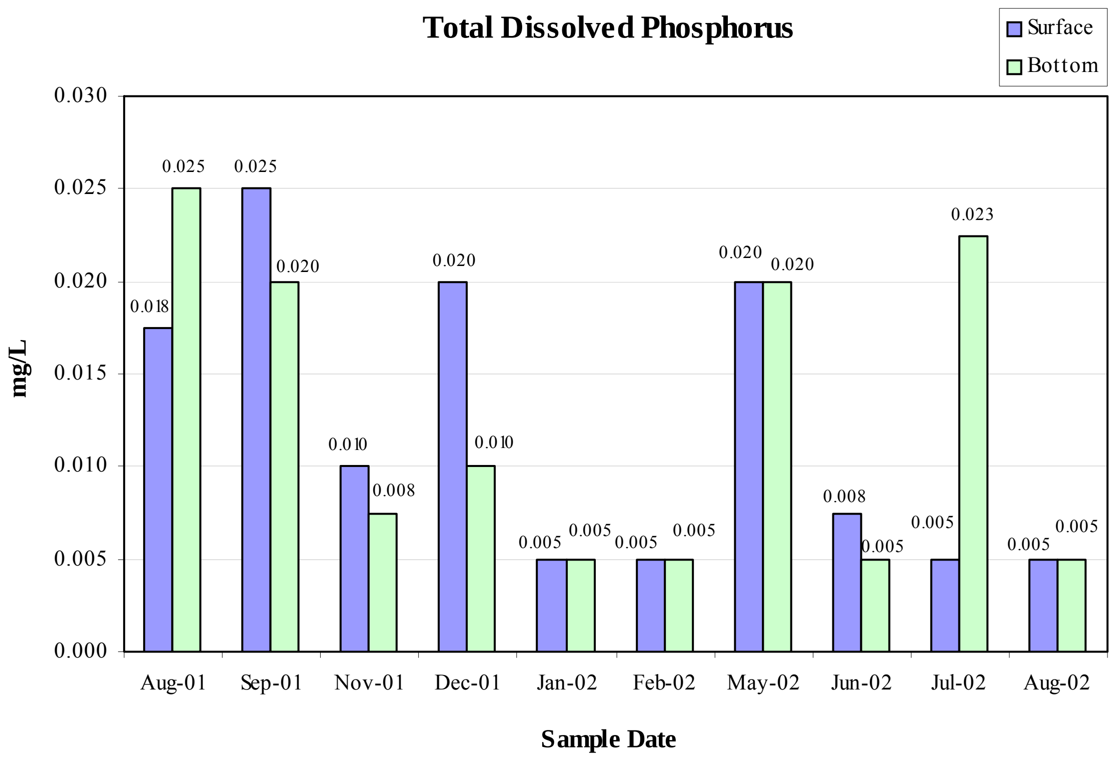

Figure 20. Average Surface and Bottom Concentrations of Total Dissolved Phosphorus by Sample Date for Center Lake.

Limiting Nutrients

Eutrophication is a term used to describe increased biological production (especially algae and aquatic plants) in lakes due to human impacts (Wetzel, 2001). Great emphasis is placed on regulating nutrient loading to waterbodies to control aquatic productivity. In aquatic systems, the most significant nutrient factors causing the shift from a lesser to a more productive state are phosphorus and nitrogen. Nitrogen is difficult to control because of its highly soluble nature. From a management perspective, phosphorus is easier to manipulate. Consequently, it is most often the nutrient targeted for reduction when attempting to control lake eutrophication.

When either nitrogen or phosphorus reduces the potential for algal growth and reproduction, it is considered the limiting nutrient. Optimal nitrogen and phosphorus concentrations for aquatic plant growth occur at a ratio of 10:1 (N:P ratio). N:P ratios greater than 10:1 indicate a phosphorus-limited system, while N:P ratios less than 10:1 indicate a nitrogen-limited system (USEPA, 1990).

N:P ratios for Center Lake ranged from 2.83 to 41.25 (Table 15). A majority (90%) of the samples collected in Center Lake were phosphorus-limited with N:P ratios above the optimal 10:1 ratio (Figure 21).

Table 15. Descriptive Statistics of N:P Ratios for Center Lake Sites.

	Average	Median	Minimum	Maximum	Standard Deviation
Surface	21.9	20.8	2.8	41.2	9.01
Bottom	16.4	18.7	5.5	27.5	6.72

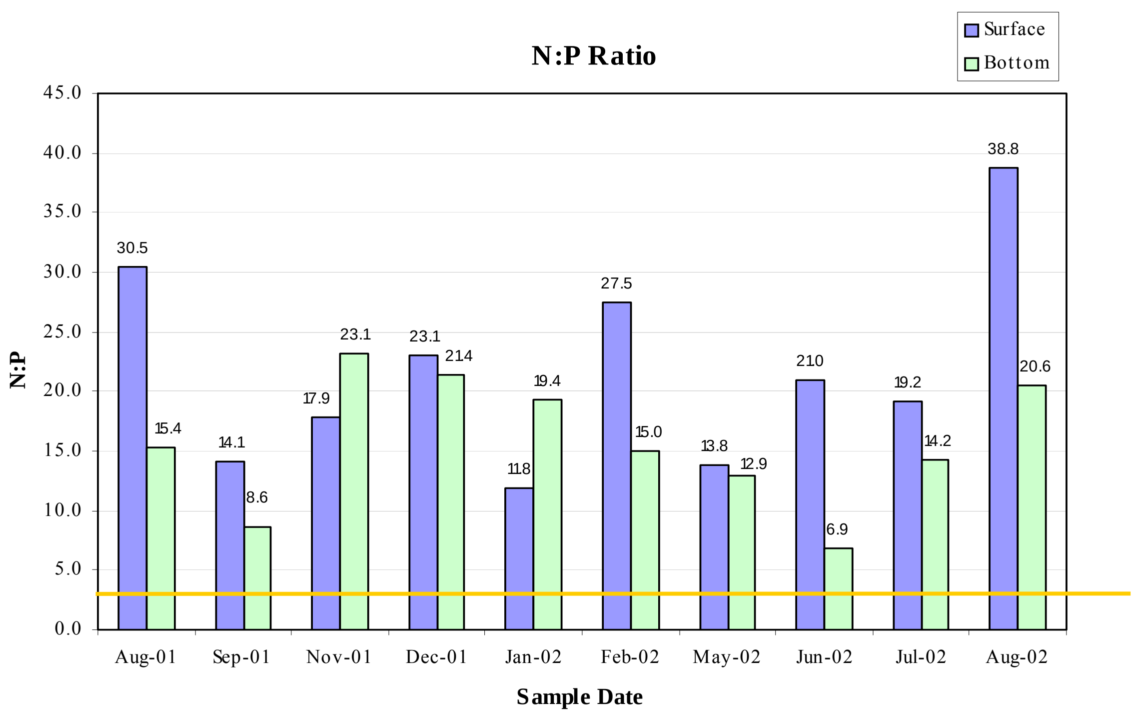

Figure 21 Nitrogen : Phosphorus Ratios for Center Lake. ***(Values above the horizontal line (N:P > 10) are considered phosphorus limited)***

Trophic State

Wetzel (2001) defines 'trophy' of a lake as "the rate at which organic matter is supplied by or to a lake per unit time." Trophic state is often measured as the amount of algal production in a lake and algae are a source of organic material. Determinations of trophic state can be made from several different measures including oxygen levels, species composition of lake biota, concentrations of nutrients, and various measures of biomass or production. An index incorporating several of these parameters is best suited to determine trophic state.

The Trophic State Index (TSI) was used to determine the approximate trophic state of Center Lake (Carlson, 1977). This index incorporates measures of Secchi disk transparency, chlorophyll a, and total phosphorus into scores ranging from 0 to 100 with each 10-unit increase representing a doubling in algal biomass. Four ranges of index values define Carlson's trophic levels, which include oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic. These levels and their numeric ranges are listed in Table 16 in order of increasing productivity.

Table 16. Carlson's Trophic Levels and Index Ranges for Each Level.

Trophic Level	TSI Range
Oligotrophic	0 - 35
Mesotrophic	36 - 50
Eutrophic	51 - 65
Hyper-eutrophic	66 - 100

TSI values were calculated for two of the three index parameters separately. Unfortunately, chlorophyll samples were inappropriately handled after collection (chlorophyll samples were not promptly shipped to the lab for analysis; all samples were past holding times by the time they were analysed), rendering chlorophyll data unavailable for this report. Actual measurements were only available for phosphorus and Secchi depth. Phosphorus TSI values ranged from 42 to 61 (mean = 52), and Secchi depth TSI values ranged from 44 to 64 (mean = 55) (Table 43). Average and median TSI for both parameters fell in the eutrophic range. The majority of phosphorus and Secchi depth TSI values indicate eutrophic conditions in Center Lake, with a few values indicating mesotrophic conditions.

Table 17. Descriptive Statistics for Observed Trophic State Index (TSI) Values Calculated for Center Lake.

	Phosphorus TSI	**Secchi TSI**
Average	51.6	54.9
Median	53.0	53.0
Minimum	41.9	44.2
Maximum	60.6	64.1
Stan. Deviation	5.41	5.95

Beneficial use attainment for Center Lake was also assessed using TSI values. The SD DENR had adopted a TSI methodology to determine support status of a lake's fishery classification based on the median value of Secchi depth and chlorophyll *a* measurements (Lorenzen, 2005). Numeric TSI criteria were established for each fishery classification. The TSI criterion for Center Lake, a coldwater permanent fishery, was a median chlorophyll *a* and Secchi depth TSI value ≤ 48. A median TSI value of 48 was the TMDL goal based on that approach.

Reduction Response Model

Inlake reduction response modeling was conducted using BATHTUB, a eutrophication response model designed by the United States Army Corps of Engineers (US ACOE, 1999). The model predicts changes in water quality parameters related to eutrophication (phosphorus, nitrogen, chlorophyll a, and transparency) using empirical relationships previously developed and tested for reservoir applications. Lake and tributary sample data were used to calculate existing conditions in Center Lake. Tributary loading data was obtained from the FLUX model output. Inlet phosphorus and nitrogen concentrations were reduced in increments of 10% and modeled to generate an inlake reduction curve.

The predicted inlake phosphorus concentrations and individual parameter (chlorophyll and Secchi depth) TSI values decreased with the reduction of tributary phosphorus load (Table 18). Predicted Secchi TSI values did not respond as rapidly as predicted chlorophyll TSI values to phosphorus load reductions. Predicted chlorophyll and Secchi depth TSI values with no reduction of phosphorus load were 53.4 and 51.5, respectively, which are considered as not supporting beneficial uses. The model indicated an approximate 70% reduction in phosphorus load was required to bring chlorophyll and Secchi depth TSI values into compliance with the fishery-based TSI criterion (Figure 22).

The TMDL goal (70% reduction of total phosphorus loads) was determined based on the load reduction required to achieve a predicted chlorophyll and Secchi TSI value ≤ 48.

Table 18. BATHTUB Model-Predicted Concentrations of Total Phosphorus and TSI Values with Successive 10-Percent Reductions in Phosphorus Inputs.

Percent Reduction	Total Phosphorus Concentration (ppb)	Predicted TSI value Phosphorus	Predicted TSI value Chlorophyll	Predicted TSI value Secchi Depth
0%	94	56.1	53.4	51.5
10%	84	55.2	52.8	51.1
20%	75	54.2	52.2	50.7
30%	66	53.1	51.4	50.3
40%	56	51.8	50.5	49.7
50%	47	50.3	49.5	49.2
60%	37	48.4	48.2	48.5
70%	28	46.1	46.6	47.8
80%	19	42.9	44.4	46.9
90%	9	37.8	41.0	45.8
100%	0	26.8	33.5	44.2

A chlorophyll *a* TSI of 48 corresponds to a concentration of 6 ppb chlorophyll *a*. This concentration is 30% lower than the ecoregion range of 9 to 12.5. This suggests that the fishery based TMDL goal will result in full attainment of the pH standard and include a generous margin of safety.

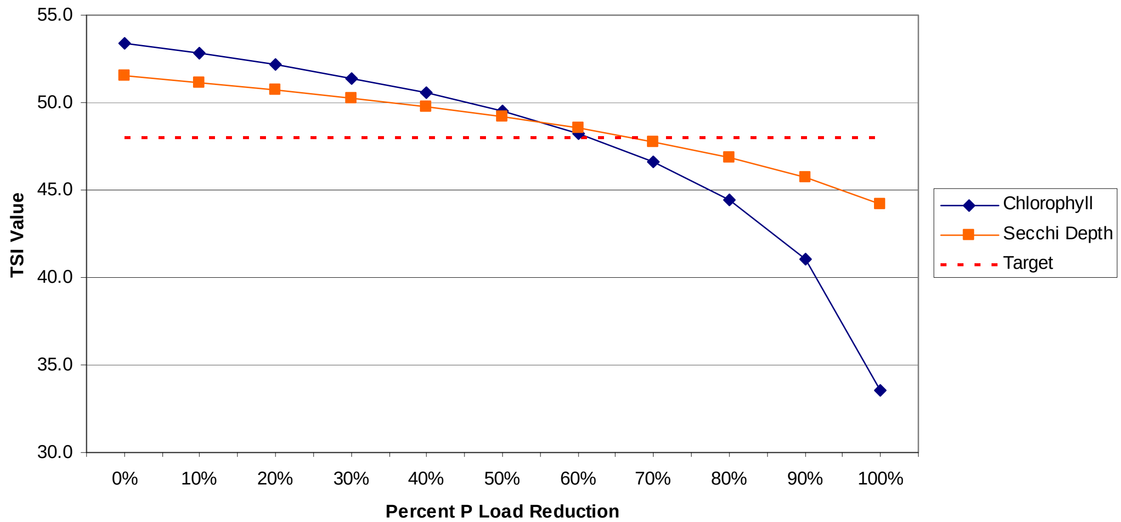

Figure 22. Model-Predicted Chlorophyll and Secchi Depth TSI Values with Successive 10-Percent Reductions in Nutrient Loading ***(Dotted line represents TMDL target of 48)***

5.1.5 Center Lake TMDL Allocations

Wasteload Allocation

There are no point source discharges of phosphorus in the watershed. Therefore, the wasteload allocation component of this TMDL is considered a zero value. The TMDL is considered wholly included within the load allocation component.

Load Allocation

According to BATHTUB model results, 70% reduction of watershed phosphorus loads is required to meet the phosphorus TMDL numeric target (i.e. chlorophyll and Secchi depth TSI ≤ 48). Current total phosphorus loads from the watershed are approximately 47.7 kg/yr. A 70% reduction of external phosphorus load to Center Lake may be achieved through the implementation of recommended BMPs, resulting in an annual load of approximately 14.3 kg (Table 19).

The annual load is a more meaningful measurement for the management of a reservoir; however, to satisfy TMDL requirements, a daily load is included in Table 19. The annual load is the critical management goal that should not be exceeded. To identify a maximum daily limit, a method from EPA's "Technical Support Document For Water Quality-Based Toxics Control," referred to as the TSD method, was used. This method, which is based on a long-term average load that considers variation in a dataset, is a recommended method in EPA's technical guidance

"Options for expressing Daily Loads in TMDLs"(USEPA 1991). The TSD method is represented by the following equation:

$MDL = LTA * e^{[z\sigma - 0.5\sigma 2]}$

Where:

MDL = maximum daily limit
LTA = long-term average
z = z statistic of the probability of occurrence
$\sigma 2 = \ln(CV2+1)$
CV = coefficient of variation

Table 19 Load Allocation (kg/yr) Summary for Center Lake

TMDL Component	Allocation (kg/year)	Allocation (kg/day)
Wasteload Allocation	0	0
Load Allocation	14.3	0.31
Margin of Safety	Implicit	Implicit
TMDL	14.3	0.31

Margin of Safety

The margin of safety for the phosphorus TMDL is implicit based on conservative estimations of lake model coefficients. The original TSI based TMDL relied only on the implicit margin of safety. Limiting the analysis to strictly the chlorophyll *a* predictions, the model suggests that this target would be reached with a 60% reduction. For the pH portion of this TMDL, the result is an additional 10% explicit margin of safety.

5.2 Legion (2107)

5.2.1 Watershed Description

The Legion Lake watershed is located in north central Custer County, South Dakota (Figure 23). The watershed consists of approximately 2,050 acres of primarily quartzite and granite outcrop covered by dense pine forest; predominately Ponderosa Pine with some Black Hills Spruce and Aspen. The Legion Lake watershed falls within the Black Hills Plateau Level IV Ecoregion, which is part of the Middle Rockies Level III Ecoregion. The Black Hills Plateau is characterized by plateau topography with broad ridges and entrenched canyons.

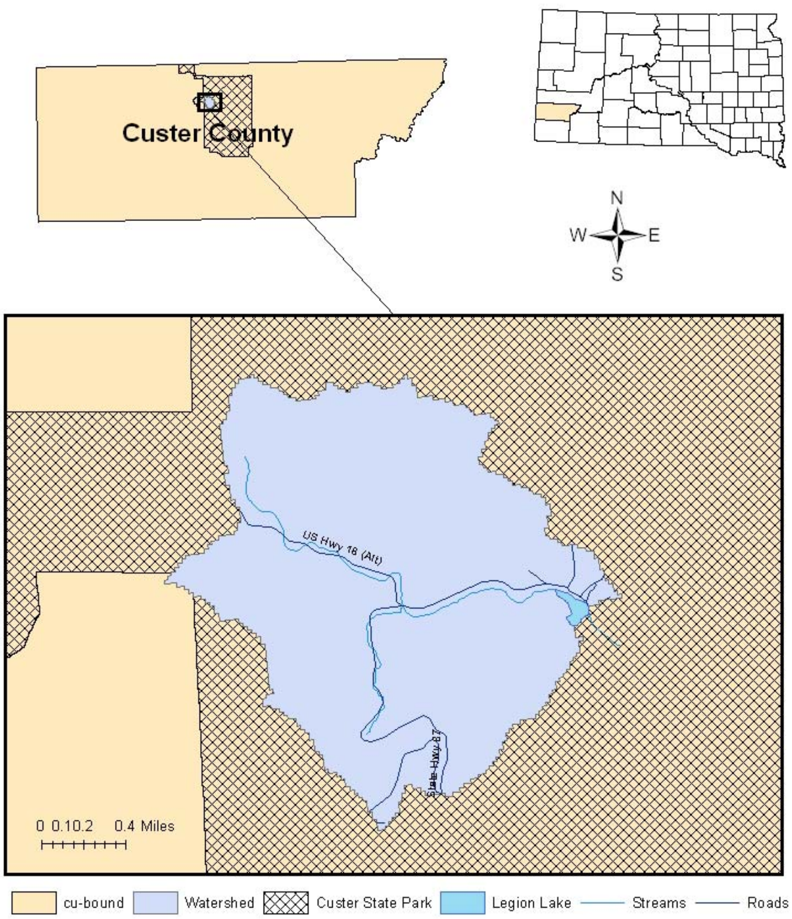

Figure 23. Location of the Legion Lake Watershed in Custer County, SD.

The lake is recharged by natural precipitation, which is quite variable in the study area. Average annual precipitation for the Black Hills of South Dakota is approximately 19 inches (Driscoll et al. 2000). Typically, most precipitation falls from early spring to late summer (Figure 24).

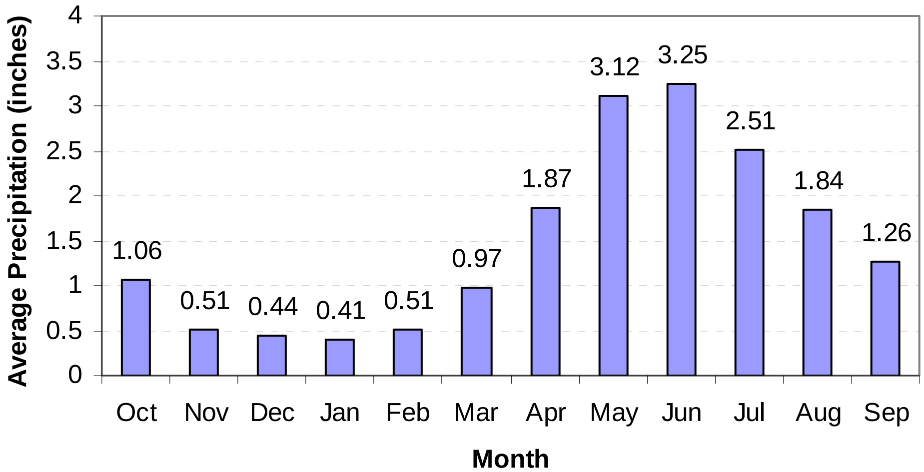

Figure 24. Average Monthly Precipitation for Custer County, SD (water years 1931-1998). (Source: Driscoll et al., 2000)

The lake has a surface area of approximately 9 acres and volume of approximately 90 acre feet. The mean and maximum depths of the lake are 10 feet and 22 feet, respectively.

5.2.2 Beneficial Use Assignment and Water Quality Standards

Each waterbody within South Dakota is assigned beneficial uses. All waters (both lakes and streams) are designated the use of fish and wildlife propagation, recreation and stock watering. All streams are assigned the use of irrigation. Additional uses may be assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in South Dakota state statutes in support of these uses. These standards consist of suites of numeric criteria that provide physical and chemical benchmarks from which management decisions may be developed.

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the states water quality standards, this is the method used in the states Integrated Water Quality Report (IR) as well as in permit development.

Additional “narrative” standards that may apply can be found in the “Administrative rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09”. These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The following beneficial uses have been assigned to Legion Lake: (1) coldwater marginal fish propagation, (2) immersion recreation, (3) limited contact recreation, and (4) wildlife propagation, recreation and livestock watering. Table 20 lists the criteria that must be met to maintain the above beneficial uses. When multiple standards exist for a particular parameter, the most stringent standard is used.

Table 20. Surface Water Quality Standards for Legion Lake

Parameters	Criteria	Unit of Measure	Beneficial Use Requiring this Standard
Total ammonia nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A of Surface Water Quality Standards	mg/L 30 average	Coldwater Marginal Fish Propagation
	Equal to or less than the result from Equation 1 in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Dissolved Oxygen	>5.0	mg/L Dailey Maximum	Coldwater Marginal Fish Propagation
Undisassociated hydrogen sulfide	<0.002	mg/L Dailey Maximum	Coldwater Marginal Fish Propagation
pH (standard units)	>6.5 to <9.0	units	Coldwater Marginal Fish Propagation
Total Suspended Solids	<90 (30 day average) <158 (single sample)	mg/L	Coldwater Marginal Fish Propagation
Temperature	<23.8	°C	Coldwater Marginal Fish Propagation
Fecal Coliform Bacteria (May 1- Sept 30)	<200 (geometric mean) <400 (single sample)	count/100 mL	Immersion Recreation
Escherichia Coli Bacteria (May 1- Sept 30)	<126 (geometric mean) <235 (single sample)	count/100 mL	Immersion Recreation
Alkalinity ($CaCO_3$)	<750 (mean) <1,313 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Nitrogen, nitrate as N	<50 (mean) <88 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Solids, total dissolved	<2,500 (mean) <4,375 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon	<10	mg/L	Wildlife Propagation and Stock Watering

5.2.3 Tributary Hydrology and Chemistry

Hydrology of Legion Lake Watershed

FLUX, a eutrophication model developed by the Army Corps of Engineers (US ACOE 1999), was used to determine hydrologic, nutrient, and sediment loadings at monitoring sites based on the flow and water quality parameter concentration data collected at the site. FLUX can calculate loadings using several available models (e.g. average flow, flow-weighted, etc.).

Two subwatersheds were delineated within the larger watershed (Figure 25) and represent the area from which sites LLT-3 and LLT-4 receive runoff. The larger delineated watershed is the area from which Legion Lake receives runoff. Hydrologic and parameter loads were calculated for each of these areas. Site LLT-5 was used to represent the load from the entire Legion Lake watershed, and sites LLT-3 and LLT-4 represent the loads from their respective subwatersheds.

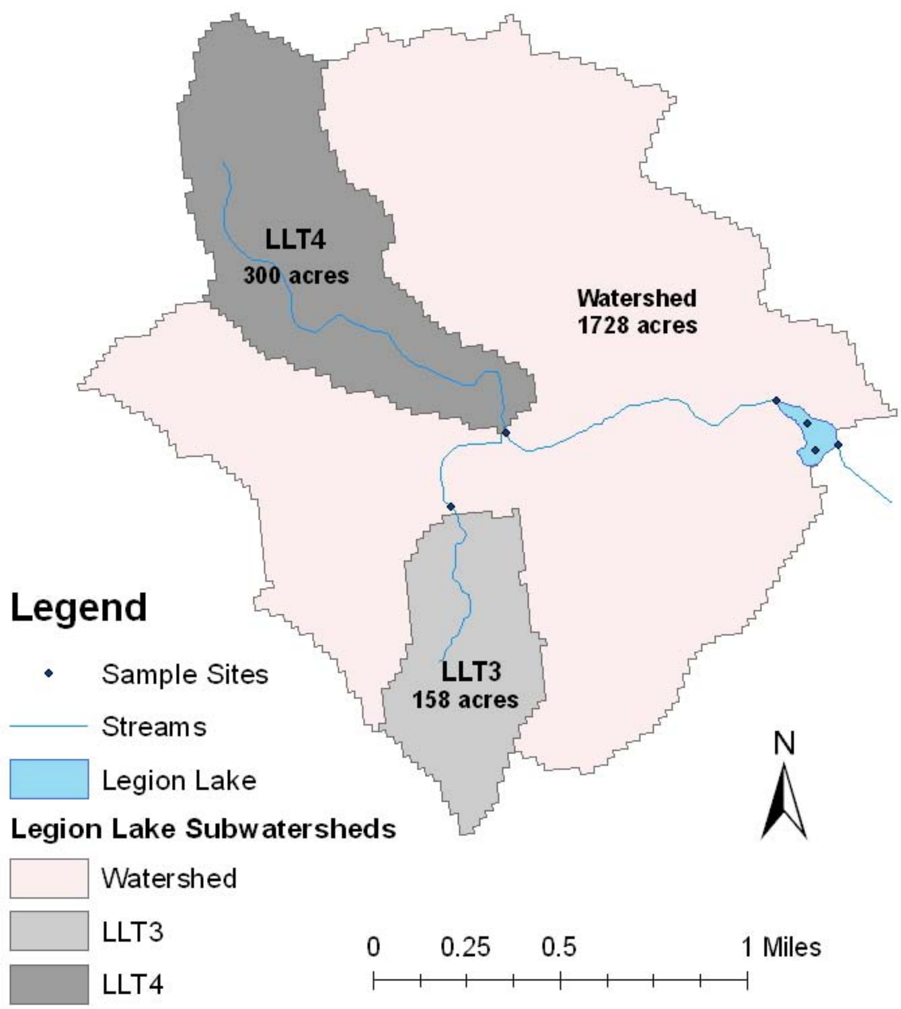

Figure 25. Delineation of Subwatershed Areas for the Legion Lake Watershed Assessment.

Seasonal Loadings

Monthly hydrologic contributions from each gauged subwatershed area were calculated by the FLUX modeling program. Estimates of hydrologic load were calculated for each season by summing three months of hydrologic load per season (i.e. the winter season was the total of December, January, and February monthly loads; spring was the total of March, April, and May monthly loads; summer was the total of June, July, and August monthly loads; and fall was the total of September, October, and November monthly loads).

Generally, estimated flow volumes were highest during the spring and fall seasons. Flow volume was highest during the fall at the inlet site (LLT-5) and during the spring at sites LLT-4 and LLO-6. Estimated volumes were approximately equal during the spring and fall seasons at site LLT-3. At all gauged sites, zero flow was recorded during winter months (Table 21).

Table 21. FLUX-Modeled Seasonal and Total Hydrologic Contributions for Each Site/Subwatershed in the Legion Lake Watershed.

	Site	Season	Volume (acre-ft)	Percent of Annual	Subwatershed area (acres)	Hydraulic Export Coefficient (acre-ft / acre)
INLETS	**LLT3**	**Winter**	**0.00**	**0%**	**158**	**0.000**
		Spring	4.86	7%	158	0.031
		Summer	3.24	5%	158	0.021
		Fall	4.86	7%	158	0.031
		Total	12.97	18%	158	0.082
	LLT4	Winter	0.00	0%	300	0.000
		Spring	8.11	11%	300	0.027
		Summer	4.86	7%	300	0.016
		Fall	9.73	14%	300	0.032
		Total	22.70	32%	300	0.076
	LLT5	Winter	0.00	0%	1728	0.000
		Spring	29.19	41%	1728	0.017
		Summer	20.27	28%	1728	0.012
		Fall	21.89	31%	1728	0.013
INLET TOTAL		Total	71.35	100%	1728	0.041
OUTLET	LLO6	Winter	0.00	0.0%	1728	0.000
		Spring	29.19	37.9%	1728	0.017
		Summer	5.67	7.4%	1728	0.003
		Fall	21.89	28.4%	1728	0.013
		Total	56.75	100.0%	1728	0.033

Water quality parameter loadings were also calculated for each gauged subwatershed using the FLUX modeling program. Sites with larger drainage areas experienced higher annual loads for all parameters. Alkalinity and dissolved and total solids loads were higher at the inlet than at the outlet of the lake (Table 22).

Table 22. Parameter Annual Loads (kg) for Each Site

Parameter	**LLT-3**	**LLT-4**	**LLT-5**	**LLO-6**
Alkalinity	967	1630	5687	4719
TKN	6.9	7.6	28.6	34.5
Nitrate+Nitrite	1.6	1.6	2.7	13.3
Ammonia	0.8	1.3	5.9	3.6
Organic Nitrogen	6.0	6.3	24.3	30.8
Inorganic Nitrogen	2.4	2.9	7.9	17.3
Total Nitrogen	7.0	9.3	25.2	48.0
Total Phosphorus	1.9	2.7	7.3	6.3
Total Dissolved Phosphorus	0.5	1.2	4.8	2.6
Total Suspended Solids	421	154	300	312
Total Dissolved Solids	3021	3565	12134	9640
Total Solids	3461	3735	12689	9894

Export Coefficients

After the hydrologic and parameter loadings for all sites were calculated, export coefficients were developed for each of the subwatershed water quality parameters. Export coefficients were calculated by taking the annual nutrient and sediment loads (kg) at a particular site and dividing by the total area of the sub-watershed (in acres) for that site. This calculation resulted in the determination of the kilograms of sediment and nutrient per acre per year (kg/acre/year) delivered from the respective subwatershed areas. Similar to the hydrologic export coefficient, these values represent a fraction of the parameter mass that might be expected from each acre in the watershed annually. Higher values indicate higher export potentials, and are signs that priority problems exist within the subwatershed.

In general, export coefficients for the LLT-3 subwatershed were greater than those for the LLT-4 subwatershed and the entire watershed (LLT-5). The total dissolved phosphorus export coefficient for subwatershed LLT-4 was only slightly higher than LLT-3. Based on these results, the LLT-3 subwatershed should be given highest priority for the implementation of management practices (Table 23).

Table 23. Export Coefficients (kg/acre/year) for Gauged Subwatersheds (LLT-3 and LLT-4) and Total Watershed (LLT-5) Areas.

Parameter	LLT-3	LLT-4	LLT-5
Alkalinity	6.1	5.4	3.3
TKN	0.044	0.025	0.017
Nitrite/Nitrate	0.010	0.005	0.002
Ammonia	0.005	0.004	0.003
Organic Nitrogen	0.038	0.021	0.014
Inorganic Nitrogen	0.015	0.010	0.005
Total Nitrogen	0.044	0.031	0.015
Total Phosphorus	0.012	0.009	0.004
Total Dissolved Phosphorus	0.003	0.004	0.003
Total Suspended Solids	2.66	0.51	0.17
Total Dissolved Solids	19.12	11.88	7.02
Total Solids	21.91	12.45	7.34

Phosphorus

Phosphorus is present in all aquatic systems. Natural sources include the leaching of phosphate-bearing rocks and organic matter decomposition. Potential anthropogenic sources of phosphorus include fertilizers and sewage.

Effects of the reservoir are apparent when comparing inlet and outlet phosphorus concentrations. Average total phosphorus concentrations were 0.11 mg/L at site LLT-3 and 0.10 mg/L at the remaining three sites (Table 24 and Figure 26). Total phosphorus annual load from the watershed was 7.3 kg, which is equivalent to 0.004 kg per watershed acre. Total phosphorus annual load measured at the outlet site was 6.3 kg. Based on these loading estimates, roughly 1 kg of phosphorus is stored in Legion Lake each year. It is expected that much of the external phosphorus load is either incorporated into aquatic plant and algal biomass or attached to suspended solids that eventually settles to the bottom of the lake.

Table 24. Descriptive Statistics of Total Phosphorus (mg/L) for Legion Lake Tributary Sites.

Site	Samples	Mean	Min	Max	Stan. Dev.	Lower Quartile	Median	Upper Quartile
LLT-3	10	0.11	0.03	0.22	0.06	0.06	0.10	0.16
LLT-4	10	0.10	0.04	0.20	0.05	0.07	0.09	0.11
LLT-5	10	0.10	0.05	0.25	0.06	0.07	0.08	0.09
LLO-6	8	0.10	0.04	0.20	0.06	0.06	0.09	0.15

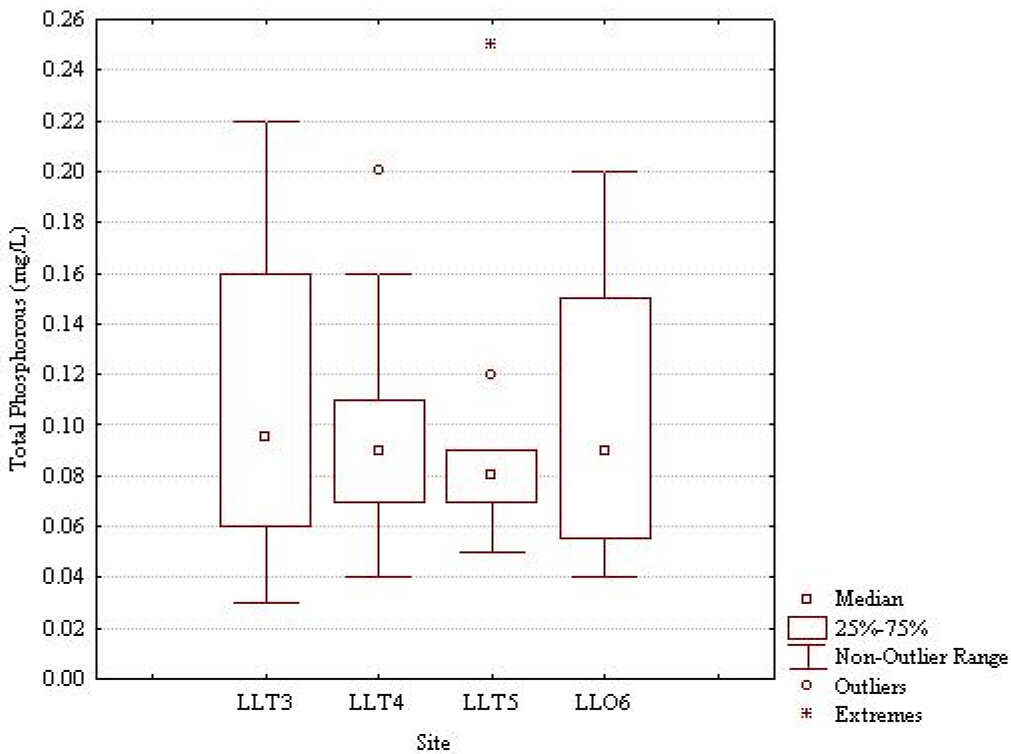

Figure 26. Box Plot of Total Phosphorus by Site for Legion Lake Tributary Sites

Slightly higher phosphorus loads are delivered from subwatershed LLT-3, than from subwatershed LLT-4 and the entire watershed (LLT-5). Approximately 0.012 kg/acre/year of total phosphorus is delivered from SLT-3 subwatershed, 0.009 kg/acre/year from SLT-4 subwatershed, and 0.004 kg/acre/year from the entire watershed (LLT-5).

Total dissolved phosphorus (TDP) concentration at LLT-5 was the highest and the outlet (LLO-6) was the most variable. Average TDP concentrations were 0.03, 0.04, 0.06, and 0.04 mg/L at sites LLT-3, LLT-4, LLT-5, and LLO-6, respectively (36.5 kg, which is equivalent to 5.8 grams per watershed acre.
and Figure 27).

Table 25. Descriptive Statistics of Total Dissolved Phosphorus (mg/L) for Legion Lake Tributary Sites.

Site	Samples	Mean	Min	Max	Stan. Dev.	Lower Quartile	Median	Upper Quartile
LLT-3	10	0.03	0.01	0.08	0.02	0.02	0.03	0.04
LLT-4	10	0.04	0.02	0.07	0.01	0.03	0.04	0.04
LLT-5	10	0.06	0.01	0.08	0.02	0.05	0.06	0.07
LLO-6	8	0.04	0.01	0.07	0.02	0.02	0.03	0.06

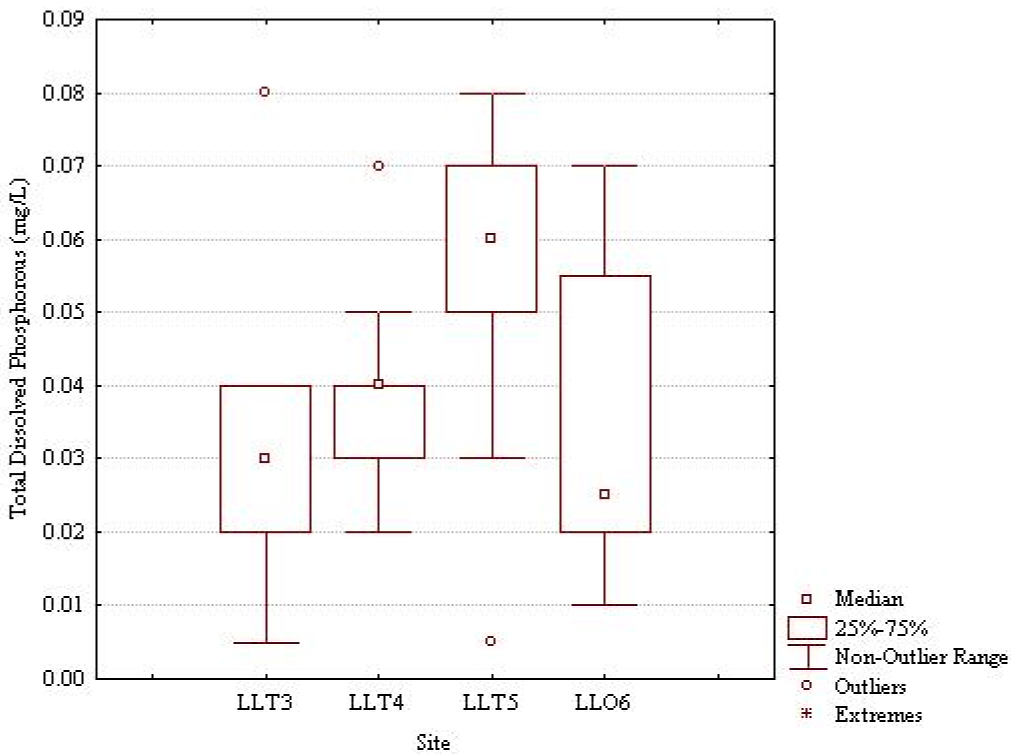

Figure 27. Box Plot of Total Dissolved Phosphorus by Site for Legion Lake Tributary Sites

5.2.4 Reservoir Chemistry

Acidification and Alkalinity

The primary measurements of acidification are alkalinity and pH. In Legion Lake, pH values ranged from 7.6 to 9.3. Approximately 15% of all available data exceed a pH value of 9.0. The pH water quality criterion for Legion Lake was a range of 6.5 to 8.8, however changes to the water quality standards during 2009 adjusted the upper limit to a value of 9.0. This change occurred after the publishing of the original Legion Lake document. As a result, the data interpretation has changed significantly requiring this section of the report to be rewritten.

This increase in pH is attributed to the photosynthetic utilization of CO_2 by algae and aquatic plants. Management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Legion Lake to a level that meets criteria established to protect the coldwater marginal fish life propagation use.

High pH in Legion Lake is also attributed, in part, to natural background sources. Because natural sources are considered uncontrollable, this report does not address a strategy to control these sources.

Alkalinity concentrations ranged from 36 to 110 mg/L (mean = 63.2). The alkalinity concentrations in Legion Lake are well below the water quality standard, which is ≤1,313 mg/L. Concentrations were low throughout the sampling period, with the highest concentrations recorded during the winter months.

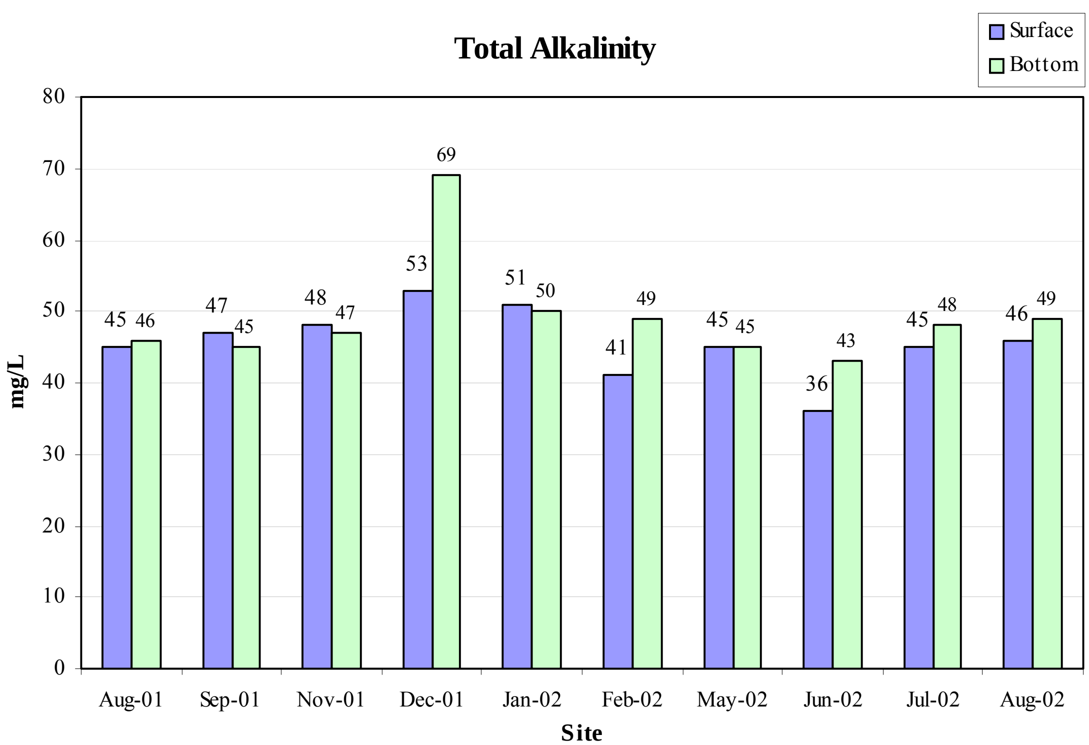

Figure 16 Figure 28. Surface and Bottom Alkalinity Concentrations by Month for Legion Lake

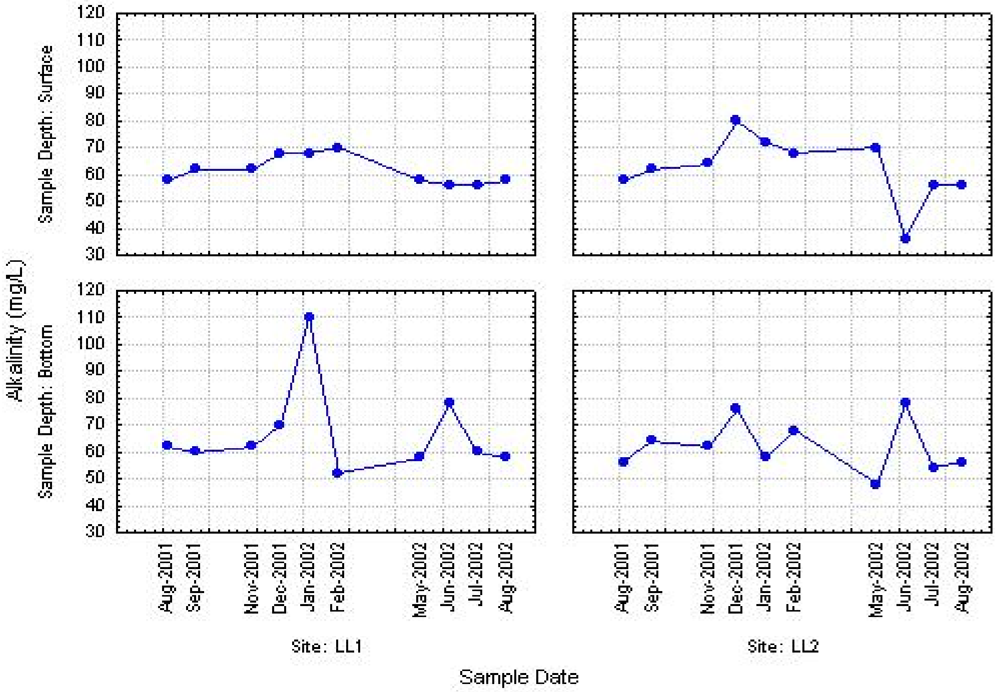

Figure 29. Monthly Alkalinity Concentrations for Legion Lake Categorized by Site and Sample Depth.

Nitrogen

Several forms of nitrogen can be found in a water body. Natural sources of nitrogen include precipitation, biological processes (i.e. nitrogen fixation), wildlife waste, and surface and groundwater drainage. Anthropogenic nitrogen sources include sewage inputs of organic nitrogen, fertilizer applications, and livestock waste.

Ammonia levels were below the detection limit (0.01 mg/L) during all but one of the sampling events. All values below detection limits were assigned half of the limit to allow calculation of statistics. Concentrations were above the detection limit in September 2001 at a maximum concentration of 0.20 mg/L. All ammonia concentrations were below the water quality standard.

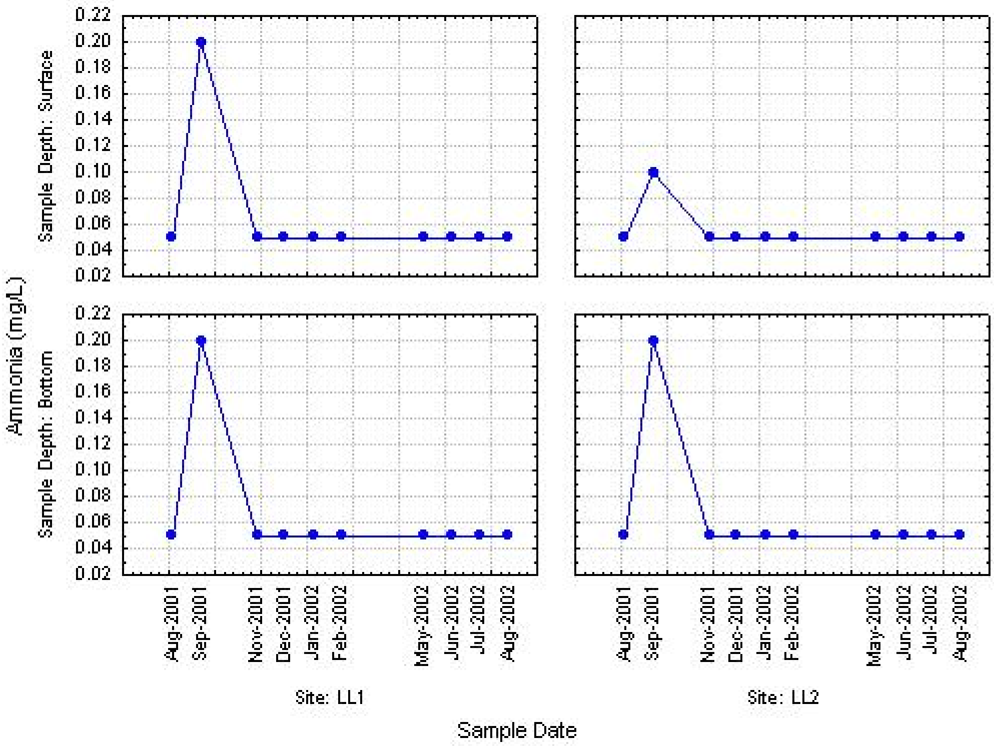

Figure 30. Monthly Ammonia Concentrations for Legion Lake Categorized by Site and Sample Depth.

Nitrate is usually present in low concentrations in natural waters, yet it is often the most abundant inorganic form of nitrogen. Natural concentrations rarely exceed 10 mg/L and are normally less than 1 mg/L (Lind, 1985). Nitrate/nitrite concentrations of all samples collected from Legion Lake were below detection limits (0.05 mg/L).

Total nitrogen was calculated by adding TKN and nitrate/nitrite concentrations. Because no nitrate/nitrite was detected in Legion Lake samples, total nitrogen is equivalent to TKN. Total nitrogen values were used to determine whether nitrogen is a limiting nutrient in Legion Lake. Total nitrogen in Legion Lake ranged from 0.28 to 1.23 mg/L (mean = 0.66) (Figure 31).

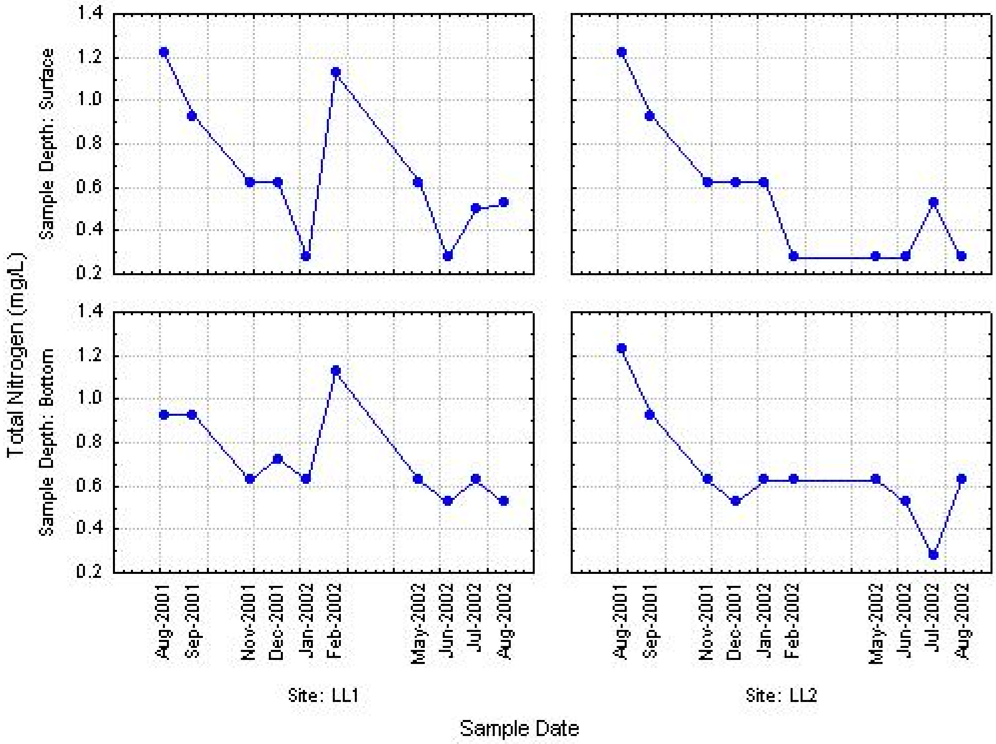

Figure 31. Monthly Total Nitrogen Concentrations for Legion Lake Categorized by Site and Sample Depth.

Phosphorus

Phosphorus is a biologically active element. It cycles through different states in the aquatic environment, and its concentration in any one state depends on the degree of biological assimilation or decomposition occurring in that system. The predominant inorganic form of phosphorus in lake systems is orthophosphate. Concentrations of orthophosphate were measured as total dissolved phosphorus (TDP) in this study. Phosphorus is often a limiting nutrient to algae and macrophyte production within many aquatic systems. Loading of this nutrient presents an increased eutrophication (primary production) risk.

Total phosphorus concentrations of non-polluted waters are usually less than 0.1 mg/L (Lind, 1985). Total phosphorus values in Legion Lake ranged from less than detection to 0.06 mg/L (mean = 0.03). Samples with the highest concentrations were collected in September of 2001. Bottom sampling depth of site LL-2 experienced the lowest total phosphorus concentrations of all sampling locations during May through August (Figure 32).

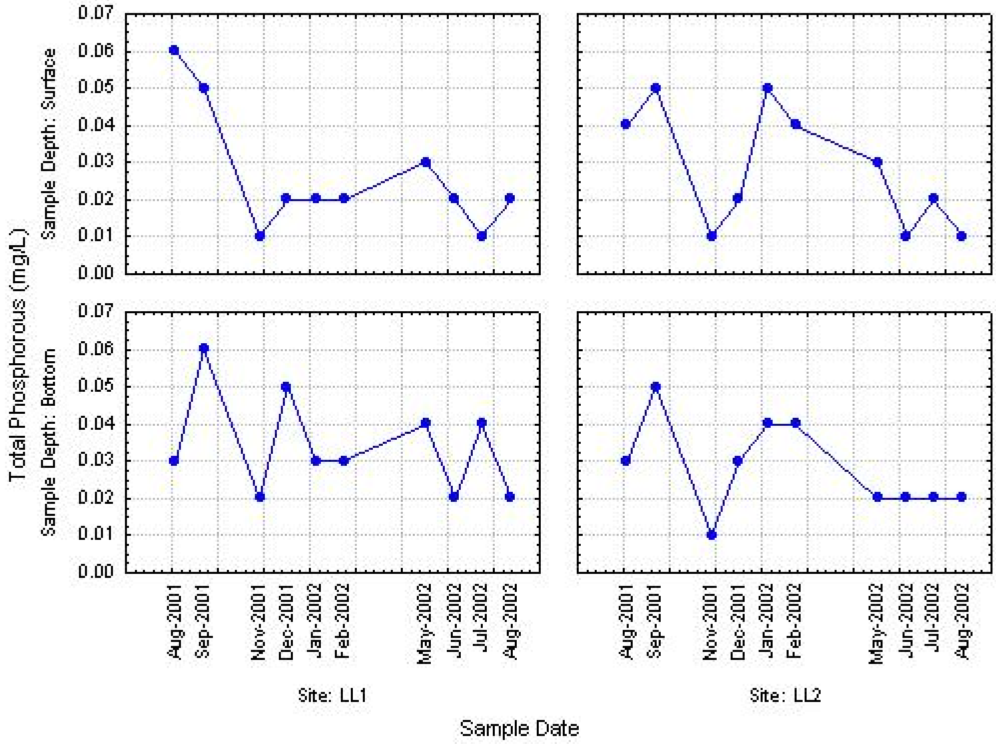

Figure 32. Total Phosphorus Concentrations by Month for Legion Lake Categorized by Site and Sample Depth

TDP is the portion of total phosphorus that is readily available for plant and algae utilization. TDP concentrations in non-polluted waters are usually less than 0.01 mg/L (Lind, 1985). TDP concentrations in Legion Lake ranged from below detection limits to 0.04 mg/L (mean = 0.01). Surface concentrations were at or above the minimum amount for rapid algal growth during August and September 2001 and May 2002, which typically requires only 0.02 mg/L (Figure 31).

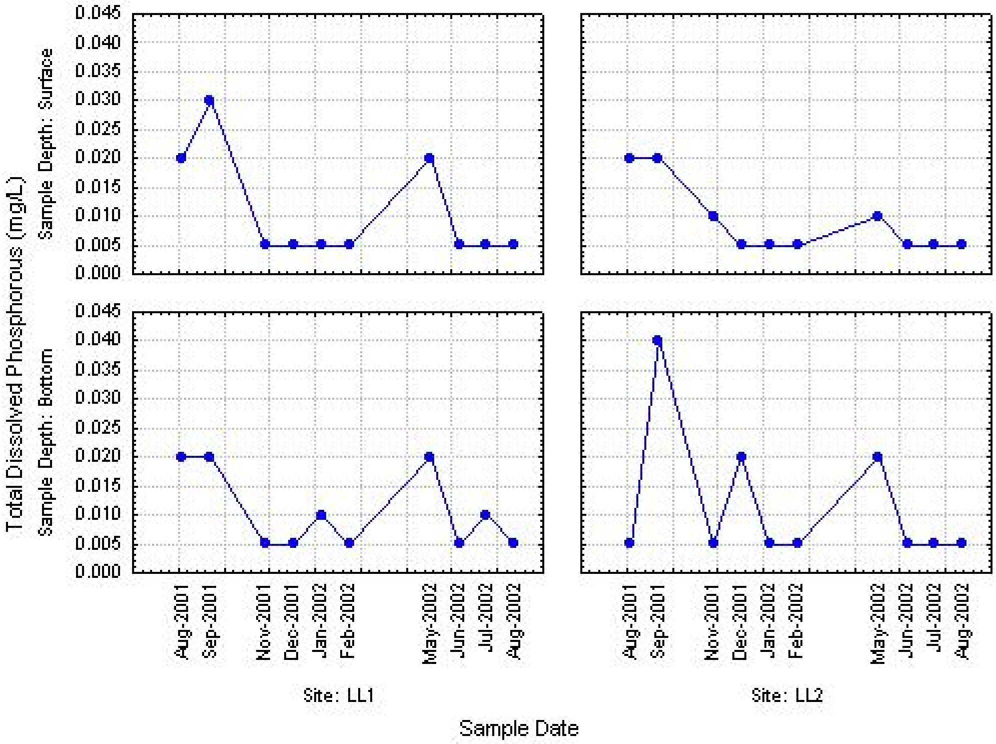

Figure 33. Total Dissolved Phosphorus Concentrations by Month for Legion Lake Categorized by Site and Sample Depth.

Limiting Nutrients

Great emphasis is placed on regulating nutrient loading to water bodies to control aquatic productivity (i.e. eutrophication). In aquatic systems, the most significant nutrient factors causing the shift from a lesser to a more productive state are phosphorus and nitrogen. Nitrogen is difficult to control because of its highly soluble nature, but phosphorus is easier to manipulate from a management perspective. Consequently, it is most often the nutrient targeted for reduction when attempting to control lake eutrophication.

When either nitrogen or phosphorus reduces the potential for algal growth and reproduction, it is considered the limiting nutrient. Optimal nitrogen and phosphorus concentrations for aquatic plant growth occur at a ratio of 10:1 (N:P ratio). N:P ratios greater than 10:1 indicate a phosphorus limited system, while N:P ratios less than 10:1 indicate a nitrogen-limited system (USEPA, 1990).

N:P ratios of all Legion Lake samples ranged from approximately 6.9 to 62.5 (mean = 26.8). 95% of samples collected in Legion Lake were considered phosphorus-limited. N:P ratios were generally lower in the winter and increased throughout the spring and summer months (Figure 34). The sample collected in November revealed the highest case of phosphorus limitation (N:P = 62.5). The ratios varied fairly substantially from month to month, but only became nitrogen-limited during the February and May samples at LL-2A.

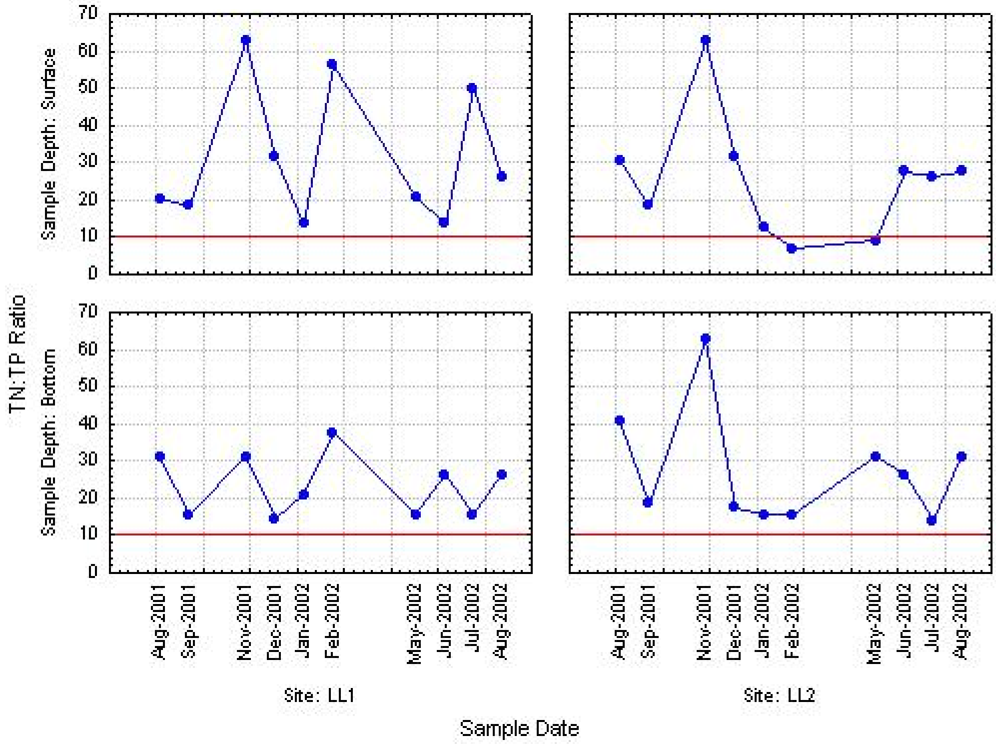

Figure 34. Nitrogen : Phosphorus Ratios by month for Legion Lake Categorized by Site and Sample Depth. (*The solid horizontal line represents the optimal nitrogen and phosphorus concentrations for aquatic plant growth ratio of 10:1)*

Trophic State

Wetzel (2001) defines 'trophy' of a lake as "the rate at which organic matter is supplied by or to a lake per unit time." Trophic state is often measured as the amount of algal production in a lake, one source of organic material. Determinations of trophic state can be made from several different measures including oxygen levels, species composition of lake biota, concentrations of nutrients, and various measures of biomass or production. An index incorporating several of these parameters is best suited to determine trophic state.

Carlson's (1977) Trophic State Index (TSI) was used to determine the approximate trophic state of Legion Lake. This index incorporates measures of Secchi disk transparency, chlorophyll *a*, and total phosphorus into scores ranging from 0 to 100 with each 10-unit increase representing a doubling in algal biomass. Four ranges of index values (Table 26) define Carlson's trophic levels, which include oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic (in order of increasing productivity).

Table 26. Carlson's Trophic Levels and Index Ranges

Trophic Level	TSI Range
Oligotrophic	0 – 35
Mesotrophic	36 – 50
Eutrophic	51 – 65
Hyper-eutrophic	66 – 100

TSI values were calculated for each of the index parameters individually. The number of samples/measurements used to calculate individual TSI values varied by parameter and year. Only surface samples/measurements from sites LL-1A and LL-2A of this study, as well as historical and more recent data, were used for TSI calculations. Phosphorus samples were collected during the SD DENR Statewide Lakes Assessment (SWLA) program twice per year during the years 1989, 1991, 1992, 1999; semi-monthly during this study from August 2001 to August 2002; and again during SWLA in June and July of 2003. Secchi depth measurements were collected at the same time as phosphorous samples, except during ice cover in December and January. Chlorophyll *a* samples were collected only during June and July 1991, August 1993, and June and July 1999 and 2003 (note that chlorophyll samples were collected as part of SD DENR statewide lakes assessment program, not during the study period).

Phosphorus TSI values ranged from 37.4 to 69.8 (mean = 52.4), chlorophyll *a* TSI values ranged from 47.0 to 71.2 (mean = 54.4), and Secchi depth TSI values ranged from 36.8 to 68.7 (mean = 48.7). Approximately 54% of phosphorus TSI values indicate eutrophic conditions, and 46% were in the mesotrophic range. Approximately 38% of the Secchi depth measurements indicated eutrophic conditions, and 62% were in the mesotrophic range. Of the seven chlorophyll samples, three were mesotrophic, three were eutrophic, and one was recorded as hyper-eutrophic in July of 1999. See Table 27 for descriptive statistics of available TSI data for Legion Lake.

Table 27. Descriptive Statistics for Trophic State Index (TSI) in Legion Lake from 1989-2003.

Statistic	Phosphorus TSI	Chlorophyll TSI	Secchi TSI
Number of Samples	28	7	24
Median	53.2	51.3	47.6
Minimum	37.4	47.0	36.8
Maximum	69.8	71.2	68.7

Historic TSI data were compiled to examine trends in trophic state. The limited historical chlorophyll TSI data did not correlate well with the phosphorus and Secchi TSI data. Annual average phosphorus and Secchi TSI values were significantly correlated (Spearman Rank rho=0.96) and appear to be declining (Table 28 and Figure 35). Additional data collected in 2007 suggests that this trend has continued. Chlorophyl *a* concentrations of 1.5ppb and 6.0ppb (corresponding to TSI values of 34 and 48 respectively) were collected that summer.

Table 28. Historic Average annual TSI Values for Legion Lake

Year	Total Phosphorus	Chlorophyll *a*	Secchi Depth
1989	65.6		58.9
1991	69.8	47.0	57.9
1992	58.4	56.2	55.6
1999	59.0	60.3	56.4
2001	51.4		50.6
2002	48.7		43.0
2003	41.7	50.4	39.8

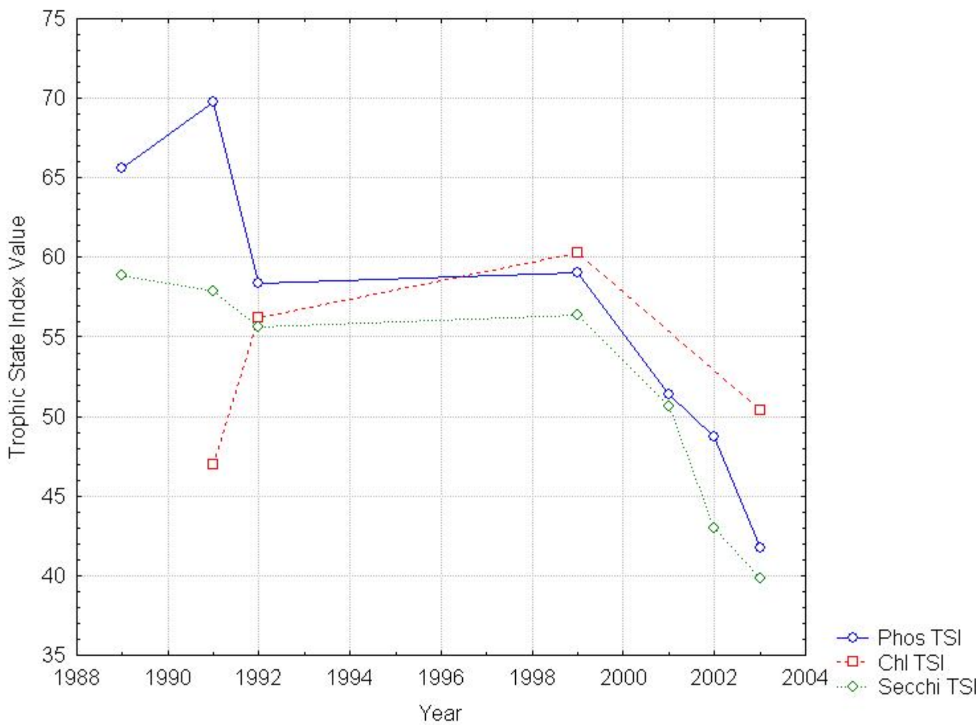

Figure 35. Historic Trophic State Index Values for Legion Lake (1989-2003).

Dissolved Oxygen

Legion Lake was listed on the 2010 Integrated Report as impaired for both high pH as well as low DO concentrations. During review of available data for this report, it was discovered that the DO only exceeded the standard during a single routine sampling event in 2007. Further examination of the data indicated that the readings collected that day were done so with a YSI rapid pulse DO probe. This probe also reports a charge which may be used to determine its functional status. The charges recorded with the low DO readings on Legion Lake were all below the acceptable value of 25. Samples collected earlier in the trip were well within the acceptable range of 25 to 75, suggesting that the membrane on the probe was punctured resulting in erroneous low readings. As a result of removing the erroneous data, the DO in Legion Lake supports the standard 100% of the time and should be removed from the impaired waters list in 2012.

5.2.5 Legion Lake TMDL Allocations

Wasteload Allocation

There are no point sources of pollutants in this watershed. Therefore, the "wasteload allocation" component of this TMDL is considered a zero value. The TMDL is considered wholly included within the "load allocation" component.

Load Allocation (LA)

Current total phosphorus loads from the watershed are approximately 7.3 kg/yr. Changes within the watershed have resulted in the trophic state steadily improving (decreasing TSI values) across all available data. As these improvements continue, chlorophyll *a* concentrations will drop to levels below the necessary ecoregion range required for full support of the pH standard.

Phosphorus loads can be maintained or reduced through the implementation of constructed wetlands and riparian zone enhancements. Legion Lake was scheduled for dredging after 2010 as part of a National Forest Service project. Completion of dredging will reduce internal loadings providing further assurance the TMDL will be met. Utilizing the current load of 7.3 kg/yr as a maximum allowable limit in the TMDL will insure that improvements attained to date are maintained.

To identify a maximum daily limit, a method from EPA's "Technical Support Document For Water Quality-Based Toxics Control," referred to as the TSD method, was used. This method, which is based on a long-term average load that considers variation in a dataset, is a recommended method in EPA's technical guidance "Options for expressing Daily Loads in TMDLs"(USEPA 1991). The TSD method is represented by the following equation:

$MDL = LTA * e^{[z\sigma - 0.5\sigma 2]}$

where,

MDL = maximum daily limit
LTA = long-term average
z = z statistic of the probability of occurrence
$\sigma 2 = \ln(CV2+1)$
CV = coefficient of variation

The daily load expression is identified as a static daily maximum load. A static daily load expression was deemed suitable because of the small watershed size, relatively constant loadings from nonpoint sources (e.g., septics, roads, in-stream sources), and the fact that a steady-state analysis was used. Assuming a probability of occurrence of 95% and a CV of 0.1 (based on available data), the maximum daily load corresponding to an average annual load of 7.3 kg/yr is 0.022 kg/day.

Table 29Load Allocation (kg/yr) Summary for Legion Lake.

TMDL Component	Long-term Average Allocation (kg/year)	Maximum Daily Allocation (kg/day)
Wasteload Allocation	0	0
Load Allocation	7.3	0.022
Margin of Safety	Implicit	Implicit
TMDL	7.3	0.022

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and land use. To determine seasonal differences, Legion Lake sample data was graphed by sampling date to facilitate viewing seasonal differences. Nearly all parameters assessed in this study displayed seasonal variation. For example, lake total phosphorus concentrations were highest during winter months in Legion Lake. Because much of the biologically available phosphorus is assimilated by algae during the growing season, concentrations increase during the winter.

Seasonal hydrologic loadings from the watershed were also calculated. Highest hydrologic loads were observed during the spring and fall, while no measurable flow was observed during the winter.

Margin of Safety

The margin of safety for the phosphorus TMDL is implicit based on conservative estimations of lake model coefficients

5.3 Horse Thief (9213)

5.3.1 Watershed Description

Horse Thief Lake is located in the southern portion of Pennington County. Average annual precipitation is approximately 25.4 inches. Approximately 73 % of the precipitation occurs during the months of April through September. In the summer, the average temperature is 65 degrees F. During the winter, the average temperature is 31 degrees F.

The majority of the watershed is located in the Black Elk Wilderness (Figure 36) which was established in 1980. This 13,426 acre (54 km²) wilderness area is considered sacred to Native Americans, especially the Sioux and is named after Black Elk, an Oglala Sioux holy man. Mount Rushmore National Memorial is immediately to the north and much of the rest of the wilderness is bordered by other protected land under the jurisdiction of state and federal agencies.

Harney Peak, which at 7,242 feet (2,207 m) is the tallest mountain in South Dakota, is located in the wilderness, and one can see into four different States from the summit. Craggy peaks and rocky slopes mixed with ponderosa pine, spruce and fir trees make for a varied ecosystem. Mountain goats and bighorn sheep inhabit the more rugged mountain slopes, while mule deer, elk and pronghorn are more common in the forested valleys.

U.S. Wilderness Areas have walking and hiking trails, but do not allow motorized or mechanized vehicles, including bicycles. Although camping and fishing are allowed with proper permit, no roads or buildings are constructed and there is also no logging or mining, in compliance with the 1964 Wilderness Act. Wilderness areas within National Forests and Bureau of Land Management areas also allow hunting in season.

The drainage area immediately surrounding the lake is not part of the wilderness. This small portion of the watershed is part of the Black Hills National Forest. The entire watershed is National Forest managed by the US Forest Service. Highway 244 crosses through or borders about 1 mile of the watershed and crosses the dam that creates the lake. The only other anthropogenic improvements are a small dirt road and parking area at the Black Elk Wilderness access point and a small forest service campground located on the northeast side of the lake.

The campground consists of 36 sites varying from RV accessible to hike in only. Wastewater from the comfort station and restrooms are vaulted, pumped, and disposed of outside of the watershed. The lake is extremely popular for fishing and swimming, achieving the highest angler satisfaction of area lakes during a 2007 SD GFP creel survey. Heavy use has resulted in excessive erosion resulting in lake sedimentation.

Prior to its wilderness status, a number of roads were constructed throughout the drainage. Historic road building did not take into account erosion or its water quality impacts. Many of these roads eventually became part of the current hiking trail system, but due to their design have been the focus of BMPs to reduce erosion. These roads most frequently followed the drainages and are suspected to have been a major source of the sediment that has entered the lake since its construction in the 1930's.

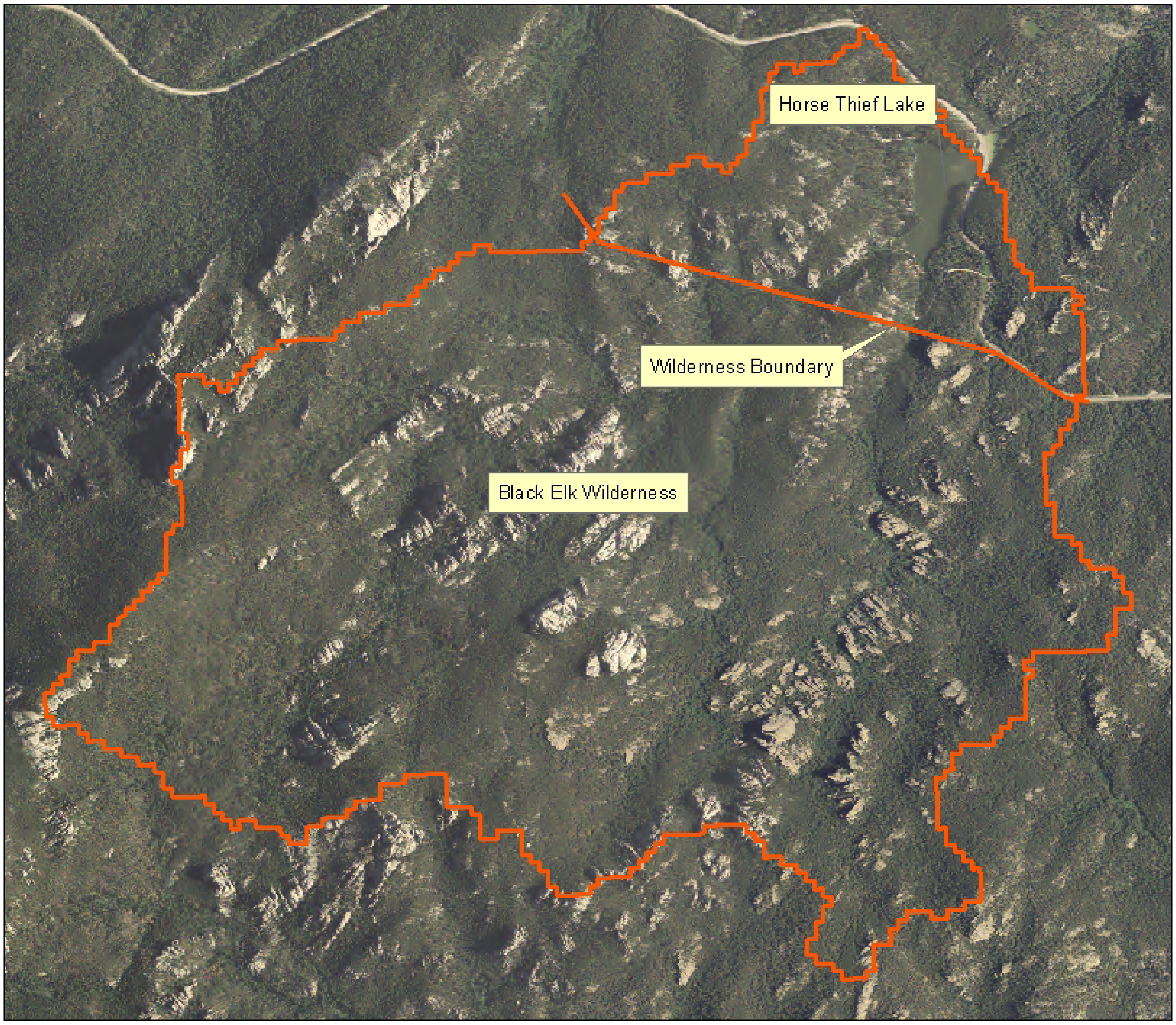

Figure 36. Horse Thief Lake Watershed

5.3.2 Beneficial Use Assignment

Each waterbody within South Dakota is assigned beneficial uses. All waters (both lakes and streams) are designated the use of fish and wildlife propagation, recreation and stock watering. All streams are assigned the use of irrigation. Additional uses may be assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in South Dakota state statutes in support of these uses. These standards consist of suites of numeric criteria that provide physical and chemical benchmarks from which management decisions can be developed.

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the states water quality standards, this is the method used in the states Integrated Water Quality Report (IR) as well as in permit development.

Additional "narrative" standards that may apply can be found in the "Administrative rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09". These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The following beneficial uses have been assigned to Horse Thief Lake: (1) coldwater permanent fish propagation, (2) immersion recreation, (3) limited contact recreation, and (4) wildlife propagation, recreation and livestock watering. Table 29 lists the criteria that must be met to maintain the above beneficial uses. When multiple standards exist for a particular parameter, the most stringent standard is used.

Table 30. Surface Water Quality Standards for Horse Thief Lake

Parameters	Criteria	Unit of Measure	Beneficial Use Requiring this Standard
Total ammonia nitrogen as N	Equal to or less than the result from Equation 3 in Appendix A of Surface Water Quality Standards	mg/L 30 average	Coldwater Permanent Fish Propagation
	Equal to or less than the result from Equation 1 in Appendix A of Surface Water Quality Standards	mg/L Daily Maximum	
Chlorides	<100	mg/L 30-day average	Coldwater Permanent Fish Propagation
	<175	mg/L Dailey Maximum	
Dissolved Oxygen	>6.0	mg/L Dailey Maximum	Coldwater Permanent Fish Propagation
	>7.0	Mg/L in spawning areas during the spawning season	
Undisassociated hydrogen sulfide	<0.002	mg/L Dailey Maximum	Coldwater Permanent Fish Propagation
pH (standard units)	>6.5 to <9.0	units	Coldwater Permanent Fish Propagation
Total Suspended Solids	<30 (30 day average) <53 (single sample)	mg/L	Coldwater Permanent Fish Propagation
Temperature	<18.3	°C	Coldwater Permanent Fish Propagation
Fecal Coliform Bacteria (May 1- Sept 30)	<200 (geometric mean) <400 (single sample)	count/100 mL	Immersion Recreation
Escherichia Coli Bacteria (May 1- Sept 30)	<126 (geometric mean) <235 (single sample)	count/100 mL	Immersion Recreation
Alkalinity ($CaCO_3$)	<750 (mean) <1,313 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Nitrogen, nitrate as N	<50 (mean) <88 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Solids, total dissolved	<2,500 (mean) <4,375 (single sample)	mg/L	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon	<10	mg/L	Wildlife Propagation and Stock Watering

5.3.3 Tributary Hydrology and Chemistry

The primary tributary to Horse Thief Lake is Pine Creek which drains 1,832 acres of the Black Elk Wilderness. Currently, there are no existing water quality data available for Pine Creek above Horse Thief Lake. Initialization of monitoring during this phase of the restoration process will likely lead to erroneous calculations and assumptions in regards to the water chemistry of the lake. As of 2010, the US Forest Service had completed watershed restoration work which would result in Pine Creek demonstrating nutrient concentrations that are lower than what would have been found prior to BMP installation. While the BMPs have affected the stream, the lake remains impaired due to nutrient accumulations in the sediment that have not cycled out of the system. A funded, but not yet implemented dredging of lake sediments is set to accelerate the cycling process and is expected to result in full support of the lakes beneficial uses.

With the location of the Pine Creek drainage entirely within the Black Elk Wilderness area, it is reasonable to expect that this stream should at minimum meet, if not exceed, any water quality criteria set forth. South Dakota does not have a nutrient criteria, however EPA has set forth recommended criteria for level III ecoregions. As a result of the current phase of mitigation activities as well as the lack of preexisting water chemistry data, utilizing the EPA guidance as the TMDL concentration was deemed the most accurate and protective approach for developing the TMDL.

Pine Creek Hydrology

Pine Creek is the primary tributary to Horse Thief Lake. It drains approximately 2.9 square miles of the Black Hills consisting primarily of the Black Elk Wilderness. From its outfall it travels 1.7 miles downstream to its confluence with Battle Creek. There are no gauge records available for Pine Creek, requiring a surrogate be used to develop flow characteristics for the watershed. Four drainages with discharge data were identified within Ecoregion 17b that were similar to Pine Creek and could be used to develop an adequate relationship (Table 30). Relative locations of these gauges may be found in Figure 37.

Table 31. USGS Gauges Compared to Pine Creek above Horse Thief Lake

Gauge Site	Drainage Area Sq/Mi	Average Annual Discharge CFS/Mile	Years of Record
USGS 06404000 BATTLE CR NEAR KEYSTONE,SD	58.4	0.149	48
USGS 06404800 GRACE COOLIDGE CREEK NEAR HAYWARD, SD	7.48	0.214	9
USGS 06405800 BEAR GULCH NEAR HAYWARD, SD	4.23	0.216	8
USGS 06404998 GRACE COOLIDGE CR NR GAME LODGE NR CUSTER,SD	26.8	0.188	33
PINE CREEK ESTIMATE BASED ON DRAINAGE AREA	3	0.222	

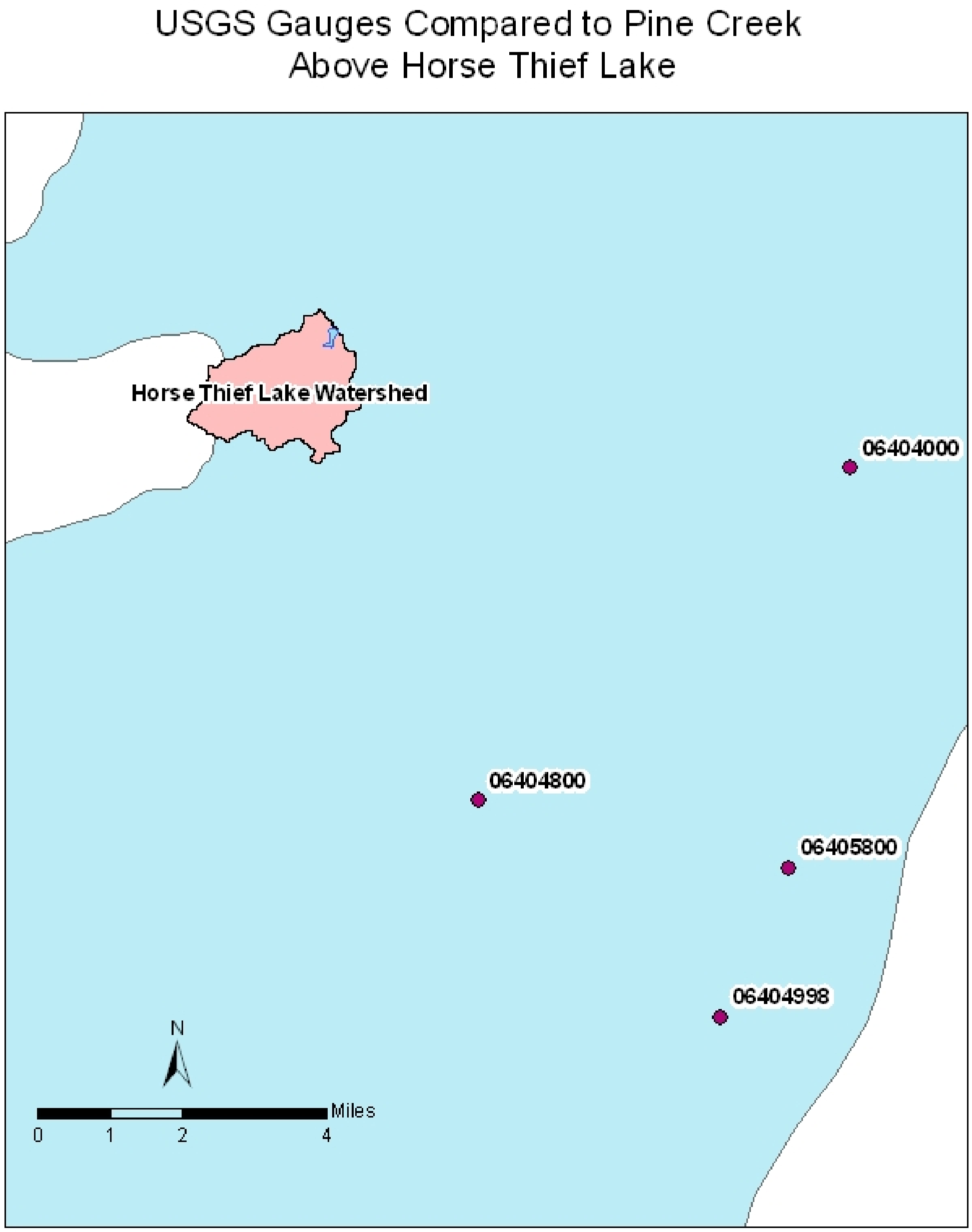

Figure 37. USGS Gauges Compared to Pine Creek above Horse Thief Lake

The gauges used in the comparison have a number of important characteristics in common with the Pine Creek drainage. The Grace Coolidge and Bear Creek drainages were most similar in size to Pine Creek, however the period of record for these streams was shorter than desired at 9 and 8 years, respectively. The timeframes for their periods of record were during the 1990's, a period which experienced rainfall and runoff rates were higher than long term averages for the region.

To improve the long term estimates, gauges with larger drainage areas on Battle Creek and an additional downstream gauge on Grace Coolidge Creek were included in the dataset. These sites had 48 and 33 years of record, respectively.

The runoff per acre for the shorter term gauges was adjusted by making a comparison of similar years of record on Battle Creek to its long term average. This method suggested that the average discharge during the 90's for this area was approximately 170% of the long term average. After final adjustments were made to the short term gauges, a relationship was developed between drainage area and average annual discharge (Figure 38).

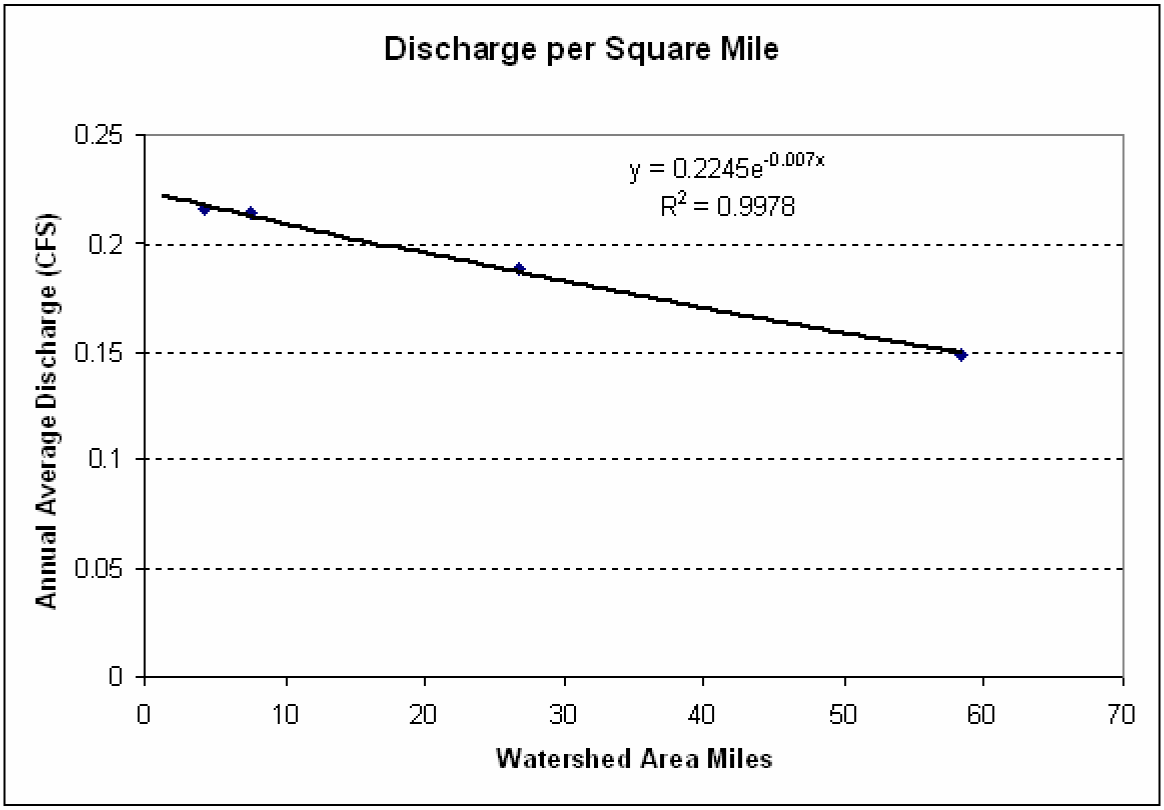

Figure 38. Average Annual Discharge per Square Mile of Drainage in Ecoregion 17b Watersheds.

The data suggest that as drainage area increases, runoff volume per square mile tends to decrease. Factors such as use by vegetation and evaporation account for a majority of the losses. Taking into consideration the geology and geography of the area, the smaller watersheds are often characterized by steep rocky slopes with high runoff coefficients while the larger watersheds have higher proportions of less steep slopes and increased vegetation that reduce runoff coefficients.

The resulting water load utilizing the equation developed in Figure 38 an average annual water load of 0.222 CFS/ sq mile. With a three square mile drainage area, the flow rate to Horse Thief Lake may be approximated at 0.666 cfs or 482 acre feet per year. This water load will be used as the annual water load for the TMDL calculations.

Pine Creek Water Chemistry

There is no existing water chemistry data for Pine Creek either above or below Horse Thief Lake. Although the absence of water chemistry in the creek creates some difficulties and uncertainties, a sufficient amount of surrogate information exists for the watershed that an adequate TMDL may be developed.

The Pine Creek water chemistry was developed utilizing ecoregion nutrient targets and modeled reductions in nutrient loading as a result of BMPs that have been utilized in the watershed. At the point of TMDL development, restoration activites in the watershed were either complete or nearing completion. The lake continued to exhibit signs of impairment during its most recent sampling. This continued impairment is considered to be a result of nutrient loadings in the past which have accumulated in the sediments. The US Forest Service has received funding and approval to dredge nutrient rich sediments from the lake, which is expected to accelerate the recovery process.

South Dakota has no numeric criteria for total nitrogen (TN) and total phosphorous (TP) but the state does have numeric criteria for ammonia and nitrates. The ammonia and nitrates criteria were not adopted to address nutrient enrichment issues. Rather, ammonia criteria were adopted to protect aquatic life from the toxicity of ammonia that can occur under specific water temperature and pH conditions. The nitrate criteria were adopted to address human and livestock health issues related to elevated levels of nitrates in drinking and stock watering waters. Both criteria are above nutrient levels associated with the eutrophication of waterbodies.

There are four nutrient ecoregions in South Dakota: II – Western Forested Mountains, IV – Great Plains Grass and Shrublands, V – South Central Cultivated Great Plains, and VI – Corn Belt and Northern Great Plains. Figure 39 shows a map of the nutrient ecoregions. Nutrient ecoregions are aggregates of USEPA's level III Ecoregions.

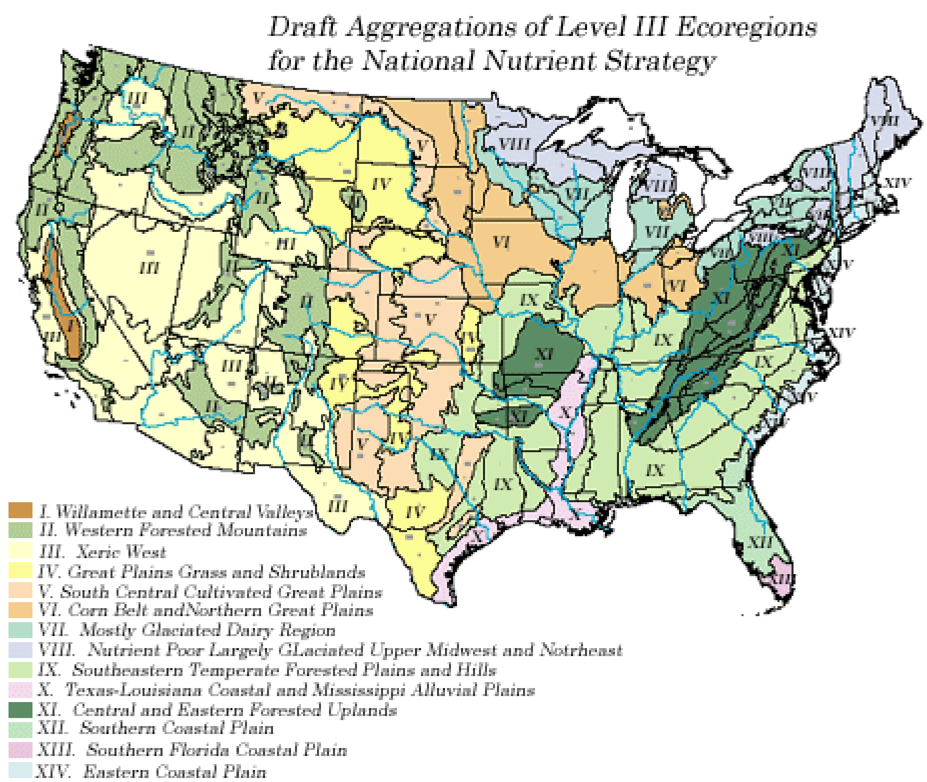

Figure 39 Nutrient Ecoregions

The USEPA recommended nutrient criteria for streams, rivers, lakes, and reservoirs in each nutrient ecoregion (USEPA 2000c, 2000d, 2000e, 2000f, 2000g, 2000h, 2001a, 2001b). The USEPA recommended criteria for each nutrient ecoregion can be found in Table 1.

Table 32 USEPA Recommended Nutrient Criteria for the Nutrient Ecoregions in South Dakota

Rivers and Streams				
Parameter	Nutrient Ecoregion II	Nutrient Ecoregion IV	Nutrient Ecoregion V	Nutrient Ecoregion VI
TP (mg/L)	0.010	0.023	0.67	0.07625
TN (mg/L)	0.12	0.56	0.88	2.18
Chlorophyll *a* (µg/L)	1.08	2.4	3	2.7
Turbidity (FTU/NTU))	1.3	4.21	7.83	6.36
Lakes and Reservoirs				
TP (mg/L)	0.0088	0.020	0.033	0.0375
TN (mg/L)	0.1	0.44	0.56	0.781
Chlorophyll *a* (µg/L)	1.9	2	2.3	8.59
Secchi (m)	4.5	2	1.3	1.356
mg/L = milligrams per liter; m = meters; FTU/NTU = formazin/nephelometric turbidity units				

The USEPA contracted with Heidleburg College to analyze ambient river and stream water quality data collected by the South Dakota Department of Environment and Natural Resources (SDDENR). A data analyses protocol was developed and the data were analyzed following the USEPA protocol for determining the lower seasonal 25th percentile of the population of all streams within a region. Similar to the USEPA's recommended criteria, the median of the seasonal percentiles for total phosphorous, total nitrogen and TKN would be the recommended criteria for each nutrient ecoregion in South Dakota. Table 2 shows the results of the data analysis.

Table 33. Recommended Total Phosphorous, Total Nitrogen and Total Kjeldahl Nitrogen Criteria for Rivers and Streams in Each Nutrient Ecoregion.

Rivers and Streams				
Parameter	Nutrient Ecoregion II	Nutrient Ecoregion IV	Nutrient Ecoregion V	Nutrient Ecoregion VI
TP (mg/L)	0.020 (144*)	0.048 (155*)	0.053 (18*)	0.129 (230*)
TN (mg/L)	3.161 (26*)	1.053 (66*)	0.970 (1*)	1.761 (134*)
TKN (mg/L	0.461 (43*)	0.473 (117*)	0.502 (14*)	0.939 (204*)
mg/L = milligrams per liter; (*) - The number of station medians that were used to calculate the South Dakota based criteria.				

These recommended criteria have not been adopted as standards. There were concerns with the small number of stations that were used to calculate the medians for some of the nutrient ecoregions, in particular nutrient ecoregion V.

The USEPA also funded data analysis of periphyton and nutrient data collected by the South Dakota Department of Environment and Natural Resources (SDDENR). In part, data from SDDENR and the Western Pilot Environmental Monitoring and Assessment Program (WEMAP) were used to develop relationships between nutrient concentrations and periphyton metrics in streams. The results of the analysis identified thresholds between 0.030 – 0.050 mg/L TP and at 0.107 mg/L TP. A concentration of 0.100 mg/L TP was recommended as a benchmark for nutrient criterion development (Stevenson, 2008).

Based on the analysis by Heidleburg College, it may be assumed that a concentration of 0.02 mg/L would be adequate for Pine Creek. As stated earlier, this stream is located entirely in a wilderness area, which suggests it should be held to a more conservative standard. As a result, this TMDL will be based on the more conservative EPA guidance of 0.01 mg/L of total phosphorus. By using the more conservative number, it will also provide for an implicit margin of safety within the TMDL. While an explicit margin of safety is normally calculated, the absence of water chemistry from Pine Creek makes an implicit margin of safety a more appropriate choice for the Horse Thief Lake TMDL.

Best Management Practices Implemented in the Pine Creek Watershed

The US Forest Service has been actively involved in watershed restoration of the Horse Thief Lake Watershed. Mitigation activities have primarily focused on the reduction of sediment entering the Pine Creek drainage and the lake itself. In addition to sediment reduction, nutrients loadings have also been reduced. Phosphorus reductions as a result of BMP implementation have been calculated and will be used to estimate annual nutrient loads to the lake and may be considered representative of the Pine Creek watershed in its impaired state.

1. Centennial 89 Trail (old road bed) Pine Creek Crosssing #1. Reconstructed wilderness trail ford in 2009 as well as 1 1/2 mile of trail reconstruction to the east of that crossing. There were two additional tributaries of Pine Creek that were also reconstructed as a part of this project.

Reconstruction of the Centennial trail addressed numerous segments of the trail that were experiencing excessive erosion. Portions of the trail were stable and required little maintenance. Some short segments were developing ephemeral gullies and eroding at a rate estimated to exceed 100 tons/ acre/yr (losses of nearly 1 vertical inch of trail surface annually).

2. Centennial 89 Trail Pine Creek Crossing #1 to Horse Thief Lake Day Use Area. A user defined (non system) trail was closed at both ends in 2005; this eliminated all horse & foot traffic. Some intentional seeding, fencing and natural tree falling was continued to rehabilitate this area back to a natural (vegetated) setting.

Closing this trail was the greatest single source of erosion control accomplished through the trail rehabilitations. The trail was slightly over 0.5 miles long with a severely eroded stream crossing. Sediment losses from the stream crossing were calculated to be in excess of 4 cubic meters. Large sections of this trail also showed indications of high rates of erosion in immediate proximity to Pine Creek, resulting in high rates of sediment delivery to the lake.

3. Centennial 89 Trail Pine Creek Crossing #2.

Similar to the previous trail reconstructions, numerous sections of the trail were improved to reduce high rates of erosion from localized sources.

4. East Shore Line Horse Thief Lake Fishing trail and platforms completed in 2006. Primary purpose was shoreline protection from soil compaction, vegetation damage, sedimentation caused by recreational foot traffic while also providing disabled person fishing access to lake.

This reconstruction affected approximately 0.5 acres of vulnerable lake shore. Steep slopes along this shore resulted in estimated erosion rates that exceeded 10 ton/acre. The boardwalk and trail construction significantly reduced the impacts on the most vulnerable portions of the shoreline. Minor modifications to this are still yielding improvements and may be expected to reduce yields by 60% or more.

5. South End Horse Thief Lake Fishing Day Use Site reconstruction in 2003. This was completed to provide a footbridge to the campground as well as reducing soil compaction, vegetation damage, sedimentation while providing disabled person fishing access to lake.

Existing evidence at this site suggest erosion rates exceeded 20 tons/ acre on this 0.1 acre site. The rip rap and fishing dock in conjunction with the parking lot improvements are expected to have reduced yields by 95%.

6. South End Horse Thief Lake Fishing Day Use Site Parking Improvements completed in 2008. This project provided asphalt paving at the parking spots as well as a filter strip barrier for toxins from parked cars.

This project not only reduced runoff from the parking area, but also acts as a buffer to 0.25 acres of roadway that drain down the hill. Prior to construction, the road was prone to the development of ephemeral gullies that drained across the lot and into the lake. The paved surface eliminates erosion from the 0.4 acre parking area as well as diverting road runoff through the filter strip.

A project for improving and preserving fishing opportunities on the Peter Norbeck Scenic Byway by dredging Horse Thief, Bismarck and Lakota lakes is funded and expected to occur sometime in 2011 or 2012. The dredging efforts may help to reduced internal nutrient loads further protecting the waterbody.

The final, and likely the most beneficial improvement in the watershed was the elimination of the road network within the watershed. Roads were developed through nearly every drainage over the past 100 years to access mining claims and for logging purposes. Many were used for only brief periods of time, possibly untill the resource was exhausted or the erosion resulted in an unusable surface. As a result of an absence of environmental awareness during their construction, many of these roads experienced significant erosion. Some road sites are still visible from the large gullies that formed after their creation. It is likely that the majority of the sediment that has accumulated in the lake may be a direct result of these roadways.

Pine Creek Nutrient and Sediment Loads

The primary nutrient of concern in Pine Creek is phosphorus. Based on the average annual water load of 0.666 cfs and utilizing the concentration of 0.01 mg/L of phosphorus, the average annual load of phosphorus may be calculated at 13.1 pounds or 5.9 kilograms. This load should be utilized to develop the TMDL target.

The phosphorus load prior to the implementation of the BMPs should be utilized for the initial phosphorus load in the TMDL calculations. To calculate that load, the reductions achieved through the BMPs will be added to the 13.1 pounds calculated for the final TMDL target. This pre BMP load may also be used to perform reduction response modeling with the BATHTUB model to verify that the calculated reductions were reasonable.

During the winter of 2009, the South Dakota Game Fish and Parks conducted a sediment survey on Horse Thief Lake. Based on their estimates from Figure 40, approximately 23,000 cubic meters of sediment have accumulated in the reservoir since its construction. A cubic meter of sediment when dried down can be expected to weigh approximately 1 ton. At 78 years of age, the sediment accumulation rate averaged out to approximately 39 tons delivered to the lake per square kilometer of drainage on an annual basis.

Sediment yield rates for ecoregion 17 were investigated in "Characterization of Suspended-Sediment Transport Conditions for Stable, "Reference" Streams in Selected Ecoregions of EPA Region 8" (Klimentz et al, 2009). This report made comparisons of sediment delivery from both stable and unstable streams. Stable reference streams in ecoregion 17 were predicted to have transport rates of 3. to 24.6 tons/km/yr with a median rate of 5.9 tons/km/yr. Unstable streams were also evaluated with expected deliveries of 30.3 to 39.5 tons/km/yr, suggesting that Pine Creek has a history of excessive sediment erosion and delivery. Due to the difficulty in calculating erosion rates for each of the individual BMPs, utilizing the accumulated sediment in the reservoir may be utilized as a method for estimating watershed loading prior to wilderness designation and BMP implementation.

During a field investigation of the watershed in October of 2010, Rapid Geomorphic Assessment (RGA) scores throughout the watershed ranged from 0 to 3.5, indicating a high degree of stability. As a result of the stable stream channel and an absence of active erosive features, the stable stream loading calculated by Klimentz made an appropriate choice for an estimate of stream sediment loading.

With a historic loading estimated at 39 tons/km/yr, and an expected current load of 5.9 tons/km/yr, it was calculated that an 85% reduction had been achieved over the long term loading rate. Nutrient concentrations, with particular emphasis on phosphorus, are frequently tied to sediment concentrations. Based on the 85% reduction in sediment, a similar reduction was assumed for phosphorus, suggesting that nutrient concentrations prior to BMP implementation could have been expected to be approximately 0.066 mg/L.

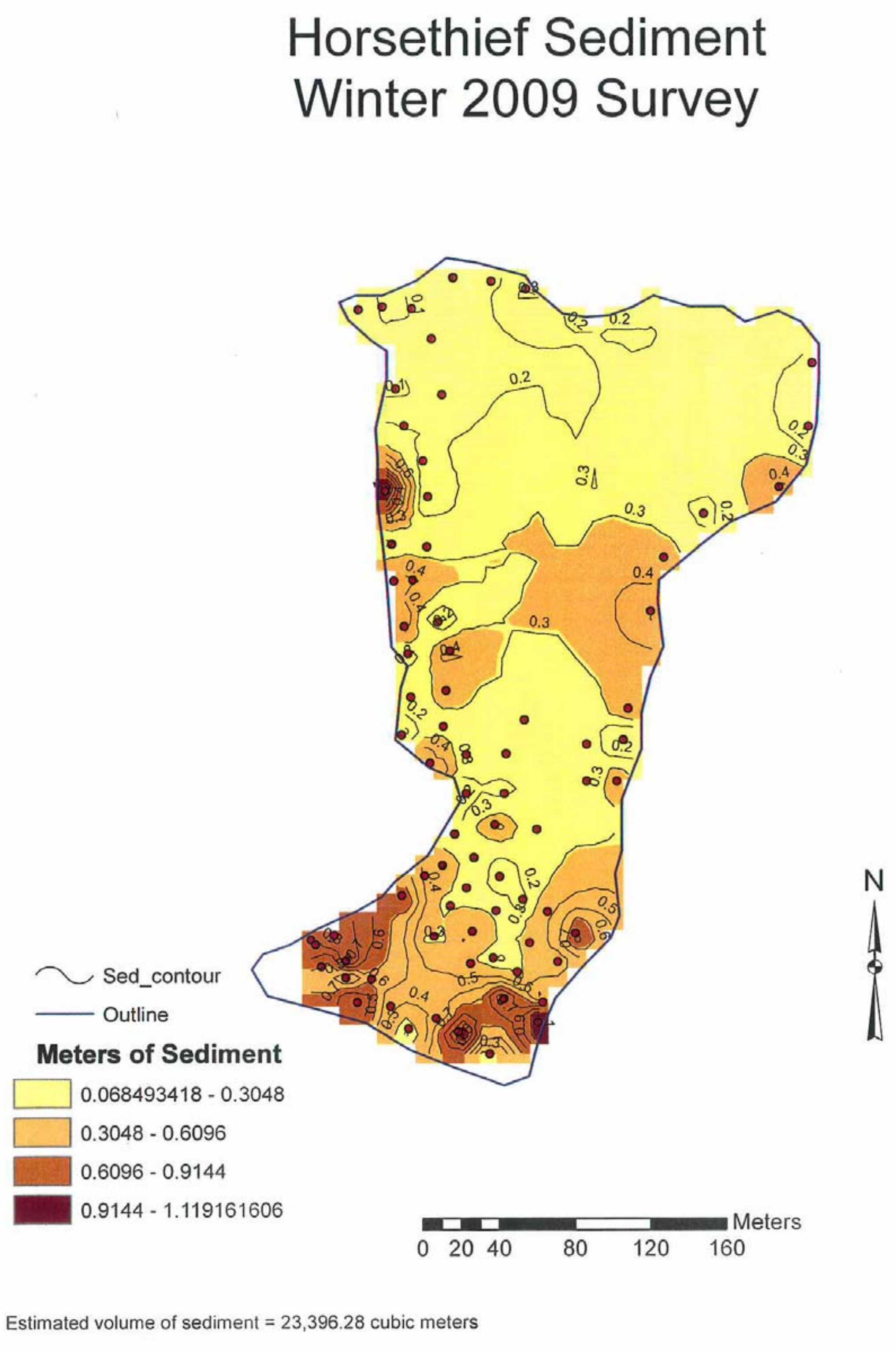

Figure 40. Sediment Accumulation in Horse Thief Lake (Provided by SD GFP)

5.3.4 Reservoir Chemistry

Acidification and Alkalinity

Horse Thief Lake was placed on the states impaired waterbodies list due to pH measurements that exceeded the state standard of 9.0 standard units. Table 33 includes all available pH and alkalinity data for Horse Thief Lake. The frequency of pH values exceeding the state standard is high with peak values recorded during 2001. The alkalinity in the lake is low with an average concentration of 28 mg/L. The low alkalinity in the reservoir reduces its ability to buffer against shifts in pH.

During 2001, complaints were received regarding a white substance in the water at the lake. Further investigation suggested that the substance was calcium carbonate precipitating out of the water. During the day, photosynthesis by algae raised the pH high enough to form the precipitate. During the evening, the precipitate would dissolve back into the water and the process would repeat the following day. This occurred for several days through the summer.

Table 34. Alkalinity and pH Data for Horse Thief Lake

Date	Time	StationID	Relative Depth	Alkalinity mg/L	pH
09/11/1979	02:00	HORSETH1HL	Surface	30	
09/11/1979	02:00	HORSETH1HL	Surface		7.9
07/11/1989	06:30	SWLAZZZ9213	Surface	47	9.24
08/16/1989	03:00	SWLAZZZ9213	Surface	28	9.16
08/16/1989	03:00	SWLAZZZ9213	Surface		9.5
07/15/1991	06:15	SWLAZZZ9213	Surface	23	8.51
07/15/1991	06:15	SWLAZZZ9213	Surface		7.8
10/01/1991		SWLAZZZ9213	Surface	25	7.22
10/01/1991		SWLAZZZ9213	Surface		7.15
06/14/1994	11:00	SWLAZZZ9213	Surface	25	
06/14/1994	11:00	SWLAZZZ9213	Surface		7.73
08/17/1994	09:00	SWLAZZZ9213	Surface	27	
08/17/1994	09:00	SWLAZZZ9213	Surface		9.53
07/10/2001	14:00	SWLAZZZ9213C	Surface		9.66
07/10/2001	14:00	SWLAZZZ9213B	Surface		9.66
07/10/2001	14:00	SWLAZZZ9213A	Surface		9.6
07/10/2001	02:00	SWLAZZZ9213	Surface	22	
07/10/2001	02:00	SWLAZZZ9213	Surface		9.6
08/08/2001	14:33	SWLAZZZ9213A	Surface		9.93
08/08/2001	14:59	SWLAZZZ9213C	Surface		10.04
08/08/2001	14:45	SWLAZZZ9213B	Surface		10.03
08/08/2001	02:00	SWLAZZZ9213	Surface	20	
08/08/2001	02:00	SWLAZZZ9213	Surface		10
06/23/2005	12:30	SWLAZZZ9213	Surface	31	8.21
07/27/2005	10:30	SWLAZZZ9213	Surface	31	8.3

Nitrogen

Nitrogen is a key element in primary productivity, including the growth of plants and algae in aquatic systems. It is found in both organic and inorganic forms with the latter being the more available to plant growth. It is measured as TKN nitrate/nitrite, and ammonia. Total nitrogen is calculated by summing the TKN and nitrate concentrations measured in a sample.

Many of the samples collected from Horse Thief Lake had nitrate and ammonia levels below detection limits. For calculation purposes, one half the detection limits was utilized for those values; the nitrate detection is 0.1 mg/L, 0.05 mg/L was substituted and the ammonia detection is 0.02 mg/L, 0.01 mg/L was substituted. Modified concentrations are highlighted in Table 34.

The data trends indicate a slight decrease in nitrogen concentrations, particularly in the bottom samples. A limited amount of confidence can be placed in these trends due to the small sample size, however their presence is significant and contributes to the evidence that the reservoir is responding to improvements in the watershed.

Table 35. Horse Thief Lake Nitrogen Samples

Sample Date	Relative Depth	TKN	Ammonia	Nitrate	Total N
9/11/79	Surface	0.48	0.10	0.05	0.58
7/11/89	Bottom	0.81	0.05	0.05	0.86
7/11/89	Surface	0.53	0.06	0.05	0.59
8/16/89	Bottom	1.13	0.60	0.05	1.73
8/16/89	Surface	0.53	0.03	0.05	0.56
7/15/91	Bottom	1.21	0.51	0.50	1.72
7/15/91	Surface	0.87	0.01	0.50	0.88
10/1/91	Surface	0.39	0.01	0.05	0.40
10/1/91	Bottom	2.15	1.02	0.05	3.17
6/14/94	Bottom	0.90	0.29	0.10	1.19
6/14/94	Surface	0.82	0.10	0.10	0.92
8/17/94	Bottom	1.36	0.32	0.05	1.68
8/17/94	Surface	1.36	0.01	0.10	1.37
7/10/01	Bottom	0.80	0.19	0.05	0.99
7/10/01	Surface	0.52	0.01	0.05	0.53
8/8/01	Bottom	1.09	0.79	0.05	1.88
8/8/01	Surface	0.87	0.01	0.05	0.88
6/23/05	Bottom	1.21	0.29	0.05	1.50
6/23/05	Surface	0.55	0.01	0.05	0.56
7/27/05	Bottom	0.96	0.26	0.05	1.22
7/27/05	Surface	0.97	0.01	0.05	0.98

Phosphorus

Like nitrogen, phosphorus is a biologically active element. It cycles through different states in the aquatic environment, and its concentration in any one state depends on the degree of biological assimilation or decomposition occurring in that system. The predominant inorganic form of phosphorus in lake systems is orthophosphate.

The phosphorus concentrations measured in Horse Thief Lake are listed in Table 35. Lab analysis for the samples collected in 1979 and 1989 utilized a method that focused specifically on ortho phosphate. More recent analysis utilized a dissolved phosphorus methodology.

Table 36. Horse Thief Lake Phosphorus Samples

Sample Date	Relative Depth	TDP	TP	Ortho P
9/11/79	Surface		0.342	<0.002
7/11/89	Bottom		0.085	0.036
7/11/89	Surface		0.031	0.008
8/16/89	Bottom		0.180	0.070
8/16/89	Surface		0.037	<0.005
7/15/91	Bottom	0.217	0.261	
7/15/91	Surface	0.041	0.058	
10/1/91	Surface	0.041	0.051	
10/1/91	Bottom	0.386	0.471	
6/14/94	Bottom	0.107	0.213	
6/14/94	Surface	0.010	0.057	
8/17/94	Bottom	0.143	0.216	
8/17/94	Surface	0.023	0.073	
7/10/01	Bottom	0.056	0.085	
7/10/01	Surface	0.011	0.033	
8/8/01	Bottom	0.174	0.226	
8/8/01	Surface	0.014	0.048	
6/23/05	Bottom	0.044	0.108	
6/23/05	Surface	0.014	0.032	
7/27/05	Bottom	0.044	0.137	
7/27/05	Surface	0.012	0.040	

Similar to the trends observed in the nitrogen samples, the phosphorus concentrations also indicated that nutrient concentrations were decreasing in the reservoir. The surface concentrations showed little change among the samples; however the bottom samples showed a significant decrease.

The fact that the bottom samples showed higher concentrations and a greater response than the surface samples may be explained by the lakes morphometry. Horse Thief Lake has a small surface area, is relatively deep, and is not as susceptible to wind mixing as many other lakes in South Dakota. The lake stratifies, and the hypolimnion presents conditions that are favorable for the release of nutrients from the sediments. Only a portion of these nutrient fluxes pass through the metalimnion into the epilimnion where they become available for productivity. As BMPs continue to impact the lake, these releases would be expected to slowly decline in magnitude and frequency as the nutrients are cycled out of the lake.

Figure 41 divides the total phosphorus concentrations of the sample set between surface and bottom samples. The small sample size limits the amount of confidence that may be placed in these trends, but as in the nitrogen trends, their presence is significant and adds evidence that the lake is experiencing a recovery.

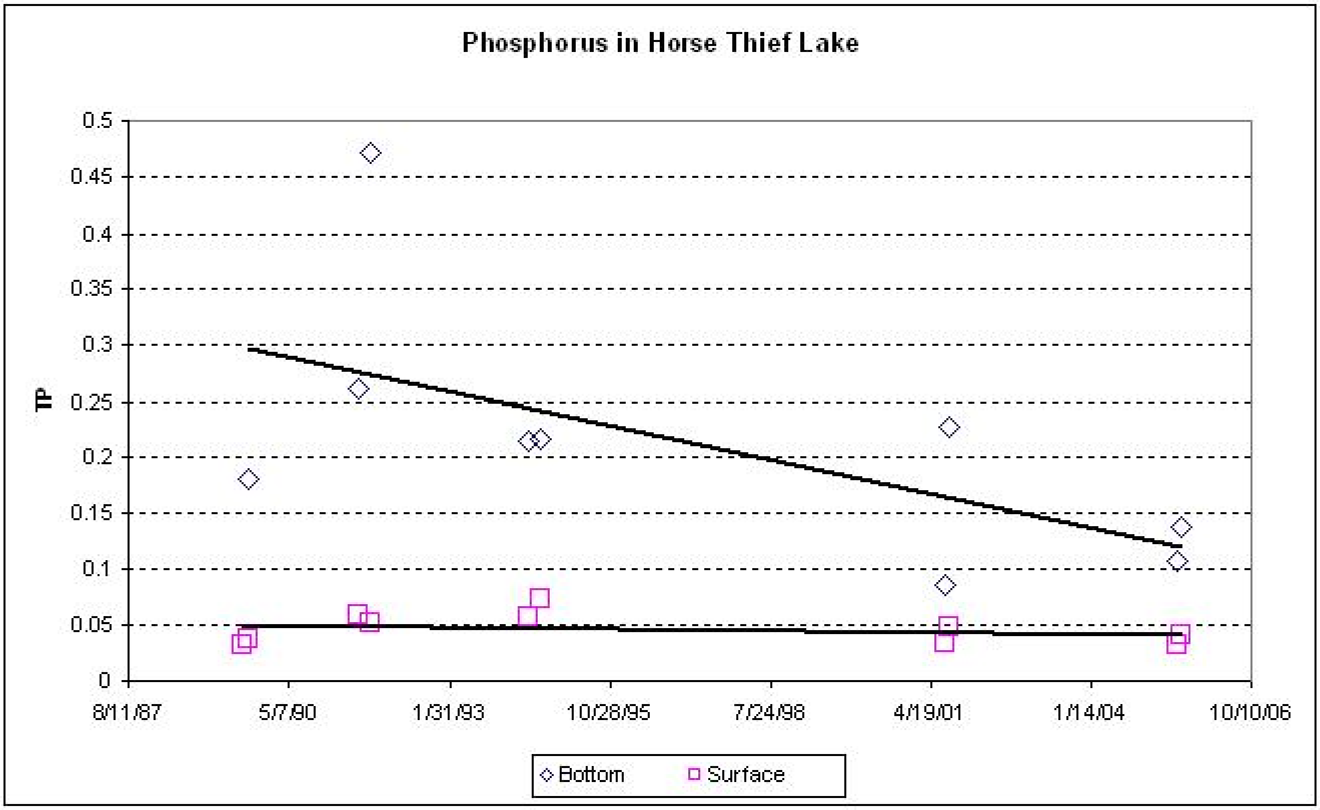

Figure 41. Phosphorus Concentrations in Horse Thief Lake

Limiting Nutrients

Phosphorus and nitrogen are required to promote plant growth. Each of these nutrients is utilized in different amounts. It is commonly accepted that for each part of phosphorus, ten parts of nitrogen are required in aquatic environments. These nutrients are compared by dividing the nitrogen concentration by the phosphorus concentration to generate a ratio. Ecoregion 17b appears to be phosphorus limited, indicating that reductions in this nutrient will result in reductions of primary productivity.

Horse Thief Lake had a relatively wide distribution of N:P ratios. Surface samples varied from a low of 7.8 to a high of 24.5. All but the lowest sample suggested a phosphorus limited system. A trend was indiscernible in the data. It is possible that as BMPs continue to impact the lake, they may reduce equal amounts of both nutrients resulting in a fairly stable ratio of the two nutrients.

Trophic State

Carlson's (1977) Trophic State Index (TSI) was used to determine the approximate trophic state of Horse Thief Lake. This index incorporates measures of Secchi disk transparency, chlorophyll a, and total phosphorus into scores ranging from 0 to 100 with each 10-unit increase representing a doubling in algal biomass. Four ranges of index values (Table 26) define Carlson's trophic levels, which include oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic (in order of increasing productivity).

Table 37. Carlson's Trophic Levels and Index Ranges

Trophic Level	TSI Range
Oligotrophic	0 – 35
Mesotrophic	36 – 50
Eutrophic	51 – 65
Hyper-eutrophic	66 – 100

All available trophic state measurements are included in Figure 42. The phosphorus level measured in 1979 does not appear to be an accurate representation of the reservoir condition over the last twenty years. More recent data is variable, but indicates that the reservoir may generally be considered eutrophic. Omitting the 1979 sample, median values are 55, 57, and 58 for Secchi, phosphorus and chlorophyll, respectively. Compared with Center and Legion which have median values in the low 50's; Horse Thief Lake is slightly more eutrophic.

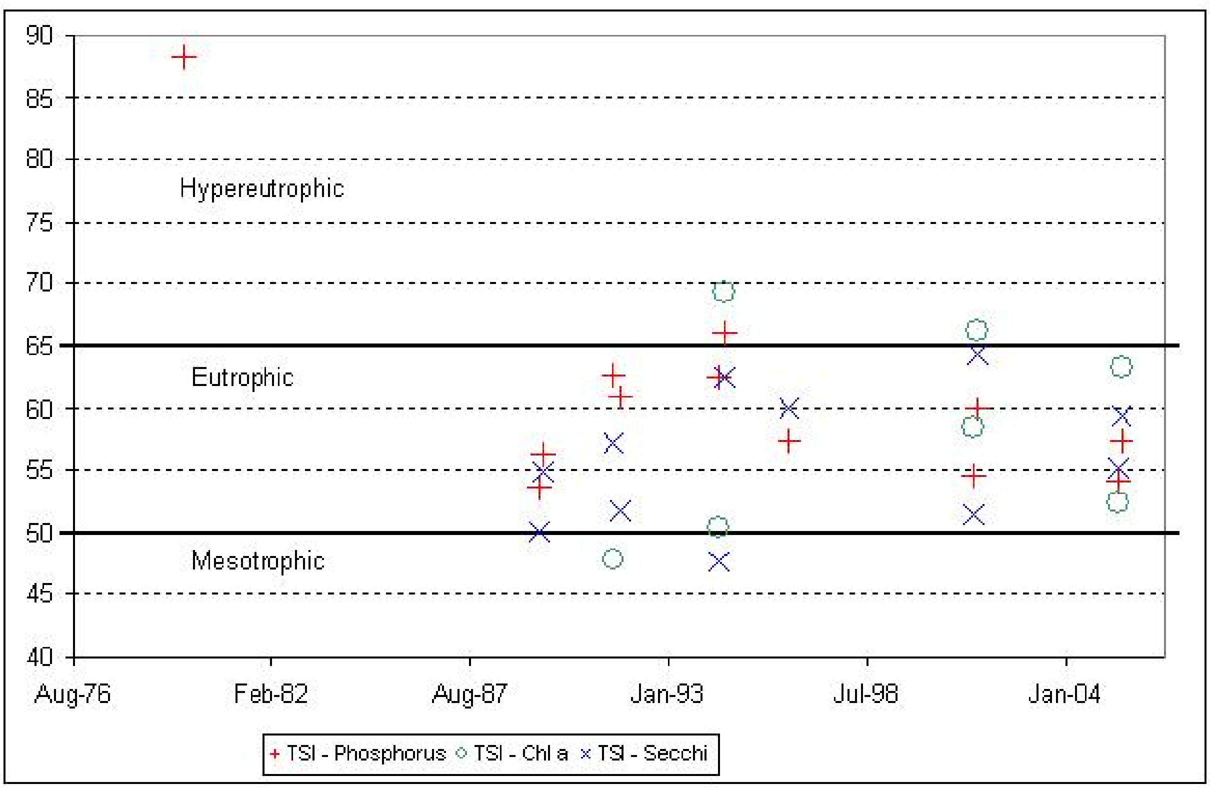

Figure 42. Trophic State of Horse Thief Lake by Date

Reduction Response Modeling

In order to determine the impacts of phosphorus reductions on the reservoir, the BATHTUB model was utilized. The BATHTUB model is a relatively simple spreadsheet model which is used to predict water quality in lakes and reservoirs. The model was originally developed for the Army Corps of Engineers (ACOE) by Walker (1996). The BATHTUB program performs water and nutrient balance calculations in a steady-state, spatially segmented hydraulic network that accounts for advective transport, diffusive transport, and nutrient sedimentation. The model predicts eutrophication related water quality conditions, such as total phosphorus, total nitrogen, chlorophyll *a*, transparency, organic nitrogen, non-orthophosphorus, and hypolimnetic oxygen depletion rate using empirical relationships previously developed and tested for reservoir applications. When calibrated to existing water quality characteristics, the BATHTUB model can be used to predict changes in water quality characteristics resulting in alterations to either hydrologic or nutrient regimes.

The BATHTUB model was utilized to model numerous scenarios based on the extremes of the uncertainty used to develop the inputs. The stream phosphorus concentration of 66 ppb was used for the primary input. A secondary source of phosphorus available in the model is internal loading. Internal loading rates are difficult to calculate, but literature values suggest rates may be expected to range from 0 to 0.4 $mg/m^2/day$.

There are nine phosphorus prediction models available within the program, each was run with multiple internal loading scenarios ranging from a low of zero to a high of 0.4 mg/m2/day. The models predicted lake water quality values from 36 ppb to 82 ppb. Surface water quality data from Horse Thief Lake provided a target value of 73 ppb. Model 7 settling velocity appeared to most closely reflect the observed water quality in the lake predicting concentrations of 71 ppb to 82 ppb and this model was selected for use. An internal loading rate of 0.2 $mg/m^2/day$ was also applied.

Upon selection of the phosphorus model in the program, the next step was to select a chlorophyll *a* prediction model that most accurately predicts the observed concentrations in the lake. Six models are available for use within the program. Observed surface water quality from Horse Thief Lake provided a target value of 23 ppb. Four of the six models predicted concentration of 20 ppb to 29 ppb suggesting any of them may be applicable for the lake.

Each of the four models was used to simulate the 85% reduction in stream loading (concentrations of 10 ppb). Utilizing this load, each of the four models predicted in lake chlorophyll concentrations between 5 ppb and 8 ppb. Of significance to note is that each of these models reacted similarly to the reductions. All four consistently suggested that an 85% reduction in watershed loading would produce slightly more than a 70% reduction in the chlorophyll concentrations. The predicted concentrations all fall below the target of 9 ppb to 12.5 ppb ecoregion target necessary to obtain pH values within the state standards.

5.3.5 Horse Thief Lake TMDL Allocations

Utilizing the water load of 162 acre feet and phosphorus concentration of 0.01 mg/L developed in the previous sections, an average annual phosphorus load of 5.9 kilograms was calculated.

Wasteload Allocation

There are no point sources of pollutants in this watershed. Therefore, the "wasteload allocation" component of this TMDL is considered a zero value. The TMDL is considered wholly included within the "load allocation" component.

Load Allocation (LA)

To identify a maximum daily limit, a method from EPA's "Technical Support Document For Water Quality-Based Toxics Control," referred to as the TSD method, was used. This method, which is based on a long-term average load that considers variation in a dataset, is a recommended method in EPA's technical guidance "Options for expressing Daily Loads in TMDLs"(USEPA 1991). The TSD method is represented by the following equation:
$MDL = LTA * e^{[z\sigma - 0.5\sigma 2]}$

where,

MDL = maximum daily limit
LTA = long-term average
z = z statistic of the probability of occurrence
σ2 = ln(CV2+1)
CV = coefficient of variation

The daily load expression is identified as a static daily maximum load. A static daily load expression was deemed suitable because of the small watershed size, relatively constant loadings from nonpoint sources, and the fact that a steady-state analysis was used. Assuming a probability of occurrence of 99.7% and a CV of 1.0, the maximum daily load corresponding to an average annual load of 5.9 kg/yr is 0.11 kg/day.

Table 38. Load Allocation (kg/yr) Summary for Legion Lake.

TMDL Component	Long-term Average Allocation (kg/year)	Maximum Daily Allocation (kg/day)
Wasteload Allocation	0	0
Load Allocation	5.9	0.11
Margin of Safety	Implicit	Implicit
TMDL	5.9	0.11

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and land use. The largest components of seasonal variation in the Horse Thief watershed are due to rainfall and recreational use. Peak flows and use coincide during late spring and early summer, making this the most critical time for loadings to occur. Installed BMPs targeted recreational use and should have minimized their impact. The TMDL calculation took into account variability in flow rates. This should account for seasonal variability, however, if the lake continues to exhibit signs of impairment, this would be the most critical time to conduct additional monitoring.

Margin of Safety

The margin of safety for the phosphorus TMDL is implicit based on conservative estimates. The most notable of these is utilizing the EPA ecoregion value of 0.01 mg/L instead of the Heidelberg College estimate of 0.02 mg/L. Due to the uncertainty in the Heidelberg study, utilizing this difference as an implicit margin of safety was more appropriate then taking the difference as a calculated explicit margin of safety.

6.0 Public Participation

Public participation was encouraged through the public notice of the original Legion and Center Lake TMDL documents. This report was public noticed in November of 2010 and all public comments were taken into consideration for its final publication. Comments, as well as DENR responses, received during the public notice are included in Appendix A.

7.0 Monitoring Strategy

The Department may adjust these load and/or wasteload allocations in this TMDL to account for new information or circumstances that are developed or come to light during the implementation of the TMDL and a review of the new information or circumstances indicate that such adjustments are appropriate. Adjustment of the load and waste load allocation will only be made following an opportunity for public participation. New information generated during TMDL implementation may include, among other things, monitoring data, BMP effectiveness information and land use information. The Department will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the loading capacity; the adjusted TMDL, including its WLAs and LAs, will be set at a level necessary to implement the applicable water quality standards; and any adjusted WLA will be supported by a demonstration that load allocations are practicable. The Department will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

Center, Horse Thief, and Legion Lakes have all been a part of the states “Statewide Lakes Assessment”. During 2008, the states lakes monitoring plan changed from targeted sampling to a random design and began including more of the lakes resources. As a result, sampling is not guaranteed during a given year, however statistically, each lake should be visited once every 5 years. Each of these lakes will remain a part of this project and will be assessed.

8.0 Implementation and Mitigation Recommendations

8.1 Center Lake Mitigation

Natural sources of phosphorus include the leaching of phosphate-bearing rocks and organic matter decomposition. Other potential sources of phosphorus include phosphorus-based detergents, fertilizers, runoff from highway maintenance operations, disturbances from tourism, defective septic systems, improper gray-water (e.g. water used for washing hands, dishes, clothing, etc.) disposal, or other human waste disposal.

The Center Lake watershed is used predominantly by tourists and campers with few permanent residents. Sources of phosphorus most likely affecting Center Lake include: 1) recreational activities resulting in bank and shoreline disturbance, 2) detergents contained in gray-water, 3) road maintenance and use, and 4) septic systems, including the system servicing the Center Lake recreational areas.

Perhaps the most significant sources of phosphorus in the Center Lake watershed are the recreational uses of Center Lake and the surrounding Custer State Park. Stream bank and shoreline disturbance from foot and vehicle traffic increase soil erosion and runoff, thus increasing the sediment and nutrient loads. Pollution in the form of litter and human waste also increase nutrient loads. Additional bathroom facilities, waste receptacles, and fish-cleaning stations are recommended for the Center Lake recreational area. Stream bank and shoreline protection is also recommended to allow sediment and nutrient loads to be filtered and reduced before reaching the receiving waterbody.

Two tent campgrounds and a day-use picnic area are located in close proximity to Center Lake and its tributaries. Limited water services and disposal areas are provided to these areas. It is recommended that water and disposal services be provided to the camping and day-use areas to decrease the likelihood of improper gray-water and other waste disposal in these areas. Literature should be provided to campers or signs posted explaining the importance of proper disposal of their gray-water and other wastes. Additionally, use of phosphorus-free detergents should be encouraged, if not required, of all persons using the campgrounds and the day-use picnic area.

Among all forest activities, roads produce the most sediment. The number of roads constructed in a forested watershed can be minimized through comprehensive road planning with adjacent landowners and by designing roads to the minimum standard necessary to accommodate anticipated use and equipment. Road construction, maintenance and use in the Center Lake watershed have resulted in increased soil erosion and runoff, resulting in increased nutrient loads. It is recommended that all roadways near Center Lake and streams contributing to Center Lake be monitored for erosion and excess weathering. Identified erosional areas should be repaired or stabilized to prevent further erosion.

Septic systems may be another source of phosphorus in the Center Lake watershed. In close proximity to the lake, a drainfield and evapotranspiration field receiving wastewater from the Center Lake recreational areas may be leaching phosphorus. Cetec Engineering Services, Inc.

was hired by the S.D. Game, Fish and Parks to analyze the Center Lake water and wastewater systems and suggest possible designs for system renovation. In their report, Cetec stated that the evapo-transpiration disposal system was constructed to replace the overloaded drainfield, however, the evapo-transpiration system has not functioned satisfactorily since construction, and most septic tank effluent is routed to the original drainfield for disposal. Loadings are closely monitored and diverted between the two systems as one or the other becomes overloaded (Cetec, 2004). It is strongly recommended that the water and sewer facilities be upgraded to eliminate substandard facilities, as well as to improve services to all Center Lake recreational areas.

As discussed earlier in this report, export coefficient values were used to make comparisons between subwatersheds represented by sites CLT-3, CLT-4 and the total watershed or site CLT-5. The inlet site (CLT-5) often exhibited higher export coefficient values than CLT-3 and CLT-4; in particular, solids and alkalinity were markedly higher. Total phosphorus export coefficient for CLT-5 was approximately two times higher than those at CLT-3 and CLT-4. These higher export coefficient values for the inlet site appear to indicate a problem area exists in the portion of the watershed below CLT-3 and CLT-4. Implementation efforts should be focused on this lower subwatershed (CLT-5).

The BATHTUB model estimated an approximate 70% reduction in watershed phosphorus loads would be required for Center Lake to meet the fishery-based TSI criterion and TMDL target (median chlorophyll and Secchi depth TSI ≤48). A 70% reduction in phosphorus loads is the TMDL goal and can be attained by implementing the above recommended management practices.

8.2 Legion Lake Mitigation

8.2.1 Watershed and Lake Management

Several possible sources of phosphorus may exist in the Legion Lake watershed, including domestic sewage, detergents, fertilizers, and animal waste. Phosphorus makes its way to streams as a result of erosion and associated runoff occurring in the watershed. Riparian buffer improvements and artificial wetland construction are recommended to reduce phosphorus loads carried by streams in the Legion Lake watershed.

A portion of the total phosphorus load is assumed to originate from lake bottom sediment. Thus, installation of practices to control phosphorus loading from the watershed may not be sufficient in maintaining the trophic state of the lake unless the internal load is also controlled. Four in-lake treatment options were considered to reduce phosphorus loadings from the bottom sediments of Legion Lake, including a chemical treatment (alum application), dredging, aeration in combination with circulation, and bioremediation. Of the four treatment alternatives evaluated, alum treatment and aeration/circulation are recommended to maintain or improve the trophic state. However, additional phosphorus load reductions could be achieved by implementing other lake management options described below.

8.2.2 *Riparian Zone Management*

Stream bank stability is directly related to the species composition of the riparian vegetation and the distribution and density of these species. Properly functioning riparian areas can significantly reduce non-point source pollution by intercepting surface runoff and by settling, filtering and storing sediment and associated pollutants. Riparian re-vegetation and enhancement of streams in the Legion Lake watershed are recommended to reduce total phosphorus loads.

8.2.3 *Artificial Wetlands*

Artificial wetlands are typically engineered systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating an effluent or other source of water. Wetland plants assimilate nutrients, reducing concentrations in receiving waters. Numerous studies have demonstrated the non-point source pollutant removal capabilities of wetland systems. It is recommended that artificial wetland(s) be constructed on the inlet stream to reduce phosphorus loads from the watershed.

8.2.4 *Aluminum Sulfate (Alum) Treatment*

Sediment-bound phosphorus loads from upland erosion accumulates at the lake bottom. Low oxygen concentrations allow this sediment-bound phosphorus to be released and available for algal growth. So even when external sources of phosphorus are eliminated, this nutrient remains in oversupply. For this reason, controlling phosphorus concentrations in lakes is a two-part process: keeping phosphorus out of the lake and reducing the availability of phosphorus from lake sediments.

Alum treatment involves the addition of aluminum sulfate slurry that produces an aluminum hydroxide precipitate. This precipitate removes phosphorus and suspended solids from the water column and settles to the bottom of the lake to form a phosphorus-binding blanket on the sediment surface. Alum has been used for centuries for clarification of drinking water, but only recently has it moved into the mainstream of lake management. It is a safe, effective, and economical means of controlling internal phosphorus loading (Welch 1995).

If external phosphorus loads are reduced, an alum treatment will control phosphorus levels and eliminate algae blooms for up to ten years. The longevity of the treatment depends on the amount of alum applied and level of external phosphorus loading (Conover 1988).

8.2.5 *Lake Aeration and Circulation*

The purpose of aeration and circulation techniques in lake management is to increase the dissolved oxygen content of the water. Various systems are available including aeration by air/oxygen injection or circulation by mechanical mixing.

Lake aeration can have multiple benefits to water quality and lake biota. Aeration can increase aquatic habitat for fish and other lake organisms. In some cases, nuisance algal blooms can be reduced or algae populations can be shifted to more desirable taxa.

The use of air injection (diffuser) systems is the most common destratification method. This system uses a compressor on shore to deliver air through lines connected to a perforated pipe(s) or other simple diffuser(s) placed near the bottom, typically in the deep area of the lake. The use of a diffuser system not only adds oxygen to the water, but also encourages mixing. The rising air bubbles cause water in the hypolimnion to rise, pulling this water into the epilimnion. When the colder, hypolimnetic water reaches the lake surface, it flows across the surface and eventually sinks, mixing with the warmer epilimnetic water.

A circulator could be used to mix the oxygen- rich surface waters with oxygen-depleted waters in the lower depths and could be supplemented with an air injection (diffuser) system. Additional oxygen delivered by an aeration system, in conjunction with the mixing action provided by circulator, may allow the lake to become completely aerated.

8.2.6 Dredging

Lake sediments contain much higher phosphorus concentrations than the water. Excavating the sediment in Legion Lake could reduce a significant source of phosphorus.

Hydraulic dredging could be considered to remove phosphorus-laden sediments. Hydraulic dredging typically involves a rotating cutter head and a suction pump to remove sediments. The cutter head cuts into sediment layers and churns them into a slurry. The pump vacuums the slurry through floating pipe to an on-shore dewatering facility. One disadvantage of this option is the amount of time and cost involved in dewatering the excavated sediments.

Dry dredging could also be considered. This option would require draining the lake and dewatering the removed sediment. While more sediment could be removed by dry dredging than hydraulic dredging, Custer State Park may experience a greater loss of revenue if the dry dredging option is pursued due to the amount of time required to drain, dredge, and refill the lake. In addition, the quality and volume of drained water, as well as surface waters downstream of draining or dewatering activities, should be considered before water is discharged downstream.

8.2.7 Bioremediation

Biofiltration is lake treatment technique based on the controlled use of the ecological characteristics of common mollusk species. Freshwater mussels are natural filter feeders, which effectively and efficiently filter organic and inorganic matter from the water.

The biofiltration technology has very low costs. Most construction, including the preparation of the bedding, can be accomplished with minimal labor and materials costs. The filtration capacity is a characteristic feature of every mollusk species. On average, a single freshwater mussel (about 3 cm in diameter) can filter approximately 100 ml/hour. The volume of water filtered can be very large. Freshwater mussel populations in an area of 100 m^2 can filter a volume up to 28,000 m^3/day and absorb up to 5.5 g of phosphorus and 11.5 g of nitrogen (United Nations Environment Programme 2004).

It should be noted that this treatment method is considered experimental. Further research may be required before this technique is widely implemented. Consideration should also be given to the species of mollusk selected; non-native species should not be used.

8.3 Horse Thief Lake Mitigation

The US Forest Service has been actively involved in watershed restoration of the Horse Thief Lake Watershed. Mitigation activities have primarily focused on the reduction of sediment entering the Pine Creek drainage and the lake itself. Total restoration costs to date are $675,000 with additional work planned. Estimated reductions for the mitigation activities are addressed in section 5.3.3 of this report. The following list of BMPs also includes approximate costs for the implemented BMPs.

1. Centennial 89 Trail (old road bed) Pine Creek Crosssing #1. Reconstructed wilderness trail ford in 2009 as well as 1 1/2 miles of trail was reconstruction to the east of this crossing. This was a major wilderness trail improvement project overall. Project Cost was $10,000

2. Centennial 89 Trail Pine Creek Crossing #1 to Horse Thief Lake Day Use Area, user defined (non system) trail closed - both ends in 2005, eliminated all horse & foot traffic. Some intentional seeding, fencing and natural tree falling has continued to rehabilitate this area back to a natural (vegetated) setting. Project Cost was $2,000.

3. Centennial 89 Trail Pine Creek Crossing #2. A priority crossing that is scheduled for wilderness trail crew reconstruction after 2010 as time and funding permits. Project Cost is estimated $1,000.

4. East Shore Line Horse Thief Lake Fishing trail and platforms completed in 2006. Primary purpose was shoreline protection from soil compaction, vegetation damage, sedimentation caused by recreation foot traffic while also providing disabled person fishing access to lake. Project Cost was $150,000.

5. South End Horse Thief Lake Fishing Day Use Site reconstruction in 2003. provided a footbridge to the campground as well as reducing soil compaction, vegetation damage, sedimentation and disabled person fishing access to lake. Project Cost was $272,000

6. South End Horse Thief Lake Fishing Day Use Site Parking Improvements completed in 2008. This project provided asphalt paving at the parking spots as well as a filter strip barrier for toxins from parked cars. Project Cost was $240,000.

7. A project for improving and preserving fishing opportunities on the Peter Norbeck Scenic Byway by dredging Horse Thief, Bismarck and Lakota lakes is funded and expected to occur sometime in 2011 or 2012.

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File Code: 2500
Date: FEB 15 2011

STEVEN M. PIRNER
DEPARTMENT SECRETARY
SOUTH DAKOTA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES
JOE FOSS BLDG
523 E CAPITOL
PIERRE, SD 57501

RECEIVED

FEB 16 2011

DEPT. OF ENVIRONMENT AND NATURAL RESOURCES, SECRETARY'S OFFICE

Dear Secretary Pirner:

This letter is to show Black Hills National Forest support for the Total Maximum Daily Load (TMDL) evaluation that was prepared for Horse Thief Lake. Sean Kruger consulted with my staff, Dave Pickford, Recreation Specialist; Paul Bosworth, Engineer; and Les Gonyer, Hydrologist, during the development of the TMDL. This consultation included a field trip to review the lake and watershed.

The watershed for Horse Thief Lake is entirely administered by the Forest, of which most occurs within the Black Elk Wilderness. Disturbances associated with past activities in the watershed, prior to wilderness designation, contributed to lake water quality issues. As outlined in the TMDL document, the Forest has completed a number of sediment control projects on areas impacted by past activities and has implemented mitigation actions for ongoing recreation use within the watershed. Based on recent site reviews of the projects that have been implemented, areas have or are stabilizing and watershed conditions are recovering. A final project currently being planned is to remove sediment that has accumulated in the lake. As specified in the TMDL document, it is expected that sediment removal will further accelerate recovery of lake conditions.

As identified in the Memorandum of Understanding between the United States Forest Service, Rocky Mountain and Northern Regions and the South Dakota Department of Environment and Natural Resources, the Black Hills National Forest continues to be interested in working with the State on understanding water quality issues and improving water quality on National Forest System lands.

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We appreciate the opportunities that were provided to consult with your staff during the development of the TMDL and to review the draft document. The Forest would like to commend SD DENR on the information presented and the quality of the document.

If you have any questions, please contact Deanna Reyher, Watershed Program Coordinator, at (605) 673-9348

Sincerely,

for CRAIG BOBZIEN
Forest Supervisor

cc:
Sean Kruger
Leslie Gonyer
Joan Y Carlson

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Total Maximum Daily Load Evaluation of pH for Reservoirs in the Black Hills Plateau Ecoregion of Custer and Pennington Counties, South Dakota (November, 2010)**
Submitted by:	**Cheryl Saunders, SD DENR**
Date Received:	**December 14, 2010**
Review Date:	**January 10, 2011**
Reviewer:	**Vern Berry, US EPA**
Rough Draft / Public Notice / Final Draft?	**Public Notice**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

- ☐ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   - 1.1.. TMDL Document Submittal Letter
   - 1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   - 1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   - 4.1. Data Set Description
   - 4.2. Waste Load Allocations (WLA)
   - 4.3. Load Allocations (LA)
   - 4.4. Margin of Safety (MOS)
   - 4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered “impaired.” When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant. A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☐ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The draft pH TMDLs for three reservoirs (i.e., Center, Legion and Horse Thief) in the Black Hills of South Dakota, were submitted to EPA for review during the public notice period via an email from Cheryl Saunders, SD DENR on December 14, 2010. The email included the draft TMDL document and a public notice announcement requesting review and comment.

COMMENTS: None.

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☐ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Black Hills TMDL document addresses the pH impairment in three reservoirs in western South Dakota: Center Lake (SD-CH-L-CENTER_01), Legion Lake (SD-CH-L-LEGION_01) and Horse Thief Lake (SD-CH-L-HORSETHIEF_01). The 2010 South Dakota Integrated Report lists 19 lakes and reservoirs as violating the pH standard defined by their beneficial uses. Three of these 19 waterbodies are located in ecoregion 17b, the Black Hills Plateau. The three impaired reservoirs are separated by less than 10 miles. The similarities between these reservoirs were a primary consideration in the decision to consolidate them into a single TMDL evaluation.

The data included in the TMDL document represents the entire ecoregion, but the distribution of reservoirs and their drainage areas is limited to a 150,000 acre region along the eastern edge of the ecoregion. The three reservoirs addressed in the TMDL document are located in the Middle Cheyenne-Spring watershed (HUC 10120109). The draft pH TMDLs for Center Lake, Legion Lake and Horse Thief Lake address pH as the primary impairment and link phosphorus loading in the watershed as the pollutant to limit through implementation of best management practices in the watershed.

The Center Lake watershed is approximately 6,270 acres and is located in the north half of Custer State Park. The Center Lake watershed contains heavily forested areas with several campgrounds and day use facilities.

The Legion Lake watershed is located in north central Custer County, South Dakota. The watershed consists of approximately 2,050 acres of primarily quartzite and granite outcrop covered by dense pine forest; predominately ponderosa pine with some black hills spruce and aspen.

Horse Thief Lake is located in the southern portion of Pennington County. The majority of the watershed is located in the Black Elk Wilderness. Mount Rushmore National Memorial is immediately to the north and much of the rest of the wilderness is bordered by other protected land under the jurisdiction of state and federal agencies.

EPA has approved SDDENR phosphorus TMDLs for Center Lake and Legion Lake on August 8, 2007 and September 2, 2008 respectively. These TMDL approvals did not include linkages to the pH impairment.

COMMENTS: The waterbody identification numbers shown on pages 10-13 are not consistent with the waterbody IDs from the most recent SD integrated report. The IDs shown are missing the "L" designation and the "_" underscore at the end of the ID. The IDs should be checked throughout the document and corrected as needed.

The pH TMDLs, for Center Lake and Legion Lake, included in this document are based on previously approved phosphorus TMDLs. These prior approvals remain in effect and the TMDL database will be updated to reflect that the phosphorus TMDLs will also address the pH impairment for these two lakes. However, EPA cannot count these as new pH TMDLs. The Horse Thief Lake TMDL for phosphorus that addresses the pH impairment will be counted as a new TMDL.

DENR Response:

The waterbody identification numbers were corrected throughout the document.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g., insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, <u>all TMDL documents must be written to meet the existing water quality standards</u> for that waterbody (CWA §303(d)(1)(C)).

Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Center Lake, Legion Lake and Horse Thief Lake are listed as impaired for pH. The pH impairment is likely to be related to internal (i.e., in-lake) and external (i.e., watershed) nutrient loading. South Dakota has applicable numeric standards for pH, associated with the coldwater permanent or marginal fish life propagation beneficial use of these reservoirs. The pH criterion for both the coldwater permanent and coldwater marginal uses is greater than 6.5 and less than 9.0 standard units. Additional narrative standards can be found in the Administrative Rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09. These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The coldwater permanent fish life propagation beneficial use is assigned to surface waters of the state which are capable of supporting aquatic life and are suitable for supporting a permanent population of coldwater fish from natural reproduction or fingerling stocking. The coldwater marginal fish life propagation beneficial use is assigned to surface waters of the state which support aquatic life and are suitable for stocked catchable-size coldwater fish during portions of the year, but which, because of critical natural conditions including low flows, siltation, or warm temperatures, are not suitable for a permanent coldwater fish population.

Other applicable water quality standards are included on pages 31, 51 and 72 of the TMDL document.

COMMENTS: None.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☐ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The three reservoirs are listed as impaired for pH and the assumed TMDL target for each lake is the pH criterion of > 6.5 s.u. - < 9.0 s.u.

COMMENTS: The TMDL document does not specifically mention a pH target for each of the lakes. The summary tables (pages 10-12) say that the target is to "meet all applicable standards." The Center Lake section (i.e., Section 5.1) mentions a TMDL target of a median chlorophyll and Secchi depth TSI ≤ 48. The Horse Thief Lake section mentions 13.1 pounds of phosphorus load being used to develop a TMDL target at or near 73 ug/L for phosphorus, and a chlorophyll-a concentration of 5-8 ug/L. There does not appear to be specific targets mentioned in the context of Legion Lake. Each lake included in the TMDL document should include an explicit statement of the pH target.

DENR Response:

The pH targets were identified for each lake within the summary tables as requested. All of the lakes in this ecoregion share a maximum pH standard of 9.0 su. Section 4.0 of the document is intended to identify the necessary chlorophyll a concentrations to obtain full support of the pH standard. The individual lake sections (sections 5.1 through 5.3) were largely existing documents that focused on phosphorus reduction impacts on trophic state, including chlorophyll a reductions. Language was added to section 4 to further clarify this.

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Landuse in the ecoregion is broken down in Table 2 excerpted from the TMDL document below. Over 97% of the ecoregion remains in native vegetation, which is predominately a ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, but the predominant form of agriculture is livestock grazing.

While not directly linked to elevated pH concentrations, increased concentrations of nitrogen and phosphorus can result in excessive macrophyte and algae growth in the waterbody. Increased respiration from excessive macrophyte and algae growth results in processes that elevate the pH. The TMDL document was not able to establish a clear pattern linking the concentrations of either nitrogen or phosphorus to elevated pH values. However, Figure 8 of the TMDL document presents empirical evidence that as chlorophyll concentrations increase, the number of samples that exceed the pH standard of 9.0 also increases. Therefore, the focus of the pH TMDLs are on reducing phosphorus loading to each of the impaired lakes.

The source of phosphorus loading from the Center Lake watershed is a combination of septic system failure, recreational uses, vehicle traffic, as well as natural background sources (i.e. wildlife, weathering, etc.). However, degraded water quality in Center Lake is primarily attributed to recreational activity within the watershed. Approximately 90% of the watershed land area is managed by the SD Department of Game, Fish and Parks (Custer State Park), while the remaining 10% is managed by the US Forest Service. Although much of the watershed remains in its natural state, the intense use of recreational facilities within Custer State Park has degraded the watershed condition.

For Legion Lake phosphorus was identified as a limiting nutrient for algae growth therefore, watershed or external phosphorus loads should be maintained or reduced using management practices recommended in the assessment report. External loads could be reduced with the implementation of riparian zone management and construction of wetlands on the inlet stream. Non-point sources of phosphorus from the watershed (external load) are only a portion of the total phosphorus load to Legion Lake. Internal phosphorus loading from lake bottom sediment is another source of phosphorus and can also be controlled.

Nonpoint sources of pollution in the Horse Thief Lake watershed have been mitigated through numerous changes in the watershed as well as through BMP installation by the US Forest Service. Additional BMPs to reduce internal nutrient loading at Horse Thief Lake are planned as part of a larger project for improving and preserving fishing opportunities on the Peter Norbeck Scenic Byway. The project has been funded and includes dredging Horse Thief, Bismarck and Lakota lakes and expected to occur sometime in 2011 or 2012. Internal loading, from past phosphorus loads into each of the three lakes addressed by the TMDL document, will continue to be a source until it cycles through. BMPs proposed for Center Lake and Legion Lake are described in Sections 8.1 and 8.2 of the TMDL document respectively.

There are no point source discharge permits located in the drainage area for Center Lake, Legion Lake or Horse Thief Lake.

Table 2. Landuse in Ecoregion 17b

Landuse	Percentage
NLCD - Evergreen Forest	62%
NLCD - Grassland Herbaceous	30%
NLCD - Shrubland	5%
NLCD - Developed	1%
NLCD - Cropland	1%
Other	1%

COMMENTS: None.

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis**.** This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☐ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The technical analysis should describe the cause and effect relationship between the identified pollutant sources, the numeric targets, and achievement of water quality standards. It should also include a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The technical analysis for the three Black Hills reservoir TMDLs describe how the total phosphorus loads were derived and discusses the empirical linkage between phosphorus loading and the pH impairment in the lakes.

Hydrologic and constituent loads were estimated from sample data and instantaneous flow measurements using the FLUX model in order to develop nutrient and hydrologic budgets for both Center Lake and Legion Lake. Seasonal and annual loads for nutrients were also calculated for both lakes using the FLUX model. Seasonal loads were derived by combining monthly loads (e.g., December, January and February). The eutrophication of Center Lake and Legion Lake is believed to be the largest cause of high pH. The vertical distribution of pH in these lakes are strongly influenced by the photosynthetic utilization of carbon dioxide in the trophogenic zone (the lighted zone where organic matter is synthesized and oxygen generated), which tends to reduce carbon dioxide content and increase pH. Therefore, management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Center Lake. Management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Legion Lake to a level that meets criteria established to protect the coldwater marginal fish life propagation use.

BATHTUB, a eutrophication response model, was used along with lake and stream sample data were used to calculate existing conditions in Center Lake. The model predicts changes in water quality parameters related to eutrophication (phosphorus, nitrogen, chlorophyll a, and transparency) using empirical relationships previously developed and tested for reservoir applications. Inlet phosphorus and nitrogen concentrations were reduced in increments of 10% and modeled to generate an inlake reduction curve. The predicted inlake phosphorus concentrations and individual TSI values decreased with the reduction of tributary phosphorus load. The model indicated an approximate 70% reduction in phosphorus load was required to bring chlorophyll and Secchi depth TSI values into compliance with the fishery-based TSI criterion. The Center Lake TMDL goal (70% reduction of total phosphorus loads) was determined based on the load reduction required to achieve a predicted chlorophyll and Secchi TSI value ≤ 48.

The primary tributary to Horse Thief Lake is Pine Creek. Pine Creek drains approximately 2.9 square miles (1,832 acres) of the Black Hills consisting primarily of the Black Elk Wilderness. From its outfall at Horse Thief Lake, it travels 1.7 miles downstream to its confluence with Battle Creek.

Currently, there is no existing water quality data available for Pine Creek above Horse Thief Lake. Also, there are no gauge records available for Pine Creek. Therefore a surrogate was used to develop flow characteristics for the watershed. The Pine Creek water chemistry was developed utilizing ecoregion nutrient targets and modeled reductions in nutrient loading as a result of BMPs that have been utilized in the watershed. South Dakota does not have a nutrient criteria, however EPA has set forth recommended criteria for level III ecoregions. As a result of the current phase of mitigation activities as well as the lack of preexisting water chemistry data, utilizing the EPA guidance as the TMDL concentration was deemed the most accurate and protective approach for developing the TMDL.

The lake continued to exhibit signs of impairment during its most recent sampling. This continued impairment is considered to be a result of nutrient loadings in the past which have accumulated in the sediments. At the time of TMDL development, restoration activities in the watershed were either complete or nearing completion. Horse Thief Lake watershed mitigation activities have primarily focused on the reduction of sediment entering the Pine Creek drainage and the lake itself. In addition to sediment reduction, nutrients loadings have also been reduced. Phosphorus reductions as a result of BMP implementation have been calculated and were used to estimate annual nutrient loads to the lake and may be considered representative of the Pine Creek watershed in its impaired state. As of 2010, the US Forest Service had completed watershed restoration work which would result in Pine Creek demonstrating nutrient concentrations that are lower than what would have been found prior to BMP installation. Implementation of the BMPs may have affected the stream, however the lake existing lake impairment is likely a result of nutrient accumulations in the sediment that have not cycled out of the system. A plan to dredge lake sediments has been developed and funded, which should accelerate the cycling process and is expected to result in full support of the lake's beneficial uses.

The USEPA contracted with Heidleburg College to analyze ambient river and stream water quality data collected by the South Dakota Department of Environment and Natural Resources (SDDENR). A data analyses protocol was developed and the data were analyzed following the USEPA protocol for determining the lower seasonal 25th percentile of the population of all streams within a region. Based on the analysis by Heidleburg College, it may be assumed that a concentration of 0.02 mg/L would be adequate for Pine Creek. As stated earlier, this stream is located entirely in a wilderness area, which suggests it should be held to a more conservative standard. As a result, the Horse Thief Lake TMDL is based on the more conservative EPA guidance of 0.01 mg/L of total phosphorus.

The BATHTUB model was utilized to model numerous scenarios based on the extremes of the uncertainty used to develop the inputs. The Pine Creek phosphorus concentration of 66 ug/L was estimated based on sediment reduction loading, and was used for the primary input to the model. A secondary source of phosphorus available in the model is internal loading. Internal loading rates are difficult to calculate, but literature values suggest rates may be expected to range from 0 to 0.4 mg/m2/day. Each of the four models was used to simulate the 85% reduction in stream loading (concentrations of 10 ppb). Utilizing this load, each of the four models predicted in lake chlorophyll concentrations between 5 ppb and 8 ppb. All four consistently suggested that an 85% reduction in watershed loading would produce slightly more than a 70% reduction in the chlorophyll concentrations. The predicted concentrations all fall below the target of 9 ppb to 12.5 ppb ecoregion target necessary to obtain pH values within the state standards. Utilizing the water load of 162 acre feet and phosphorus concentration of 0.01 mg/L, an average annual phosphorus load of 5.9 kilograms was calculated.

COMMENTS: The technical analysis and TMDL sections for Legion Lake do not include much information or data on the pH impairment. Section 5.2.4 says that the pH values ranged from 7.6 to 9.3, but doesn't include a table of the data or mention how many data points exceed the standard. The section also mentions BMPs recommended to reduce phosphorus loading, yet the external phosphorus loading will remain at the current rate of 7.3 kg/yr. Is the pH expected to improve due to reduction in the internal loading as a result of the external reductions that have already taken place? Additional language needs to be added to included the pH data, clarify the Legion Lake reductions and their relation to the TMDL loads and the pH impairment.

DENR Response:

The percentage of violations (19%) for Legion Lake was included in section 5.2.4. The report addresses the fact that there is some variability in the datasets used for the development of the original Legion and Center Lake TMDLs and the data set used to develop ecoregion target in section 4. This is also true for the pH values used in writing the Legion Lake report and the percentage of violations. The 19% was based on the most current listing methodology used for South Dakotas 2010 Integrated Report. A majority of these violations occurred during the 2007 sampling trip that yielded inaccurate DO data. Sufficient information was available to identify the DO measurements as incorrect; however the pH values collected on that trip did not have enough supporting evidence to determine their validity. Other data collected that day (low chlorophyll a) suggests that these values are questionable. Due to the uncertainty surrounding these values, DENR choose not to list the individual values and only the percentage of violations. SD DENR expects that continued monitoring of Legion Lake will yield data that fully supports the all of the lakes beneficial uses.

Additional language was added to the Waste Load Allocation section (5.2.5) for Legion Lake to more clearly identify that the pH is expected to improve at the continued current load due to changes in the *watershed. Due to the use of an implicit margin of safety, additional BMPs such as dredging are intended to increase the MOS and assure that the TMDL results in full attainment of the standard.*

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☐ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The data set from ecoregion 17b was collected through numerous sources including ambient monitoring programs such as SD DENR statewide lake assessment project as well as individual projects such as the Custer State Park Lakes assessment. Samples included in the analysis were limited with respect to their completeness of measurements. To prevent bias associated with partial samples, only those that included all of the following parameters were included; pH, chlorophyll a, phosphorus, and nitrogen. Data was not excluded based on the age of the sample. The resulting data set consisted of 94 samples from the nine reservoirs.

For Center Lake, the pH data set includes 20 values which ranged from 6.7 to 9.7. This data is presented in the form of a bar graph in Figure 15 of the TMDL document. Forty (40) percent of the measurements at both sampling sites and both near surface and near bottom depths exceeded the upper limit of the water quality criterion for coldwater permanent fish life use.

For Horse Thief Lake, the pH data set includes 20 values which ranged from 7.15 to 10.04. This data is presented in Table 33 of the TMDL document. 12 of the 20 values (60 percent) of the measurements exceeded the upper limit of the water quality criterion for coldwater permanent fish life use.

COMMENTS: As mentioned in the comments above, additional information needs to be provided for the Legion Lake data set.

DENR Response:

The absence of the individual pH measurements for Legion Lake is addressed in the previous DENR response for section4.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: There are no point source discharge permits located in the drainage area for any of the lake TMDLs addressed in the TMDL document for Center, Legion, or Horse Thief Lake. Therefore, the wasteload allocations for all three TMDLs are zero.

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream)

unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL explains that the landuse in the ecoregion is over 97% native vegetation, which is predominately a ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, as well as livestock grazing. The load allocation is provided to the limited agricultural and recreational nonpoint sources in the drainage area of each lake.

Table 38 below, excerpted from the TMDL document, includes the daily maximum and annual total phosphorus load estimates for Horse Thief Lake. The phosphorus TMDLs for Center Lake and Legion Lake were previously approved on August 8, 2007 and September 2, 2008 respectively. Those approvals remain in effect and the loadings do not needed to be repeated in this review and approval process.

TMDL Component	Long-term Average Allocation (kg/year)	Maximum Daily Allocation (kg/day)
Wasteload Allocation	0	0
Load Allocation	5.9	0.11
Margin of Safety	Implicit	Implicit
TMDL	5.9	0.11

COMMENTS: None.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the

TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

☒ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.

☐ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.

☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Horse Thief Lake TMDL includes an implicit MOS by using the EPA ecoregion value of 0.01 mg/L total phosphorus instead of the Heidelberg College estimate of 0.02 mg/L as the basis for deriving the loading capacity. Due to the uncertainty in the Heidelberg study, utilizing this difference as an implicit margin of safety was more appropriate then taking the difference as a calculated explicit margin of safety.

COMMENTS: None.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The largest components of seasonal variation in the Horse Thief Lake watershed are related to rainfall and recreational use. Peak flows and use coincide during late spring and early summer, making this the most critical time for loadings to occur. Installed BMPs targeted recreational use and should have minimized their impact. The TMDL calculations took into account variability in flow rates which should account for seasonal variability, however, if the lake continues to exhibit signs of impairment, this would be the most critical time to conduct additional monitoring.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process so far. In particular, the State has encouraged participation through prior public notices for the Center Lake and Legion Lake phosphorus TMDLs, as well as the pH TMDLs being available for a 30-day public notice period prior to finalization.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☐ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☒ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL (See: http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf).

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Monitoring Strategy section (7.0) included in the Black Hills reservoirs pH TMDL document covers the situations when the TMDLs may need to be revised, but does not discuss future monitoring plans.

COMMENTS: Generally TMDLs developed by SD DENR include brief statements of whether or not monitoring will be continued for the lake and or streams in the watershed as part of the State's statewide lake assessment project, fixed station monitoring, post implementation monitoring or some other means to collect data. The pH TMDL document for the three lakes should be revised to include future monitoring efforts for Center Lake, Legion Lake and Horse Thief Lake and their immediate drainage areas. For Horse Thief Lake it seems particularly important to collect data from streams feeding and flowing out of the lake so that the assumptions made in the derivation of the TMDL can be verified and revised as needed.

DENR Response:

Language was added to section 7.0 (Monitoring Strategy) reflecting that each of these lakes will continue to be a part of the states statewide lake assessment project. DENR will add a monitoring station at Pine Creek as a part an appropriate project to verify the assumptions made in the TMDL.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY:

The Implementation and Mitigation Recommendations section (8.0) of the TMDL document describes several best management practices that are recommended to reduce nutrient loading to the three Black Hills reservoirs. Since there are no point sources within the drainage area of the three reservoirs covered by the pH TMDL document, there is no need to include a discussion of reasonable assurance.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Horse Thief Lake TMDL annual total phosphorus loads in kg/yr were used to derive daily loads using the methods described in EPA's "Technical Support Document of Water Quality-Based Toxics Control." Following this methodology, daily total phosphorus loads, in kg/day, are included in the TMDL (see Table 38 of the TMDL document).

COMMENTS: None.

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RECEIVED

MAR 29 2011

DEPT. OF ENVIRONMENT AND NATURAL RESOURCES, SECRETARY'S OFFICE

MAR 24 2011

Ref: 8EPR-EP

Steven M. Pirner
Secretary
South Dakota Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Horse Thief Lake; Phosphorus; SD-CH-L-HORSETHIEF_01

Dear ~~Mr. Pirner~~ Steve:

We have completed our review of the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq.*), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1). Based on our review, we feel the separate elements of the TMDLs listed in the enclosed table adequately address the pollutants of concern as given in the table, taking into consideration seasonal variation and a margin of safety. We will modify our previous phosphorus approvals for Center Lake and Legion Lake to recognize that the pH impairments in those lakes will be addressed by the nutrient reductions proposed in the Black Hills pH document.

Thank you for submitting these TMDLs for our review and approval. If you have any questions, the most knowledgeable person on my staff is Vern Berry and he may be reached at 303-312-6234.

Sincerely,

Carol L. Campbell

Carol L. Campbell
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures

ENCLOSURE 1: APPROVED TMDLs

Total Maximum Daily Load Evaluation of pH for Reservoirs in the Black Hills Plateau Ecoregion of Custer and Pennington Counties, South Dakota (SD DENR, November 2010)

1	Pollutant TMDLs completed.
3	Causes addressed from the 2010 303(d) list.
0	Determinations that no pollutant TMDL needed.

Submitted: 1/31/2011

Segment: Horse Thief Lake

303(d) ID: SD-CH-L-HORSETHIEF 01

Parameter/Pollutant (303(d) list cause): PHOSPHORUS - 29

Water Quality Targets: PH >= 6.0 - <= 9.0 S.U.

Allocation*	Value	Units	Permits
WLA	0	KG/YR	
LA	5.9	KG/YR	
TMDL	5.9	KG/YR	

Notes: The Horse Thief Lake phosphorus TMDL was written to address the pH impairment in the lake. Linkages were also provided between the previously approved phosphorus TMDLs for Center Lake and Legion Lake and the pH impairments in those lakes. EPA's TMDL tracking system will be revised to provide credit for addressing the pH impairment via the specified phosphorus reductions. Daily phosphorus load allocations were also provided in the TMDL document.

* LA = Load Allocation, WLA = Wasteload Allocation, MOS = Margin of Safety, TMDL = sum(WLAs) + sum(LAs) + MOS

ENCLOSURE 2

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Total Maximum Daily Load Evaluation of pH for Reservoirs in the Black Hills Plateau Ecoregion of Custer and Pennington Counties, South Dakota (November, 2010)**
Submitted by:	**Cheryl Saunders, SD DENR**
Date Received:	**January 31, 2011**
Review Date:	**March 15, 2011**
Reviewer:	**Vern Berry, US EPA**
Rough Draft / Public Notice / Final Draft?	**Final**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

- ☒ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   - 1.1. TMDL Document Submittal Letter
   - 1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   - 1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   - 4.1. Data Set Description
   - 4.2. Waste Load Allocations (WLA)
   - 4.3. Load Allocations (LA)
   - 4.4. Margin of Safety (MOS)
   - 4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered "impaired." When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant. A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☒ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water

Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Final pH TMDLs for three reservoirs (i.e., Center, Legion and Horse Thief) in the Black Hills of South Dakota, were submitted to EPA for review and approval via an email from Cheryl Saunders, SD DENR on January 31, 2011. The email included the final TMDL document and a letter requesting approval of the TMDL.

COMMENTS: None.

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☐ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Black Hills TMDL document addresses the pH impairment in three reservoirs in western South Dakota: Center Lake (SD-CH-L-CENTER_01), Legion Lake (SD-CH-L-LEGION_01) and

Horse Thief Lake (SD-CH-L-HORSETHIEF_01). The 2010 South Dakota Integrated Report lists 19 lakes and reservoirs as violating the pH standard defined by their beneficial uses. Three of these 19 waterbodies are located in ecoregion 17b, the Black Hills Plateau. The three impaired reservoirs are separated by less than 10 miles. The similarities between these reservoirs were a primary consideration in the decision to consolidate them into a single TMDL evaluation.

The data included in the TMDL document represents the entire ecoregion, but the distribution of reservoirs and their drainage areas is limited to a 150,000 acre region along the eastern edge of the ecoregion. The three reservoirs addressed in the TMDL document are located in the Middle Cheyenne-Spring watershed (HUC 10120109). The draft pH TMDLs for Center Lake, Legion Lake and Horse Thief Lake address pH as the primary impairment and link phosphorus loading in the watershed as the pollutant to limit through implementation of best management practices in the watershed.

The Center Lake watershed is approximately 6,270 acres and is located in the north half of Custer State Park. The Center Lake watershed contains heavily forested areas with several campgrounds and day use facilities.

The Legion Lake watershed is located in north central Custer County, South Dakota. The watershed consists of approximately 2,050 acres of primarily quartzite and granite outcrop covered by dense pine forest; predominately ponderosa pine with some black hills spruce and aspen.

Horse Thief Lake is located in the southern portion of Pennington County. The majority of the watershed is located in the Black Elk Wilderness. Mount Rushmore National Memorial is immediately to the north and much of the rest of the wilderness is bordered by other protected land under the jurisdiction of state and federal agencies.

EPA has approved phosphorus TMDLs developed by SD DENR for Center Lake and Legion Lake on August 8, 2007 and September 2, 2008 respectively. These previous TMDL approvals did not include linkages to the pH impairment, but those linkages have now been provided in the Black Hills pH document. EPA will modify the accounting for those prior approvals to recognize that the proposed phosphorus reductions will also address the pH impairments. The review included in this checklist document will mainly focus on the new TMDL approval for Horse Thief Lake: the phosphorus loading calculations and proposed reductions to address the existing pH impairment.

COMMENTS: None.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g., insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, all TMDL documents must be written to meet the existing water quality standards for that waterbody (CWA §303(d)(1)(C)).

Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Center Lake, Legion Lake and Horse Thief Lake are listed as impaired for pH. The pH impairment is likely to be related to internal (i.e., in-lake) and external (i.e., watershed) nutrient loading. South Dakota has applicable numeric standards for pH, associated with the coldwater permanent or marginal fish life propagation beneficial use of these reservoirs. The pH criterion for both the coldwater permanent and coldwater marginal uses is greater than 6.5 and less than 9.0 standard units. Additional narrative standards can be found in the Administrative Rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09. These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The coldwater permanent fish life propagation beneficial use is assigned to surface waters of the state which are capable of supporting aquatic life and are suitable for supporting a permanent population of coldwater fish from natural reproduction or fingerling stocking. The coldwater marginal fish life propagation beneficial use is assigned to surface waters of the state which support aquatic life and are suitable for stocked catchable-size coldwater fish during portions of the year, but which, because of critical natural conditions including low flows, siltation, or warm temperatures, are not suitable for a permanent coldwater fish population.

Other applicable water quality standards for the lakes are included on pages 31, 51 and 72 of the TMDL document.

COMMENTS: None.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The three reservoirs are listed as impaired for pH and the TMDL target for each lake is the pH criterion of > 6.5 s.u. - < 9.0 s.u.

COMMENTS: None.

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Landuse in the ecoregion is broken down in Table 2 excerpted from the TMDL document below. Over 97% of the ecoregion remains in native vegetation, which is predominately ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, but the predominant form of agriculture is livestock grazing.

While not directly linked to elevated pH concentrations, increased concentrations of nitrogen and phosphorus can result in excessive macrophyte and algae growth in the waterbody. Increased respiration from excessive macrophyte and algae growth results in processes that elevate the pH. The TMDL document was not able to establish a clear pattern linking the concentrations of either nitrogen or phosphorus to elevated pH values. However, Figure 8 of the TMDL document presents empirical evidence that as chlorophyll concentrations increase, the number of samples that exceed the pH standard of 9.0 also increases. Therefore, the focus of the pH TMDLs are on reducing phosphorus loading to each of the impaired lakes.

The degraded water quality in Center Lake is primarily attributed to recreational activity within the watershed. Approximately 90% of the watershed land area is managed by the SD Department of Game, Fish and Parks (Custer State Park), while the remaining 10% is managed by the US Forest Service. Although much of the watershed remains in its natural state, the intense use of recreational facilities within Custer State Park has degraded the watershed condition. Overall, the sources of phosphorus loading from the Center Lake watershed is likely to be a combination of septic system failure, recreational uses, vehicle traffic, as well as natural background sources (i.e. wildlife, weathering, etc.).

For Legion Lake phosphorus was identified as a limiting nutrient for algae growth therefore, watershed or external phosphorus loads should be maintained or reduced using management practices recommended in the assessment report. External loads could be reduced with the implementation of riparian zone management and construction of wetlands on the inlet stream. Non-point sources of phosphorus from the watershed (external load) are only a portion of the total phosphorus load to Legion Lake. Internal phosphorus loading from lake bottom sediment is another source of phosphorus and can also be controlled.

Nonpoint sources of pollution in the Horse Thief Lake watershed have been mitigated through numerous changes in the watershed as well as through BMP installation by the US Forest Service. Additional BMPs to reduce internal nutrient loading at Horse Thief Lake are planned as part of a larger project for improving and preserving fishing opportunities on the Peter Norbeck Scenic Byway. The project has been funded and includes dredging Horse Thief, Bismarck and Lakota lakes and expected to occur sometime in 2011 or 2012. Internal loading, from past phosphorus loads into each of the three lakes addressed by the TMDL document, will continue to be a source until it cycles through. BMPs proposed for Center Lake and Legion Lake are described in Sections 8.1 and 8.2 of the TMDL document respectively.

There are no point source discharge permits located in the drainage area for Center Lake, Legion Lake or Horse Thief Lake.

Table 2. Landuse in Ecoregion 17b

Landuse	Percentage
NLCD - Evergreen Forest	62%
NLCD - Grassland Herbaceous	30%
NLCD - Shrubland	5%
NLCD - Developed	1%
NLCD - Cropland	1%
Other	1%

COMMENTS: None.

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis. This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment

impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The technical analysis should describe the cause and effect relationship between the identified pollutant sources, the numeric targets, and achievement of water quality standards. It should also include a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The technical analysis for the three Black Hills reservoir TMDLs describe how the total phosphorus loads were derived and discusses the empirical linkage between phosphorus loading and the pH impairment in the lakes.

Hydrologic and constituent loads were estimated from sample data and instantaneous flow measurements using the FLUX model in order to develop nutrient and hydrologic budgets for both Center Lake and Legion Lake. Seasonal and annual loads for nutrients were also calculated for both lakes using the FLUX model. Seasonal loads were derived by combining monthly loads (e.g., December, January and February). The eutrophication of Center Lake and Legion Lake is believed to be the largest cause of high pH. The vertical distribution of pH in these lakes are strongly influenced by the photosynthetic utilization of carbon dioxide in the trophogenic zone (the lighted zone where organic matter is synthesized and oxygen generated), which tends to reduce carbon dioxide content and increase pH. Therefore, management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Center Lake. Management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Legion Lake to a level that meets criteria established to protect the coldwater marginal fish life propagation use.

BATHTUB, a eutrophication response model, was used along with lake and stream sample data were used to calculate existing conditions in Center Lake. The model predicts changes in water quality parameters related to eutrophication (phosphorus, nitrogen, chlorophyll a, and transparency) using empirical relationships previously developed and tested for reservoir applications. Inlet phosphorus and nitrogen concentrations were reduced in increments of 10% and modeled to generate an inlake reduction curve. The predicted inlake phosphorus concentrations and individual TSI values decreased with the reduction of tributary phosphorus load. The model indicated an approximate 70% reduction in phosphorus load was required to bring chlorophyll and Secchi depth TSI values into compliance with the fishery-based TSI criterion. The Center Lake TMDL goal (70% reduction of total phosphorus loads) was determined based on the load reduction required to achieve a predicted chlorophyll and Secchi TSI value ≤ 48, which should also reduce the pH to values that meet the beneficial use criteria.

The primary tributary to Horse Thief Lake is Pine Creek. Pine Creek drains approximately 2.9 square miles (1,832 acres) of the Black Hills consisting primarily of the Black Elk Wilderness. From its outfall at Horse Thief Lake, it travels 1.7 miles downstream to its confluence with Battle Creek.

Currently, there is no existing water quality data available for Pine Creek above Horse Thief Lake. Also, there are no gauge records available for Pine Creek. Therefore a surrogate was used to develop flow characteristics for the watershed. The Pine Creek water chemistry was developed utilizing ecoregion nutrient targets and modeled reductions in nutrient loading as a result of BMPs that have been utilized in the watershed. South Dakota does not have nutrient criteria, however EPA has set forth recommended criteria for level III ecoregions. As a result of the current phase of mitigation activities as well as the lack of preexisting water chemistry data, utilizing the EPA guidance as the TMDL concentration was deemed the most accurate and protective approach for developing the TMDL.

The lake continued to exhibit signs of impairment during its most recent sampling. This continued impairment is considered to be a result of nutrient loadings in the past which have accumulated in the sediments. At the time of TMDL development, restoration activities in the watershed were either complete or nearing completion. Horse Thief Lake watershed mitigation activities have primarily focused on the reduction of sediment entering the Pine Creek drainage and the lake itself. In addition to sediment reduction, nutrients loadings have also been reduced. Phosphorus reductions as a result of BMP implementation have been calculated and were used to estimate annual nutrient loads to the lake and may be considered representative of the Pine Creek watershed in its impaired state. As of 2010, the US Forest Service had completed watershed restoration work which would result in Pine Creek demonstrating nutrient concentrations that are lower than what would have been found prior to BMP installation. Implementation of the BMPs may have affected the stream, however the lake existing lake impairment is likely a result of nutrient accumulations in the sediment that have not cycled out of the system. A plan to dredge lake sediments has been developed and funded, which should accelerate the cycling process and is expected to result in full support of the lake's beneficial uses.

The USEPA contracted with Heidleburg College to analyze ambient river and stream water quality data collected by the South Dakota Department of Environment and Natural Resources (SDDENR). A data analyses protocol was developed and the data were analyzed following the USEPA protocol for determining the lower seasonal 25th percentile of the population of all streams within a region. Based on the analysis by Heidleburg College, it may be assumed that a concentration of 0.02 mg/L would be adequate for Pine Creek. As stated earlier, this stream is located entirely in a wilderness area, which suggests it should be held to a more conservative standard. As a result, the Horse Thief Lake TMDL is based on the more conservative EPA guidance of 0.01 mg/L of total phosphorus.

The BATHTUB model was utilized to model numerous scenarios based on the extremes of the uncertainty used to develop the inputs. The Pine Creek phosphorus concentration of 66 ug/L was estimated based on sediment reduction loading, and was used for the primary input to the model. A secondary source of phosphorus available in the model is internal loading. Internal loading rates are difficult to calculate, but literature values suggest rates may be expected to range from 0 to 0.4 mg/m2/day. Each of the four models was used to simulate the 85% reduction in stream loading (concentrations of 10 ppb). Utilizing this load, each of the four models predicted in lake chlorophyll concentrations between 5 ppb and 8 ppb. All four consistently suggested that an 85% reduction in watershed loading would produce slightly more than a 70% reduction in the chlorophyll concentrations. The predicted concentrations all fall below the target of 9 ppb to 12.5 ppb ecoregion target necessary to obtain pH values within the state standards. Utilizing the water load of 162 acre feet and phosphorus concentration of 0.01 mg/L, an average annual phosphorus load of 5.9 kilograms was calculated.

COMMENTS: None.

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The data set from ecoregion 17b was collected through numerous sources including ambient monitoring programs such as SD DENR statewide lake assessment project as well as individual projects such as the Custer State Park Lakes assessment. Samples included in the analysis were limited with respect to their completeness of measurements. To prevent bias associated with partial samples, only those that included all of the following parameters were included; pH, chlorophyll a, phosphorus, and nitrogen. Data was not excluded based on the age of the sample. The resulting data set consisted of 94 samples from the nine reservoirs.

For Center Lake, the pH data set includes 20 values which ranged from 6.7 to 9.7. This data is presented in the form of a bar graph in Figure 15 of the TMDL document. Forty (40) percent of the measurements at both sampling sites and both near surface and near bottom depths exceeded the upper limit of the water quality criterion for coldwater permanent fish life use.

For Horse Thief Lake, the pH data set includes 20 values which ranged from 7.15 to 10.04. This data is presented in Table 33 of the TMDL document. 12 of the 20 values (60 percent) of the measurements exceeded the upper limit of the water quality criterion for coldwater permanent fish life use.

For Legion Lake, the pH data set includes an unspecified number of values ranging from 7.6 to 9.3. Approximately 15 percent of the measurements exceeded the upper limit of the water quality criterion for coldwater marginal fish life use. There was some uncertainty in the validity of the sample data, therefore a data table was not included in the TMDL document.

COMMENTS: None.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: There are no point source discharge permits located in the drainage area for any of the lake TMDLs addressed in the TMDL document for Center, Legion, or Horse Thief Lake. Therefore, the wasteload allocations for all three TMDLs are zero.

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream)

unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL explains that the landuse in the ecoregion is over 97% native vegetation, which is predominately ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, as well as livestock grazing. The load allocation is provided to the limited agricultural and recreational nonpoint sources in the drainage area of each lake.

Table 38 below, excerpted from the TMDL document, includes the daily maximum and annual total phosphorus load estimates for Horse Thief Lake. The phosphorus TMDLs for Center Lake and Legion Lake were previously approved on August 8, 2007 and September 2, 2008 respectively. Those approvals remain in effect and the loadings do not needed to be repeated in this review and approval process.

TMDL Component	Long-term Average Allocation (kg/year)	Maximum Daily Allocation (kg/day)
Wasteload Allocation	0	0
Load Allocation	5.9	0.11
Margin of Safety	Implicit	Implicit
TMDL	5.9	0.11

COMMENTS: None.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the

TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

- ☒ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
- ☐ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
- ☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Horse Thief Lake TMDL includes an implicit MOS by using the EPA ecoregion value of 0.01 mg/L total phosphorus instead of the Heidelberg College estimate of 0.02 mg/L as the basis for deriving the loading capacity. Due to the uncertainty in the Heidelberg study, utilizing this difference as an implicit margin of safety was more appropriate then taking the difference as a calculated explicit margin of safety.

COMMENTS: None.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

- ☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The largest components of seasonal variation in the Horse Thief Lake watershed are related to rainfall and recreational use. Peak flows and use coincide during late spring and early summer, making this the most critical time for loadings to occur. Installed BMPs targeted recreational use and should have minimized their impact. The TMDL calculations took into account variability in flow rates which should account for seasonal variability, however, if the lake continues to exhibit signs of impairment, this would be the most critical time to conduct additional monitoring.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:

☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☒ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process so far. In particular, the State has encouraged participation through prior public notices for the Center Lake and Legion Lake phosphorus TMDLs, as well as the pH TMDLs being available for a 30-day public notice period prior to finalization.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☐ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☒ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL (See: http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Monitoring Strategy section (7.0) says that Center, Horse Thief, and Legion Lakes have all been a part of the State's Statewide Lakes Assessment. During 2008, the State's lakes monitoring plan changed from targeted sampling to a random design and began including more of the lakes resources. As a result, sampling is not guaranteed during a given year, however statistically, each lake should be visited once every 5 years. Each of these lakes will remain a part of this project and will be assessed.

COMMENTS: None.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY:
The Implementation and Mitigation Recommendations section (8.0) of the TMDL document describes several best management practices that are recommended to reduce nutrient loading to the three Black Hills reservoirs. Since there are no point sources within the drainage area of the three reservoirs covered by the pH TMDL document, there is no need to include a discussion of reasonable assurance.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Horse Thief Lake TMDL annual total phosphorus loads in kg/yr were used to derive daily loads using the methods described in EPA's "Technical Support Document of Water Quality-Based Toxics Control." Following this methodology, daily total phosphorus loads, in kg/day, are included in the TMDL (see Table 38 of the TMDL document).

COMMENTS: None.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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MAR 24 2011

Ref: 8EPR-EP

Steven M. Pirner
Secretary
South Dakota Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Horse Thief Lake; Phosphorus; SD-CH-L-HORSETHIEF_01

Dear ~~Mr. Pirner~~ Steve:

We have completed our review of the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq.*), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1). Based on our review, we feel the separate elements of the TMDLs listed in the enclosed table adequately address the pollutants of concern as given in the table, taking into consideration seasonal variation and a margin of safety. We will modify our previous phosphorus approvals for Center Lake and Legion Lake to recognize that the pH impairments in those lakes will be addressed by the nutrient reductions proposed in the Black Hills pH document.

Thank you for submitting these TMDLs for our review and approval. If you have any questions, the most knowledgeable person on my staff is Vern Berry and he may be reached at 303-312-6234.

Sincerely,

Carol L. Campbell

Carol L. Campbell
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures

ENCLOSURE 1: APPROVED TMDLs

Total Maximum Daily Load Evaluation of pH for Reservoirs in the Black Hills Plateau Ecoregion of Custer and Pennington Counties, South Dakota (SD DENR, November 2010)

1	Pollutant TMDLs completed.
3	Causes addressed from the 2010 303(d) list.
0	Determinations that no pollutant TMDL needed.

Submitted: 1/31/2011

Segment: Horse Thief Lake

303(d) ID: SD-CH-L-HORSETHIEF 01

Parameter/Pollutant (303(d) list cause): PHOSPHORUS - 29

Water Quality Targets: PH >= 6.0 - <= 9.0 S.U.

Allocation*	Value	Units	Permits
WLA	0	KG/YR	
LA	5.9	KG/YR	
TMDL	5.9	KG/YR	

Notes: The Horse Thief Lake phosphorus TMDL was written to address the pH impairment in the lake. Linkages were also provided between the previously approved phosphorus TMDLs for Center Lake and Legion Lake and the pH impairments in those lakes. EPA's TMDL tracking system will be revised to provide credit for addressing the pH impairment via the specified phosphorus reductions. Daily phosphorus load allocations were also provided in the TMDL document.

* LA = Load Allocation, WLA = Wasteload Allocation, MOS = Margin of Safety, TMDL = sum(WLAs) + sum(LAs) + MOS

ENCLOSURE 2

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Total Maximum Daily Load Evaluation of pH for Reservoirs in the Black Hills Plateau Ecoregion of Custer and Pennington Counties, South Dakota (November, 2010)**
Submitted by:	**Cheryl Saunders, SD DENR**
Date Received:	**January 31, 2011**
Review Date:	**March 15, 2011**
Reviewer:	**Vern Berry, US EPA**
Rough Draft / Public Notice / Final Draft?	**Final**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

- ☒ Approve
- ☐ Partial Approval
- ☐ Disapprove
- ☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   1.1. TMDL Document Submittal Letter
   1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   4.1. Data Set Description
   4.2. Waste Load Allocations (WLA)
   4.3. Load Allocations (LA)
   4.4. Margin of Safety (MOS)
   4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered "impaired." When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant. A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☒ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water

Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Final pH TMDLs for three reservoirs (i.e., Center, Legion and Horse Thief) in the Black Hills of South Dakota, were submitted to EPA for review and approval via an email from Cheryl Saunders, SD DENR on January 31, 2011. The email included the final TMDL document and a letter requesting approval of the TMDL.

COMMENTS: None.

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☐ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Black Hills TMDL document addresses the pH impairment in three reservoirs in western South Dakota: Center Lake (SD-CH-L-CENTER_01), Legion Lake (SD-CH-L-LEGION_01) and

Horse Thief Lake (SD-CH-L-HORSETHIEF_01). The 2010 South Dakota Integrated Report lists 19 lakes and reservoirs as violating the pH standard defined by their beneficial uses. Three of these 19 waterbodies are located in ecoregion 17b, the Black Hills Plateau. The three impaired reservoirs are separated by less than 10 miles. The similarities between these reservoirs were a primary consideration in the decision to consolidate them into a single TMDL evaluation.

The data included in the TMDL document represents the entire ecoregion, but the distribution of reservoirs and their drainage areas is limited to a 150,000 acre region along the eastern edge of the ecoregion. The three reservoirs addressed in the TMDL document are located in the Middle Cheyenne-Spring watershed (HUC 10120109). The draft pH TMDLs for Center Lake, Legion Lake and Horse Thief Lake address pH as the primary impairment and link phosphorus loading in the watershed as the pollutant to limit through implementation of best management practices in the watershed.

The Center Lake watershed is approximately 6,270 acres and is located in the north half of Custer State Park. The Center Lake watershed contains heavily forested areas with several campgrounds and day use facilities.

The Legion Lake watershed is located in north central Custer County, South Dakota. The watershed consists of approximately 2,050 acres of primarily quartzite and granite outcrop covered by dense pine forest; predominately ponderosa pine with some black hills spruce and aspen.

Horse Thief Lake is located in the southern portion of Pennington County. The majority of the watershed is located in the Black Elk Wilderness. Mount Rushmore National Memorial is immediately to the north and much of the rest of the wilderness is bordered by other protected land under the jurisdiction of state and federal agencies.

EPA has approved phosphorus TMDLs developed by SD DENR for Center Lake and Legion Lake on August 8, 2007 and September 2, 2008 respectively. These previous TMDL approvals did not include linkages to the pH impairment, but those linkages have now been provided in the Black Hills pH document. EPA will modify the accounting for those prior approvals to recognize that the proposed phosphorus reductions will also address the pH impairments. The review included in this checklist document will mainly focus on the new TMDL approval for Horse Thief Lake: the phosphorus loading calculations and proposed reductions to address the existing pH impairment.

COMMENTS: None.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g., insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, all TMDL documents must be written to meet the existing water quality standards for that waterbody (CWA §303(d)(1)(C)).

Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Center Lake, Legion Lake and Horse Thief Lake are listed as impaired for pH. The pH impairment is likely to be related to internal (i.e., in-lake) and external (i.e., watershed) nutrient loading. South Dakota has applicable numeric standards for pH, associated with the coldwater permanent or marginal fish life propagation beneficial use of these reservoirs. The pH criterion for both the coldwater permanent and coldwater marginal uses is greater than 6.5 and less than 9.0 standard units. Additional narrative standards can be found in the Administrative Rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09. These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The coldwater permanent fish life propagation beneficial use is assigned to surface waters of the state which are capable of supporting aquatic life and are suitable for supporting a permanent population of coldwater fish from natural reproduction or fingerling stocking. The coldwater marginal fish life propagation beneficial use is assigned to surface waters of the state which support aquatic life and are suitable for stocked catchable-size coldwater fish during portions of the year, but which, because of critical natural conditions including low flows, siltation, or warm temperatures, are not suitable for a permanent coldwater fish population.

Other applicable water quality standards for the lakes are included on pages 31, 51 and 72 of the TMDL document.

COMMENTS: None.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The three reservoirs are listed as impaired for pH and the TMDL target for each lake is the pH criterion of > 6.5 s.u. - < 9.0 s.u.

COMMENTS: None.

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: Landuse in the ecoregion is broken down in Table 2 excerpted from the TMDL document below. Over 97% of the ecoregion remains in native vegetation, which is predominately ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, but the predominant form of agriculture is livestock grazing.

While not directly linked to elevated pH concentrations, increased concentrations of nitrogen and phosphorus can result in excessive macrophyte and algae growth in the waterbody. Increased respiration from excessive macrophyte and algae growth results in processes that elevate the pH. The TMDL document was not able to establish a clear pattern linking the concentrations of either nitrogen or phosphorus to elevated pH values. However, Figure 8 of the TMDL document presents empirical evidence that as chlorophyll concentrations increase, the number of samples that exceed the pH standard of 9.0 also increases. Therefore, the focus of the pH TMDLs are on reducing phosphorus loading to each of the impaired lakes.

The degraded water quality in Center Lake is primarily attributed to recreational activity within the watershed. Approximately 90% of the watershed land area is managed by the SD Department of Game, Fish and Parks (Custer State Park), while the remaining 10% is managed by the US Forest Service. Although much of the watershed remains in its natural state, the intense use of recreational facilities within Custer State Park has degraded the watershed condition. Overall, the sources of phosphorus loading from the Center Lake watershed is likely to be a combination of septic system failure, recreational uses, vehicle traffic, as well as natural background sources (i.e. wildlife, weathering, etc.).

For Legion Lake phosphorus was identified as a limiting nutrient for algae growth therefore, watershed or external phosphorus loads should be maintained or reduced using management practices recommended in the assessment report. External loads could be reduced with the implementation of riparian zone management and construction of wetlands on the inlet stream. Non-point sources of phosphorus from the watershed (external load) are only a portion of the total phosphorus load to Legion Lake. Internal phosphorus loading from lake bottom sediment is another source of phosphorus and can also be controlled.

Nonpoint sources of pollution in the Horse Thief Lake watershed have been mitigated through numerous changes in the watershed as well as through BMP installation by the US Forest Service. Additional BMPs to reduce internal nutrient loading at Horse Thief Lake are planned as part of a larger project for improving and preserving fishing opportunities on the Peter Norbeck Scenic Byway. The project has been funded and includes dredging Horse Thief, Bismarck and Lakota lakes and expected to occur sometime in 2011 or 2012. Internal loading, from past phosphorus loads into each of the three lakes addressed by the TMDL document, will continue to be a source until it cycles through. BMPs proposed for Center Lake and Legion Lake are described in Sections 8.1 and 8.2 of the TMDL document respectively.

There are no point source discharge permits located in the drainage area for Center Lake, Legion Lake or Horse Thief Lake.

Table 2. Landuse in Ecoregion 17b

Landuse	Percentage
NLCD - Evergreen Forest	62%
NLCD - Grassland Herbaceous	30%
NLCD - Shrubland	5%
NLCD - Developed	1%
NLCD - Cropland	1%
Other	1%

COMMENTS: None.

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis. This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment

impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The technical analysis should describe the cause and effect relationship between the identified pollutant sources, the numeric targets, and achievement of water quality standards. It should also include a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The technical analysis for the three Black Hills reservoir TMDLs describe how the total phosphorus loads were derived and discusses the empirical linkage between phosphorus loading and the pH impairment in the lakes.

Hydrologic and constituent loads were estimated from sample data and instantaneous flow measurements using the FLUX model in order to develop nutrient and hydrologic budgets for both Center Lake and Legion Lake. Seasonal and annual loads for nutrients were also calculated for both lakes using the FLUX model. Seasonal loads were derived by combining monthly loads (e.g., December, January and February). The eutrophication of Center Lake and Legion Lake is believed to be the largest cause of high pH. The vertical distribution of pH in these lakes are strongly influenced by the photosynthetic utilization of carbon dioxide in the trophogenic zone (the lighted zone where organic matter is synthesized and oxygen generated), which tends to reduce carbon dioxide content and increase pH. Therefore, management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Center Lake. Management practices recommended to reduce phosphorus loads, thereby reducing algae growth, are expected to also reduce the pH of Legion Lake to a level that meets criteria established to protect the coldwater marginal fish life propagation use.

BATHTUB, a eutrophication response model, was used along with lake and stream sample data were used to calculate existing conditions in Center Lake. The model predicts changes in water quality parameters related to eutrophication (phosphorus, nitrogen, chlorophyll a, and transparency) using empirical relationships previously developed and tested for reservoir applications. Inlet phosphorus and nitrogen concentrations were reduced in increments of 10% and modeled to generate an inlake reduction curve. The predicted inlake phosphorus concentrations and individual TSI values decreased with the reduction of tributary phosphorus load. The model indicated an approximate 70% reduction in phosphorus load was required to bring chlorophyll and Secchi depth TSI values into compliance with the fishery-based TSI criterion. The Center Lake TMDL goal (70% reduction of total phosphorus loads) was determined based on the load reduction required to achieve a predicted chlorophyll and Secchi TSI value ≤ 48, which should also reduce the pH to values that meet the beneficial use criteria.

The primary tributary to Horse Thief Lake is Pine Creek. Pine Creek drains approximately 2.9 square miles (1,832 acres) of the Black Hills consisting primarily of the Black Elk Wilderness. From its outfall at Horse Thief Lake, it travels 1.7 miles downstream to its confluence with Battle Creek.

Currently, there is no existing water quality data available for Pine Creek above Horse Thief Lake. Also, there are no gauge records available for Pine Creek. Therefore a surrogate was used to develop flow characteristics for the watershed. The Pine Creek water chemistry was developed utilizing ecoregion nutrient targets and modeled reductions in nutrient loading as a result of BMPs that have been utilized in the watershed. South Dakota does not have nutrient criteria, however EPA has set forth recommended criteria for level III ecoregions. As a result of the current phase of mitigation activities as well as the lack of preexisting water chemistry data, utilizing the EPA guidance as the TMDL concentration was deemed the most accurate and protective approach for developing the TMDL.

The lake continued to exhibit signs of impairment during its most recent sampling. This continued impairment is considered to be a result of nutrient loadings in the past which have accumulated in the sediments. At the time of TMDL development, restoration activities in the watershed were either complete or nearing completion. Horse Thief Lake watershed mitigation activities have primarily focused on the reduction of sediment entering the Pine Creek drainage and the lake itself. In addition to sediment reduction, nutrients loadings have also been reduced. Phosphorus reductions as a result of BMP implementation have been calculated and were used to estimate annual nutrient loads to the lake and may be considered representative of the Pine Creek watershed in its impaired state. As of 2010, the US Forest Service had completed watershed restoration work which would result in Pine Creek demonstrating nutrient concentrations that are lower than what would have been found prior to BMP installation. Implementation of the BMPs may have affected the stream, however the lake existing lake impairment is likely a result of nutrient accumulations in the sediment that have not cycled out of the system. A plan to dredge lake sediments has been developed and funded, which should accelerate the cycling process and is expected to result in full support of the lake's beneficial uses.

The USEPA contracted with Heidleburg College to analyze ambient river and stream water quality data collected by the South Dakota Department of Environment and Natural Resources (SDDENR). A data analyses protocol was developed and the data were analyzed following the USEPA protocol for determining the lower seasonal 25th percentile of the population of all streams within a region. Based on the analysis by Heidleburg College, it may be assumed that a concentration of 0.02 mg/L would be adequate for Pine Creek. As stated earlier, this stream is located entirely in a wilderness area, which suggests it should be held to a more conservative standard. As a result, the Horse Thief Lake TMDL is based on the more conservative EPA guidance of 0.01 mg/L of total phosphorus.

The BATHTUB model was utilized to model numerous scenarios based on the extremes of the uncertainty used to develop the inputs. The Pine Creek phosphorus concentration of 66 ug/L was estimated based on sediment reduction loading, and was used for the primary input to the model. A secondary source of phosphorus available in the model is internal loading. Internal loading rates are difficult to calculate, but literature values suggest rates may be expected to range from 0 to 0.4 mg/m2/day. Each of the four models was used to simulate the 85% reduction in stream loading (concentrations of 10 ppb). Utilizing this load, each of the four models predicted in lake chlorophyll concentrations between 5 ppb and 8 ppb. All four consistently suggested that an 85% reduction in watershed loading would produce slightly more than a 70% reduction in the chlorophyll concentrations. The predicted concentrations all fall below the target of 9 ppb to 12.5 ppb ecoregion target necessary to obtain pH values within the state standards. Utilizing the water load of 162 acre feet and phosphorus concentration of 0.01 mg/L, an average annual phosphorus load of 5.9 kilograms was calculated.

COMMENTS: None.

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The data set from ecoregion 17b was collected through numerous sources including ambient monitoring programs such as SD DENR statewide lake assessment project as well as individual projects such as the Custer State Park Lakes assessment. Samples included in the analysis were limited with respect to their completeness of measurements. To prevent bias associated with partial samples, only those that included all of the following parameters were included; pH, chlorophyll a, phosphorus, and nitrogen. Data was not excluded based on the age of the sample. The resulting data set consisted of 94 samples from the nine reservoirs.

For Center Lake, the pH data set includes 20 values which ranged from 6.7 to 9.7. This data is presented in the form of a bar graph in Figure 15 of the TMDL document. Forty (40) percent of the measurements at both sampling sites and both near surface and near bottom depths exceeded the upper limit of the water quality criterion for coldwater permanent fish life use.

For Horse Thief Lake, the pH data set includes 20 values which ranged from 7.15 to 10.04. This data is presented in Table 33 of the TMDL document. 12 of the 20 values (60 percent) of the measurements exceeded the upper limit of the water quality criterion for coldwater permanent fish life use.

For Legion Lake, the pH data set includes an unspecified number of values ranging from 7.6 to 9.3. Approximately 15 percent of the measurements exceeded the upper limit of the water quality criterion for coldwater marginal fish life use. There was some uncertainty in the validity of the sample data, therefore a data table was not included in the TMDL document.

COMMENTS: None.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: There are no point source discharge permits located in the drainage area for any of the lake TMDLs addressed in the TMDL document for Center, Legion, or Horse Thief Lake. Therefore, the wasteload allocations for all three TMDLs are zero.

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream)

unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL explains that the landuse in the ecoregion is over 97% native vegetation, which is predominately ponderosa pine forest with a grass under story. Small portions of the ecoregion are used for crops and hay ground, as well as livestock grazing. The load allocation is provided to the limited agricultural and recreational nonpoint sources in the drainage area of each lake.

Table 38 below, excerpted from the TMDL document, includes the daily maximum and annual total phosphorus load estimates for Horse Thief Lake. The phosphorus TMDLs for Center Lake and Legion Lake were previously approved on August 8, 2007 and September 2, 2008 respectively. Those approvals remain in effect and the loadings do not needed to be repeated in this review and approval process.

TMDL Component	Long-term Average Allocation (kg/year)	Maximum Daily Allocation (kg/day)
Wasteload Allocation	0	0
Load Allocation	5.9	0.11
Margin of Safety	Implicit	Implicit
TMDL	5.9	0.11

COMMENTS: None.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the

TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

- ☒ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
- ☐ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
- ☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Horse Thief Lake TMDL includes an implicit MOS by using the EPA ecoregion value of 0.01 mg/L total phosphorus instead of the Heidelberg College estimate of 0.02 mg/L as the basis for deriving the loading capacity. Due to the uncertainty in the Heidelberg study, utilizing this difference as an implicit margin of safety was more appropriate then taking the difference as a calculated explicit margin of safety.

COMMENTS: None.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

- ☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The largest components of seasonal variation in the Horse Thief Lake watershed are related to rainfall and recreational use. Peak flows and use coincide during late spring and early summer, making this the most critical time for loadings to occur. Installed BMPs targeted recreational use and should have minimized their impact. The TMDL calculations took into account variability in flow rates which should account for seasonal variability, however, if the lake continues to exhibit signs of impairment, this would be the most critical time to conduct additional monitoring.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:
☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☒ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process so far. In particular, the State has encouraged participation through prior public notices for the Center Lake and Legion Lake phosphorus TMDLs, as well as the pH TMDLs being available for a 30-day public notice period prior to finalization.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☐ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☒ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL (See: http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Monitoring Strategy section (7.0) says that Center, Horse Thief, and Legion Lakes have all been a part of the State's Statewide Lakes Assessment. During 2008, the State's lakes monitoring plan changed from targeted sampling to a random design and began including more of the lakes resources. As a result, sampling is not guaranteed during a given year, however statistically, each lake should be visited once every 5 years. Each of these lakes will remain a part of this project and will be assessed.

COMMENTS: None.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY:
The Implementation and Mitigation Recommendations section (8.0) of the TMDL document describes several best management practices that are recommended to reduce nutrient loading to the three Black Hills reservoirs. Since there are no point sources within the drainage area of the three reservoirs covered by the pH TMDL document, there is no need to include a discussion of reasonable assurance.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Horse Thief Lake TMDL annual total phosphorus loads in kg/yr were used to derive daily loads using the methods described in EPA's "Technical Support Document of Water Quality-Based Toxics Control." Following this methodology, daily total phosphorus loads, in kg/day, are included in the TMDL (see Table 38 of the TMDL document).

COMMENTS: None.