Black Lake Watershed Assessment and Total Maximum Daily Load

FINAL REPORT

Idaho Department of Environmental Quality
Coeur d'Alene Tribe
U.S. Environmental Protection Agency, Region 10

March, 2011

Cover Photo: Photograph of Black Lake provided by Coeur d'Alene Tribe taken in 2006.

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U.S. Environmental Protection Agency, Region 10

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- Project management and technical input were provided by Jayne Carlin and Bill Stewart.
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Statement Regarding Joint Development and Issuance of this TMDL

Nothing in this TMDL is or shall be construed to be a waiver of the sovereignty, jurisdiction, ownership or any claim of the Coeur d'Alene Tribe or the State of Idaho. Each party reserves, and nothing in this TMDL affects, any rights, powers, and remedies of any Party now or hereafter existing in law or equity by statute, treaty executive order, regulation, court decision or otherwise

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Abbreviations, Acronyms, and Symbols

§303(d) Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section

µ micro, one-one thousandth

§ Section (usually a section of federal or state rules or statutes)

BATHTUB a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes

BMP best management practice

BURP Beneficial Use Reconnaissance Program

°C degrees Celsius

CFR Code of Federal Regulations (refers to citations in the federal administrative rules)

cfs cubic feet per second

cm centimeters

C/N carbon and nitrogen

CVMP Citizens Volunteer Monitoring Program

CWA Clean Water Act

DEQ Department of Environmental Quality

DO dissolved oxygen

EPA United States Environmental Protection Agency

°F degrees Fahrenheit

GIS Geographical Information Systems

HPLC High performance liquid chromatography

IDAPA Refers to citations of Idaho administrative rules

km kilometer

km^2 square kilometer

LA load allocation

LC load capacity

m meter

m^2 square meter

m^3 cubic meter

mi mile

mi^2 square miles

mg/L milligrams per liter

mm millimeter

MOS margin of safety

NB natural background

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

ppm part(s) per million

SBA subbasin assessment

TKN total Kjeldahl nitrogen

TMDL total maximum daily load

TP total phosphorus

TSS total suspended solids

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USGS United States Geological Survey

WLA wasteload allocation

yr year

Executive Summary

The Federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

This document addresses the water bodies in the Black Lake Subbasin. This subbasin assessment (SBA) and TMDL analysis have been developed to comply with Idaho's TMDL schedule. The assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions in the Black Lake Subbasin, located in northern Idaho.

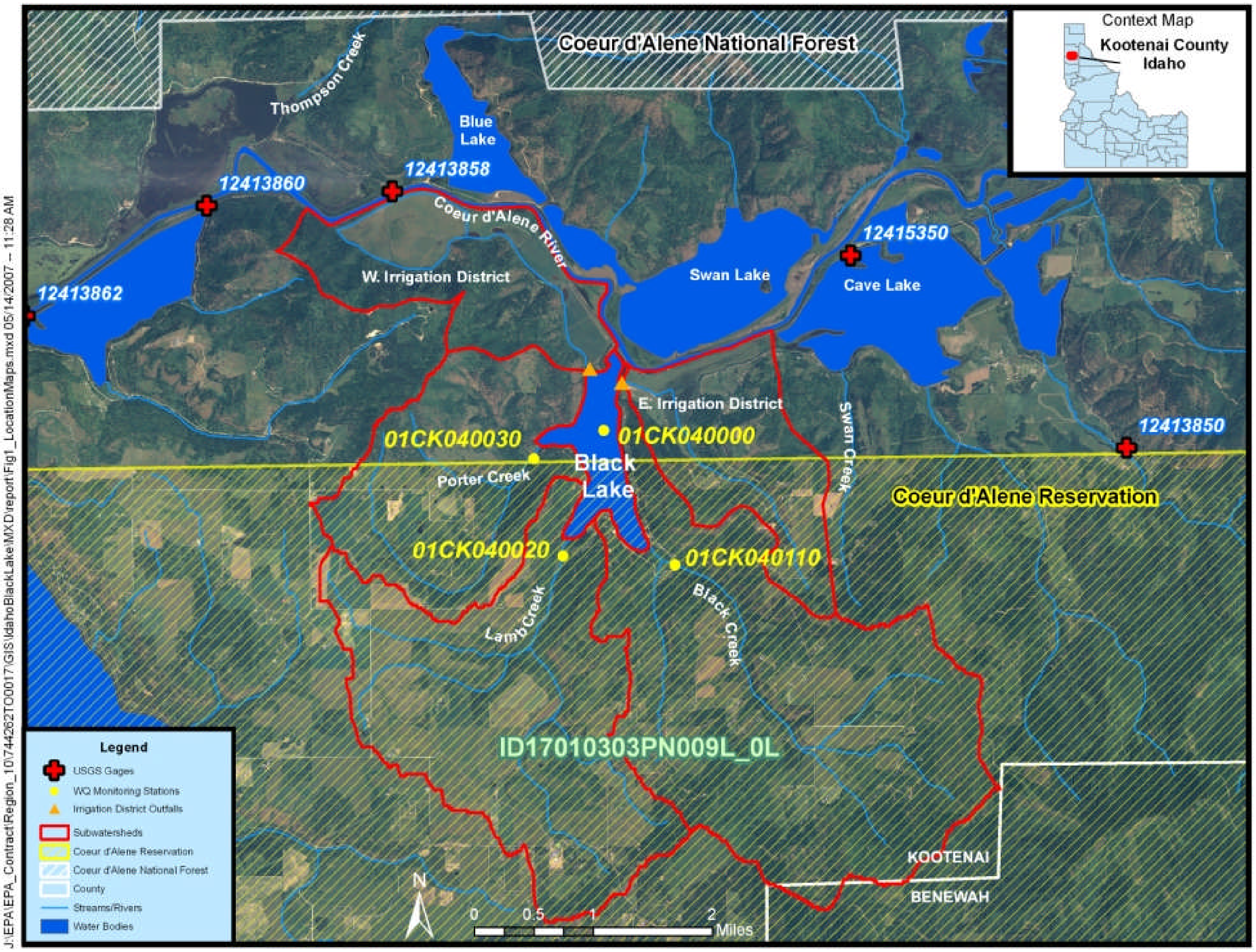
The first part of this document, the SBA, is an important first step in leading to the TMDL. The starting point for this assessment was Idaho's current §303(d) list of water quality limited water bodies. Black Lake is on Idaho's current §303(d) list (in Idaho's 2008 Integrated Report). The SBA examines the current status of §303(d) listed waters and defines the extent of impairment and causes of water quality limitation throughout the subbasin. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards.

Subbasin at a Glance

Black Lake (ID 17010303PN009L_0L) is located in the Idaho panhandle in southern Kootenai County. Black Lake, one of several lateral lakes along the Coeur d'Alene River, is approximately 5 miles west of Harrison, Idaho. The entire Black Lake watershed falls within Kootenai County, Idaho. Approximately two-thirds of the Black Lake watershed is located within the Coeur d'Alene Reservation, including the two southern arms of Black Lake. There are three primary tributaries draining to Black Lake: Porter Creek, Lamb Creek, and Black Creek. Lamb and Black Creek are considered perennial streams, and Porter Creek is considered intermittent. The land use/land cover in each subwatershed is primarily forested or used for agriculture. Only 1 percent of the Black Lake watershed has been developed.

There are no NPDES-permitted facilities within or outside of the Black Lake watershed that discharge to Black Lake or its tributaries. However, direct discharges into the lake are present as a result of dewatering historical seasonal wetlands on the north end of the lake for agricultural grazing purposes. This property is referred to as the West Pasture and the East Pasture. Due to legal exemptions/decisions, this discharge is an exemption under the NPDES permitting process. Therefore, all of the known or suspected sources of nutrient loading to Black Lake are the result of nonpoint sources and legally NPDES-exempt direct discharges to Black Lake.

There are seven discrete nonpoint sources into Black Lake. Nutrient loads are transported to Black Lake by the three tributaries, Porter Creek, Lamb Creek, and Black Creek; septic systems within 100 meters of the Black Lake shoreline and within 20 meters of any Black Lake tributary; the East Pasture and the West Pasture on the north end of Black Lake; and the Coeur d'Alene River. The Coeur d'Alene River and atmospheric deposition are considered background sources of total phosphorus (TP).



Key Findings

Black Lake is a shallow, eutrophic lake with a history of water quality problems. Water quality monitoring data collected by DEQ and the Coeur d'Alene Tribe over the past 20 years and paleolimnology explorations of Black Lake have demonstrated that the lake is not supporting cold water aquatic life use as a result of excessive nutrient loading. Although there is a limited amount of water quality data available to substantiate the spatial and temporal severity of the cold water aquatic life use impairment in Black Lake, a weight-of-evidence approach substantiates that the cold water aquatic life use narrative criteria are not fully supported. Therefore, Black Lake have placed the water body on Idaho's 303(d) list of impaired lakes requiring the development of a TMDL to restore the beneficial use of cold water aquatic life. Since the majority of Porter Creek, and all of Lamb Creek, and Black Creek, lie within the Coeur d'Alene Reservation and assessment of beneficial use attainment within these tributaries will be conducted by the Coeur d'Alene Tribe at a later date. Thus, TMDLs will not be written for the Black Lake tributaries.

This TMDL has been jointly developed by Coeur d'Alene Tribe, EPA and Department of Environmental Quality. For this TMDL, the Coeur d'Alene Tribe has agreed to apply Idaho's water quality standards as the basis for establishing an appropriate water quality target for nutrients in Black Lake. The Coeur d'Alene Tribe, Region 10, and DEQ have agreed that the interpretation of the narrative criteria used in the TMDL will meet and protect the criteria and the designated uses of both the Coeur d'Alene Tribe and the state of Idaho for Black Lake.

All TP loading to Black Lake is the result of nonpoint sources transported to the lake directly from the watershed as well as from sources outside the watershed. The primary pollutant transport pathway for sources within the Black Lake watershed is from rainfall/snow melt runoff occurring between February and June and from septic systems. External nonpoint sources of TP are transported to Black Lake via direct discharges from the East and West Pastures and from seasonal flooding of the lake by the Coeur d'Alene River. Thus, the inter-relationship between these transport mechanisms and the land use activities generating TP sources demonstrate that both anthropogenic and natural sources of phosphorus are nonpoint source in origin and will warrant an integrated approach to best management practices (BMP) to effectively reduce loadings to Black Lake over time.

Since numeric nutrient criteria do not exist in the Idaho water quality standards for Black Lake, a critical step in development of the TMDL is formulation of a rationale for creating a numeric water quality target for Idaho's narrative water quality standard - "surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses." This water quality target will provide a measurable in-lake water column target, which, when attained, will restore cold water aquatic life use.

After thorough evaluation of the different data sources, DEQ and the Coeur d'Alene Tribe concluded that an appropriate water quality target should correlate with a mesotrophic status. As a result, the TP water quality target recommended for the Black Lake TMDL is 20 µg/L. It is assumed that reductions in TP to meet this water quality target will reverse the trend of eutrophication and eventually provide full support of the cold water aquatic life use of Black Lake. The target concentration for TP in Black Lake is based on an average concentration for the months of July through September – times of greatest concern for high densities of algae and DO problems.

Pollutant loading analysis to estimate the load capacity for Black Lake was conducted by integrating modeling outputs from GWLF and BATHTUB. The GWLF model estimates dissolved and total nitrogen and phosphorus loads in surface runoff from complex watersheds. BATHTUB is a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes. Since there are no point sources discharging to the Black Lake watershed, no estimation of existing point source loads is necessary. For the

Black Lake TP TMDL, existing nonpoint source loads were estimated using two different methods:

- GWLF modeling summarized by subwatershed, and
- Literature values derived from the 1987 Kann and Falter report for Black Creek, Lamb Creek and the East and West Pastures.

The method which uses the Kann and Falter estimates supposes that larger existing flows and higher TP concentrations (and therefore loads) from the East and West Pastures. *This method was the preferred method for final load allocations and percent reduction goals to achieve the water quality target of 20 µg/L in Black Lake*. Using this method, the estimated existing load of 1000 kg/yr TP needs to be reduced to 322 kg/yr TP —an overall percent reduction of 68 percent (Table X). Since reductions are not practical from the Coeur d'Alene River and atmospheric deposition, these two sources are considered background sources and no load reduction is required.

Table X. TP Load Allocations and Percent Reduction Goals required for all Nonpoint Sources to Black Lake using BATHTUB and 1987 Kann and Falter Values

Source	Avg Annual Flow (million m^3/yr)	Existing Condition	Average Annual Allocation	
		Existing Load (kg/yr)	Allocated Load (kg/yr)	% Load Reduction
Lamb Creek	2.362	206.8	47.6	77%
Black Creek	4.523	218.1	50.2	77%
Porter Creek[1]	0.60	75.6	17.4	77%
West Pasture	1.059	127.1	29.2	77%
East Pasture	0.824	214.1	49.2	77%
Coeur d'Alene River	3.92	82.3	82.3	0%
Septic Systems[2]	0.003	38.6	9.0	77%
Atmospheric Deposition[3]	-	36.8	36.8	0%
	Existing Load	1,000	Load Capacity 322	
	Overall Reduction Needed	68%		

[1] Based on GWLF estimate, given lack of site-specific data
[2] Reduction of nutrient loads from septic systems will be implemented through reducing flow from failing septic tanks
[3] Derived from BATHTUB default data input, given lack of site-specific data

To account for uncertainty associated with insufficient or even unknown data, and the relationship between pollutant loads and beneficial use impairment, a margin of safety (MOS) is included in development of load analyses. There are several ways to implement a MOS. For Black Lake, conservative assumptions were utilized in the watershed loading model and the lake model.

Meeting the pollutant load allocations for TP discussed in this TMDL requires implementation of various policies, programs, and projects aimed at improving water quality in Black Lake. Like the TMDL, the goal of the implementation plan is to reduce nutrient loading to support beneficial uses. DEQ and the Coeur d'Alene Tribe recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or if substantial progress is not being made toward achieving those goals. Conversely, should monitoring show beneficial uses are being supported prior to attainment of TMDL targets, less restrictive load allocations will be considered.

1. Watershed Assessment – Watershed Characterization

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. (In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.)

This document addresses the water bodies in the Black Lake watershed that have been placed on Idaho's current §303(d) list.

The overall purpose of the watershed assessment and TMDL is to characterize and document pollutant loads within the Black Lake watershed. The first portion of this document is partitioned into four major sections: watershed characterization, water quality concerns and status, pollutant source inventory, and a summary of past and present pollution control efforts (Sections 1 – 4). This information is then used to develop a TMDL for total phosphorus (TP) for the Black Lake watershed (Section 5).

1.1 Introduction

In 1972, Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Water Environment Federation 1987, p. 9). The act and the programs it has generated have changed over the years, as experience and perceptions of water quality have changed.

The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to ensure "swimmable and fishable" conditions. This goal, along with a 1972 goal to restore and maintain chemical, physical, and biological integrity, relates water quality with more than just chemistry.

Background

The federal government, through the U.S. Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. The Department of Environmental Quality (DEQ) implements the CWA in Idaho and the Coeur d'Alene Tribe implements the CWA for tribal waters within the Coeur d'Alene Reservation. The EPA oversees Idaho and the Tribe and certifies the fulfillment of CWA requirements and responsibilities. For water bodies such as Black Lake, that are located in both Tribal and State jurisdiction, the Coeur d'Alene Tribe and DEQ collaborate to ensure consistency in the implementation of water quality management programs.

Section 303 of the CWA requires DEQ to adopt water quality standards and to review those standards every three years (EPA must approve Idaho's water quality standards). Additionally, DEQ must monitor waters to identify those not meeting water quality standards. For those waters not meeting standards, DEQ must establish a TMDL for each pollutant impairing the waters. Further, the agency must set appropriate controls to restore water quality and allow the water bodies to meet their designated uses.

These requirements result in a list of impaired waters, called the "§303(d) list." This list describes water bodies not meeting water quality standards. Waters identified on this list require further analysis. This report provides a summary of the water quality status and allowable TMDL for water bodies on the §303(d) list. *Black Lake Watershed Assessment and Total Maximum Daily Load* provides this summary for the currently listed waters in the Black Lake watershed.

Sections 1 through 4 include an evaluation and summary of the current water quality status, pollutant sources, and control actions in the Black Lake watershed to date. While this assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up to date and accurate. The TMDL is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (water quality planning and management, 40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

Some conditions that impair water quality do not receive TMDLs. The EPA does consider certain unnatural conditions, such as flow alteration, human-caused lack of flow, or habitat alteration, that are not the result of the discharge of a specific pollutants as "pollution." However, TMDLs are not required for water bodies impaired by pollution, but not by specific pollutants. A TMDL is only required when a pollutant can be identified and in some way quantified.

Idaho's Role

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The state may assign or designate beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho water quality standards and include the following:

- Aquatic life support-cold water, seasonal cold water, warm water, salmonid spawning, modified
- Contact recreation-primary (swimming), secondary (boating)
- Water supply-domestic, agricultural, industrial

- Wildlife habitats
- Aesthetics

The Idaho legislature designates uses for water bodies. Industrial water supply, wildlife habitats, and aesthetics are designated beneficial uses for all water bodies in the state. If a water body is unclassified, then cold water and primary contact recreation are used as additional default designated uses when water bodies are assessed. See Appendix A for a summary of the state and site-specific water quality standards and criteria applicable to Black Lake.

An SBA entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, and landscape data to address several objectives:

- Determine the degree of designated beneficial use support of the water body (i.e., attaining or not attaining water quality standards).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identity and location of pollutant sources.
- Determine the causes and extent of the impairment when water bodies are not attaining water quality standards.

The Role of the Coeur d'Alene Tribe

The Coeur d'Alene Tribe is responsible for developing and implementing water quality standards for all waters flowing within, onto or through Coeur d'Alene tribal lands. With 87 percent of the Black Lake watershed located within the Coeur d'Alene reservation, the Tribe played a lead role in the development of the water quality targets, evaluating TMDL calculations, and implementing management measures that restore water quality. The Coeur d'Alene Tribe has provided key technical support in the following areas essential to development of the *Black Lake Watershed Assessment and Total Maximum Daily Load:*

- The degree of designated beneficial use support of the water body (i.e., attaining or not attaining water quality standards).
- Descriptive information, water quality data, and flow data about Black Lake and its tributaries.
- Information on the causes and extent of the impairment.

Public Input and Meetings

In compliance with Idaho Code §39-3611(8), the development of the Black Lake Subbasin Assessment and TMDL included extensive public participation by the Black Lake Watershed Advisory Group (WAG). In July, 2009, the WAG was formed and the following is a summary of the public process:

<u>WAG Meetings</u>:

July 30, 2009: topics covered with Idaho Water Quality Standards, TMDLs, proposed WAG operating procedures, and history of water quality on Black Lake.

August 27, 2009: presentation of the Black Lake TMDL

November 5, 2009: WAG feedback on TMDL

February 18, 2010: DEQ response to WAG feedback

Public Comment Period for the Black Lake Subbasin Assessment and TMDL

On May 19, 2010, the Black Lake Subbasin Assessment and TMDL was posted on the DEQ website for public comment, and the comment period close June 17, 2010. Copies of the draft TMDL was also available at the DEQ Coeur d'Alene Regional Office. Public notice of the comment period was posted in local newspapers and on the DEQ webpage. The public comments received were individually address by DEQ and are provided in Appendix I.

Idaho DEQ has complied with the WAG consultation requirements set forth in Idaho Code §39-3611. DEQ has provided the WAG with all available information concerning applicable water quality standards, water quality data, monitoring, assessments, reports, procedures, and schedules. All presentation and drafts provided at WAG meetings were made available on the DEQ website devoted to the Black Lake WAG throughout the process.

DEQ utilized the knowledge, expertise, experience, and information of the WAG in developing this TMDL. DEQ also provided the WAG with an adequate opportunity to participate in drafting the TMDL and to suggest changes to the document. Final copies of the TMDL will be submitted to EPA Region 10 and made available to the general public and distributed to the WAG who are listed in Appendix H.

1.2 Physical and Biological Characteristics

Watershed characteristics relevant to pollutants impairing beneficial uses are assessed by describing physical and biological characteristics of the watershed, including a description of the climate, hydrology, and unique characteristics of the individual streams in the watershed. To evaluate the Black Lake watershed for sensitivity to activities that may impair beneficial uses of the water bodies, the geology, soil, vegetation, and assemblages of aquatic life are identified and described.

Black Lake (ID 17010303PN009L_0L) is located in the Idaho panhandle in southern Kootenai County. Black Lake, one of several lateral lakes along the Coeur d'Alene River, is approximately 5 miles west of Harrison, Idaho. Figure 1 shows the location of the Black Lake watershed as well as watersheds of the two adjacent grazing pastures that are not hydrologically connected to Black Lake. These pastures are historical wetlands, but for agricultural grazing purposes, they are drained and water is discharged into Black Lake. In this document, the pastures will be referred to as the East Pasture and the West Pasture. Black Lake lies at an elevation of approximately 2,150 feet and is a watershed of the Coeur d'Alene Lake and River SBA Unit (17010303).

Climate

Local climates are influenced by both Pacific maritime air masses from the west as well as continental air masses from Canada. Table 1 shows temperature, precipitation, and snowfall data for the period 1948 to 2006, recorded at the Saint Maries National Weather Service Station, which is south of the watershed and the closest station to Black Lake (see Figure 6). In winter, the average temperature is 32.8 degrees Fahrenheit (°F), and the average daily minimum is 24.2 °F. In summer, the average temperature is 76.4 °F, and the average daily maximum is 81.3 °F.

As shown in Table 1, the average monthly precipitation in the Black Lake watershed ranges from 1.0 inch in July to 4.3 inches in January. The average annual precipitation is about 30.5 inches. Of this total, 10.2 inches, or 33 percent, generally falls from April through September, which includes the growing season for most crops. The average total snowfall is 51.4 inches, with the highest monthly average in January (17.1 inches).

Table 1. Monthly Climate Summary for Saint Maries National Weather Station

Month	Average Temperature (°F)	Average Max. Temperature (°F)	Average Min. Temperature (°F)	Average Total Precipitation (in)	Average Total Snowfall (in)
January	30.3	34.7	22.5	4.3	17.1
February	36.6	41.7	25.7	3.1	8.2
March	43.6	49.3	29.1	2.7	4.2
April	52.8	58.7	34	2.3	0.4
May	62.3	67.6	40.5	2.4	0.1
June	70.0	75.1	46.5	2.1	0
July	80.3	84.5	49.7	1.0	0
August	79.1	84.3	48.6	1.2	0
September	69.3	74.5	41.9	1.3	0
October	54.3	59.5	34.8	2.3	0.3
November	38.4	42.9	29.4	3.9	5.7
December	31.6	35.3	24.3	4.1	16.4
Annual	54.0	59.0	35.6	30.5	52.4

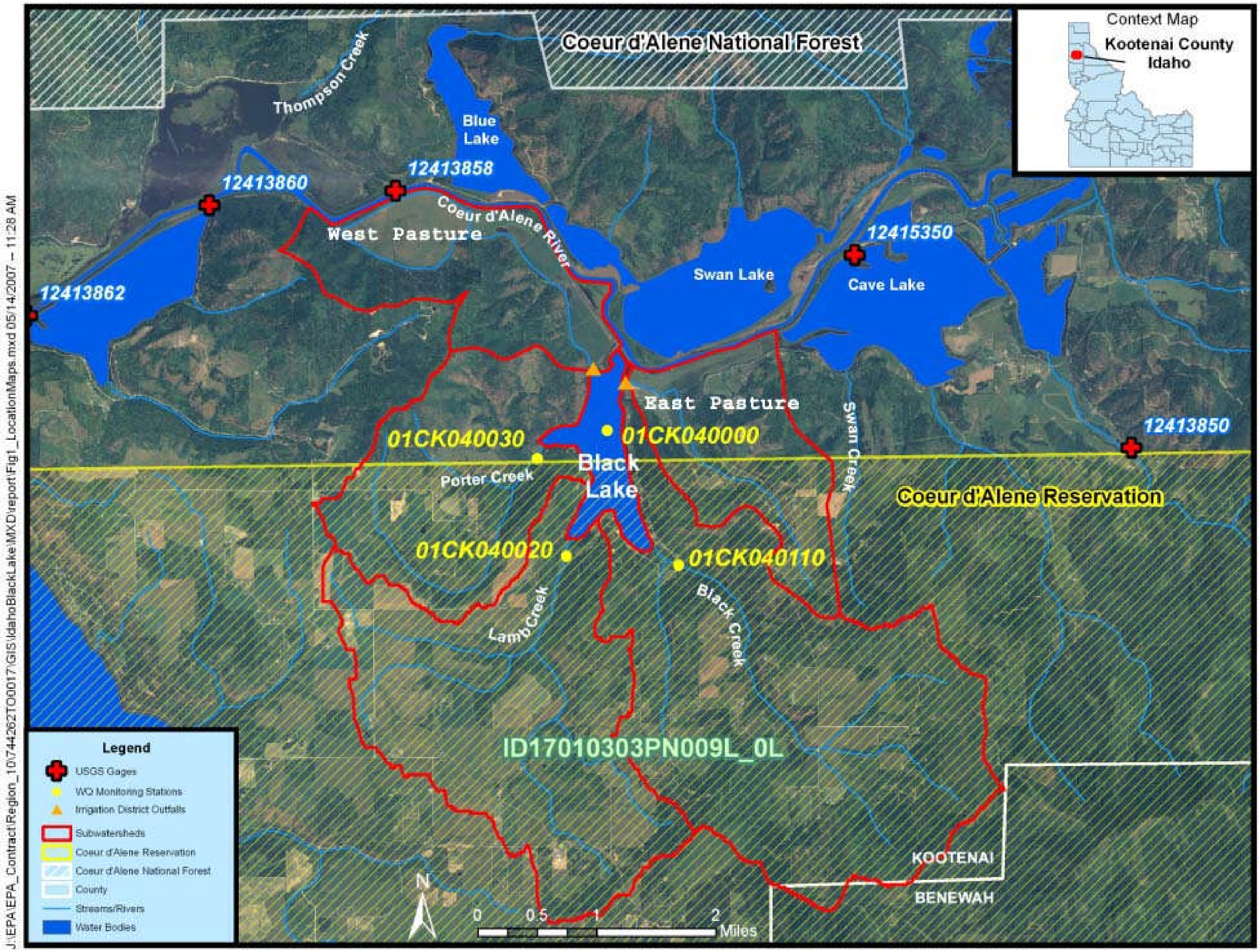


Figure 1. Black Lake Watershed

Watershed Characteristics

Hydrography. A summary of morphometric and limnologic characteristics of Black Lake is shown in Table 2. Water levels fluctuate as a function of levels in Coeur d'Alene River and Coeur d'Alene Lake downstream. Black Lake, located approximately 8 miles upstream of Coeur d'Alene Lake, has a surface area of 400 acres, a maximum depth of about 25 feet and a mean depth of 15 feet (IDHW 1985). Using the 2004 bathymetry data from the Coeur d'Alene Tribe the top elevation of the lake is 2,128 feet and the bottom or lowest point in the lake is 2,069 feet. Based on these elevations, the maximum depth is 59 feet and the average depth is 9 feet. Its hydraulic retention time has been calculated at 0.55 year (Kann and Falter 1987; Bos and Stockner 2005) due to its high watershed to surface area ratio (28:1). There is one outflow channel connecting Black Lake to the Coeur d'Alene River, with backflow into the Lake occurring seasonally at high flows typically in March and April (Kann and Falter 1985). Runoff patterns are influenced by the relative low elevation of the watershed resulting in snowmelt contributing earlier to maximum discharge (mid-March). The average flushing time for Black Lake is 10.5 months and the surface level fluctuates 1.5 to 2.0 m annually (Kann and Falter 1985). Given Black Lake's low mean depth 4.5 m, wind can create sufficient wave action to break up the seasonal stratification that occurs in the lake.

Table 2. Characteristics of Black Lake

Characteristic	Value[a]
MORPHOMETRY	
Elevation	647.1 m
Area of Watershed or Drainage	16.06 miles^2 (10,282 acres)
Surface Area	140 hectares (347 acres)
Average Depth	4.3 m (14.1 feet)
Greatest Depth	7.3 m (23.95 feet)
Flushing Rate	1.4 years
Lake volume	5,280 acre feet
Hydraulic Residence Time	0.55 year

[a] Values derived from 1987 Kann and Falter Report

Soil. Figure 2 displays the Black Lake watershed soil survey data from the State Soil Geographic Database. The different soil series include:

- Blinn-Lacy Santa;
- Lumberjack Variant-AHRS-Bouldercreek;
- McCrosket-Huckleberry-Ardenvoir;
- Santa-Santa-Variant-Cald; and
- Slickens-Pywell-Udarents.

The dominant soil type throughout the watershed is the Santa-Santa-Variant-Cald series. Characteristics of this erosive soil series include a silt loam surface layer, a silt subsurface layer and a silt loam and silty clay loam subsoil (NRCS SCS 1981). Some additional notable characteristics of this soil series include:

- a perched water table and very slow permeability, which impedes septic tank absorption capability; and
- good hay, pasture, small grain crops dependent on applications of commercial fertilizer (NRCS SCS 1981).

The McCrosket-Huckleberry-Ardenvoir series surrounds Black Lake. Characteristics of this soil series include silty or gravelly loam surface layer and very gravelly silt loam subsoil. Steep slopes and poor suitability for septic tank absorption are also typical characteristics of this soil series (NRCS SCS 1981).

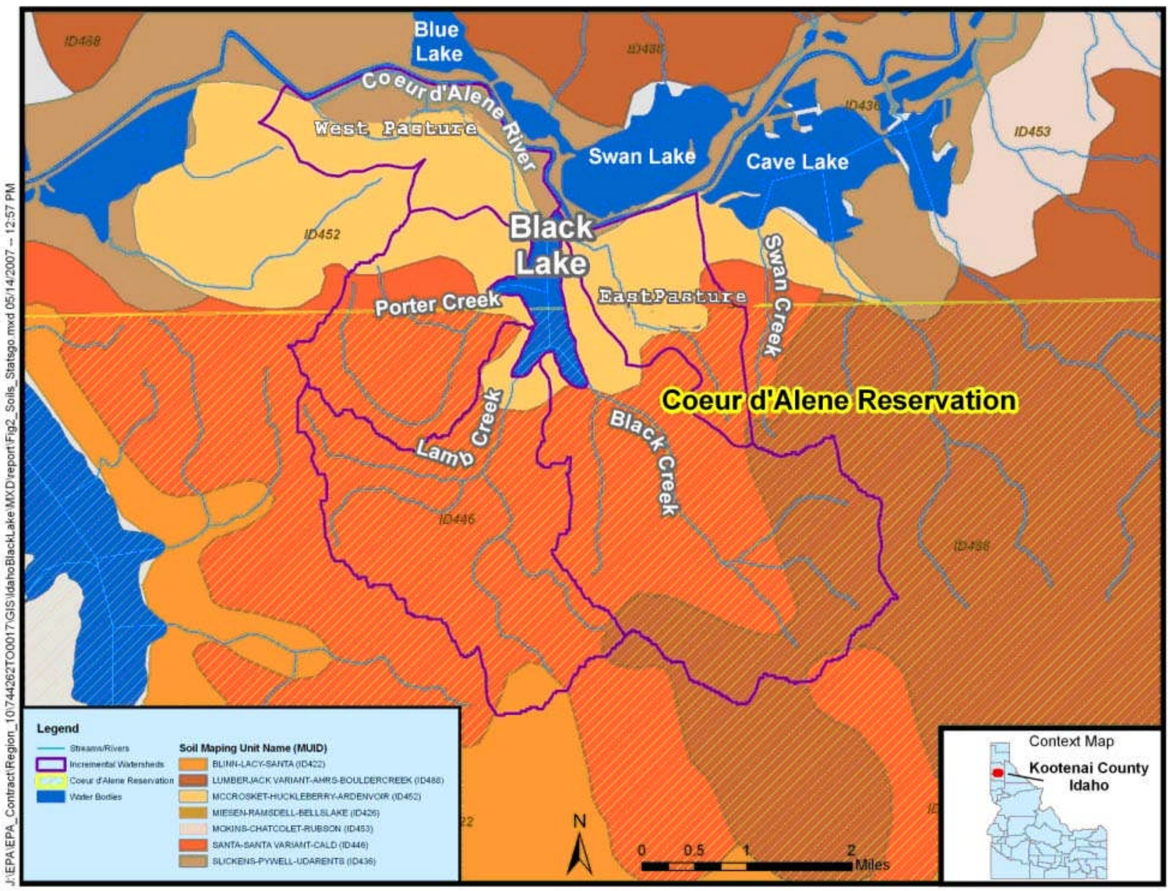


Figure 2. Black Lake Watershed Soil Types

Vegetation. Historically the Black Lake watershed has been dominated by forest cover. Approximately 55 percent of the watershed is currently classified as forest (evergreen, mixed, and deciduous shrubland) (USGS 2006). Lumbering and the processing of wood products are still important activities in and around the Black Lake watershed. Natural vegetation is mainly Douglas fir (*Psuedotsuga menziessii*), ponderosa pine (*Pinus* *ponderosa*), lodgepole pine (*Pinus contorta*), and western larch (*Larix occidentalis*), with an understory of myrtle pachystima, oneleaf foamflower (*Tiarella trifoliata var. unifoliata*), longtube twinflower (*Linnaea borealis var. longiflora*) , darkwoods violet (*Viola orbiculata*), and wild ginger (*Asarum*). Ground cover is predominantly pinegrass (USDA 2002). The forest land and water resources support a diverse wildlife population that frequent the watershed, including elk, deer, bear, grouse, pheasant, duck, geese, and a variety of small mammals.

<u>Fisheries and Aquatic Fauna</u> Black Lake, located in the Spokane River basin, and part of the Coeur d'Alene River chain of lakes, supports a year-round consumptive fishery. Black Lake is recognized as a key watershed for bull trout and is designated as critical habitat (Idaho Governor's Office 1996). The bull trout is listed as a threatened species by the U.S. Fish and Wildlife Services (Idaho Fish and Game 2007). The various species identified in Black Lake include brown bullhead (*Ameiurus nebulosus*), channel catfish (*Ictalarus punctatus*), black bullhead (*Ameiurus melas*), pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus smoides*), yellow perch (*Perca flavescens*), black crappie (*Pomoxis nigomaculatus*), and bluegill (*lepomis macrochirus*) ((Idaho Fish and Game 2006). Other native game fish in the Spokane River basin include the westslope cutthroat trout (*Oncorhynchus clarki*), bull trout (*Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*) (Idaho Fish and Game 2006). Other introduced game species in the Spokane River basin include rainbow trout (*Oncorhynchus mykiss*), kokanee salmon (*Oncorhynchus nerka)*, brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta)*, splake (*Salvelinus namaycush* X *Salvelinus fontinalis*, Chinook salmon (*Oncorhynchus tshawytscha),* and northern pike (*Esox lucius*) (Idaho Fish and Game 2006). The cumulative impact of habitat degradation, declining water quality, and shoreline development are having a deletrious effect on the fishery population of Black Lake complicating the success of fishery management options (Idaho Fish and Game 2006).

Subwatershed Characteristics

The three primary tributaries draining to Black Lake include Porter Creek, Lamb Creek, and Black Creek. Lamb and Black Creek are considered perennial streams, and Porter Creek is considered intermittent. The subwatersheds for each of these tributaries are shown in Figure 1. There are no gage stations within the Black Lake watershed and as a result, insufficient flow data are available to display a historical hydrograph of the three Black Lake tributaries. The limited flow data collected from the three Black Lake tributaries by the Coeur d'Alene Tribe between June 2005 and April 2006 are summarized in Appendix B.

Two other adjacent subwatersheds shown in Figure 1, the East Pasture and the West Pasture, are cattle and horse grazing areas that are historical wetlands that are drained, and the water is pumped on a seasonal basis directly into Black Lake using two separate pipes. As previously stated, these pastures are not naturally hydrologically connected to Black Lake. The effluent from these two subwatersheds discharges into Black Lake and is typically generated by spring flood water that has collected on the floodplain pastures during spring runoff season (Kann and Falter 1985). Although this is a direct discharge through a pipe into Black Lake, this discharge is exempt under the EPA NPDES program. The flow from each Pasture pipe is unknown. Table 3 compares various attributes of each subwatershed. The riparian corridor of each creek typically moves from agricultural land in the headwaters through forested areas toward Black Lake.

Table 3. Subwatershed Attributes

Subwatershed	Mean Elevation (meters)	Dominant Slope	Total Acres	Percent of Black Lake Watershed Total Acres
Porter Creek	827	0-10 32% 10-35 39% >35 29%	2,053	20
Lamb Creek	825	0-10 53% 10-35 35% >35 12%	3,499	34
Black Creek	853	0-10 30% 10-35 49% >35 21%	4,702	46
West Pasture	741		1,538	
East Pasture	754		1,353	

1.3 Cultural Characteristics

This section provides a brief summary of various cultural and anthropogenic influences within and around the Black Lake watershed.

Land Use

The Black Lake watershed (ID 17010303PN009L_0L) is approximately 10,282 acres. Figure 3 displays the land use categories for the three Black Lake subwatersheds and the two pasture watersheds that discharge into Black Lake. Data are derived from the 1992 National Land Cover Dataset from the Multi-Resolution Land-cover Characteristics Project (USGS 2006). Table 4 summarizes the acreage and the percent of total of each land use category for each subwatershed. The land use/land cover categories are also displayed in Figure 4 to facilitate comparisons. The land use/land cover in each subwatershed is primarily forested or used for agriculture (pasture and crops). Forest, composed of deciduous, evergreen, and mixed forest, accounts for 55 percent of the Black Lake watershed and is the dominant land use in the Black Creek and Lamb Creek subwatersheds. Small grain cropland plus pasture and hay cover account for 37 percent of the Black Lake watershed. Only 1 percent of the Black Lake watershed is classified as developed (High or Low Intensity Commercial or Residential), and only a minimal number of rural roadways traverse the watershed. The East Pasture is 38 percent small grain, grassland, and pasture and hay cover, and approximately 56 percent of the subwatershed is forested. The West Pasture is 39 percent small grain, grassland, and pasture and hay cover and 55 percent forested.

Land Ownership, Cultural Features, and Population

The entire Black Lake watershed falls within Kootenai County, Idaho. Approximately two-thirds of the Black Lake watershed is located within the Coeur d'Alene Reservation, including the two southern arms of Black Lake. The remaining (northern) portion of the Black Lake watershed is in Kootenai County. The entire West Pasture is located in Kootenai

County, and the southern half of the East Pasture is located in the Coeur d'Alene Reservation (See Figure 1). The Coeur d'Alene Reservation boundary cuts across Black Lake, and necessitates a collaborative approach to the stewardship of water quality by the Tribe, DEQ and local land owners. There are no municipalities located within the watershed or on the periphery. Most of the land in the watershed is privately owned.

The Coeur d'Alene Tribe (Schitsu´umsh Tribe) has a current enrollment of over 1,900 tribal members. The tribe's name comes from French fur traders who called them "heart of an awl" in recognition of their sharp trading skills (Schitsu´umsh Tribe 2006). The 2005 population estimate of Kootenai County is 127,668; the land area of the County is 1,245 square miles, and there are 52,411 housing units (U.S. Census Bureau 2006). In comparison, the land area of the Black Lake watershed is 16.06 square miles and there are only 233 households within the watershed. There are approximately 40 year-round and summer residences scattered around the lake shore, and households are sparsely scattered throughout the watershed (Kann and Falter 1985). Based on the 2000 population census, Kootenia County experienced an estimated population growth of 17.5 percent between 2000 and 2005 (U.S. Census Bureau 2006).

History and Economics

Agricultural activities such as horse/cattle ranching, wheat farming, and timber activities occur in the Black Lake watershed. Black Lake itself sustains extensive recreational use by fisherman and water skiers during the summer months (Kann and Falter 1985). There are no major industrial activities occurring in the watershed. The lakeshore landowners around Black Lake have established an informal committee interested in addressing the declining water quality of Black Lake.

Figure 3. Black Lake Watershed Land Use

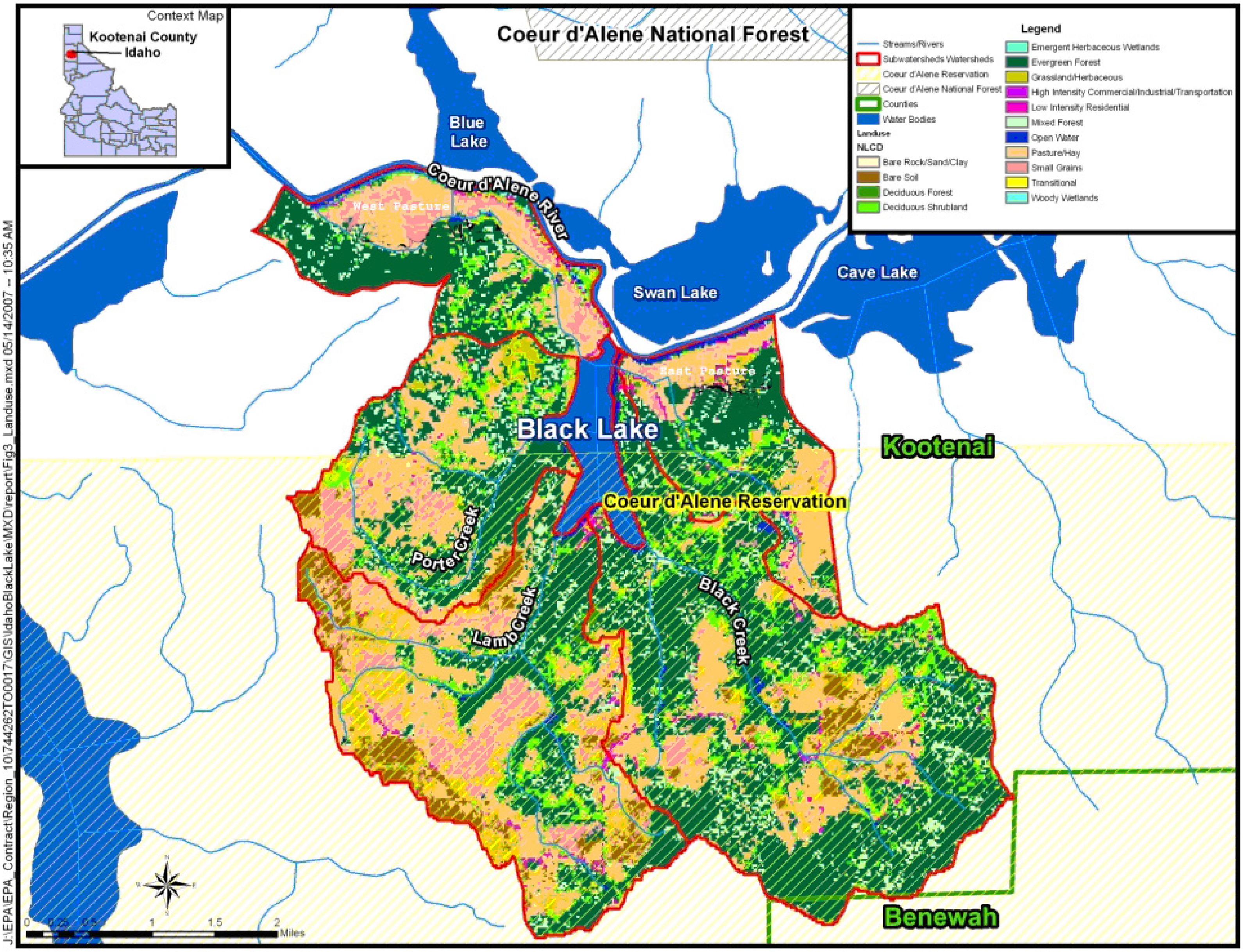


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Table 4. Summary of Black Lake Watershed Land Use/Land Cover

Name	Landuse Category	Sum of Acreage	Percentage of Watershed
Porter Creek	Bare Soil	59.10	2.88
	Deciduous Forest	9.27	0.45
	Deciduous Shrubland	159.19	7.75
	Emergent Herbaceous Wetlands	0.02	0.00
	Evergreen Forest	752.64	36.66
	Grassland/Herbaceous	148.91	7.25
	High Intensity Commercial/Industrial/Transportation	2.08	0.10
	Low Intensity Residential	4.56	0.22
	Mixed Forest	142.45	6.94
	Open Water	9.43	0.46
	Pasture/Hay	585.33	28.51
	Small Grains	180.04	8.77
Porter Creek Total		**2,053.01**	**100.00**
Lamb Creek	Bare Rock/Sand/Clay	0.64	0.02
	Bare Soil	380.80	10.88
	Deciduous Forest	10.64	0.30
	Deciduous Shrubland	182.38	5.21
	Emergent Herbaceous Wetlands	0.32	0.01
	Evergreen Forest	910.31	26.02
	Grassland/Herbaceous	432.08	12.35
	High Intensity Commercial/Industrial/Transportation	39.33	1.12
	Low Intensity Residential	12.82	0.37
	Mixed Forest	137.53	3.93
	Open Water	17.64	0.50
	Pasture/Hay	862.62	24.66
	Small Grains	511.57	14.62
Lamb Creek Total		**3,498.68**	**100.00**
Black Creek	Bare Rock/Sand/Clay	0.32	0.01
	Bare Soil	160.12	3.38
	Deciduous Forest	11.01	0.23
	Deciduous Shrubland	386.22	8.16
	Emergent Herbaceous Wetlands	0.78	0.02
	Evergreen Forest	2,526.73	53.41
	Grassland/Herbaceous	249.83	5.28
	High Intensity Commercial/Industrial/Transportation	35.73	0.76
	Low Intensity Residential	27.97	0.59
	Mixed Forest	416.52	8.81
	Open Water	58.44	1.24
	Pasture/Hay	722.76	15.28
	Small Grains	132.83	2.81
	Transitional	0.73	0.02
	Woody Wetlands	0.48	0.01
Black Creek Total		**4,730.46**	**100.00**
Subtotal (Porter Creek, Lamb Creek, Black Creek)		**10,282.15**	
East Pasture	Bare Soil	4.67	0.35
	Deciduous Forest	8.24	0.61
	Deciduous Shrubland	75.82	5.60
	Emergent Herbaceous Wetlands	0.64	0.05
	Evergreen Forest	583.25	43.12
	Grassland/Herbaceous	76.51	5.66
	High Intensity Commercial/Industrial/Transportation	20.13	1.49
	Low Intensity Residential	26.75	1.98
	Mixed Forest	90.14	6.66
	Open Water	33.06	2.44
	Pasture/Hay	380.09	28.10
	Small Grains	51.74	3.82
	Woody Wetlands	1.74	0.13
East Pasture Total		**1,352.77**	**100.00**
West Pasture	Bare Rock/Sand/Clay	0.16	0.01
	Bare Soil	2.72	0.18
	Deciduous Forest	3.99	0.26
	Deciduous Shrubland	119.20	7.75
	Emergent Herbaceous Wetlands	1.70	0.11
	Evergreen Forest	625.74	40.69
	Grassland/Herbaceous	59.55	3.87
	High Intensity Commercial/Industrial/Transportation	7.17	0.47
	Low Intensity Residential	17.66	1.15
	Mixed Forest	96.02	6.24
	Open Water	51.77	3.37
	Pasture/Hay	406.84	26.46
	Small Grains	133.52	8.68
	Transitional	1.12	0.07
	Woody Wetlands	10.51	0.68
West Pasture Total		**1,537.67**	**100.00**
Subtotal East and West Pastures		**2,890.43**	
Grand Total		**13,519.91**	

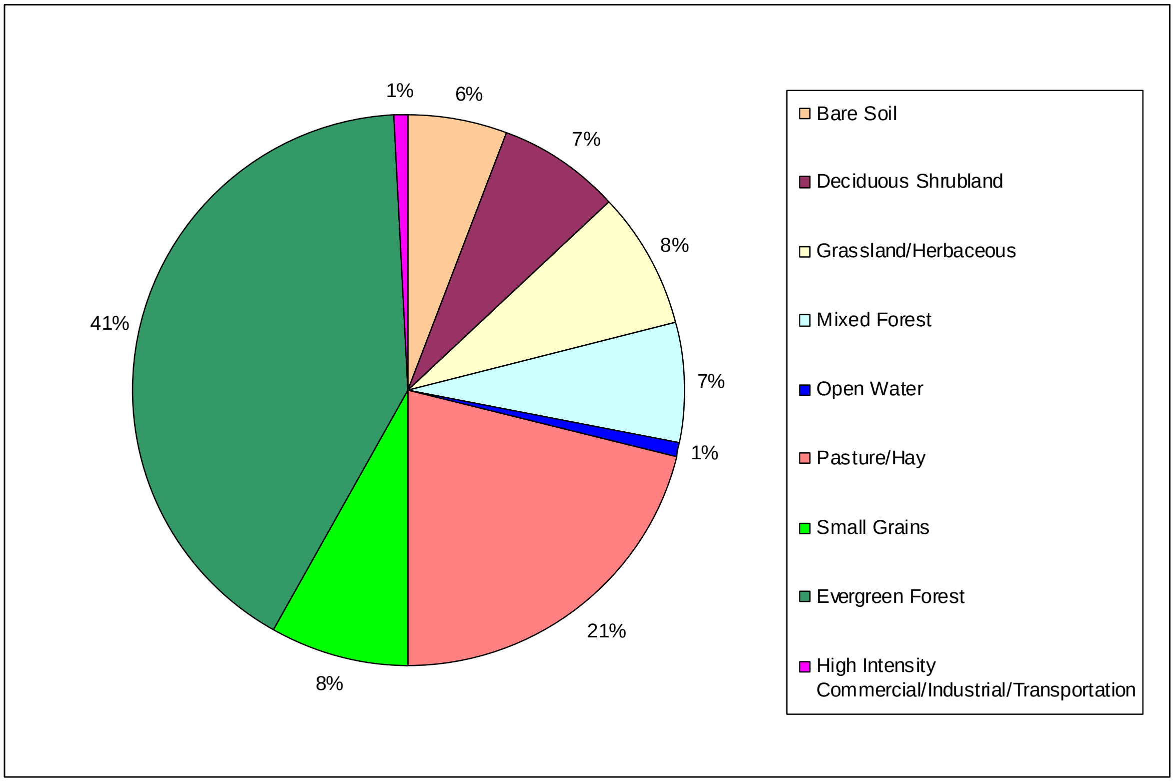


Figure 4. Black Lake Watershed Percent Land Use/Land Cover

2. Watershed Assessment – Water Quality Concerns and Status

Black Lake is a shallow, eutrophic lake with a history of water quality problems. Water quality monitoring data collected by DEQ and the Coeur d'Alene Tribe over the past 20 years consistently demonstrate water quality concerns for nutrients in Black Lake, which is identified in the Integrated Report on the list of impaired lakes. Reported algal blooms and the continuing eutrophication of Black Lake have placed the water body on the DEQ 303(d) List requiring the development of a TMDL to restore the beneficial use of cold water aquatic life.

2.1 Water Quality Limited Assessment Units Occurring in the Watershed

Black Lake, located in the Panhandle Basin, was placed on the DEQ 1998 §303(d) list for excessive nutrients. Figure 1 displays the Black Lake assessment unit and its subwatersheds.

Section 303(d) of the CWA states that waters that are unable to support their beneficial uses and that do not meet water quality standards must be listed as water quality limited waters. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

Listed Waters

Table 5 shows the pollutant and the basis for listing the Black Lake assessment unit (ID 17010303PN009L_0L) on the 1998 §303(d) list. An investigation, using recently collected data, was performed to substantiate this conclusion. The data summary of this investigation is contained in the following sections.

Table 5. §303(d) Segments in the Black Lake Watershed

Water Body Name	Assessment Unit ID Number	1998 §303(d) Boundaries	Pollutants	Listing Basis
Black Lake	ID17010303PN009_0L	Entire lake	Nutrients	Algal blooms, eutrophication

2.2 Applicable Water Quality Standards

State water quality standards are established as the "yardstick" for the fishable and swimmable goal of the CWA. Water quality standards contain three key components: designated uses, water quality criteria (numeric and narrative), and an antidegradation policy. These components as defined by the Idaho Administrative Procedures Act 58 Title 01, Chapter 02 are summarized below.

Beneficial Uses

Idaho water quality standards require that surface waters of the state be protected for beneficial uses, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described in the following paragraphs. The *Water Body Assessment Guidance*, second edition (Grafe et al. 2002) gives a more detailed description of beneficial use identification for use assessment purposes.

Existing Uses

Existing uses under the CWA are "those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards." The existing in-stream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.050.02, .02.051.01, and .02.053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. A practical application of this concept would be to apply the existing use of salmonid spawning to a water that could support salmonid spawning, but salmonid spawning is not occurring due to other factors, such as dams blocking migration.

Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing uses).

Presumed Uses

In Idaho, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. These undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric cold water criteria and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., intergravel dissolved oxygen [DO], temperature). However, if for example, cold water aquatic life is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01). The beneficial uses set for Black Lake are identified in Table 6.

Table 6. Black Lake Beneficial Uses

Water Body	Uses	Type of Use
Black Lake (ID17010303PN009_0L)	CWAL, PCR	Presumed Uses

[a] CWAL – cold water aquatic life, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, AWS – agricultural water supply, DWS – domestic water supply

Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as bacteria, DO, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250).

Narrative criteria for excess nutrients are described in IDAPA 58.01.02.200.06, which states: "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses." Narrative criteria for floating, suspended, or submerged matter are described in IDAPA 58.01.02.200.05, which states: "Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities."

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the Water Body Assessment Guidance (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations. Figure 5 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

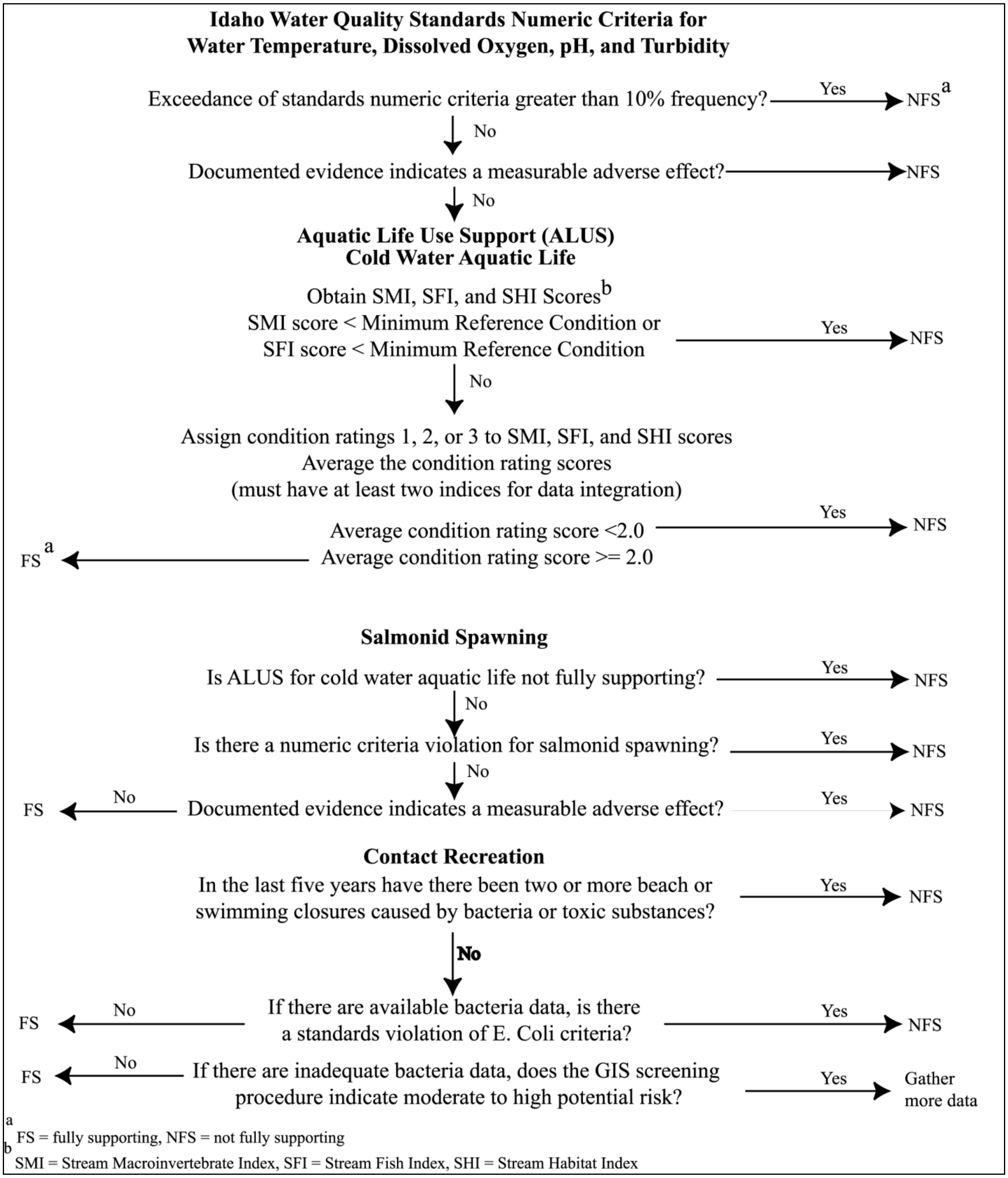


Figure 5. Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: *Water Body Assessment Guidance,* Second Edition (Grafe *et al*. 2002)

Numeric nutrient criteria do not exist in the Idaho water quality standards for Black Lake. The listing of Black Lake as water quality-limited on the 303(d) list is based on the narrative criteria and documented evidence of a measurable adverse effect on water quality. The documented evidence is a number of reported toxic blooms of colonial blue-green algae in the 1980s and recent water quality sampling indicating high levels of TP in both Lake and tributary samples.

States and tribes may each have their own federally-approved water quality standards for Clean Water Act programs, such as for TMDLs to develop pollution reduction targets. Federally-approved state water quality standards apply on state waters, but do not on tribal waters. Although tribes can develop federally-approved water quality standards for Clean Water Act programs, the Coeur d'Alene Tribe has not obtained approval for water quality standards in Black Lake thus far. In the absence of federally approved tribal water quality standards, EPA has a tribal trust responsibility to work with tribes in a government-to-government relationship and issue federal actions, such as TMDLs on their behalf. The Coeur d'Alene Tribe has adopted tribal water quality standards for the waters within its Reservation; however, EPA has not yet approved Coeur d'Alene Tribal nutrient water quality standards covering Black Lake. Both the tribal and state water quality standards contain similar narrative criteria for the protection of waters from excess nutrients.

Therefore, this TMDL has been jointly developed by Coeur d'Alene Tribe, EPA and Department of Environmental Quality. For this TMDL, the Coeur d'Alene Tribe has agreed to apply Idaho's water quality standards as the basis for establishing an appropriate water quality target for nutrients in Black Lake. Therefore the state of Idaho's cold water aquatic life beneficial use and narrative criteria for nutrients were used as the basis for establishing a TMDL for Black Lake. As a result, the Coeur d'Alene Tribe, Region 10, and DEQ have agreed that the interpretation of the narrative criteria used in the TMDL will meet and protect the criteria and the designated uses of both the Coeur d'Alene Tribe and the state of Idaho for Black Lake.

While the DEQ reliance on biological assessment incorporates a weight-of-evidence approach, it does not provide a numeric water column value with which to establish the pollutant load capacity of a water body. This requires a case by case evaluation to establish a site specific numeric target, greatly complicating TMDL development unless 'other appropriate measures' are used in place of a traditional load (IDEQ 1999). As a result, a critical component of this TMDL is the establishment of a site-specific water quality target for TP which will function as a numeric translator for the narrative water quality standard - "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses." The following section provides pertinent background associated with establishing water quality targets for a select group of pollutants that can influence nutrient levels in Black Lake. The specific rationale for establishing a water quality target for the Black Lake TP TMDL is summarized in Section 5.1. If EPA promulgates federal standards or approves water quality standards on nutrients that cover Black Lake for the Coeur d'Alene Tribe under the Clean Water Act, this agreement may be revisited.

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in streams and lakes are naturally occurring characteristics and processes that have been altered by humans. That is, water bodies naturally have sediment, nutrients, and the like, but when anthropogenic sources cause these to reach unnatural levels, they are considered “pollutants” and can impair the beneficial uses of streams or lakes.

Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to stream or lake purification. Dissolved oxygen is the concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. While air contains approximately 20.9% oxygen gas by volume, the proportion of oxygen dissolved in water is about 35%, because nitrogen (the remainder) is less soluble in water. Oxygen is considered to be moderately soluble in water. A complex set of physical conditions that include atmospheric and hydrostatic pressure, turbulence, temperature, and salinity affect the solubility.

Dissolved oxygen levels of 6 mg/L and above are considered optimal for aquatic life. When DO levels fall below 6 mg/L, organisms are stressed, and if levels fall below 3 mg/L for a prolonged period, these organisms may die; oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Dissolved oxygen levels below 1 mg/L are often referred to as hypoxic; anoxic conditions refer to those situations where there is no measurable DO.

Juvenile aquatic organisms are particularly susceptible to the effects of low DO due to their high metabolism and low mobility (they are unable to seek more oxygenated water). In addition, oxygen is necessary to help decompose organic matter in the water and bottom sediments. Dissolved oxygen reflects the health or the balance of the aquatic ecosystem.

Oxygen is produced during photosynthesis and consumed during plant and animal respiration and decomposition. Oxygen enters water from photosynthesis and from the atmosphere. Where water is more turbulent (e.g., riffles, cascades), the oxygen exchange is greater due to the greater surface area of water coming into contact with air. The process of oxygen entering the water is called aeration.

Water bodies with significant aquatic plant communities can have significant DO fluctuations throughout the day. An oxygen sag will typically occur once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. Nutrient enriched waters have a higher biochemical oxygen demand due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand can result in lower lake DO levels.

Sediment

Both suspended (floating in the water column) and lake bed sediment can have negative effects on aquatic life communities. Many fish species can tolerate elevated suspended sediment levels for short periods of time, such as during natural spring runoff, but longer durations of exposure are detrimental. Elevated suspended sediment levels can interfere with feeding behavior (difficulty finding food due to visual impairment), damage gills, reduce growth rates, and in extreme cases eventually lead to death.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on streams and estuaries. For rainbow trout, physiological stress, which includes reduced feeding rate, is evident at suspended sediment concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species, although the data sets are less reliable. Adverse effects on habitat, especially spawning and rearing habitat presumably from sediment deposition, were noted at similar concentrations of suspended sediment. Organic suspended materials can also settle to the bottom and, due to their high carbon content, diminish DO through decomposition.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. Excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system.

The first step in identifying a water body’s response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass. Either phosphorus or nitrogen may be the limiting factor for algal growth, although phosphorous is most commonly the limiting nutrient in Idaho waters. Ecologically speaking, a resource is considered limiting if the addition of that resource increases growth.

Total phosphorus (TP) is the measurement of all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90% of the TP present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than TP that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the TP fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

Nitrogen may be a limiting factor at certain times if there is substantial depletion of nitrogen in sediments due to uptake by rooted macrophyte beds. In systems dominated by blue-green algae, nitrogen is not a limiting nutrient due to the algal ability to fix nitrogen at the water/air interface.

Total nitrogen to TP ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited system. Only biologically available forms of the nutrients are used in the ratios because these are the forms that are used by the immediate aquatic community.

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in either the sediments or the water column, aquatic plants will store an abundance of such nutrients in excess of the plants' actual needs, a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays in the water column and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the river sediment. As a result of this process, nutrients (including orthophosphate) that are initially released into the water column in a dissolved form will eventually become incorporated into the river bottom sediment. Once these nutrients are incorporated into the river sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. This cycle is known as nutrient spiraling. Nutrient spiraling results in the availability of nutrients for later plant growth in higher concentrations downstream.

Sediment – Nutrient Relationship

The linkage between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems. Phosphorus is typically bound to particulate matter in aquatic systems and, thus, sediment can be a major source of phosphorus to rooted macrophytes and the water column. While most aquatic plants are able to absorb nutrients over the entire plant surface due to a thin cuticle (Denny 1980), bottom sediments serve as the primary nutrient source for most sub-stratum attached macrophytes. The USDA (1999) determined that other than harvesting and chemical treatment, the best and most efficient method of controlling growth is by reducing surface erosion and sedimentation.

Sediment acts as a nutrient sink under aerobic conditions. However, when conditions become anoxic, sediments release phosphorous into the water column. Nitrogen can also be released, but the mechanism by which it happens is different. The exchange of nitrogen between sediment and the water column is for the most part a microbial process controlled by the amount of oxygen in the sediment. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced. This results in a loss of nitrogen oxide (NO_x) to the atmosphere.

Sediments can play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters and large rivers. In many cases there is an immediate response in phytoplankton biomass when external sources are reduced. In other cases, the response time is slower, often taking years. Nonetheless, the relationship is important and must be addressed in waters where phytoplankton is in excess.

Floating, Suspended, or Submerged Matter (Nuisance Algae)

Algae are an important part of the aquatic food chain. However, when elevated levels of algae impact beneficial uses, the algae are considered a nuisance aquatic growth. The excess growth of phytoplankton, periphyton, and/or macrophytes can adversely affect both aquatic life and recreational water uses. Algal blooms occur where adequate nutrients (nitrogen and/or phosphorus) are available to support growth. In addition to nutrient availability, flow rates, velocities, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. Low velocity conditions allow algal concentrations to increase because physical removal by scouring and abrasion does not readily occur. Increases in temperature and sunlight penetration also result in increased algal growth. When the aforementioned conditions are appropriate and nutrient concentrations exceed the quantities needed to support normal algal growth, excessive blooms may develop.

Commonly, algae blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, blue-green algae often produce toxins that can result in skin irritation to swimmers and illness or even death in organisms ingesting the water. The toxic effect of blue-green algae is worse when an abundance of organisms die and accumulate in a central area.

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water and can produce intense coloration of both the water and shorelines as cells accumulate along the banks. In extreme cases, algal blooms can also result in impairment of agricultural water supplies due to toxicity. Water bodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. The extent of the effect is dependent on both the type(s) of algae present and the size, extent, and timing of the bloom.

When algae die in low flow velocity areas, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, a large algal bloom can substantially deplete DO concentrations near the bottom. Low DO in these areas can lead to decreased fish habitat as fish will not frequent areas with low DO. Both living and dead (decomposing) algae can also affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low DO levels caused by decomposing organic matter can lead to changes in water chemistry and a release of sorbed phosphorus to the water column at the water/sediment interface.

Excess nutrient loading can be a water quality problem due to the direct relationship of high TP concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on DO and pH within aquatic systems. Therefore, the reduction of TP inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae, which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in nutrients (phosphorus), nuisance algae, DO, and pH.

2.4 Summary and Analysis of Existing Water Quality Data

Limited recent data are available to support development of the TP TMDL for Black Lake. With no long term monitoring sites in Black Lake and no BURP sites on the tributaries, data used to support this report are derived from a series historical reports and recent targeted water quality monitoring conducted by the Coeur d'Alene Tribe between 2002 and 2006. It should be noted, that the time period from 2003 to 2005 were below normal water years based on USGS flow statistics on the Coeur d'Alene River at Cataldo.

A brief historical summary of water quality concerns, toxic algal blooms were recorded in Black Lake in 1972, 1981, 1982, 1983, and 1985 (Kann and Falter 1987). Water samples collected by the USGS in 1991 and the Idaho DEQ in 1997 suggest that levels of P and N in the Lake were quite high in the past and that external loading from activities in the watershed and internal loading from lake sediments may be two major sources of mobilizing soluble reactive phosphorus in the Lake (Bos and Stockner 2005). In addition, a paleolimnology analysis using a sediment core was completed in 2005 and substantiates that Black Lake is quite different in ecological function, i.e., pelagic food-chain driven, from the lake that existed pre-European settlement (Bos and Stockner 2005).

Flow Characteristics

Black Lake Tributaries

There are no flow gages located in any of the tributaries to Black Lake. The only available data are limited to instantaneous flow measurements at the mouth of the tributaries conducted by the Coeur D'Alene Tribe between June 2005 and April 2006 (see Appendix B). During this sampling period, flow was measurable only during the months of January through April. Black Creek exhibited the highest flow rates, which ranged from 1.5 to 4 cubic feet per second (cfs), with an average of 2.5 cfs. Flows at Lamb Creek were between 0.5 and 2 cfs with an average of 1.25 cfs, while Porter Creek flow rates (the lowest of the three tributaries) ranged from 0.15 to 0.75 cfs, with and average of 0.42 cfs.

Given the absence of gage data, annual hydrographs for the three tributaries were derived from the *Generalized Watershed Loading Function* (GWLF) model output. GWLF provides monthly total flows calculated using precipitation, evaporation, and land use data in conjunction with the Soil Conservation Service Number Equation (USDA 1986). GWLF results for a 6-year period (2000-2005) were averaged to obtain the hydrographs depicted in Figure 6. It is noted that Water Years 2001 and 2003-2005 were below average water years.

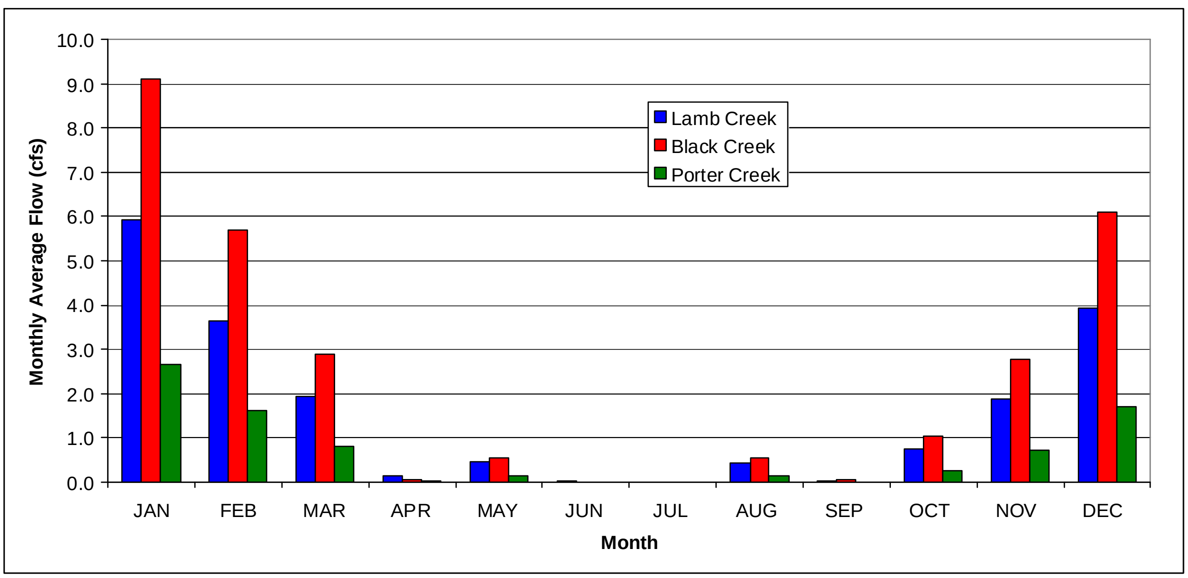


Figure 6. Six-year Average Annual Hydrographs for Black Lake Tributaries

As can be seen in Figure 6, the three tributaries exhibited very little to no flow during the period April to September. This is in agreement with the fact that for the sampling events conducted in June-August of 2004 and 2005, the sampling crews observed no measurable flow in the streams (see Appendix B). It is noted that this period of record was a period of drought years. The hydrographs also indicate that the highest flows occur in the December to

January period, with Black Creek showing the highest flows. Average base and extreme peak flows could not be calculated since GWLF only provides data on a monthly and annual basis.

Coeur d'Alene River

Depending on the water surface elevation of the Coeur d'Alene River, the river can discharge into Black Lake, thus, becoming a source of flow and TP loading. Limited data pertaining to the flow and stage volume of the Coeur d'Alene River immediately upstream and downstream of the Black Lake outfall are available. To estimate the seasonal inflow from the Coeur d'Alene River into Black Lake, mass balance and regression calculations were prepared using data from USGS gage 12413860 (Coeur d'Alene River near Harrison, Idaho) downstream and an upstream USGS gage at Cataldo (12413500). The method utilized to estimate monthly inflows from Coeur d'Alene River into Black Lake between 2000 and 2005 is summarized in Appendix C. Based on that method, the Coeur d'Alene River contributes between 46 and 85 percent of the annual flow into Black Lake. It is noted that Water Years 2001 and 2003-2005 were below average water years.

Water Column Data

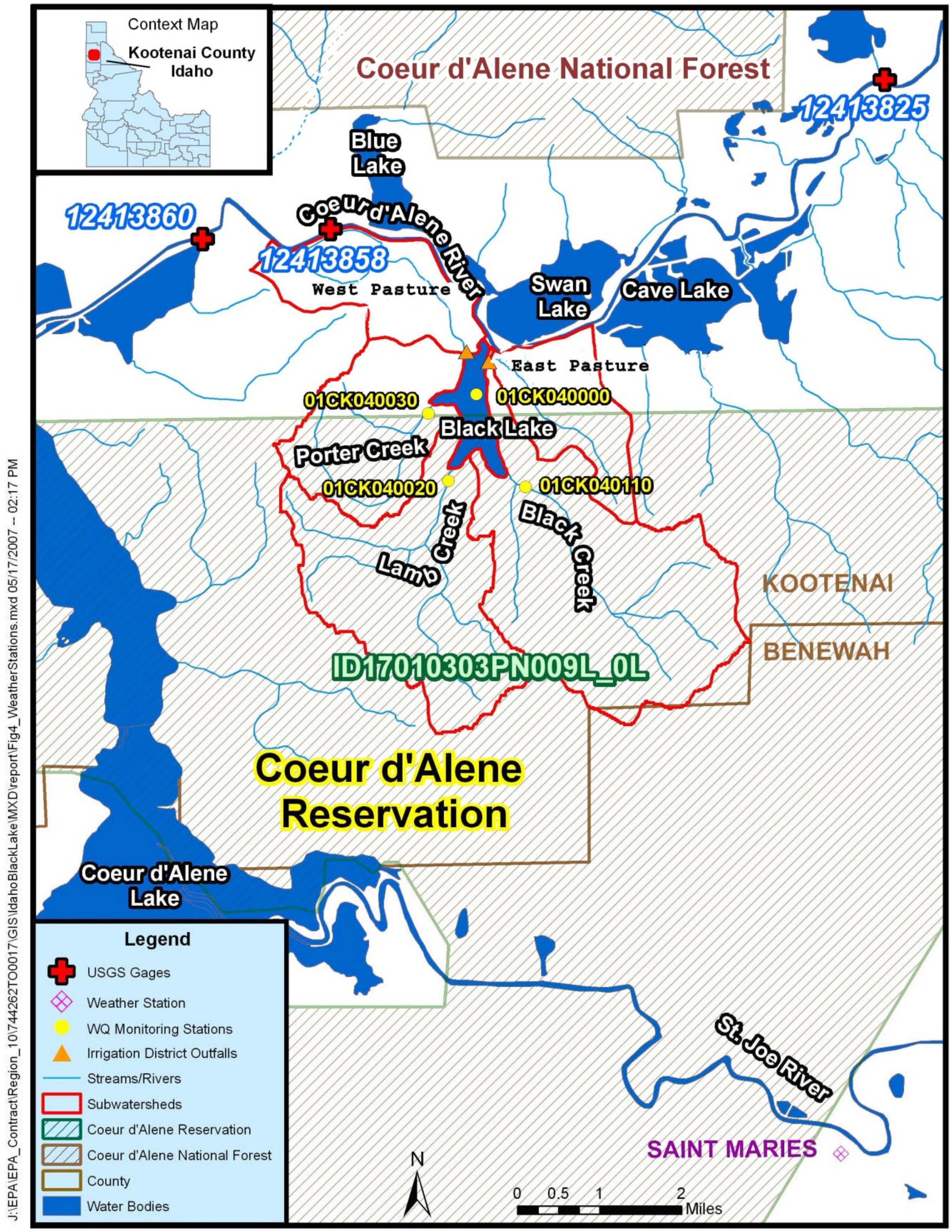
Water column data are summarized in this section to characterize recent water quality conditions in Black Lake, Porter Creek, Lamb Creek, Black Creek, and Coeur d'Alene River. The data summarized in this section include historic data and recent water chemistry data from samples collected at the water quality monitoring stations in Black Lake and the three Black Lake tributaries listed in Table 7.

Table 7. Water Quality Monitoring Stations within Black Lake Watershed

Station Name	Station Identification No.	Agency
Black Lake	CK040000	Coeur d'Alene Tribe
Porter Creek	01CK040030	Coeur d'Alene Tribe
Lamb Creek	01CK040020	Coeur d'Alene Tribe
Black Creek	01CK040010	Coeur d'Alene Tribe

For the Coeur d'Alene River, data from USGS gage 12413860 near Harrison were utilized to characterize TP concentrations. The locations of these various water quality monitoring stations are displayed in Figure 7 below. Insufficient water quality data were available to adequately characterize TP concentrations for effluent from the East and West Pasture outfalls. At the time of drafting this document, DEQ was unable to obtain actual flow and TP data from the owner of the East and West Pasture outfalls; however, negotiations for actual monitoring data collection continue to be pursued.

Figure 7. Water Quality Monitoring Stations



Black Lake Historical Data

Available historical records provide water quality data collected from Black Lake between 1983 and 2001. In addition, there were various special studies on Black Lake conducted in 1984, 1985, and 1986 that involved collection of water chemistry data. In these studies, algal bioassays were run on Black Lake samples which indicated that Black Lake is a eutrophic lake. The water quality data from 1991 to 2001 (42 measurements) indicated that TP concentrations ranged from 1 microgram per liter (µ/L) to 530 µ/L, resulting in an estimated geometric mean of 39 µg/L. A summary of the historic nutrient data for Black Lake is provided in Appendix D. Reported algal blooms coupled with these water quality samples subsequently resulted in the placement of Black Lake on the 303(d) list for nutrient impairment. While this body of historical data influenced the initial use impairment determination used by DEQ to support 303(d) listing, DEQ and the Coeur d'Alene Tribe recognized that additional, more recent water quality data were necessary to support TMDL development. As a result, historical data were used to substantiate the need for collecting additional water quality monitoring data to support this nutrient TMDL report. Consequently the historical data were not used in the following data analysis summary.

The Coeur d'Alene Tribe collected water chemistry data between 2002 and 2006 at Black Lake water quality monitoring station CK040000 for both upper (approximately 3 feet below the surface) and lower (approximately 3 feet above the ground) depths, which are summarized in Appendix D. Average TP concentrations are 32.5 and 52.1 µg/L for the upper and lower measurements, respectively. These elevated concentrations typically correspond to eutrophic conditions in lakes with physical characteristics similar to Black Lake. With the exception of the samples collected on September 18, 2002, the lower measurement was consistently higher than the upper measurement. As can be observed in Figure 8, the upper concentrations exhibited a statistically significant decreasing trend over time, while the lower concentrations showed no trend.

Black Lake Tributaries

Water chemistry data were collected at the mouths of the three major tributaries between June and October 2005 and between January and April 2006 with the last measurement made in September 2006. Nutrient data for the three tributaries are summarized in Appendix B. Lamb Creek (01CK040020) exhibited the highest TP concentrations, which ranged from 60 to 194 µg/L, with an average of 114.9 µg/L. TP at Porter Creek (01CK040030) was between 72 and 136 µg/L with an average of 104.7 µg/L, while Black Creek (01CK040010) TP concentrations (the lowest of the three tributaries) ranged from 33 to 128 µg/L, with and average of 73.9 µg/L.

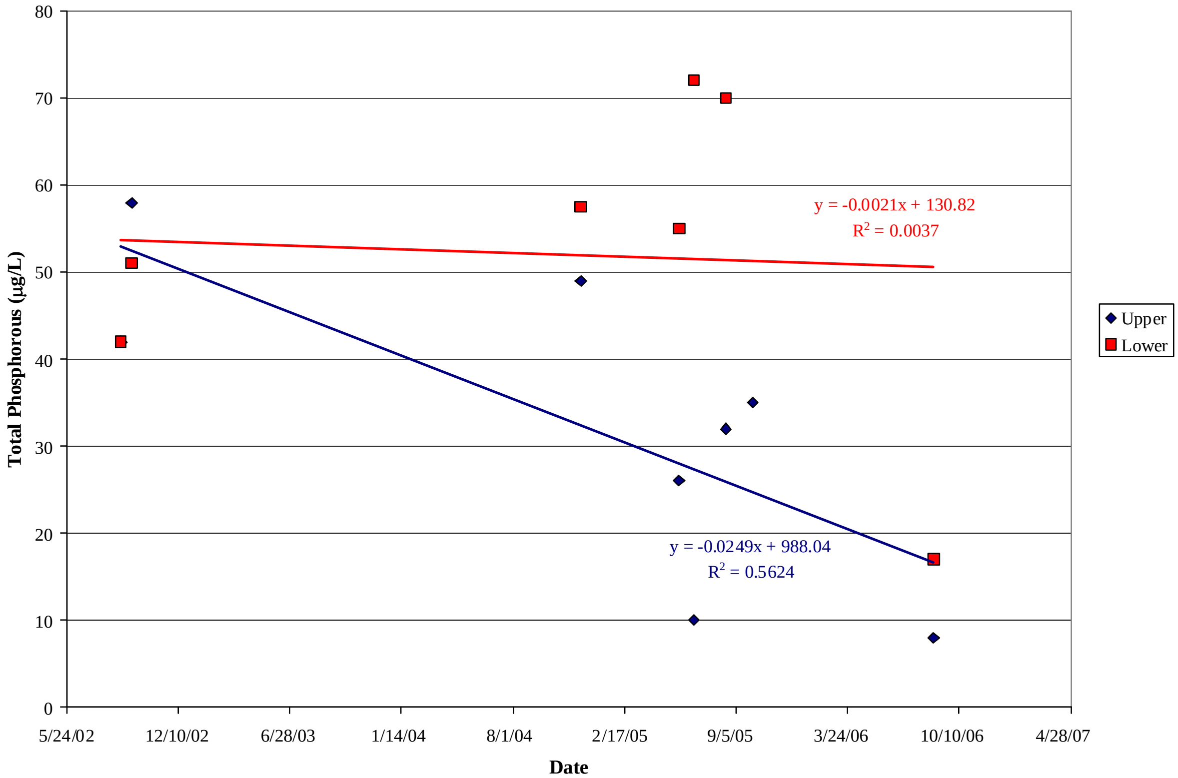


Figure 8. Phosphorous Concentrations in Black Lake

Given the limited data available to characterize the water chemistry of Black Creek and Lamb Creek, the Coeur d'Alene Tribe and DEQ decided to also rely on historical data results presented in the 1987 Kann and Falter report titled *"Development of Toxic Blue-Green Algal Blooms in Black Lake, Kootenai County, Idaho."* To support the development of a TMDL for TP in this report estimated TP loading values and annual average flows from the Kann and Falter report were utilized to characterize the water quality and flow of Black Creek and Lamb Creek which are summarized in Section 5.

East and West Pastures

Insufficient data are available to adequately characterize the water chemistry of the effluent discharged to Black Lake from the East and West Pastures. No water quality data were collected during the project period from the East Pasture outfall pipe. TP was measured at the West District Discharge pipe on three separate occasions between May and August 2005 with marginal success. TP levels measured at the discharge pipe varied from 34 to 48 µg/L. However, only one sample collected on August 18, 2005, which measured 48 µg/L, was successfully collected without being mixed with Black Lake water.

Given the paucity of data available to characterize the water chemistry of the effluent discharged to Black Lake from the East and West Pastures, the Coeur d'Alene Tribe and DEQ decided to also rely on historical data results presented in the 1987 Kann and Falter report titled *"Development of Toxic Blue-Green Algal Blooms in Black Lake, Kootenai County, Idaho."* To support the development of a TMDL for TP in this report, estimated TP loading values and annual average flows from the Kann and Falter report were utilized to characterize the water quality and flow of the East and West Pastures. The specific values derived from the Kann and Falter report to support TMDL development are summarized in Section 5.

Coeur d'Alene River

Limited nutrient data are available to characterize the water quality of inflows from the Coeur d'Alene River into Black Lake. The only phosphorous data available for the Coeur d'Alene River above Black Lake are not acceptable for use in TMDL development because the data are too old and too far upstream. The measurements were collected in 1972 from the station at Cataldo, Idaho (USGS station 12413500), located approximately 25 miles upstream of the mouth of Black Lake. The nearest station on the Coeur d'Alene River is USGS gage 12413858 below Blue Lake near Harrison, which is less than 3 miles downstream of the point where Black Lake discharges to the river. The phosphorous data at this station was also of no practical use since there was only one measurement collected in 1999.

As a result, to adequately characterize the nutrient concentrations in the Coeur d'Alene River, it was necessary to utilize water quality data from USGS gage 12413860 near Harrison, Idaho. Although this station is downstream of Black Lake, data collected between October 2003 and August 2005 and provide the best representation of instream nutrient concentrations necessary to support modeling and TMDL development. Table 8 lists the sampling results for orthophosphate, TP, and total nitrogen from the 16 different measurements collected. An average concentration 21 μg/L for TP was used as an important model input to quantify TP loadings to Black Lake.

Table 8. Summary of Water Quality Data from USGS Gage 12413860, 2003-2005

Date	Ortho-phosphate (μg/L)	TP-unfiltered (μg/L)	TN unfiltered (μg/L)
10/9/2003	< 6	4	110
12/9/2003	< 6	11	200
3/3/2004			
4/7/2004	E 3	16	90
4/27/2004			
5/10/2004	< 6	5	50
6/8/2004	< 6	8	40
7/19/2004	< 6	E 2	70
9/1/2004	< 6	6	140
10/12/2004	< 6	60	110
12/13/2004	< 6	50	220
2/8/2005	E 3	10	120
3/14/2005	E 4	12	130

Date	Ortho-phosphate (µg/L)	TP-unfiltered (µg/L)	TN unfiltered (µg/L)
3/30/2005	E 4	31	150
5/12/2005	<6	7	80
6/28/2005	< 6	10	70
7/18/2005	< 6	7	70
8/25/2005	< 6	6	170
Average		21.4	124.4
Median		10	110

E = estimated value

Biological and Other Data

Data from the Idaho Fish and Game and the 1996 Bull Trout Conservation Plan are summarized in Section 1.2 of this report. Specific fishery population information and other relevant biological data are not available for Black Lake and its tributaries.

A paleolimnology analysis of Black Lake using a sediment core from the center of the lake was completed in 2005 (Bos and Stockner 2005). Sediment core analysis was performed and the data were used to supplement an existing limnological data set. Several tasks were completed as part of this sediment core analysis, such as:

1. Preparation of samples and slide preparation for diatom analysis;
2. Preparation of samples for Carbon and Nitrogen (C/N) analysis;
3. Preparation of samples and slides for fossil cladoceran analysis; and
4. Pigment analysis for 12 subsamples.

The pigment subsamples were analyzed using high performance liquid chromatography (HPLC) by the University of Regina, Saskatchewan, Limnology Laboratory, but the analysis was not conducted until a clear diatom profile was defined so a more reliable match to probable dates of toxic bloom events during the 1970s and 1980s could be made. Both diatoms and C/N work were done at 2 cm intervals from 80 cm (pre-European contact period) to surface, i.e., 40 samples, while samples for pigment analyses and cladocerans were reduced to 12 each. Using an assumed sedimentation rate of +/- 2 mm/yr, it was estimated that each 2 cm interval would represent about 8-12 years of "events" in the lake's maturation, which is expected to provide sufficient resolution to reliably track major changes in P loading and C production increases following man-induced landscape alteration, e.g., logging, cattle ranching, etc. Paleolimnologic results clearly verified that Black Lake has always been somewhat productive, and findings strongly suggest that mesotrophic conditions have prevailed throughout its history, although eutrophy has dominated during the 20th century (Bos and Stockner 2005). Phytoplankton and zooplankton species diversity and trophic interaction has changed dramatically during the past century, further supporting this finding. The pigment analysis appears to support the findings regarding fossil species distributions; blue-green algae, while historically present, has recently dramatically increased to well above historical levels. In addition, levels of C, N, inorganics, and C/N ratio closely corroborate the other independent lines of evidence.

Appendix E summarizes the specific results of the diatom analysis, the algal pigment analysis results, and demonstrates the corroboration with chemical results from the sediment cores (especially the C/N ratio data). These data in sediment clearly indicate a significant change in sediment sources and/or nutrient composition about the time that the “industrial revolution” began to influence the region (Bos and Stockner 2005). Changes in sediment and nutrient composition are due to erosion from various disturbances within the watershed.

Status of Beneficial Uses

Recent additional water quality data collected from Black Lake continue to demonstrate that the lake is not supporting cold water aquatic life use as a result of excessive nutrient loading.

The majority of Porter Creek, and all of Lamb Creek, and Black Creek, lie within the Coeur d'Alene Reservation and assessment of beneficial use attainment within these tributaries will be conducted by the Coeur d'Alene Tribe at a later date. Thus, TMDLs will not be written for the Black Lake tributaries.

Conclusions

In summary, the recent water quality data and paleolimnology explorations of Black Lake yielded several key findings. Water quality data for Black Lake, while limited demonstrate elevated TP concentrations indicative of eutrophic conditions. Average TP concentrations from recent sampling clearly exceed the recommended water quality target and other regional lakes. Paleolimnology data verified that Black Lake has always been productive and probably mesotrophic until recent years, when anthropogenic activities accelerated eutrophication. The data were used to infer limnologic characteristics and support quantitative estimates of key limiting nutrients to establish a lake-specific water quality target. Although productivity decreased during the past two decades, it is still about 300 percent higher than previous levels prior to anthropogenic disturbances (Bos and Stockner 2005). This suggests that major sources of TP to Black Lake are the result of external loading, which warrants the need for a loading analysis, TMDL allocation, and implementation plan.

2.5 Data Gaps

As previously stated, there is a limited amount of water quality data available to substantiate the spatial and temporal severity of the cold water aquatic life use impairment in Black Lake. However, the available water quality data provide a weight-of-evidence approach that the cold water aquatic life use narrative criteria are not fully supported. The following list summarizes the various data gaps that would provide a more rigorous understanding of the variables affecting water quality conditions of the East and West Pastures, the three Black Lake tributaries and the Coeur d’Alene River, all of which influence water quality of Black Lake.

- Monthly flow data from the three Black Lake tributaries, the East and West Pastures outfall pipes, and stage data for the Coeur d’Alene River immediately upstream and downstream of the Black Lake outflow channel.

- Additional water chemistry data collected on the same schedule from the three Black Lake tributaries, the East and West Pastures outfall pipes, and the Coeur d'Alene River immediately upstream and downstream of the Black Lake outflow channel.
- BURP data to evaluate impact of nutrients and sediments on cold water aquatic life use in the three Black Lake tributaries.
- Stage volume calculations of Black Lake to provide more robust evaluation of Lake dynamics.
- Other water chemistry (i.e. dissolved oxygen) and biological data to assess other beneficial uses in Black Lake or the three tributaries.
- There are a number of springs that discharge directly into the Black Lake. Monitoring data is needed to sufficiently characterize nutrient concentrations in these springs.
- Current biological data from Black Lake and its tributaries are needed to better understand biological conditions and trends. This data will further assist in defining the trophic status of Black Lake and other chain lakes to more effectively understand the impacts of nutrient loading.

The Coeur d'Alene Tribe, DEQ and Region 10 will collaborate to develop a phased monitoring plan to collect this type of data over time to support and enhance the technical basis of the TMDL calculations provided in this report.

3. Watershed Assessment–Pollutant Source Inventory

This section includes an assessment of the known and suspected sources of phosphorus contributing to the eutrophication of Black Lake. Nutrient sources identified are categorized and quantified to the extent that reliable information is available. Generally, sources of phosphorus may be point or nonpoint in nature.

3.1 Sources of Pollutants of Concern

Point sources, discrete end-of-pipe discharges, are typically those regulated through the National Pollution Discharge Elimination System (NPDES) program. Point sources can be categorized as municipal, industrial, or storm water discharges. Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body at a single location. These sources are related to land activities that contribute phosphorus to surface waters as a result of runoff producing storm events or groundwater/surface water transfer. The following discussion describes what is known regarding point and nonpoint sources of TP contributing to the eutrophication of Black Lake.

Point Source Discharges

There are no NPDES permitted facilities within or outside of the Black Lake watershed that discharge to Black Lake or its tributaries. However, direct discharges from pumps draining the East and West Pastures occur. Due to legal exemptions/decisions, this discharge is an exemption under the NPDES permitting process. Therefore, all of the known or suspected sources of nutrient loading to Black Lake are the result of nonpoint sources and legally NPDES-exempt direct discharges to Black Lake.

Nonpoint Sources

For over 30 years, reductions in point source pollution have been the focus of the resource agencies responsible for the protection of water quality. However, during the last decade, reduction of nonpoint source pollution has been the targeted goal of these agencies. The institutional mechanism for identifying and reducing these loads is through the quantitative process of establishing TMDLs for parameters such as nutrients, which can cause eutrophication in a lake resulting in impairment of beneficial uses. Because of climatic conditions (most moisture falls as snow with associated spring melting) and surrounding land uses (sparse rangeland, agriculture, and forest), the Black Lake watershed is susceptible to erosion and therefore nonpoint source loadings. Land use practices can accelerate the erosion process and contribute anthropogenic sources of particulate and dissolved phosphorus to tributaries of Black Lake. Excessive nutrients can impair the Black Lake's aesthetic quality, recreational uses, and cold water aquatic life uses.

Nonpoint sources for TP may originate from natural sources and anthropogenic sources. For the nonpoint source pollutant assessment of Black Lake four different delivery mechanisms of TP were evaluated:

- Loading from the entire Black Lake watershed (Porter Creek, Lamb Creek, and Black Creek) (primarily anthropogenic, some natural);

- Direct seasonal discharges from the West and East Pastures (anthropogenic);
- Seasonal flooding of Black Lake from high flows of the Coeur d'Alene River (primarily background); and
- Internal recycling of nutrients within Black Lake (natural).

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. Excess nutrients to a lake system can result in accelerated plant growth and result in a eutrophic or enriched system.

Black Lake Watershed Loading

A variety of natural and anthropogenic activities within the watershed ensure the availability of TP for delivery to Black Lake. Nutrient loads are transported to Black Lake by the three tributaries, Porter Creek, Lamb Creek, and Black Creek. Nutrient sources within the Black Lake watershed may include:

- septic tanks;
- residential development;
- agricultural practices and livestock;
- wildlife;
- delivery of organic matter from nearshore areas;
- atmospheric deposition; and
- naturally occurring concentrations in soil.

Using a geographic information system (GIS), the Coeur d'Alene Tribe prepared an inventory to estimate the number of septic systems within the Black Lake watershed. Figure 9 depicts all the septic systems located within the Black Lake watershed. Spatial analysis using GIS differentiated those septic systems within 100 meters of the Black Lake shoreline and within 100 meters of any Black Lake tributary. Several factors coalesce to indicate that septic systems near the tributaries and around the perimeter of Black Lake are sources of nutrient loading. First, septic tank effluent contains elevated concentrations of phosphorous from sources such as human waste and other phosphorus-containing products such as toothpastes and detergents. Second, aging septic tanks are known to malfunction and leak. Approximately 40 percent of the existing septic tanks were installed prior to 1979 (personal communication, Rothrock, IDEQ 2007). Third, the steep slopes and soil types around Black Lake have poor suitability for septic tank absorption.

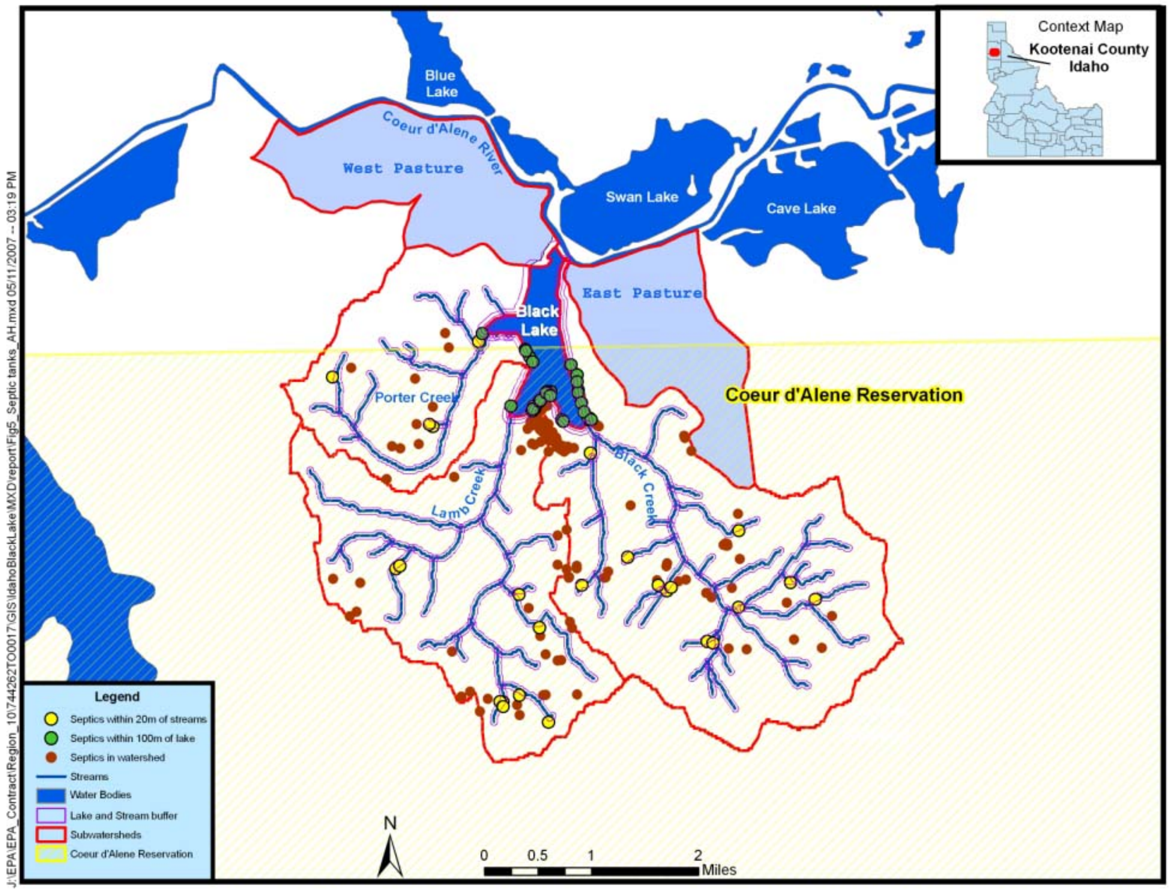


Figure 9. Septic Systems located near Black Lake Shoreline and Tributaries

Table 9 summarizes the number of septic systems by subwatershed and within the nearshore perimeter of Black Lake. In Table 9 the estimated phosphorus load by watershed is shown for information purposes only to demonstrate that septic systems can be a significant source of nutrient loading.

Table 9. Septic Systems by Subwatershed and Near Black Lake Shoreline

Water Body	No. Septic Tanks	Estimated Population Served	Effluent flow (L/day)[b]	Estimated Phosphorous Load (lb/day)[c]	Estimated Phosphorus Load (lb/yr)[c]
Black Creek, Lamb Creek, Porter Creek	36	144	21,600	0.7	260
Black Lake Nearshore within 100 meters	52	208	31,200	1.0	375
SUM					**635**

[a] Assumed 4 people/home

[b] Assumed system effluent flow 150 L/person/day (Woods 1991)

[c] Assumed Total Phosphorous concentration in effluent 15 mg/L (Woods 1991)

Other anthropogenic activities within the watershed that contribute phosphorus to Black Lake are transported by rainfall/snowmelt runoff. These activities include livestock, crop production, other agricultural activities, commercial fertilization (lawn or crops), and automobile products. Products such as detergents, hydraulic fluids, fuels, tires, and rubber compounds contain phosphorus and, therefore, runoff from roads and residential and commercial areas may be a potential source of phosphorus. Manure from livestock and household pets, as well as commercial fertilizer normally contain some form of phosphorus. All of these specific sources occur within the Black Lake watershed to some degree; however, no population data are currently available for these domestic animal species. According to observations from site visits, cattle are known to graze in proximity to the lake. Commercial fertilizer is an important supplement for the crops within the watershed. As stated in the NRCS county soil survey report for Kootenai County, additional phosphorus fertilizer application is required for acceptable crop production for the various soil series prevalent in the Black Lake watershed (NRCS 1981). Given the relatively small population and limited residential, commercial, and industrial land use, nutrient loads from current land development activities in the Black Lake watershed are expected to be minimal, while those related to agriculture are recognized as a major source.

Decomposition of organic materials (plants) produces phosphates, and background concentrations of phosphorus in soil, wildlife manure, and atmospheric deposition are all natural sources which generate TP loads that can enter the lake via runoff and erosion. Review of the NRCS Kootenai County Area Soil Survey Report indicates that for the predominant soil series in and around Black Lake watershed, natural background concentrations of phosphorus are not elevated such that they would be considered a source of loading (NRCS 1981). Atmospheric deposition of TP and nitrogen from rainfall is recognized as another pollutant source, but site-specific data is not available and as a result, a default value derived from the public domain model BATHTUB was used to estimate TP loading associated with annual average precipitation. This default value of 30mg/m^2/yr was acknowledged as an acceptable value by DEQ (Rothrock, personal communication 2007). The BATHTUB model and its application to support the Black Lake TMDL are summarized in Section 5.4 and in Appendix F.

Waste from wild animals produces organic phosphates which can be deposited directly into surface waters since wildlife have direct access or can enter into the surface waters via stormwater runoff. Thus wildlife can contribute concentrations of phosphorus that are then carried directly into the Lake. While no population data are currently available for wildlife within the watershed, animals such as mule deer, moose, elk, and a wide variety of small mammals, birds, and waterfowl are known to inhabit the watershed. The creeks and the lake are an important source of water for wildlife and as a result, direct deposition of manure into the water may be a source of phosphorus loading. Phosphorus loading from wildlife, which cannot be quantified with existing data, is considered part of the background load.

East and West Pastures TP Loading

Flanking both sides of Black Lake are the East Pasture and West Pasture that have historically operated as horse and winter cattle feeding areas. Three factors influence the seasonal inundation of these two watersheds all of which potentially deliver external phosphorus loads: groundwater infiltration, spring flooding from high flows in the Coeur d'Alene River, and surface waters that flow directly into and through the East and West

Pastures. As a result of the seasonal inundation during spring runoff of these two watersheds, pumps were installed to drain the East and West Pastures and the effluent is discharged directly into Black Lake. Typically, the west pipe discharges from late March to the beginning of September and the east pipe discharges from January to April. Due to accessibility issues, flow monitoring data and water quality data of the effluent were not acquired for these irrigation outfalls. While livestock management within these two subwatersheds varies from year to year, effluent from both the East and West Pastures are recognized NPDES-exempt TP discharges and loading to Black Lake.

TP Loading from High Flows of the Coeur d'Alene River

Because Black Lake is connected to the Coeur d'Alene River and there are no structures controlling the flow between those two water bodies, the Coeur d'Alene River can act as a nutrient source to Black Lake when the river water surface elevations are higher than the corresponding water surface elevations of the lake. Flows from the Coeur d'Alene River to the lake and vice versa were estimated by means of a volume-balance method that accounted for daily inputs from tributaries and pastures, lake elevations, and Coeur d'Alene River elevations, as detailed in Appendix C. Phosphorous concentrations in the Coeur d'Alene River were obtained from data collected between October 2003 and August 2005 at USGS gage 12413860 near Harrison, Idaho. An average concentration of 21 µg/L for TP, derived from the 16 measurements collected, was used to calculate the loads of the Coeur d'Alene River to Black Lake. A summary of the contributing Coeur d'Alene River flows and estimated loads are presented in Table 10.

Table 10. Input of Coeur d'Alene River to Black Lake by Year

Year	# days CDR discharges to Lake	Annual Flow (million m^3/yr)	TP Annual Load (kg/yr)a
2000	33	17.24	362.0
2001	21	3.92	82.3
2002	43	37.67	791.1
2003	28	18.20	413.2
2004	46	10.07	540.2
2005	34	5.60	117.7

[a] Assuming river discharges a constant TP concentration of 21 µg/L.

Internal P Cycling Within the Lake

Neither detailed hydrologic studies nor specific modeling have been conducted to evaluate the internal dynamics of nutrient cycling within Black Lake. As with all lakes, internal sources of phosphorus include nutrient releases from lake sediments and decomposition of aquatic plants. Historical land-disturbing activities such as logging, construction, and agricultural activities in the Black Lake watershed, have introduced large amounts of phosphorus-containing sediments that accumulated at the bottom of the lake. Black Lake experiences some stratification from June through August but this stratification may be periodic being broken up by wind/wave action. This limited stratification can result in reduced DO conditions near the bottom of the lake which enhance phosphorus partition into the water column. In the 1987 Kann and Falter study, the percentage of TP estimated to be contributed by internal loading was relatively small at 9.3 percent (Kann and Falter 1987). In addition, the Kann and Falter study concluded that internal phosphorus loading does not appear to vary greatly from year to year and, therefore, Kann and Falter concluded that summer internal phosphorus alone does not explain annual bloom variations in Black Lake (Kann and Falter 1987). Despite these historical observations, additional lake study and modeling, which is beyond the scope of this TMDL, may be warranted to better define the contributions of TP from internal lake dynamics.

Pollutant Transport

In summary, all TP loading to Black Lake is the result of nonpoint sources transported to the lake directly from the watershed as well as from sources outside the watershed. The primary pollutant transport pathway for sources within the Black Lake watershed is from rainfall/snow melt runoff occurring between February and June. External nonpoint sources of TP are transported to Black Lake via direct discharges from the East and West Pastures and from seasonal flooding of the lake by the Coeur d'Alene River. Thus, the inter-relationship between these transport mechanisms and the land use activities generating TP sources demonstrate that both anthropogenic and natural sources of phosphorus are nonpoint source in origin and will warrant an integrated approach to best management practices (BMP) to effectively reduce loadings to Black Lake over time.

3.2 Data Gaps

As previously stated, there is a limited amount of data available for the development of a TP TMDL for Black Lake. The following summarizes the various data gaps that limit the accuracy of accounting for all the variables associated with the nonpoint sources of loading and their effect on the eutrophication of Black Lake. The Coeur d'Alene Tribe, DEQ and Region 10 will collaborate to develop a phased monitoring plan to collect data over time to support and enhance the technical understanding of nutrient sources to Black Lake and its tributaries.

Point Sources

Since there are no point source dischargers there are no data gaps associated with characterizing nutrient loading from point sources.

Nonpoint Sources

The following list summarizes the various data gaps affecting the quantification of TP loading to Black Lake. In response to these data gaps, various conservative assumptions have been made in the models and calculations used to establish the TP TMDL for Black Lake. Where appropriate these assumptions are identified and incorporated into the margin of safety (MOS) discussed in Section 5.

- No site specific aerial deposition data to more accurately estimate TP and nitrogen loading to Black Lake. A primary need would be a survey of septic loading risk.
- No regionally appropriate data available that documents the failure rate of septic systems.

- No watershed-specific livestock, pet, or wildlife census data to estimate phosphorus loading from animal manure.
- No long-term water quality data immediately upstream of the Black Lake outfall channel to more accurately estimate phosphorus loading from the Coeur d'Alene River.
- Insufficient data available to quantify nutrient concentrations or loads of the effluent from the East and West Pastures.
- Additional data and modeling are warranted to better understand TP contributions from internal lake dynamics.
- There may be additional springs in the watershed, and it is unknown what TP concentrations they might have.

4. Watershed Assessment – Summary of Past and Present Pollution Control Efforts

Road grading and other implementation actions by the Black Lake Shores Association has been done in the past few years to decrease direct runoff into Black Lake.

5. Total Maximum Daily Load

A TMDL prescribes an upper limit on discharge of a pollutant from all sources to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA).

Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. For Black Lake, it was assumed that natural background levels are included in target concentrations chosen for nutrients. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (water quality planning and management, 40 CFR Part 130) require that a MOS be part of the TMDL. Practically, both natural background and MOS are reductions in the load capacity that would otherwise be available for allocation to human-caused sources of pollutants.

The TMDL can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First, the load capacity is determined. Then the load capacity is broken down into its components: the necessary MOS is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, sometimes independently, the determination of critical conditions can become fairly complicated.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as an LA where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

5.1 Water Quality Target

The goal of the Black Lake TMDL is to restore "full support of designated beneficial uses" (Idaho Code 39.3611, 3615). The designated beneficial use targeted for restoration is the long-term maintenance of the cold water aquatic life use. The listing of Black Lake as water quality-limited on the 303(d) list is based on nonsupport of the narrative criteria and documented evidence of a measurable adverse effect on water quality and the cold water aquatic life use. The documented evidence is a number of reported toxic blooms of colonial blue-green algae in the 1980s and recent water quality sampling indicating high levels of TP in both Black Lake and tributary samples. Guided by this goal DEQ, the Coeur d'Alene Tribe, and other federal and local agencies and stakeholders must establish and implement a TMDL for TP for Black Lake.

Target Selection

Black Lake was assigned for TMDL development on the Idaho DEQ 1998 303(d) list. 40 CFR§130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standard." Since numeric nutrient criteria do not exist in the Idaho water quality standards for Black Lake, a critical step in development of the TMDL is formulation of a rationale for creating a numeric translator for narrative criteria to serve as the water quality target. This water quality target will convert a qualitative statement (narrative criteria) in the Idaho water quality standards into a numeric, measurable in-lake water column target, which, when attained, will restore cold water aquatic life use. Surrogate water quality targets for nutrients allow the flexibility necessary to address characteristics of both nonpoint and point sources of pollutants in more practical and tangible ways. The rationale utilized for the Black Lake water quality target incorporates a weight-of-evidence approach to recommend a numeric water column value for TP with which to establish a practical pollutant load capacity for Black Lake. Establishing and achieving a target for TP in Black Lake is expected to mitigate conditions that contribute to algal blooms.

Rationale for TP Water Quality Target

A variety of data sources were utilized to develop a recommendation for the Black Lake TP water quality target. These data sources, which include EPA national ecoregion guidance, Idaho DEQ nutrient data analysis of regionally similar lakes, and a paleolimnology study conducted on Black Lake, are summarized below.

Discussion of EPA National Ecoregion Nutrient Guidance

Between 1998 and 2003 EPA developed and finalized nutrient criteria guidance to assist states and tribes in adopting nutrient standards. Unlike most water quality criteria, EPA criteria were not based on identifying causal relationships between nutrient levels and adverse water conditions, but rather on distinguishing natural background versus anthropogenic eutrophication in ecoregions around the country. EPA utilized standardized statistical methods of establishing nutrient criteria designed to reflect reference conditions in each water body type (rivers and streams, lakes and reservoirs, wetlands) within each ecoregion. The criteria values derived for ecoregions were developed by combining data for all lakes in that region into a single analysis to develop a single number for each water quality constituent for which a criterion was developed.

A primary issue in deciding whether to accept EPA ecoregion-based nutrient criteria or to develop alternative value(s) is whether or not to accept the level of spatial resolution and specificity of the regional values. At Level III of this classification system, the continental United States contains 104 ecoregions. There are 10 Level III ecoregions in Idaho (maps and explanations for Idaho are available at the EPA Western Ecology Division website). The Level III ecoregion containing Black Lake is Ecoregion #15, which encompasses the upper two thirds of Idaho plus a portion of western Montana.

The criteria of greatest interest in Black Lake is total phosphorus and total dissolved phosphorus. TP data (410 records) were available for 25 lakes in Ecoregion #15 and were used by EPA to calculate an ecoregion TP criterion. The EPA TP reference condition estimated for these 25 lakes, and applicable to Black Lake, is 6.25 µg/L (EPA 2000). As a point of comparison, lake water samples from British Columbia lakes (within the same ecoregion) suggest a natural (i.e., pre-anthropogenic) or reference level of TP between 6 and 15 µg/L (J. Stockner, pers. comm. 2004).

DEQ Nutrient Data Analysis Summary

The Idaho DEQ compiled data for Upper Priest Lake, Spirit Lake, and Upper Twin Lake to compare the different TP ranges and trophic status. While the DEQ acknowledges differences in limnology and trophic status between these three lakes and Black Lake, this data compilation was useful in demonstrating other practical ranges of TP concentrations that needed to be considered when setting a lake-specific water quality target. Figure 10 displays the results of the DEQ data analysis of TP concentrations for the three lakes as well as Cocolalla Lake, Idaho and Hauser Lake, Montana.

Table 11 provides a comparison of the EPA nutrient criteria for TP of 6.25 µg/L and the DEQ regional reference values for TP for the select group of lakes ranging from 6 to 18 µg/L.

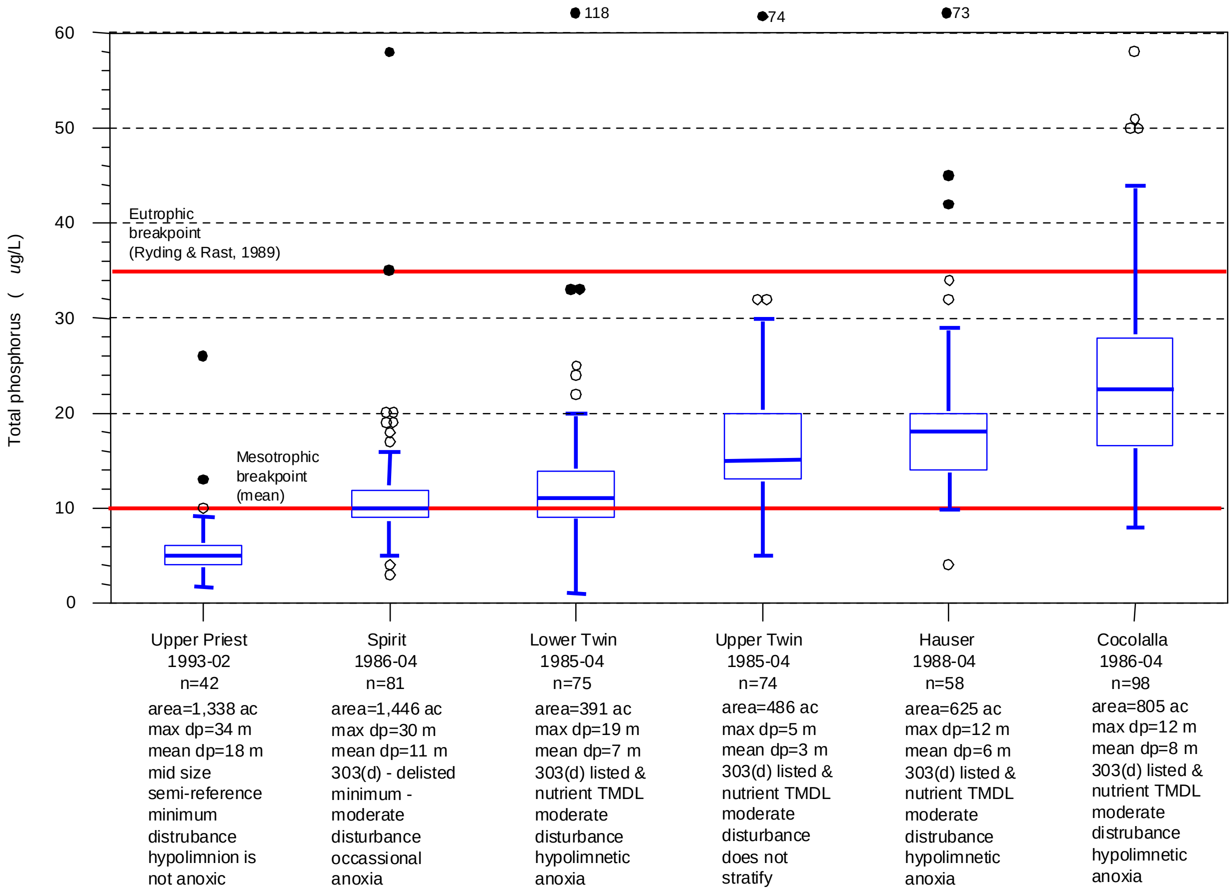


Figure 10. Northern Idaho Sampling Results Among Mid-size Evaluated Lakes from Baseline Studies and CVMP Monitoring Mean Total Phosphorus in Photic Zone, April-October

Table 11. Comparison of Nutrient Criteria and Regional Reference Values with Method Detection Limits

Constituent	State of Idaho and Coeur d'Alene Tribe Aquatic Uses Criteria	EPA Nutrient Ecoregion Criteria	Upper Priest Lake Mean Seasonal April –Oct.	Spirit Lake Mean Seasonal April – Oct.	Upper Twin Lake Mean Seasonal April – Oct.	MDL
Chlorophyll a	--	2.1 µg/L (Fluorometric method)	2.0 µg/L[a] (1.9 median)	3.5 µg/L [b] (2.5 median)	6.1 µg/L [b] (5.6 median)	5 µg/L (Spectro. method)
Total Phosphorus	[1]Narrative criteria	6.25 µg/L	6 µg/L[a] (5 µg/L median)	12 µg/L[b] (10 µg/L median)	18 µg/L[b] (16 µg/L median)	1 µg/L
Total Nitrogen(TKN)	[1]Narrative criteria	50 µg/L	115 µg/L[a]	380 µg/L[c]	260 µg/L[d]	50 µg/L

[1]Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. (IDAPA 58.01.02.200.06): Nutrients or other substances from anthropogenic causes shall not be present in concentrations which will produce objectionable algal densities or nuisance aquatic vegetation, result in a dominance of nuisance species, or otherwise cause nuisance conditions.

Sources : [a] Idaho DEQ baseline study from 1993 – 1995 (Rothrock 1997)
[b] Citizens Volunteer Monitoring Program (CVMP) 1988 – 2002 – oversight by Idaho DEQ
[c] Eastern Washington baseline study 1984 (Soltero and Hall 1985)
[d] University of Idaho study 1985 – 1986 (Falter 1987)

Black Lake Water Quality Data and Paleolimnology

Nutrient data were collected by the Coeur d'Alene Tribe from 2003 through 2005 in Black Lake, which proved to be valuable information in developing the water quality target for TP. TP analysis results were used in conjunction with other limnological data to derive a nutrient target for Black Lake.

A tool utilized to evaluate historic changes in lake-water conditions and the evolution of physical, chemical and biological characteristics of Black Lake, was the application of a paleolimnology study based on a single sediment core retrieved from the deepest part of the lake. Using a "weight of evidence" approach, the collective data from the sediment core analyses for diatoms, cladoceran head capsules, and pigment samples, were used to estimate a nutrient target for Black Lake, expressed both as a TP and a total dissolved P concentration. Changes within diatom assemblages over time permitted the realistic appraisal of pre-settlement conditions through and including present state conditions of the trophic status of the lake.

The paleolimnology results clearly verified that Black Lake has always been somewhat productive, and findings strongly suggest that mesotrophic conditions prevailed throughout its history, although eutrophic conditions dominated during the 20th century (Bos and Stockner 2005). Phytoplankton and zooplankton species diversity and trophic interaction changed dramatically during the past century, further supporting this finding. The pigment analysis appears to support the findings regarding fossil species distributions; and blue-green algae, while historically present, increased dramatically in recent years to well above historical levels.

In summary, the paleolimnologic explorations at Black Lake yielded several key findings that were used to infer limnologic characteristics and support quantitative estimates of key limiting nutrients. It was verified that Black Lake has always been productive and probably mesotrophic until recent years, when anthropogenic activities led to clear eutrophication. Although productivity decreased during the past two decades, it is still about 300 percent higher than previous levels prior to anthropogenic disturbances (Bos and Stockner 2005).

Conclusions and Recommendations for TP Water Quality Target

After thorough evaluation of the different data sources (EPA national ecoregion guidance, DEQ nutrient data analysis of regionally similar lakes, and a paleolimnology study conducted on Black Lake) summarized above, DEQ and the Coeur d'Alene Tribe concluded that an appropriate water quality target should correlate with a mesotrophic status. Thus, the EPA ecoregion criteria recommendation of 6.25 µg/L was inappropriate for Black Lake since it correlates with oligotrophic lakes. DEQ used the data analysis presented in Figure 10 to define the range of 10-35 ug/L TP as representative of a mesotrophic lake in north Idaho. Because a paleolimnological assessment suggests that Black Lake has been a mesotrophic lake for the last 1000 years, it is reasonable to assume a water quality target for Black Lake would fall at least in the middle of this mesotrophic range. The average flushing time of 1.4 years in Black Lake would indicate TP delivered to Black Lake from sources would readily be flushed from the lake during non-drought years; therefore, a middle-of-the range value also seems reasonable from this perspective. As such, the TP water quality target recommended for the Black Lake TMDL is 20 ug/L. To the extent which this has been evaluated, it is assumed that reductions in TP to meet this water quality target will reverse the trend of eutrophication and diminish the conditions that cause algal blooms in Black Lake. In addition, meeting this target will result in improvement of dissolved oxygen concentrations to levels that will support aquatic live and will decrease internal cycling of TP in the lake. Seasonal variation is accounted for by this TMDL since the TMDL endpoint accounts for the variable flow conditions occurring annually.

The ultimate goal is to support beneficial uses, not to solely meet target criteria. Should reductions in pollutant loading result in achievement of beneficial uses prior to meeting the recommended target, then there may be no need to reduce loads further to meet the target (except to allow for a margin of safety). Equally, if the target was to be met and beneficial uses not supported, the chosen target would be reexamined and possibly made more stringent. This assessment will be made during the 5-year review of the TMDL.

Monitoring Points

As funding allows, the Black Lake monitoring station CK040000 will continue to be used as the primary monitoring location to evaluate future progress toward restoring and maintaining the cold-water aquatic life use. For Black Lake, the target should be evaluated based on an average concentration of TP of one sample per month for the months July through September. This progress measurement could also be compared to an annual average TP concentration which should be used to demonstrate a statistical trend toward the 20 µg/L target. Showing progress of TP reductions over time by comparing the target to an annual average TP concentration is a practical approach for managing nonpoint sources and long-term recovery of uptake in lakes. In addition, DEQ and the U.S. Geological Survey (USGS) should establish a water quality monitoring station on the Coeur d'Alene River upstream of Black Lake to better quantify the long-term influence of nutrient loading from seasonal flooding into the lake. At both of these stations, typical water chemistry analysis should be done on water samples collected with emphasis on TP. Stage and flow data should also be collected for both Black Lake and the Coeur d'Alene River. Sampling should also be considered on the three Black Lake tributaries to evaluate the collective effectiveness of implementation actions in reducing nutrient loading to the lake. Samples and analysis will be conducted in accordance with EPA guidance under an approved quality assurance project plan. As time and funding allows, the Coeur d'Alene Tribe, DEQ, and USGS will develop and coordinate an appropriate sampling plan as part of TMDL implementation.

5.2 Load Capacity

The load capacity is the assimilative capacity or the upper load limit Black Lake can receive and stay at or below the water quality target of 20µg/L TP. Pollutant loads are calculated on a mass per unit time basis. An actual TMDL is considered too refined (i.e., daily basis) to be practical for nonpoint source pollutants including TP. At the other extreme, a TMDL may mask short, intense periods (i.e., spring runoff or episodic storm events), when loads are excessive and need to be controlled, followed by longer periods of relative inactivity. Therefore, some period between daily and annual loads is useful to establish load allocations and guide implementation. Pollutant loading analysis to estimate the load capacity for Black Lake was conducted by integrating modeling outputs from GWLF and BATHTUB. BATHTUB is a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes.

As with most models, data limitations and gaps require the need to set certain assumptions to complete the modeling analyses. As a steady-state model, BATHTUB is limited in its ability to simulate various in-lake dynamics; thus, the following assumptions are inherent in the analysis:

- There is no explicit inclusion of wind mixing in the model (general mixing / diffusion is captured in the diffusive transport rates)
- Phosphorus loading rate from sediments are set to zero in BATHTUB (since the pre-calibrated nutrient retention models already account for nutrient recycling that would normally occur). Because the sedimentation models within BATHTUB have been empirically calibrated, effects of internal loading or phosphorus recycling from bottom sediments are inherently reflected in the model parameter values and error statistics.

5.3 Estimates of Existing Pollutant Loads

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading,…" (water quality planning and management, 40 CFR § 130.2(I)). Since there are no point sources discharging to the Black Lake watershed, no estimation of existing point source loads is necessary. Nonpoint sources can be estimated based on the type of sources (land use) or area (such as a subwatershed), but may be aggregated by type of source or land area.

For the Black Lake TP TMDL, existing nonpoint source loads were estimated using two different methods:

- GWLF modeling summarized by subwatershed, and
- Literature values derived from the 1987 Kann and Falter report for Black Creek, Lamb Creek and the East and West Pastures.

The GWLF model estimates dissolved and total nitrogen and phosphorus loads in surface runoff from complex watersheds. In addition, the model can account for nutrient loads from both point sources and on-site wastewater disposal (septic) systems. For modeling purposes, the Black Lake watershed was divided into five subwatersheds that correspond to the three major tributaries and two pastures (Lamb Creek, Black Creek, Porter Creek, West Pasture, and East Pasture). The model was run for each subwatershed separately using a 7-year period beginning in January 1999 and ending December 2005. The first year results were ignored to eliminate effects of arbitrary initial conditions, as recommended in the GWLF manual. A detailed description of the GWLF modeling approach is provided in Appendix F. Table 12 summarizes the average nonpoint source loads by subwatershed derived from GWLF outputs. Table 12 also summarizes the existing pollutant loads estimated from septic systems within 100 meters of Black Lake and the seasonal inflow from the Coeur d'Alene River. The literature values for estimated TP loads from the Kann and Falter report are provided in the last column of Table 12. From Table 12 the estimated existing pollutant load to Black Lake based on the GWLF modeling from all seven discrete nonpoint sources, presented as an annual average load, is 581 kg/yr.

Table 12. Estimated Existing TP Loads from Nonpoint Sources to Black Lake

Location	Type	Annual Load Range (kg/yr)	6-yr Average Annual Load (kg/yr)	Estimation Method	Literature Values[d] (kg/yr)
Lamb Creek	Runoff and septic systems	112 - 186	149	GWLF model	206.8
Black Creek	Runoff and septic systems	158-221	200	GWLF model	218.1
Porter Creek	Runoff and septic systems	53-80	75	GWLF model	NA
West Pasture	Runoff	16	16	GWLF model	127.1
East Pasture	Runoff	20	20	GWLF model	214.1
Black Lake	Septic systems	38.3	39	GIS and simple parameter assumptions[a]	NA
Coeur d'Alene River	Runoff	82-540	82[c]	Lake volume-balance[b]	NA
Internal P Cycling	Internal	118	118	P retention model	118

[a] See Section F-2 BATHTUB Modeling in Appendix F for a description of the assumptions.

[b] The reader is referred to Appendix C for a description of the procedure employed to complete the water balance in Black Lake.

[c] The annual load selected for the Coeur d'Alene River was derived from the load estimated in 2001 which corresponds to the lowest flow value used for the assessment period.

[d] Kann and Falter 1987

NA = Values provided in the Kann and Falter report were not used. The same values derived from GWLF modeling for Porter Creek, Septic systems, and the Coeur d'Alene River were considered to be more representative values for TMDL development purposes.

5.4 Load Allocation

The quantification of current pollutant loads by source allows for the allocation of loads by watershed, the specification of load reductions as percentages, and an equitable distribution of load reduction responsibility. As previously discussed, the following equation: LC = MOS + NB + LA + WLA = TMDL is used as the method for quantifying the TMDL and allocating the loads among sources. Also as previously stated, it was assumed that natural background levels are included in target concentrations chosen for TP and that the MOS for the Black Lake TP TMDL is implicit, which is summarized in more detail later in this section. Therefore, the Black Lake TP TMDL is equal to the LA which is the sum of all the nonpoint sources of TP quantified in the BATHTUB model which include:

- Lamb Creek,
- Black Creek,
- Porter Creek,

- West Pasture,
- East Pasture,
- Coeur d'Alene River,
- Septic Systems around Black Lake, and
- Atmospheric Deposition.

Modeling Procedures and TMDL Allocation

To evaluate the effect of phosphorus loading on ambient water quality in Black Lake, BATHTUB model (Version 6.1) was used to link nutrient sources with the TMDL water quality target (TP = 20 µg/L). BATHTUB is a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes. As a public domain model it has been applied to numerous reservoirs throughout the country, particularly in the Southeastern United States. BATHTUB has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited. A detailed description of the BATHTUB modeling application for Black Lake is provided in Appendix F. Total phosphorus loads were first estimated using GWLF + BATHTUB, but model output loads from the East and West Pasture pipes were too low given the TP concentrations observed. Therefore, the Kann & Falter data was used. While both tables will remain in the TMDL, the final load allocation in the TMDL is based on the model output using the Kann & Falter data.

Key BATHTUB Inputs

The period of record simulated using BATHTUB was 2000 through 2005. Nutrient nonpoint source concentrations from five different subwatersheds were modeled as inflows to Black Lake. The key GWLF model inputs to BATHTUB (expressed as annual means of flow and concentration) for Black Lake are provided in Table 13.

Table 13. GWLF Outputs by Subwatershed for BATHTUB Modeling

Current Condition	Flow (million m^3/yr)	Concentration (µg/L)	
		Total Phosphorous	Ortho-Phosphorous
Lamb Creek	1.414	105	35
Black Creek	2.144	93	17
Porter Creek	0.600	126	74
West Pasture	0.353	45	23
East Pasture	0.390	51	51

Table 14 includes the key inputs to BATHTUB derived from the literature values provided in the Kann and Falter report. The ortho-phosphorus values required by BATHTUB were not available in the Kann and Falter report and thus were back calculated from the TP values using a ratio of 0.3 ortho-phosphorus/TP.

Table 14. Literature Values from 1987 Kann and Falter Report used for BATHTUB Modeling

Current Condition	Flow (million m^3/yr)	Concentration (µg/L)	
		Total Phosphorous	Ortho-Phosphorous
Lamb Creek	2.362	87.6	26.3
Black Creek	4.523	48.2	14.5
West Pasture	1.059	120	36
East Pasture	0.824	259.8	77.9

Table 15 presents the key model inputs for flow and TP concentration used to estimate the loads from the Coeur d'Alene River inflow and septic tanks within 50 meters of Black Lake. The lowest annual average inflow from the Coeur d'Alene River to Black Lake occurred in 2001. Thus, the 2001 flow was used as input to the model to be conservative in the overall TMDL calculation. A default value from BATHTUB of 30 mg/m^2-yr was used for TP from atmospheric deposition which was the last pollutant source included in the model. This value was considered valid based on comparisons by DEQ field staff with atmospheric deposition data from other locations in Idaho.

Table 15. Summary of Flow and TP Concentration for Coeur d'Alene River and Septic Systems within 50 Meters of Black Lake

Nonpoint Source	Annual Flow (million m^3/yr)	Total Phosphorous (µg/L)
Coeur d'Alene River	3.92	21
Septic Systems within 50 meters of Black Lake	0.0033	11,700

TMDL Allocation Results

Allocating pollutant loads is a key component of the technical approach for establishing TMDLs. Its purpose is to create a technically feasible and reasonably fair division of the allowable pollutant load among known sources. The Black Lake load capacity expressed as an annual average load is 220 kg/yr TP. There are no point sources discharging to Black Lake, so the WLA is set as zero. TP loads associated with internal recycling within Black Lake are not addressed in this TMDL however, future investigations are necessary to verify the seasonal alterations of water quality in Black Lake in response to internal TP cycling.

For the LA, a range of pollutant load allocations were calculated using the two different BATHTUB model inputs for estimating existing pollutant loads – GWLF modeling results and the literature values from the 1987 Kann and Falter report. In both scenarios, existing estimated loading for Porter Creek, septic systems, Coeur d'Alene River and atmospheric deposition were derived from GWLF or BATHTUB default values since these were considered more representative than those provided in the Kann and Falter report.

In both TMDL scenarios load reduction responsibility to achieve the LA is distributed equally among the six controllable nonpoint sources of TP which are Lamb, Porter, and Black Creek, the East and West Pastures, and septic systems around the perimeter of Black Lake. Using the GWLF model results as inputs to BATHTUB, to achieve the water quality target of 20 µg/L the existing load of 617 kg/yr TP needs to be reduced to 220 kg/yr TP which is an overall percent reduction of 64 percent. This reduction goal distributed equally among six of the eight nonpoint sources is summarized in Table 16. Since reductions are not practical from the Coeur d'Alene River and atmospheric deposition, these two sources are considered background sources and no load reduction is required. The target TP concentrations for the three Black Lake tributaries and the two Pastures are presented in Table 16 and vary as a function of flow. The TP concentration of 21 µg/L and the corresponding estimated annual TP load from the Coeur d'Alene River is maintained.

Table 16. TP Load Allocations and Percent Reduction Goals required for all Nonpoint Sources to Black Lake using BATHTUB and GWLF Outputs

Source	Avg Annual Flow (million m^3/yr)	Existing Condition		Average Annual Allocation		
		Concentration (µg/L)	Load (kg/yr)	Allocated Concentration (µg/L)	Allocated Load (kg/yr)	% Load Reduction
Lamb Creek	1.41	105.4	149	21.1	30	80
Black Creek	2.14	93.3	199	19.0	41	80
Porter Creek	0.60	125.5	76	24.9	15	80
West Pasture	0.35	45.1	16	9.0	3	80
East Pasture	0.39	51.3	20	10.2	4	80
Coeur d'Alene River	3.92	21.0	82	21.0	82	0
Septic Systems	0.003	11700	39	2480.4[2]	8	79
Atmospheric Deposition	-	39.5[1]	37	39.5[1]	37	0
	Existing Load		617	Load Capacity	220	
	Overall Reduction Needed		64%			

[1] Derived on BATHTUB default data input, given lack of site-specific data
[2] Reduction of nutrient loads from septic systems will be implemented through reducing flow from failing septic tanks

A second scenario for the LA was derived by using the estimated loading values from the 1987 Kann and Falter report for Lamb Creek, Black Creek, and the East and West Pastures. This scenario, which is summarized in Table 17, supposes that larger existing flows and higher concentrations (and therefore loads) are associated with the East and West Pastures. *This scenario is the chosen load allocation and percent reduction goals, and all TMDL implementation will be based on these numbers.* Using the Kann and Falter values as inputs to BATHTUB, to achieve the water quality target of 20 µg/L, the estimated existing load of 1000 kg/yr TP needs to be reduced to 322 kg/yr TP which is an overall percent reduction of 68 percent. Again, since reductions are not practical from the Coeur d'Alene River and atmospheric deposition, these two sources are considered background sources and no load reduction is required.

Table 17. TP Load Allocations and Percent Reduction Goals required for all Nonpoint Sources to Black Lake using BATHTUB and 1987 Kann and Falter Values

Source	Avg Annual Flow (million m^3/yr)	Existing Condition	Average Annual Allocation	
		Existing Load (kg/yr)	Allocated Load (kg/yr)	% Load Reduction
Lamb Creek	2.362	206.8	47.6	77
Black Creek	4.523	218.1	50.2	77
Porter Creek[1]	0.60	75.6	17.4	77
West Pasture	1.059	127.1	29.2	77
East Pasture	0.824	214.1	49.2	77
Coeur d'Alene River	3.92	82.3	82.3	0
Septic Systems[2]	0.003	38.6	9.0	77
Atmospheric Deposition[3]	-	36.8	36.8	0
	Existing Load	1,000	Load Capacity 322	
	Overall Reduction Needed	68%		

[1] Based on GWLF estimate, given lack of site-specific data
[2] Reduction of nutrient loads from septic systems will be implemented through reducing flow from failing septic tanks
[3] Derived from BATHTUB default data input, given lack of site-specific data

For comparison of the two different scenarios, the annual average load capacity is 220 kg/yr (Table 16) and 322 kg/yr (Table 17). These TMDL allocations have been converted to lbs per day using a method derived from the EPA 1991 Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001) (EPA 1991b). The methodology and calculations for conversion of a long-term average load to a maximum daily load is provided in Appendix F.

Margin of Safety

To account for uncertainty associated with insufficient or even unknown data, and the relationship between pollutant loads and beneficial use impairment, a MOS is included in development of load analyses. There are several ways to implement a MOS. For Black Lake, conservative assumptions were utilized in the watershed loading model and the lake model. These conservative assumptions, which convey an implicit MOS when estimating the load allocation, are summarized below.

Conservative assumptions made as part of LA of the Black Lake watershed and the East and West Pasture watersheds were used in the GWLF model. The GWLF model describes nonpoint sources with a distributed model for runoff, erosion and urban wash off, and a lumped parameter linear reservoir ground water model. The conservative assumptions used in the model, which are considered part of an implicit MOS, include the following.

- Water balances in GWLF are computed from daily precipitation data, but flow routing is not considered. Hence, daily values are summed to provide monthly estimates of streamflow and nutrient fluxes. This computation results in higher runoff volumes reaching the streams and, consequently, higher estimated nutrient loads.
- Nutrient losses from plant cover are assumed to be 75 percent of the nutrient uptake of plants.
- Conservative Curve Numbers used for each soil type and land use in the GWLF model likely overestimate runoff.
- Annual flows to Black Lake were calibrated using average measured flows for the various tributaries. If no-flow periods had been included in the averages, the resulting flows discharged by the tributaries would have been lower. Thus, the flows (and subsequently loads) to Black Lake were overestimated.
- Nutrient concentrations in soil were assumed to be high to match the dissolved/total P ratios observed in measured data which likely overestimates nutrient loading from the watersheds of Black Lake tributaries.

Design Conditions and Seasonal Variation

Although much of the TP loading is during spring runoff, the critical period for nutrients affecting beneficial uses in Black Lake generally is the warmer months of summer and early fall. Nutrients promote growth of aquatic vegetation, which usually is at its highest density in late summer - a time of high recreational use. When vegetative matter such as algae dies, it sinks to the bottom where microbial action uses oxygen to break down organic matter. Warmer water temperature occurs in summer, and because saturation levels of gases decline as temperature increases, decreased concentrations of DO result. These conditions stress aquatic biota when oxygen levels are low, and respiration of dense aquatic vegetation pushes DO concentrations lower. The modeling approach used did account for seasonal variation by averaging the data from the 6–year period of record. The target concentration for TP in Black Lake will be based on an average concentration for the months of July through September – times of greatest concern for high densities of algae and DO problems.

Reasonable Assurance

The EPA requires that TMDLs with a combination of point and nonpoint sources and with wasteload allocations dependent on nonpoint source controls, provide reasonable assurance that the nonpoint source controls will be implemented and effective in achieving the load allocation (EPA 1991a). Nonpoint source reductions listed in the Black Lake TMDL will be achieved through state authority within the Idaho Nonpoint Source Management Program. Section 319 of the federal CWA requires each state to submit to EPA a management plan for controlling pollution from nonpoint sources to waters of the state.

The plan must: identify programs to achieve implementation of BMPs; furnish a schedule containing annual milestones for utilization of program implementation methods; provide certification by the attorney general of the state that adequate authorities exist to execute the plan for implementation of BMPs; and include a listing of available funding sources for these programs. The current Idaho Nonpoint Source Management Plan has been approved by EPA (December 1999) as meeting the intent of §319 of the CWA.

As described in the Idaho Nonpoint Source Management Plan, Idaho water quality standards require that if monitoring indicates water quality standards are not met due to nonpoint source impacts, even with the use of current BMPs, the practices will be evaluated and modified as necessary by the appropriate agencies in accordance with provisions of the Administrative Procedure Act (IDAPA). If necessary, injunctive or other judicial relief may be initiated against the operator of a nonpoint source activity in accordance with authority of the Director of Environmental Quality provided in Section 39-108, Idaho Code (IDAPA 58.01.02.350). Idaho water quality standards list designated agencies responsible for reviewing and revising nonpoint source BMPs based on water quality monitoring data generated through the state's water quality monitoring program. Designated agencies are: Department of Lands for timber harvest activities, oil and gas exploration and development, and mining activities; Soil Conservation Commission for grazing and agricultural activities; Transportation Department for public road construction; Department of Agriculture for aquaculture; and the Department of Environmental Quality for all other activities (Idaho Code 39-3602).

Existing authorities and programs for assuring implementation of BMPs to control nonpoint sources of pollution in Idaho are as follows:

- Nonpoint Source 319 Grant Program
- State Agricultural Water Quality Program
- Wetlands Reserve Program
- Resource Conservation and Development
- Agricultural Pollution Abatement Plan
- Conservation Reserve Program
- Idaho Forest Practices Act
- Environmental Quality Improvement Program
- Stream Channel Protection Act
- Water Quality Certification for Dredge and Fill

The Idaho water quality standards direct appointed advisory groups to recommend specific actions needed to control point and nonpoint sources affecting water quality limited water bodies. Upon approval of this TMDL by EPA Region 10, the Black Lake Watershed Advisory Group, with the assistance of appropriate local, state, tribal, and federal agencies, will begin formulating specific pollution control actions for achieving water quality targets listed in the Black Lake TMDL. The plan should be completed within 18 months of finalization and approval of the TMDL by EPA.

5.5 Implementation Strategies

Meeting the pollutant load allocations for TP discussed in this TMDL requires implementation of various policies, programs, and projects aimed at improving water quality in Black Lake. Like the TMDL, the goal of the implementation plan is to reduce nutrient loading to support beneficial uses. DEQ and the Coeur d'Alene Tribe recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or if substantial progress is not being made toward achieving those goals. Conversely, should monitoring show beneficial uses are being supported prior to attainment of TMDL targets, less restrictive load allocations will be considered. Any implementation plan will concentrate on reducing nutrients. Reduction in pollutant loadings for nonpoint sources will most likely require a mix of policy changes, program initiatives, and implementation of BMPs.

Time Frame

Because pollutants in Black Lake come from nonpoint sources, implementation of pollution reduction is strictly on an opportunistic basis. Therefore, the time frame proposed for attainment of beneficial uses in Black Lake is 20 years. This will be in a two-phase approach. Phase I will address the effluent discharged to Black Lake from the East and West Pastures, and Phase II will address nonpoint source pollution to the lake, primarily from septic systems. Although the initial focus will be on Phase I, it is feasible that Phase II would occur concurrently with Phase I, as negotiations under Phase I evolve. Using this two-phased approach, substantial progress is expected within 10 years once Phase I is complete.

Approach

Phase I of the implementation plan will explore opportunities to reduce TP pollution to Black Lake from the East and West Pastures. This includes discussions with the landowner about alternative management strategies such as placement of easements and/or installation of BMPs on the pastures. Phase II will include working with Panhandle Health District, the Coeur d'Alene Tribe and the local Watershed Advisory Group to develop and implement a strategy to work with the community to mitigate pollutant input to Black Lake from septic systems. Implementation of BMPs for other non-point sources to the lake will be addressed by Designated Management Agencies. Grazing and agricultural aspects of the implementation plan will be written and developed by Soil Conservation Commission. Public road construction activities fall under the auspices of Transportation Department. All other activities are under the purview of the DEQ.

As time and resources allow, DEQ, the Tribe, the WAG, and/or Designated Management Agencies will develop and implement a monitoring plan(s) to measure changes to water quality once management actions are taken and BMPs are installed. If monitoring shows phosphorus reduction efforts are not being achieved, DEQ and the Coeur d'Alene Tribe will determine whether load reduction targets, load allocations and/or the implementation strategy should be revised.

Responsible Parties

The implementation of a plan to improve water quality in Black Lake will require the cooperation of many entities. These may include, but not be limited to, the following:

- Tribal Government – Coeur d'Alene Tribe
- Federal Government – Natural Resources Conservation Service, U.S. Forest Service, Bureau of Land Management, Bureau of Indian Affairs

- State Government – Departments of Environmental Quality, Lands, Transportation, Fish and Game, and Agriculture, Soil Conservation Commission
- County Government – Kootenai County
- Local Government –
- Quasi-Government – Kootenai Soil Conservation District
- Irrigation Companies –
- Numerous private individuals

Monitoring Strategy

The DEQ and the Coeur d'Alene Tribe will develop a collaborative strategy to monitor BMP implementation through annual reports submitted as part of any implementation program. Due to constraints of money, time, and personnel, DEQ and the Coeur d'Alene Tribe will be limited in their ability to directly monitor BMP effectiveness. Funding agencies executing implementation strategies should include monitoring as part of project funding requests. Tributary monitoring at the confluence of affected streams would help determine watershed BMP effectiveness. The DEQ and the Coeur d'Alene Tribe will divide responsibility for monitoring both Black Lake and its tributaries for compliance with TMDL allocations and progress toward supporting beneficial uses. Ambient water quality monitoring will be dependent on money, time, and personnel available to DEQ and the Coeur d'Alene Tribe.

5.6 Pollution Trading

Pollutant trading (also known as *water quality trading*) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost effective local solutions to problems caused by pollutant discharges to surface waters.

The appeal of trading emerges when pollutant sources face substantially different pollutant reduction costs. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction.

Pollutant trading is voluntary. Parties trade only if both are better off because of the trade, and trading allows parties to decide how to best reduce pollutant loadings within the limits of certain requirements.

Pollutant trading is recognized in Idaho's Water Quality Standards at IDAPA 58.01.02.054.06. Currently, DEQ's policy is to allow for pollutant trading as a means to meet total maximum daily loads (TMDLs), thus restoring water quality limited water bodies to compliance with water quality standards. The *Pollutant Trading Guidance* document sets forth the procedures to be followed for pollutant trading:

http://www.deq.idaho.gov/water/prog_issues/waste_water/pollutant_trading/pollutant_trading_guidance_entire.pdf

Trading Components

The major components of pollutant trading are *trading parties* (buyers and sellers) and *credits* (the commodity being bought and sold). Additionally, *ratios* are used to ensure environmental equivalency of trades on water bodies covered by a TMDL. All trading activity must be recorded in the trading database through the Idaho Clean Water Cooperative, Inc.

Both point and nonpoint sources may create marketable credits, which are a reduction of a pollutant beyond a level set by a TMDL:

- Point sources create credits by reducing pollutant discharges below NPDES effluent limits set initially by the waste load allocation.
- Nonpoint sources create credits by implementing approved best management practices (BMPs) that reduce the amount of pollutant run-off. Nonpoint sources must follow specific design, maintenance, and monitoring requirements for that BMP, apply discounts to credits generated if required, and provide a water quality contribution to ensure a net environmental benefit. The water quality contribution also ensures the reduction (the marketable credit), is surplus to the reductions the TMDL assumes the nonpoint source is achieving to meet the water quality goals of the TMDL.

Watershed-Specific Environmental Protection

Trades must be implemented so that the overall water quality of the water bodies covered by the TMDL are protected. To do this, hydrologically-based ratios are developed to ensure trades between sources distributed throughout TMDL water bodies result in environmentally equivalent or better outcomes at the point of environmental concern. Moreover, localized adverse impacts to water quality are not allowed.

Trading Framework

For pollutant trading to be authorized, it must be specifically mentioned within a TMDL document. After adoption of an EPA approved TMDL, DEQ, in concert with the Watershed Advisory Group (WAG), must develop a pollutant trading framework document as part of an implementation plan for the watershed that is the subject of the TMDL.

The elements of a trading document are described in DEQ's Pollutant Trading Guidance:

http://www.deq.idaho.gov/water/prog_issues/waste_water/pollutant_trading/pollutant_trading_guidance_entire.pdf.

5.7 Conclusions

The data support nutrient TMDLs for tributaries, irrigation outfalls, and septic systems transporting TP to Black Lake. Load allocations were developed for nonpoint sources. Reservoir modeling predicts that if the phosphorus load is reduced as recommended, the target level of 20 µg/L TP will be achieved under all but the highest annual flow conditions. The GWLF model was used to determine nutrient load allocations for Lamb Creek, Black Creek, and Porter Creek and the East and West Pastures. Significant additional data are needed from water bodies and discharges to Black Lake to evaluate other beneficial uses. Since the TMDL for Black Lake will hinge on the success of a concentration based water quality target and not mass loading, this will be a significant driver in establishing long-term monitoring goals and watershed management activities for Black, Lamb, and Porter Creeks and the East and West Pastures.

Data examined did not indicate that nutrients, sediment, or DO are impairing beneficial uses in the Coeur d'Alene River itself. As a tributary to Black Lake, nitrogen and phosphorus loads from the Coeur d'Alene River do contribute to nutrient problems; however no allocation was made for the Coeur d'Alene River based on the premise that there will be no increase above current pollutant loads from the river in the future. However, improved nutrient management in the Coeur d'Alene River Subbasin upstream of Black Lake will have a beneficial effect on improving water quality in the lake.

References Cited

American Geological Institute. 1962. Dictionary of geological terms. Doubleday and Company. Garden City, NY. 545 p.

Armantrout, N.B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society. Bethesda, MD. 136 p.

Batt, P.E. 1996. Governor Philip E. Batt's Idaho bull trout conservation plan. State of Idaho, Office of the Governor. Boise, Idaho. 20 p + appendices.

Bos D. and J. Stockner. 2005. Paleolimnological Assessment of Water Quality Changes in Black Lake, Idaho. Final report to Parsons, October 2005.

Clean Water Act (Federal water pollution control act), 33 U.S.C. § 1251-1387. 1972.

Denny, P. 1980. Solute movement in submerged angiosperms. Biology Review. 55:65-92.

EPA 1991a. Guidance for Water Quality-. Based Decisions: The TMDL Process. Office of Water, USEPA 440/4-91-001.

EPA 1991b. Technical Support Document for Water Quality-based Toxics Control. Office of Water, EPA505/2-90-001 PB91-127415. March 1991.

EPA 1996. Biological criteria: technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water. Washington, DC. 162 p.

EPA 2000. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria. Lakes and Reservoirs in Nutrient Ecoregion II. EPA 822-B-00-007. U.S. EPA Office of Water, Washington DC.

Falter, C.M. and D. Hallock. 1987. Limnological study and management plan for Upper and Lower Twin Lakes, Kootenai County, Idaho. Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho.186 p.

Franson, M.A.H., L.S. Clesceri, A.E. Greenberg, and A.D. Eaton, editors 1998. Standard methods for the examination of water and wastewater, twentieth edition. American Public Health Association. Washington, DC. 1,191 p.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D.T. Mosier. 2002. The Idaho Department of Environmental Quality water body assessment guidance, second edition-final. Department of Environmental Quality. Boise, Idaho. 114 p.

Haith, D.A., M. Ross, and R.S. Wu. 1992. GWLF Generalized Watershed Loading Functions, Version 2.0, User's Manual. Department of Biological and Agricultural Engineering, Cornell University, December 1992.

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference condition. In: Davis, W.S. and T.P. Simon, editors. Biological assessment and criteria: tools for water resource planning and decision making. CRC Press. Boca Raton, FL. p 31-48.

Idaho Code § 39.3611. Development and implementation of total maximum daily load or equivalent processes.

Idaho Code § 39.3615. Creation of watershed advisory groups.

IDHW 1985. Water Quality Assessment for Black Lake (Kootenai County). Idaho Dept. of Health and Welfare, Report No. WQ-54, Sept. 1985.

IDAPA 58.01.02. Idaho water quality standards and wastewater treatment requirements.

IDEQ 1999. Guidance for Development of Total Maximum Daily Loads. Surface Water Section, IDEQ. June 8, 1999.

Idaho Fish and Game 2006. Fisheries Management Plan 2001-2006.

Idaho Fish and Game 2007. Threatened and Endangered Species by County. http://fishandgame.idaho.gov/cms/tech/cdc/t&e_vertebrates_by_county.cfm

Idaho Governor's Office 1996. Governor Philip E. Batt. Bull Trout Conservation Plan, July 1, 1996. http://species.idaho.gov/list/bulltrout.html

Kann, J. and C. M. Falter 1985. Blue-Green Algae Toxicity in Black Lake, Kootenai County, Idaho. Research Technical Completion Report, Sept. 1985, 55 pp.

Kann, J. and C. M. Falter 1987. Development of Toxic Blue-Green Algal Blooms in Black Lake, Kootenai County, Idaho. Idaho Water Resources Research Institute, Technical Report, Oct. 1987, 37 pp.

Karr, J.R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1:66-84.

Kuo, C.Y., K.A. Cave, and G.V. Loganathan. 1988. Planning of Urban Best Management Practices. Water Resources Bulletin 24(1): 125-132.

Mills, W.B., D.B. Porcella, M.J. Ungs, S.A. Gherini, K.V. Summers, L. Mok, G.L. Rupp, G.L. Bowie, and D.A. Haith. 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water. EPA/600/6-85/002. U.S. Environmental Protection Agency, Athens GA.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. Volume 16(4): 693-727.

NRCS 1981. Soil Survey Report of Kootenai County Area. Text Accessed via Internet, November 2006.

Omernik, J.M. 1977. Nonpoint Source – Stream Nutrient Level Relationships: A Nationwide Study. EPA-600/3-77-105. U.S. Environmental Protection Agency, Corvallis OR.

Rand, G.W., editor. 1995. Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment, second edition. Taylor and Francis. Washington, DC. 1,125 p.

Rothrock, Glenn. IDEQ, 2006, personal communication.

Rothrock, Glenn. IDEQ, 2007, personal communication.

Rothrock, G.C. and D.T. Mosier. 1997. Phase 1 diagnostic analysis, Priest Lake, Bonner County, Idaho, 1993 - 1995. Idaho Dept. of Health and Welfare, Div. of Environ. Quality, Boise, Idaho. 198 p.

Schwarz, G.E., and Alexander, R.B., 1995, State Soil Geographic (STATSGO) data base for the conterminous United States: U.S. Geological Survey Open-File Report 95-449, accessed October 15, 2006, from URL http://water.usgs.gov/lookup/getspatial?ussoils

Soltero, R.A. and J.A. Hall. 1985. Water Quality Assessment of Spirit Lake, Idaho. Dept. of Biology, Eastern Washington University, Cheney, WA. 85 p.

Stockner, J. 2004, personal communication.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Transactions American Geophysical Union 38:913-920.

Schitsu umsh Tribe 2006. http://www.boisestate.edu/history/issuesonline/fall2004_issues/coeur.html

U.S. Census Bureau 2006. U.S. Census Bureau State and County QuickFacts. http://quickfacts.census.gov/qfd/states/16/16055.html

USDA 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Natural Resources Conservation Service, Conservation Engineering Division, June 1986.

USDA 1999. A procedure to estimate the response of aquatic systems to changes in phosphorus and nitrogen inputs. National Water and Climate Center, Natural Resources Conservation Service. Portland, OR.

USDA 2002. USDA National Agricultural Statistics Service http://www2.ftw.nrcs.usda.gov/osd/dat/H/HUCKLEBERRY.html

USGS 1987. Hydrologic unit maps. Water supply paper 2294. United States Geological Survey. Denver, CO. 63 p.

USGS 2006. 1992 National Land Cover Dataset from the Multi-Resolution Land-cover Characteristics Project (USGS 2006)

Water Environment Federation 1987. The Clean Water Act of 1987. Water Environment Federation. Alexandria, VA. 318 p.

Water Quality Act of 1987, Public Law 100-4. 1987.

Water quality planning and management, 40 CFR Part 130.

Wetzel, R.G. 1983. Limnology. Saunders College Publishing. New York, NY.

Woods, P.F. 1991. Nutrient Load/Lake Response Model, Pend Oreille Lake, Idaho, 1989-90. Prepared in cooperation with Idaho Department of Health and Welfare, Division of Environmental Quality, by the United States Geological Survey, Boise, Idaho.

Woods, P.F. 1991b. Nutrient Load/Lake Response Model, Pend Oreille Lake, Idaho, 1989-90. Prepared in cooperation with Idaho Department of Health and Welfare, Division of Environmental Quality, by the United States Geological Survey, Boise, Idaho.

GIS Coverages

Restriction of liability: Neither the State of Idaho nor the Department of Environmental Quality, nor any of its employees make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information or data provided. Metadata is provided for all data sets, and no data should be used without first reading and understanding its limitations. The data could include technical inaccuracies or typographical errors. The Department of Environmental Quality may update, modify, or revise the data used at any time, without notice.

GIS data was obtained from the Coeur d'Alene Tribe to support the preparation of this TMDL. Data was obtained through coordination with the Coeur d'Alene Tribe and the use of their GIS Data Discovery Tool.

Glossary

305(b)

Refers to section 305 subsection “b” of the Clean Water Act. The term “305(b)” generally describes a report of each state’s water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

§303(d)

Refers to section 303 subsection “d” of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Acre-foot

A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers.

Adsorption

The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules

Aeration

A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.

Aerobic

Describes life, processes, or conditions that require the presence of oxygen.

Adfluvial

Describes fish whose life history involves seasonal migration from lakes to streams for spawning.

Adjunct

In the context of water quality, adjunct refers to areas directly adjacent to focal or refuge habitats that have been degraded by human or natural disturbances and do not presently support high diversity or abundance of native species.

Alevin
A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.

Algae
Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.

Alluvium
Unconsolidated recent stream deposition.

Ambient
General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions, not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996).

Anadromous
Fish, such as salmon and sea-run trout, that live part or the majority of their lives in the saltwater but return to fresh water to spawn.

Anaerobic
Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.

Anoxia
The condition of oxygen absence or deficiency.

Anthropogenic
Relating to, or resulting from, the influence of human beings on nature.

Anti-Degradation
Refers to the U.S. Environmental Protection Agency's interpretation of the Clean Water Act goal that states and tribes maintain, as well as restore, water quality. This applies to waters that meet or are of higher water quality than required by state standards. State rules provide that the quality of those high quality waters may be lowered only to allow important social or economic development and only after adequate public participation (IDAPA 58.01.02.051). In all cases, the existing beneficial uses must be maintained. State rules further define lowered water quality to be 1) a measurable change, 2) a change adverse to a use, and 3) a change in a pollutant relevant to the water's uses (IDAPA 58.01.02.003.61).

Aquatic

Occurring, growing, or living in water.

Aquifer

An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs.

Assemblage (aquatic)

An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996).

Assessment Database (ADB)

The ADB is a relational database application designed for the U.S. Environmental Protection Agency for tracking water quality assessment data, such as use attainment and causes and sources of impairment. States need to track this information and many other types of assessment data for thousands of water bodies and integrate it into meaningful reports. The ADB is designed to make this process accurate, straightforward, and user-friendly for participating states, territories, tribes, and basin commissions.

Assessment Unit (AU)

A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit.

Assimilative Capacity

The ability to process or dissipate pollutants without ill effect to beneficial uses.

Autotrophic

An organism is considered autotrophic if it uses carbon dioxide as its main source of carbon. This most commonly happens through photosynthesis.

Batholith

A large body of intrusive igneous rock that has more than 40 square miles of surface exposure and no known floor. A batholith usually consists of coarse-grained rocks such as granite.

Bedload

Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.

Beneficial Use

Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Beneficial Use Reconnaissance Program (BURP)

A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers

Benthic

Pertaining to or living on or in the bottom sediments of a water body

Benthic Organic Matter.

The organic matter on the bottom of a water body.

Benthos

Organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the lake and stream bottoms.

Best Management Practices (BMPs)

Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Best Professional Judgment

A conclusion and/or interpretation derived by a trained and/or technically competent individual by applying interpretation and synthesizing information.

Biochemical Oxygen Demand (BOD)

The amount of dissolved oxygen used by organisms during the decomposition (respiration) of organic matter, expressed as mass of oxygen per volume of water, over some specified period of time.

Biological Integrity

1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).

Biomass	The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.
Biota	The animal and plant life of a given region.
Biotic	A term applied to the living components of an area.
Clean Water Act (CWA)	The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.
Coliform Bacteria	A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).
Colluvium	Material transported to a site by gravity.
Community	A group of interacting organisms living together in a given place.
Conductivity	The ability of an aqueous solution to carry electric current, expressed in micro (μ) mhos/centimeter at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.
Cretaceous	The final period of the Mesozoic era (after the Jurassic and before the Tertiary period of the Cenozoic era), thought to have covered the span of time between 135 and 65 million years ago.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.

Cubic Feet per Second

A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

Cultural Eutrophication

The process of eutrophication that has been accelerated by human-caused influences. Usually seen as an increase in nutrient loading (also see Eutrophication).

Culturally Induced Erosion

Erosion caused by increased runoff or wind action due to the work of humans in deforestation, cultivation of the land, overgrazing, and disturbance of natural drainages; the excess of erosion over the normal for an area (also see Erosion).

Debris Torrent

The sudden down slope movement of soil, rock, and vegetation on steep slopes, often caused by saturation from heavy rains.

Decomposition

The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.

Depth Fines

Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 millimeters depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 centimeters).

Designated Uses

Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.

Discharge

The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen (DO)

The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.

Term	Definition
Disturbance	Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment.
E. coli	Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.
Ecology	The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature.
Ecological Indicator	A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework.
Ecological Integrity	The condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes (EPA 1996).
Ecosystem	The interacting system of a biological community and its non-living (abiotic) environmental surroundings.
Effluent	A discharge of untreated, partially treated, or treated wastewater into a receiving water body.
Endangered Species	Animals, birds, fish, plants, or other living organisms threatened with imminent extinction. Requirements for declaring a species as endangered are contained in the Endangered Species Act.
Environment	The complete range of external conditions, physical and biological, that affect a particular organism or community.

Eocene	An epoch of the early Tertiary period, after the Paleocene and before the Oligocene.
Eolian	Windblown, referring to the process of erosion, transport, and deposition of material by the wind.
Ephemeral Stream	A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from melting snow or other sources. Its channel is at all times above the water table (American Geological Institute 1962).
Erosion	The wearing away of areas of the earth's surface by water, wind, ice, and other forces.
Eutrophic	From Greek for "well nourished," this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.
Eutrophication	1) Natural process of maturing (aging) in a body of water. 2) The natural and human-influenced process of enrichment with nutrients, especially nitrogen and phosphorus, leading to an increased production of organic matter.
Exceedance	A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.
Existing Beneficial Use or Existing Use	A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).
Exotic Species	A species that is not native (indigenous) to a region.
Extrapolation	Estimation of unknown values by extending or projecting from known values.
Fauna	Animal life, especially the animals characteristic of a region, period, or special environment.

Fecal Coliform Bacteria

Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

Fecal Streptococci

A species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.

Feedback Loop

In the context of watershed management planning, a feedback loop is a process that provides for tracking progress toward goals and revising actions according to that progress.

Fixed-Location Monitoring

Sampling or measuring environmental conditions continuously or repeatedly at the same location.

Flow

See *Discharge*.

Fluvial

In fisheries, this describes fish whose life history takes place entirely in streams but migrate to smaller streams for spawning.

Focal

Critical areas supporting a mosaic of high quality habitats that sustain a diverse or unusually productive complement of native species.

Fully Supporting

In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Fully Supporting Cold Water

Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

Fully Supporting but Threatened

An intermediate assessment category describing water bodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a "not fully supporting" status.

Geographical Information Systems (GIS)

A georeferenced database.

Geometric Mean	A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.
Grab Sample	A single sample collected at a particular time and place. It may represent the composition of the water in that water column.
Gradient	The slope of the land, water, or streambed surface.
Ground Water	Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow.
Growth Rate	A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population.
Habitat	The living place of an organism or community.
Headwater	The origin or beginning of a stream.
Hydrologic Basin	The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed).
Hydrologic Cycle	The cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Atmospheric moisture, clouds, rainfall, runoff, surface water, ground water, and water infiltrated in soils are all part of the hydrologic cycle.
Hydrologic Unit	One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more

commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively.

Hydrologic Unit Code (HUC)
The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units.

Hydrology
The science dealing with the properties, distribution, and circulation of water.

Impervious
Describes a surface, such as pavement, that water cannot penetrate.

Influent
A tributary stream.

Inorganic
Materials not derived from biological sources.

Instantaneous
A condition or measurement at a moment (instant) in time.

Intergravel Dissolved Oxygen
The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.

Intermittent Stream
1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. 2) A stream that has a period of zero flow for at least one week during most years.

Interstate Waters
Waters that flow across or form part of state or international boundaries, including boundaries with Native American nations.

Irrigation Return Flow
Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams.

Key Watershed
A watershed that has been designated in Idaho Governor Batt's *State of Idaho Bull Trout Conservation Plan* (1996) as critical

	to the long-term persistence of regionally important trout populations.
Knickpoint	Any interruption or break of slope.
Land Application	A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge.
Limiting Factor	A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.
Limnology	The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes.
Load Allocation (LA)	A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area).
Load(ing)	The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration.
Load(ing) Capacity (LC)	A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load.
Loam	Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use.
Loess	A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible.
Lotic	An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth.

Luxury Consumption	A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants' current needs.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen.
Macrophytes	Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp*.), are free-floating forms not rooted in sediment.
Margin of Safety (MOS)	An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution.
Mass Wasting	A general term for the down slope movement of soil and rock material under the direct influence of gravity.
Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Median	The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11.
Metric	1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement.

Milligrams per Liter (mg/L)

A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm).

Million Gallons per Day (MGD)

A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

Miocene

Of, relating to, or being an epoch of, the Tertiary between the Pliocene and the Oligocene periods, or the corresponding system of rocks.

Monitoring

A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

Mouth

The location where flowing water enters into a larger water body.

National Pollution Discharge Elimination System (NPDES)

A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

Natural Condition

The condition that exists with little or no anthropogenic influence.

Nitrogen

An element essential to plant growth, and thus is considered a nutrient.

Nodal

Areas that are separated from focal and adjunct habitats, but serve critical life history functions for individual native fish.

Nonpoint Source

A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Not Assessed (NA)

A concept and an assessment category describing water bodies that have been studied, but are missing critical information needed to complete an assessment.

Not Attainable

A concept and an assessment category describing water bodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

Not Fully Supporting

Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

Not Fully Supporting Cold Water

At least one biological assemblage has been significantly modified beyond the natural range of its reference condition.

Nuisance

Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

Nutrient

Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

Nutrient Cycling

The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic

The Greek term for “poorly nourished.” This describes a body of water in which productivity is low and nutrients are limiting to algal growth, as typified by low algal density and high clarity.

Organic Matter

Compounds manufactured by plants and animals that contain principally carbon.

Orthophosphate

A form of soluble inorganic phosphorus most readily used for algal growth.

Oxygen-Demanding Materials

Those materials, mainly organic matter, in a water body that consume oxygen during decomposition.

Parameter

A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake.

Partitioning

The sharing of limited resources by different races or species; use of different parts of the habitat, or the same habitat at different times. Also the separation of a chemical into two or more phases, such as partitioning of phosphorus between the water column and sediment.

Pathogens

A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms.

Perennial Stream

A stream that flows year-around in most years.

Periphyton

Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants.

Pesticide

Substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

pH

The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Phased TMDL	A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a water body. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.
Phosphorus	An element essential to plant growth, often in limited supply, and thus considered a nutrient.
Physiochemical	In the context of bioassessment, the term is commonly used to mean the physical and chemical factors of the water column that relate to aquatic biota. Examples in bioassessment usage include saturation of dissolved gases, temperature, pH, conductivity, dissolved or suspended solids, forms of nitrogen, and phosphorus. This term is used interchangeable with the term "physical/chemical."
Plankton	Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.
Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable "point" of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Pollution	A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.
Population	A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.

Pretreatment
The reduction in the amount of pollutants, elimination of certain pollutants, or alteration of the nature of pollutant properties in wastewater prior to, or in lieu of, discharging or otherwise introducing such wastewater into a publicly owned wastewater treatment plant.

Primary Productivity
The rate at which algae and macrophytes fix carbon dioxide using light energy. Commonly measured as milligrams of carbon per square meter per hour.

Protocol
A series of formal steps for conducting a test or survey.

Qualitative
Descriptive of kind, type, or direction.

Quality Assurance (QA)
A program organized and designed to provide accurate and precise results. Included are the selection of proper technical methods, tests, or laboratory procedures; sample collection and preservation; the selection of limits; data evaluation; quality control; and personnel qualifications and training (Rand 1995). The goal of QA is to assure the data provided are of the quality needed and claimed (EPA 1996).

Quality Control (QC)
Routine application of specific actions required to provide information for the quality assurance program. Included are standardization, calibration, and replicate samples (Rand 1995). QC is implemented at the field or bench level (EPA 1996).

Quantitative
Descriptive of size, magnitude, or degree.

Reach
A stream section with fairly homogenous physical characteristics.

Reconnaissance
An exploratory or preliminary survey of an area.

Reference
A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments.

Reference Condition
1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest

level of support attainable. 2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995).

Reference Site

A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies.

Representative Sample

A portion of material or water that is as similar in content and consistency as possible to that in the larger body of material or water being sampled.

Resident

A term that describes fish that do not migrate.

Respiration

A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

Riffle

A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.

Riparian

Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.

Riparian Habitat Conservation Area (RHCA)

A U.S. Forest Service description of land within the following number of feet up-slope of each of the banks of streams:

- 300 feet from perennial fish-bearing streams
- 150 feet from perennial non-fish-bearing streams
- 100 feet from intermittent streams, wetlands, and ponds in priority watersheds.

River

A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.

Runoff	The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Settleable Solids	The volume of material that settles out of one liter of water in one hour.
Species	1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.
Spring	Ground water seeping out of the earth where the water table intersects the ground surface.
Stagnation	The absence of mixing in a water body.
Stenothermal	Unable to tolerate a wide temperature range.
Stratification	A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).
Stream	A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally supports communities of plants and animals within the channel and the riparian vegetation zone.
Stream Order	Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order.
Storm Water Runoff	Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the

	stream. The water often carries pollutants picked up from these surfaces.
Stressors	Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.
Subbasin	A large watershed of several hundred thousand acres. This is the name commonly given to 4th field hydrologic units (also see Hydrologic Unit).
Subbasin Assessment (SBA)	A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho.
Subwatershed	A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units.
Surface Fines	Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 millimeters depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.
Surface Runoff	Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.
Surface Water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.
Suspended Sediments	Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Taxon

Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).

Tertiary

An interval of geologic time lasting from 66.4 to 1.6 million years ago. It constitutes the first of two periods of the Cenozoic Era, the second being the Quaternary. The Tertiary has five subdivisions, which from oldest to youngest are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs.

Thalweg

The center of a stream's current, where most of the water flows.

Threatened Species

Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Total Maximum Daily Load (TMDL)

A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

Total Dissolved Solids

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

Toxic Pollutants

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Tributary

A stream feeding into a larger stream or lake.

Trophic State

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

Turbidity

A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Vadose Zone

The unsaturated region from the soil surface to the ground water table.

Wasteload Allocation (WLA)

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

Water Body

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

Water Column

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

Water Pollution

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Water Quality

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

Water Quality Criteria

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

Water Quality Limited

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Limited Segment (WQLS)

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."

Water Quality Management Plan

A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

Water Quality Modeling

The prediction of the response of some characteristics of lake or stream water based on mathematical relations of input variables such as climate, stream flow, and inflow water quality.

Water Quality Standards

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Water Table

The upper surface of ground water; below this point, the soil is saturated with water.

Watershed

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a water body.

Water Body Identification Number (WBID)

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

Wetlands

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

Young of the Year

Young fish born the year captured, evidence of spawning activity.

Appendix A. State and Site-Specific Standards and Criteria

Black Lake Beneficial Uses

Water Body	Uses	Type of Use
Black Lake (ID17010303PN009_0L)	CWAL, PCR	Presumed Uses

[a] CWAL – cold water aquatic life, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, AWS – agricultural water supply, DWS – domestic water supply

Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as bacteria, DO, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250).

Narrative criteria for excess nutrients are described in IDAPA 58.01.02.200.06, which states: “Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.” Narrative criteria for floating, suspended, or submerged matter are described in IDAPA 58.01.02.200.05, which states: “Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities.”

DEQ’s procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the Water Body Assessment Guidance (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations. Figure 5 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

Appendix B. Flow and Water Chemistry Data Summary: Black Lake Tributaries and West Pasture

Table B-1 Flow and Water Chemistry Data Summary: Black Lake Tributaries and West Pastures

Date	Flow (ft^3/s)	TSS (mg/L)	Turbidity (NTU)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate as N (µg/L)	Nitrite as N (µg/L)	ortho-Phosphate as P (µg/L)	Sulfate (mg/L)	TKN (µg/L)	Total Phosphorous (µg/L)	DO (mg/L)	Temp (oC)	pH (s.u.)	SpCond (µmhos/cm)	DO%
Black Creek 01CK040010																
12/6/2004		<1.0						41		450	180					
6/30/2005	<1.0	ND	5.18	2.57	0.05	80	ND	ND	4.76	60	33	9.3	9.4	7.1	77.7	88.6
7/27/2005	<0.25	31	7.26	2.84	0.05	20	ND	20	4.1	580	128	7.6	15.4	6.9	82.0	82.5
8/24/2005	<0.1	2.77	5	3.36	0.06	20	ND	10	2.16	380	98	6.6	16.9	6.8	100.8	74.9
9/14/2005	<0.1	13	3.28	3.44	0.06	10	ND	ND	1.43	470	112	8.4	10.6	7.3	106.3	82.0
10/20/2005		3	2.46	3.3	ND	ND	ND	ND	6.25	300	49	7.1	8.5	7.2	92.7	65.7
1/4/2006	4	4	11.7	3.55	ND	117	ND	11	5.10	ND	74	10.8	3.4	7.1	37.7	86.7
2/8/2006	2	2	9.37	2.79	0.070	43	ND	33	5.73	70	54	11.8	3.1	7.0	47.4	95.3
4/26/2006	1.5	ND	8.02	2.28	ND	41	ND	ND	4.09	150	42	10.7	6.6	6.7	34.6	94.5
9/11/2006		2	3.61	3.46	0.059	ND	ND	16	0.863	520	75	5.9	10.2	7.1	114.8	57.9
Lamb Creek 01CK040020																
12/4/2004		<1.0						31		350	74					
6/30/2005	<0.5	ND	2.56	4.51	0.08	70	ND	20	5.48	100	61	9.3	12.0	7.5	149.1	94.7
7/27/2005	<0.25	2	9.81	4.36	0.09	70	ND	60	5.48	160	92	8.5	19.0	7.6	141.6	99.6
8/24/2005	<0.1	7.25	8	4.22	0.09	ND	ND	30	4.33	320	163	7.7	17.1	7.4	157.5	87.5
9/14/2005	<0.1	2	5.3	4.02	0.09	ND	ND	ND	4.14	430	151	7.0	12.9	7.3	183.4	72.6
10/20/2005		ND	1.11	5.28	0.13	ND	ND	60	8.77	270	60	7.8	8.9	7.5	165.1	73.2
1/4/2006	2	4	11.7	6.07	0.056	371	ND	66	5.49	ND	124	10.9	3.3	7.6	56.1	87.9
2/8/2006	1.25	ND	9.35	5.14	0.070	204	ND	65	5.66	ND	105	11.9	3.2	7.4	82.7	96.1
4/26/2006	0.5	ND	7.13	4.75	0.076	116	ND	ND	3.86	160	84	11.6	7.5	7.3	59.1	104.6
9/11/2006		4	7.34	3.87	0.055	ND	ND	15	2.79	240	194	1.4	8.6	7.0	211.0	13.1
Porter Creek 01CK040030																
6/30/2005	<0.25	3	4.61	2.06	0.11	110	ND	40	9.1	130	90	8.9	12.8	7.6	119.8	91.3
7/27/2005	<0.25	13	2.63	2.17	0.12	270	ND	110	9.18	150	123	7.1	15.8	7.4	177.3	78.0
8/24/2005	<0.1	3.51	16	2.23	0.12	40	ND	80	8.8	170	116	6.5	13.7	7.2	184.9	69.2
10/20/2005		ND	1.22	2.68	0.11	ND	ND	100	9.41	170	90	8.3	9.0	7.6	166.5	78.6
1/4/2006	0.75	14	19.3	3.23	0.061	927	ND	56	8.00	320	136	11.0	2.7	8.2	71.6	86.9
2/8/2006	0.25	3	12.3	3.11	0.069	666	ND	56	8.95	ND	106	12.3	3.1	7.9	92.0	99.0
4/26/2006	0.25	4	7.17	3.00	0.077	270	ND	ND	6.50	280	72	11.1	7.1	7.5	64.8	99.6
West Discharge Pipe																
5/26/2005		6.98	9	2.03	0.051	ND	ND	12	7.99	660	47	--	–	--	--	--
6/21/2005		ND	8.41	0.82	0.07	ND	ND	ND	9.09	460	34	--	–	--	--	--
8/18/2005		17	11.3	1.05	0.08	ND	ND	22	16	160	48	--	–	--	--	--

Appendix C. Coeur d'Alene River Flow to Black Lake

Black Lake is connected to the Coeur d'Alene River and, depending on the water surface elevation of the river with respect to that of the lake, the river can discharge into the lake, thus, becoming a source of flow and total phosphorus (TP) loading.

To determine the daily flows that are contributed from the Coeur d'Alene River to Black Lake, a spreadsheet was created to perform a mass balance estimation. Input to the spreadsheet included:

1. **Daily Coeur d'Alene River and Black Lake water surface elevations**. With the absence of structures controlling the flow from the lake to the Coeur d'Alene River and vice versa, the water surface elevations for both water bodies should be equal. It was assumed that the lake/river system "equilibrates" within a day and, thus, the water surface elevations of those two bodies were considered equal on any given day. Surface elevations for the Coeur d'Alene River were assumed equal to those measured at USGS gage 12413860 (Coeur d'Alene River near Harrison Idaho), which is located about 3 miles downstream of the Black Lake mouth. Stage data for the Harrison gage were only available for the period October 2004-September 2006. Thus, the following procedure was used to obtain daily water surface elevations for the entire model period (January 2000 to December 2005).

    a. A flow regression was performed using data for the Harrison gage and an upstream gage at Cataldo (12413500). The gage at Cataldo, located approximately 22 miles upstream of the lake mouth, was selected because it is the only gage in the vicinity with a complete record for the modeling period. A regression was performed for the period October 2005 to March 2006, the period for which flow data have been reported for the Harrison gage by USGS. Figure C-1 depicts the results of the flow regression.

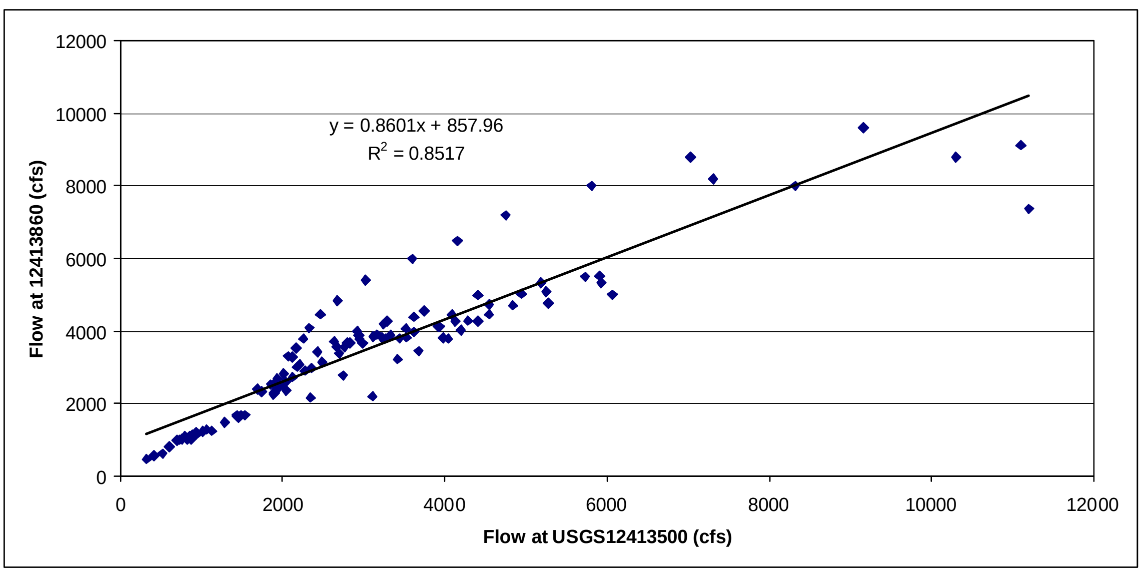


Figure C-1. Flow Regression between Cataldo and Harrison USGS Gages

b. A rating curve for the Harrison gage was derived using flow and stage data for the period November 2005 to April 2006 as obtained from USGS. The resulting rating curve is shown in Figure C-2.

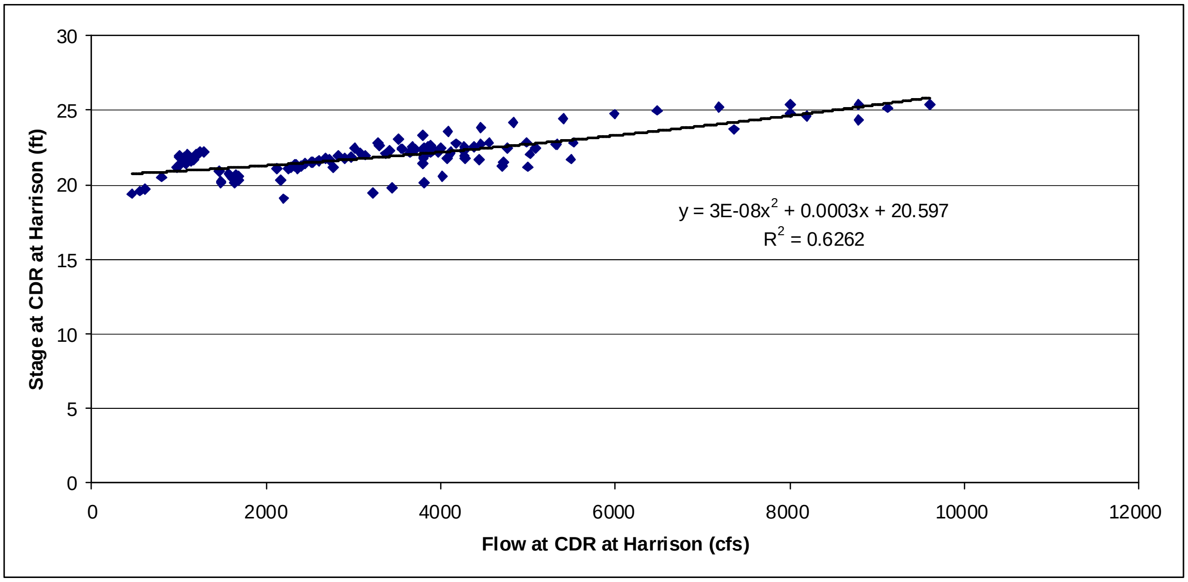


Figure C-2. Rating Curve for the USGS Gage in CDR at Harrison

c. Stage elevations for the period January 2000-September 2003 were calculated using the regressions described in b and c, while reported daily stage elevations were used for the period October 2003-December 2005. In both cases, the water surface elevation of the Coeur d'Alene River was calculated by adding the gage elevation (2,100 feet above mean sea level) to the stage data.

2. **Daily Black Lake volumes**. Water surface elevation-surface area and water surface elevation-volume relationships for Black Lake were developed in ArcGIS using bathymetry data and digital elevation model data. Figure C-3 shows the obtained relationships. For a given day, the lake volume was estimated using the water surface elevation obtained in (1) and the rating curve.

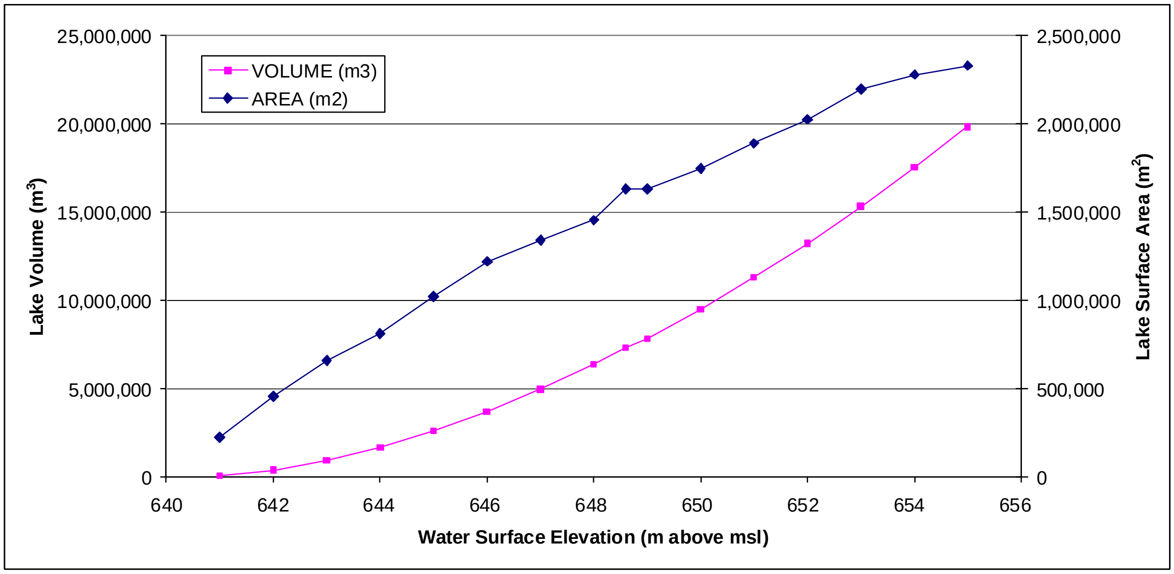


Figure C-3. Rating Curves for Black Lake

3. **Daily inflows from the three major tributaries and the pastures**. In this case, monthly runoff flows expressed as m^3/day were assumed constant throughout a given month. A summary of daily flows by monthly for the various tributaries is presented in Table C-1.

Table C-1. Flow Rates from Tributaries to Black Lake (m^3/day)

Year	Month	Lamb Creek	Black Creek	Porter Creek	West Pasture	East Pasture
2000	January	14,640	22,711	6,631	4,429	4,590
	February	18,742	29,222	9,177	6,464	6,450
	March	0	0	0	0	0
	April	473	0	0	0	0
	May	458	0	0	0	0
	June	473	0	0	0	0
	July	0	0	0	0	0
	August	0	0	0	0	0
	September	473	634	0	0	0
	October	1,830	2,455	553	201	353
	November	3,782	5,708	1,427	624	912
	December	2,288	3,069	829	201	353
2001	January	3,203	4,297	1,105	403	530
	February	7,598	12,232	3,059	1,783	2,150

Year	Month	Lamb Creek	Black Creek	Porter Creek	West Pasture	East Pasture
	March	0	0	0	0	0
	April	946	634	285	0	0
	May	0	0	0	0	0
	June	0	0	0	0	0
	July	0	0	0	0	0
	August	0	0	0	0	0
	September	0	0	0	0	0
	October	3,203	3,683	1,105	403	530
	November	7,564	12,051	3,140	1,664	2,007
	December	20,588	32,532	9,117	6,040	6,356
2002	January	26,078	40,511	11,604	7,650	7,945
	February	8,611	13,591	3,671	2,006	2,346
	March	15,098	23,325	6,355	3,624	4,237
	April	473	0	0	0	0
	May	458	0	0	0	0
	June	0	0	0	0	0
	July	0	0	0	0	0
	August	1,373	1,228	276	0	177
	September	0	0	0	0	0
	October	0	0	0	0	0
	November	946	634	285	0	0
	December	7,320	11,049	3,039	1,611	1,766
2003	January	12,810	19,642	5,526	3,422	3,708
	February	5,065	7,475	2,141	1,114	1,368
	March	5,490	7,980	2,210	1,007	1,236
	April	0	0	0	0	0
	May	0	0	0	0	0
	June	0	0	0	0	0
	July	0	0	0	0	0
	August	1,373	1,228	276	0	177
	September	0	0	0	0	0

Year	Month	Lamb Creek	Black Creek	Porter Creek	West Pasture	East Pasture
	October	0	0	0	0	0
	November	5,200	7,611	1,998	832	1,095
	December	10,065	15,959	4,421	2,617	2,825
2004	January	13,268	20,870	5,802	3,825	4,061
	February	13,170	21,067	5,812	3,566	3,909
	March	915	614	276	0	0
	April	0	0	0	0	0
	May	4,575	6,752	1,658	805	1,059
	June	0	0	0	0	0
	July	0	0	0	0	0
	August	3,660	5,524	1,381	805	883
	September	0	0	0	0	0
	October	915	1,228	276	0	177
	November	1,891	2,537	571	208	365
	December	8,693	13,504	3,592	2,013	2,295
2005	January	16,928	25,780	8,289	5,838	5,650
	February	0	0	0	0	0
	March	6,863	10,435	2,763	1,208	1,589
	April	0	0	0	0	0
	May	1,373	1,228	276	0	177
	June	0	0	0	0	0
	July	0	0	0	0	0
	August	0	0	0	0	0
	September	0	0	0	0	0
	October	5,033	7,980	1,934	1,208	1,412
	November	8,037	12,051	3,140	1,664	2,007
	December	8,693	13,504	3,868	2,416	2,472

The spreadsheet was used to calculate the delta in lake volume for any two consecutive days and to compare it to the sum of volumes coming from the tributaries on a daily basis. The flow from the Coeur d'Alene River was then calculated as the difference between ΔVolume and the sum of tributary inflows. If the resulting Coeur d'Alene River flow was positive, it was assumed that the river was discharging to the lake. Table C-2 presents a summary of monthly flows derived using the spreadsheet.

Table C-2. Summary of Monthly Inflows to Black Lake[a]

Year	Month	Average Lake Volume (m3)	Average Δvol (m3)	Tributary Input (m3/month)	Coeur d'Alene River input (m3/month)
2000	January	4,267,972	-4,260	1,643,050	149,614
	February	4,437,293	13,222	1,961,521	614,443
	March	4,735,546	8,246	0	1,317,414
	April	6,934,656	18,352	14,183	13,521,481
	May	5,025,310	-21,883	14,183	1,507,568
	June	4,454,188	-12,781	14,183	127,336
	July	4,206,129	-4,123	0	0
	August	4,177,269	0	0	0
	September	4,177,269	0	33,211	0
	October	4,177,269	0	167,161	0
	November	4,177,269	0	373,629	0
	December	4,177,269	0	208,937	0
2001	January	4,177,269	0	295,638	0
	February	4,177,269	0	751,029	0
	March	4,255,603	4,123	0	383,426
	April	4,576,317	44,788	55,959	2,035,167
	May	4,816,947	-43,343	0	1,088,016
	June	4,253,954	-4,260	0	0
	July	4,177,269	0	0	0
	August	4,177,269	0	0	0
	September	4,177,269	0	0	0
	October	4,177,269	0	276,609	0
	November	4,211,351	0	792,805	304,145
	December	4,222,621	0	2,313,620	106,351
2002	January	4,735,332	4,123	2,907,449	4,876,918
	February	4,545,488	13,694	846,295	2,619,020
	March	4,541,772	0	1,631,786	1,093,752
	April	6,974,371	32,007	14,183	18,772,386
	May	6,687,247	55,552	14,183	9,809,224
	June	5,036,911	-97,931	0	396,535

Year	Month	Average Lake Volume (m3)	Average Δvol (m3)	Tributary Input (m3/month)	Coeur d'Alene River input (m3/month)
	July	4,251,481	-8,246	0	0
	August	4,177,269	0	94,643	0
	September	4,177,269	0	0	0
	October	4,177,269	0	0	0
	November	4,177,269	0	55,959	0
	December	4,197,883	0	768,304	103,025
2003	January	4,432,675	42,920	1,398,348	2,628,863
	February	4,928,383	-42,954	480,608	7,020,675
	March	5,110,483	16,491	555,595	6,413,940
	April	4,855,638	-8,521	0	1,215,825
	May	4,490,606	0	0	511,234
	June	4,258,215	-12,781	0	0
	July	4,177,269	0	0	0
	August	4,177,269	0	94,643	0
	September	4,177,269	0	0	0
	October	4,177,269	0	0	0
	November	4,194,310	4,260	502,105	222,143
	December	4,222,621	-4,123	1,112,494	183,843
2004	January	4,218,498	20,614	1,482,580	495,567
	February	4,340,335	-13,222	1,330,676	240,853
	March	4,739,352	25,583	55,959	1,584,809
	April	5,177,455	-13,655	0	2,356,279
	May	4,668,312	4,123	460,330	1,157,551
	June	4,450,364	-21,301	0	140,918
	July	4,181,392	-4,123	0	0
	August	4,185,515	0	379,870	115,555
	September	4,177,269	0	0	0
	October	4,993,173	0	80,460	1,594,059
	November	4,518,966	30,259	167,161	1,641,189
	December	5,005,965	-25,160	932,996	742,109
2005	January	4,325,506	20,614	1,937,019	1,154,725

Year	Month	Average Lake Volume (m3)	Average Δvol (m3)	Tributary Input (m3/month)	Coeur d'Alene River input (m3/month)
	February	4,254,867	-41,081	0	0
	March	3,870,723	50,743	708,573	1,651,468
	April	5,380,967	4,697	0	704,590
	May	5,712,351	9,091	94,643	275,730
	June	5,831,904	4,697	0	281,836
	July	5,825,995	-4,546	0	140,918
	August	5,789,629	0	0	0
	September	5,620,527	-18,789	0	0
	October	4,981,544	-21,460	544,562	123,352
	November	4,377,503	-21,301	806,988	100,909
	December	3,577,507	20,614	959,516	1,169,234

a All calculations were performed on a daily-basis. Monthly values are presented only to give an indication of the magnitude of the flows.

Appendix D. Black Lake Water Quality Data

Table D-1 Black Lake Historical Nutrient Data

TP (mg/L)

Source	Original Source	Date	Site	Depth (m)	Concentration (mg/L)				
					Actual Value	Min	Max	Mean	Count
Sept 11, 2000 Tetra Tech Memo (Black Lake Review) from John Craig and Jessica Koenig to Jane Carlin	STORET	Jun 83 - Oct 85	200235	--	--	0.98	1.78	1.38	2
	STORET	Jun 83 - Oct 86	200236	--	--	0.029	0.31	0.157	9
	STORET	Jun 83 - Oct 87	200237	--	--	0.01	0.13	0.056	13
	STORET	Jun 83 - Oct 88	200238	--	--	0.006	0.11	0.046	8
	STORET	Jun 83 - Oct 89	200245	--	--	0.01	0.1	0.029	10
	STORET	Jun 83 - Oct 90	200246	--	--	0.01	0.11	0.033	8
	STORET	Jun 83 - Oct 91	200247	--	--	0.01	0.06	0.026	8
	STORET	Jun 83 - Oct 92	200248	--	--	0.01	0.114	0.038	25
	STORET	Jun 83 - Oct 93	200249	--	--	0.01	0.15	0.037	23
	STORET	Jun 83 - Oct 94	200250	--	--	0.01	0.18	0.058	8
NA	USGS	8/7/1991	472656116394000	1	0.015	NA	NA	NA	NA
NA	USGS	8/7/1991	472656116394000	4.5	0.077	NA	NA	NA	NA
Sept 11, 2000 Tetra Tech Memo (Black Lake Review) from John Craig and Jessica Koenig to Jane Carlin	IDEQ	8/24/1997	2000246	Deep	0.135	NA	NA	NA	NA
	IDEQ	8/24/1997	2000246	Shallow	0.063	NA	NA	NA	NA
	IDEQ	8/7/1997	2000246	Mid-Lake	0.055	NA	NA	NA	NA
	IDEQ	8/7/1997	200235 or pipe A	--	0.53	NA	NA	NA	NA
	IDEQ	8/7/1997	2000236 or Pipe Mixing	--	0.33	NA	NA	NA	NA
NA	Black Lake CVMP	5/25/1998	Mid Lake Station	2	0.022	NA	NA	NA	NA
NA	Black Lake CVMP	5/25/1998	Mid Lake Station	bottom	0.052	NA	NA	NA	NA
NA	Black Lake CVMP	6/29/1998	Mid Lake Station	4.5	0.02	NA	NA	NA	NA
NA	Black Lake CVMP	6/29/1998	Mid Lake Station	bottom	0.026	NA	NA	NA	NA
NA	Black Lake CVMP	7/27/1998	Mid Lake Station	4	0.014	NA	NA	NA	NA
NA	Black Lake CVMP	7/27/1998	Mid Lake Station	bottom	0.025	NA	NA	NA	NA
NA	Black Lake CVMP	7/27/1998	Pump 1 Station	mid-column	0.012	NA	NA	NA	NA
NA	Black Lake CVMP	7/27/1998	Bell Swim Area	mid-column	0.012	NA	NA	NA	NA
NA	Black Lake CVMP	8/31/1998	Mid Lake Station	4	0.023	NA	NA	NA	NA
NA	Black Lake CVMP	9/21/1998	Mid Lake Station	1.5	0.027	NA	NA	NA	NA
NA	Black Lake CVMP	9/21/1998	Pump 1 Station	mid-column	0.024	NA	NA	NA	NA
NA	Black Lake CVMP	6/29/1999	Mid Lake Station	3.5	0.013	NA	NA	NA	NA
NA	Black Lake CVMP	6/29/1999	Mid Lake Station	bottom	0.028	NA	NA	NA	NA
NA	Black Lake CVMP	6/29/1999	Pump 1 Station	mid-column	0.017	NA	NA	NA	NA
NA	Black Lake CVMP	7/27/1999	Mid Lake Station	3.5	0.086	NA	NA	NA	NA
NA	Black Lake CVMP	7/27/1999	Pump 1 Station	mid-column	0.014	NA	NA	NA	NA
NA	Black Lake CVMP	8/30/1999	Mid Lake Station	3.5	0.027	NA	NA	NA	NA
NA	Black Lake CVMP	8/30/1999	Mid Lake Station	bottom	0.043	NA	NA	NA	NA
NA	Black Lake CVMP	8/30/1999	Pump 1 Station	mid-column	0.048	NA	NA	NA	NA
NA	Black Lake CVMP	9/28/1999	Mid Lake Station	2	0.034	NA	NA	NA	NA

Source	Original Source	Date	Site	Depth (m)	Concentration (mg/L)				
					Actual Value	Min	Max	Mean	Count
NA	Black Lake CVMP	9/28/1999	Mid Lake Station	bottom	0.036	NA	NA	NA	NA
NA	Black Lake CVMP	9/28/1999	Pump 1 Station	mid-column	0.026	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Mid Lake Station	2	0.016	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Mid Lake Station	bottom	0.026	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Mid Lake Station	4.7	0.036	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Mid Lake Station	bottom	0.029	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Mid Lake Station	2.5	0.025	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Mid Lake Station	bottom	0.025	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Pump 1 Station	mid-column	0.024	NA	NA	NA	NA
NA	Black Lake CVMP	7/24/2000	Pump 1 Station	mid-column	0.024	NA	NA	NA	NA
NA	Black Lake CVMP	8/28/2000	Pump 1 Station	mid-column	0.028	NA	NA	NA	NA
NA	Black Lake CVMP	5/29/2000	Bell Swim Area	mid-column	0.023	NA	NA	NA	NA
NA	Black Lake CVMP	7/24/2000	Bell Swim Area	mid-column	0.015	NA	NA	NA	NA
NA	Black Lake CVMP	8/28/2000	Bell Swim Area	mid-column	0.039	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/6/2001	01-Black Lake	--	0.028	NA	NA	NA	NA

Ammonia (mg/L)

Source	Original Source	Date	Site	Depth (m)	Concentration (mg/L)				
					Actual Value	Min	Max	Mean	Count
Sept 11, 2000 Tetra Tech Memo (Black Lake Review) from John Craig and Jessica Koenig to Jane Carlin	STORET	Jun 83 - Oct 85	200235	--	--	0.008	0.757	0.088	81
	STORET	Jun 83 - Oct 86	200236						
	STORET	Jun 83 - Oct 87	200237						
	STORET	Jun 83 - Oct 88	200238						
	STORET	Jun 83 - Oct 89	200245						
	STORET	Jun 83 - Oct 90	200246						
	STORET	Jun 83 - Oct 91	200247						
	STORET	Jun 83 - Oct 92	200248						
	STORET	Jun 83 - Oct 93	200249						
	STORET	Jun 83 - Oct 94	200250						
NA	USGS	8/7/1991	472656116394000	1	0.014	NA	NA	NA	NA
Sept 11, 2000 Tetra Tech Memo (Black Lake Review) from John Craig and Jessica Koenig to Jane Carlin	IDEQ	8/24/1997	2000246	Deep	0.41	NA	NA	NA	NA
	IDEQ	8/24/1997	2000246	Shallow	0.125	NA	NA	NA	NA
	IDEQ	8/7/1997	2000246	Mid-Lake	0.013	NA	NA	NA	NA
	IDEQ	8/7/1997	200235 or pipe A	--	0.216	NA	NA	NA	NA
	IDEQ	8/7/1997	2000236 or Pipe Mixing	--	0.19	NA	NA	NA	NA

TKN (mg/L)

Source	Original Source	Date	Site	Depth (m)	Concentration (mg/L) Actual Value	Min	Max	Mean	Count
Sept 11, 2000 Tetra Tech Memo (Black Lake Review) from John Craig and Jessica Koenig to Jane Carlin	STORET	Jun 83 - Oct 85	200235	--	--	0.026	1.4	0.548	112
	STORET	Jun 83 - Oct 86	200236						
	STORET	Jun 83 - Oct 87	200237						
	STORET	Jun 83 - Oct 88	200238						
	STORET	Jun 83 - Oct 89	200245						
	STORET	Jun 83 - Oct 90	200246						
	STORET	Jun 83 - Oct 91	200247						
	STORET	Jun 83 - Oct 92	200248						
	STORET	Jun 83 - Oct 93	200249						
	STORET	Jun 83 - Oct 94	200250						
NA	USGS	8/7/1991	472656116394000	1	0.3	NA	NA	NA	NA
NA	USGS	8/8/1991	472656116394000	4.5	1.4	NA	NA	NA	NA
Sept 11, 2000 Tetra Tech Memo	IDEQ	8/24/1997	2000246	Deep	0.91	NA	NA	NA	NA
(Black Lake Review) from John Craig	IDEQ	8/24/1997	2000246	Shallow	0.62	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/6/2001	01-Black Lake	--	0.198	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	8/30/2002	01CK040000U	--	0.66	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	8/30/2002	01CK040000L	--	0.43	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/18/2002	01CK040000U	--	0.51	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/18/2002	01CK040000L	--	0.49	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/23/2003	04-CK000000	--	0.01U	NA	NA	NA	NA

Nitrate (mg/L)

Source	Original Source	Date	Site	Depth (m)	Concentration (mg/L)				
					Actual Value	Min	Max	Mean	Count
NA	Coeur D'Alene Tribe	9/6/2001	01-Black Lake	--	0.005U	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	8/30/2002	01CK040000U	--	0.006	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	8/30/2002	01CK040000L	--	0.006	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/18/2002	01CK040000U	--	0.004	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/18/2002	01CK040000L	--	0.007	NA	NA	NA	NA

Nitrite (mg/L)

Source	Original Source	Date	Site	Depth (m)	Concentration (mg/L)				
					Actual Value	Min	Max	Mean	Count
NA	Coeur D'Alene Tribe	9/6/2001	01-Black Lake	--	0.01U	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	8/30/2002	01CK040000U	--	0.01U	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	8/30/2002	01CK040000L	--	0.01U	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/18/2002	01CK040000U	--	0.01U	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/18/2002	01CK040000L	--	0.01U	NA	NA	NA	NA
NA	Coeur D'Alene Tribe	9/23/2003	04-CK000000	--	0.005U	NA	NA	NA	NA

Notes: -- indicates not available
U indicates not detected at concentration shown
NA indicates not applicable

Table D-2 Black Lake Nutrient Data Collected by Coeur d'Alene Tribe 2002-2006

Date	TSS (mg/L)	Turbidity (NTU)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate as N (µg/L)	Nitrite as N (µg/L)	ortho-Phosphate as P (µg/L)	Sulfate (mg/L)	TKN (µg/L)	Phosphorous (µg/L)	Chlorophyll a (mg/L)	DO (mg/L)	Temp (°C)	pH (s.u.)	SpCond (µmhos/cm)	DO%	Secchi Depth (m)
Black Lake - 1 m from the top																	
8/30/02[a]					6	<10			660	42	3.6						
9/18/02[a]					4	<10			510	58	19.5						
12/04/04	<1.0						<1.0		620	49		9.28	3.88	7.13	60.5	77	1.9
5/26/05	4	2.29	3.13	0.05	ND	ND	7	7.89	540	26	0.56	8.9	17.43	7.74	64	101.5	2
6/21/05	ND	1.17	2.99	0.05	ND	ND	ND	7.73	230	10	1.48	9.02	20.03	7.64	67.7	109	2.5
8/18/05	4	4.14	2.97	0.06	ND	ND	10	7.36	390	32	1.21	8.5	21.5	7.6	64	--	1.6
10/5/05	7	4.77	2.92	0.07	10	ND	9	6.28	ND	35	--	7.3	13.36	7.39	77.4	75.4	1.4
8/25/06	3	1.31	2.87	ND	ND	ND	10	5.31	370	8							
Black Lake - 1 m from the bottom																	
8/30/02[a]					6	<10			430	42							
9/18/02[a]					7	<10			490	51							
12/04/04	<1.0						<1.0		550	57.5		9.29	3.89	7.18	60.3	77.1	
5/26/05	9	5.64	3.26	0.05	ND	ND	10	7.64	700	55	1.91	0.34	12.38	6.54	74	3.5	
6/21/05	ND	7.53	3.14	0.06	ND	ND	ND	7.06	610	72	4.78	2.82	15.17	6.65	77.5	30.8	
8/18/05	14	19.6	3	0.06	ND	ND	24	7.08	390	70	--	7	21.1	6.9	64	--	
8/25/06	3	2.69	2.98	ND	ND	ND	17	4.71	520	17							

Appendix E. Paleoenvironmental Analysis Summary

Paleolimnological Assessment of Water Quality Changes in Black Lake, Idaho

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Summary

Paleoenvironmental data from data from Black Lake suggest that the lake has been mesotrophic, i.e. moderate production, throughout the last 1000 years. However, significant changes have taken place in the lake after European settlement of the drainage basin in the early 1800's; most notable is a drastic reduction in aquatic macrophyte coverage in the lake and a likely switch from a macrophyte dominated lake to a pelagic one, i.e. a phytoplankton dominated lake. These changes have likely occurred as a result of land clearance, construction of a railway berm along the outlet, construction of the Post Falls Dam at the outlet of Cour d' Alene Lake and increased external/internal phosphorus loading. As a result of these activities, fossil pigment analyses suggest that the productivity of the lake has increased by approximately 300%, algal and invertebrate assemblages have shifted from littoral to pelagic, and the development of anoxia deepest parts of the lake basin is now more severe than it was in the distant past. Results from the most recent sections of the sediment core show some recovery of the lake since the late 1980's and are encouraging to suggest that further remediation of the trophic position of the lake may be possible.

Introduction

In order to investigate past changes in lake-water conditions in Black Lake, Idaho, physical, chemical and biological characteristics were examined from a single sediment core retrieved from the deepest profundal area of the lake. The core utilized was extracted from the lake on July 29, 2001 by J.C. Headwaters Inc. and was referred to as Core A in their April 2002 report to Tetra Tech Inc. Core analyses including ^{210}Pb dating, water and organic content and elemental phosphorus had been conducted on the core prior to it being shipped to Eco-Logic for further analysis. Sampling for the current study was thus restricted to the remaining sediment intervals delivered to Dr. J. Stockner of Eco- Logic Ltd in West Vancouver, BC.

A multi-proxy approach was used to infer past levels of productivity and ecological food-web structure in Black Lake. Past algal species composition was inferred using HPLC analysis of algal pigments preserved in the lake sediments. Planktonic and littoral invertebrate assemblages were reconstructed by extracting the remains of cladocerans, bryazoans and sponges from the sediments. Changes in the physical/chemical nature of the lake sediments were also investigated using elemental carbon (C) and nitrogen (N) analyses.

Study Site

Black Lake is part of the Cour d'Alene River drainage and is located in the flood plain of the Cour d' Alene River. Black Lake receives seasonal inputs from the river during spring flooding (freshet), although the magnitude of these annual inputs may have been altered over time through anthropogenic modification of the outlet of Black Lake, including the development of a railway berm. The lake has a surface area of roughly 3.8 km, a maximum depth of 7.3m and a mean depth of 4.3m. The Black Lake watershed is approximately 21 km^2 and has a variety of land uses. Presently, 58% of the basin is forested, while 38% is used for agriculture.

Toxic algal blooms were recorded in Black Lake in 1972, 1981, 1982, 1983, and 1985 (Kann and Falter, 1987). Water samples collected by the USGS in 1991 and the IDEQ in 1997 suggest that levels of P and N in the lake have been quite high in the past and that external loading from activities in the catchment and internal loading from lake sediments may be two major sources of mobilizing soluble reactive phosphorus into the lake.

Black Lake experiences weak periods of stratification from June through August, when water below 5m depth often becomes anaerobic (Kann and Falter 1987). Some mixing of the deeper water occurs periodically during strong wind events during the summer. The flushing rate and hydraulic residence time of the lake are high (1.4 yr^{-1} and 0.55yrs)

Methods

Sedimentary Elemental Composition

Elemental Carbon and Nitrogen composition of the sediment was analysed at the Soils Science Laboratory at the University of British Columbia, Vancouver, BC, Canada, using a Leco CN-2000® elemental analyzer with infrared detection of carbon (as CO_2) and thermal conductivity analysis of nitrogen. Samples were combusted at 1050^o C. Organic matter content of the sediment was estimated as twice the organic carbon content of the sediment (Meyers and Teranes 2001). Inorganic content of the sediment was calculated as the residual from total sediment less water content and organic content.

Cladocera

Cladoceran samples were prepared by deflocculating a known mass of wet sediment (~ 2 g) in 200 mL of 10% KOH solution at 70° C for 1 hr. Samples were then sieved through a 34 mm Nytex® mesh. Material retained on the mesh was washed into a vial and the volume was adjusted to 5 mL. 100 µL of this solution was plated onto microscope slides/cover-slips with glycerin jelly as a mounting medium. Slides were enumerated at 400X magnification. The entire sample under each cover slip was enumerated to avoid bias that could result from an uneven distribution of remains. Entire coverslips were enumerated until at least 100 remains had been identified. Taxonomy follows that outlined in Bos (2001).

Algal Pigments

Sedimentary pigments were extracted, filtered and dried under N_2 gas following the procedures of Leavitt et al. (1989). In order to improve the reproducibility of pigment extraction, well-mixed sediment sub-samples were freeze-dried under a hard vacuum (<0.1 Pa) for 72 h. Lipid-soluble (polar) pigments were extracted from the bulk sediments by soaking powdered sediments in a mixture of degassed acetone:methanol:water (80:15:5, by volume) for 24 h in the dark and under an inert N_2 atmosphere at 0^oC. Pigment concentrations were quantified by reversed-phase high performance liquid chromatography (RP-HPLC), which separates complex mixtures according to the relative attraction of individual pigments for the non-polar stationary phase (both coating and support material) and the polar mobile solvent phase.

Carotenoid, Chlorophyll (Chl), and pigment-derivative concentrations were quantified using a Hewlett-Packard 1050 HPLC system following the reversed-phase procedure of

Mantoura and Llewellyn (1983), as modified by Leavitt et al. (1989). The Hewlett-Packard (HP) 1050 system was equipped with a Rainin Model 200 Microsorb C-18 column (5-µm particle size; 10 cm length), an HP model 1050 scanning photodiode array spectrophotometer (435-nm detection wavelength), and an HP fluorescence detector (435-nm excitation wavelength, 667-nm detection wavelength). Analytical separation was achieved by isocratic delivery (i.e., no gradient) of mobile phase A (10% ion-pairing reagent in methanol) for 1.5 min at 1.5 ml min^{-1} and 21,000 kPa pressure, followed by a linear ramp to 100% solvent mixture B (27% acetone in methanol) over 7 min and isocratic hold for an additional 12.5 min. IPR was prepared as 7.7 g ammonium acetate and 0.75 g tertrabutyl ammonium acetate in 100 mL of deionize, distilled water. The column is re-equilibrated by a continued isocratic delivery for 3 min, a linear return to 100% solution A over 3 min, and a further isocratic hold for 12.5 min. An internal reference standard (3.2 mg $\cdot$ L^{-1}) of Sudan II (Sigma Chemical Corp., St. Louis, MO) was injected in each sample. This dye runs at a central, unique position on the chromatogram (near myxoxanthophyll), has carotenoid-like absorption characteristics (lambda max = 485, 442.5 nm in acetone), and allows correction for dilution and injection errors. If the reference peak area was different from expectations based on prior calibration, a percent deviation was calculated and used to correct all pigment peak areas. Reference peaks were typically within 10% of expectations.

Pigments isolated from sediments were compared to authentic standards obtained from US Environmental Protection Agency as well as those from uni-algal cultures of known pigment composition (Leavitt et al. 1989). Spectral characteristics and chromatographic mobility were used to establish tentative pigment identity (Leavitt et al. 1989). Acid and methyl derivatives of chlorophyllous pigments were created either by aqueous-alcohol extraction (chlorophyllides) or by acidification following the procedures of Leavitt et al. (1989). Not all fossil pigments were positively identified. We restricted our analysis to carotenoids characteristic of cryptophytes (alloxanthin), diatoms with chrysophytes and some dinoflagellates (fucoxanthin), mainly diatoms (diatoxanthin),chlorophytes and cyanobacteria (lutein-zeaxanthin), all cyanobacteria (echinenone), colonial cyanobacteria (myxoxanthophyll) colonial cyanobacteria of the group Nostocales (canthoxanthin) and purple sulfur bacteria (okenone), as well as the major *a*, *b*, and *c*-phorbins (chlorophyll derivatives). Lutein from green algae and zeaxanthin from cyanobacteria co-elute on our

HPLC system, therefore pheophytin *b*, a chemically-stable derivative of Chl *b* was used to identify the unique contributions of chlorophyte (green) algae. Similarly, okenone from phototrophic bacteria was present only at low concentrations, although its characteristic spectrum allowed confirmation of its presence in many sediment samples. Organic content of sediment was estimated by weight loss on ignition for 1 h at 500^{o}C (Dean 1974). Pigment concentration was expressed as nmoles pigment g^{-1} organic matter, an index that is linearly related to algal biomass in the water column (Leavitt and Findlay 1994).

Results

Sedimentary Elemental Composition

The elemental composition and water content of the sediment core remained stable from the lowermost sample at 100 cm up to near 50 cm (Figure 1). Based on ^{210}Pb dating, this change would have begun sometime during the mid to late 1800s. After this point percent carbon and nitrogen content of the core begin to gradually decline while the inorganic component of the sediment increases. Although %C and %N values begin to change at 50 cm, the ratio of C/N (an indicator of changes in sediment source or changing nutrient composition) increases only slightly until 40cm in the core, at which point the C/N ratio begins to increase abruptly eventually peaking at 26cm and declining to lower values near 14cm, although the C/N ratio remains slightly elevated compared to levels seen prior to 50cm. Inorganic content of the core, which may indicate erosion from catchment disturbance, remains elevated until the uppermost part of the core.

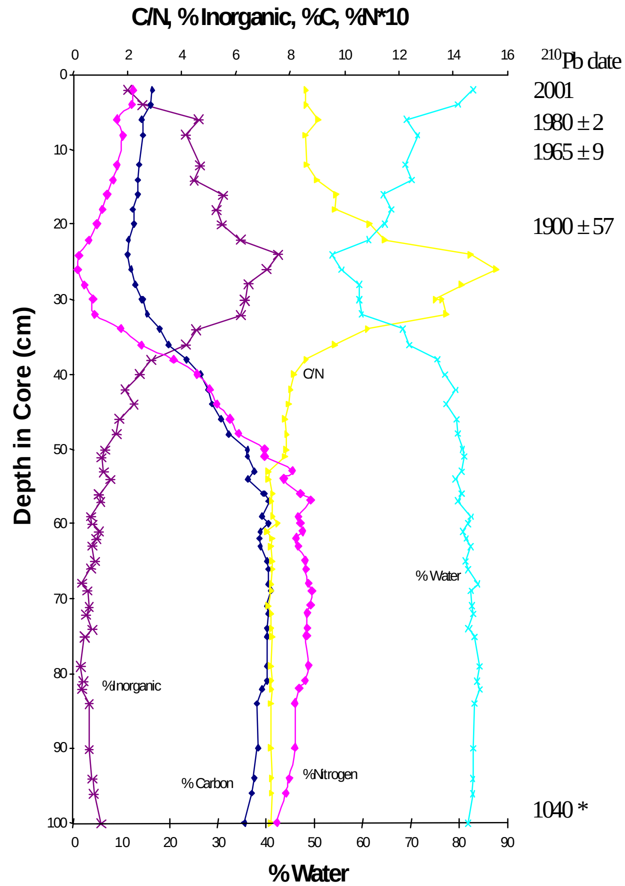

Figure 1. Elemental composition of core. Nitrogen values are magnified by one order of magnitude in order to show trends. ^{210}Pb dates are shown ± one standard deviation. *extrapolated date based on a sedimentation rate of 0.93mm per year from lowermost ^{210}Pb dated sections of the core.

Invertebrate Microfossils

Throughout the core, pelagic species dominate the cladoceran species assemblage (Figure 2). However, species associated with littoral and macrophyte habitats are common at the base of the core, but become much less abundant and some disappear entirely between 50 and 40 cm. *Daphnia cf dentifera* and *Sinobosmina* sp. are the two most abundant pelagic species found in the core. Early in the core the species assemblage is dominated by the larger-bodied *Daphnia*. However, coinciding with the change in C/N composition of the core, *Sinobosmina* rapidly increases in abundance after 40 cm and becomes the dominant cladoceran by 45cm.

Sponge spicules are abundant in the lowermost sediments of the core, generally they follow a similar pattern of decline seen for other littoral species, although the initiation of their decline precedes that of most other species and is generally more gradual. Bryazoans, are filter feeders like sponges, and although their remains were less common, they showed similar trends in abundance to the sponge microfossils.

Algal Pigments

Analysis of fossil pigments suggested that total algal production increased significantly during the period of time represented by the core (Figure 3). Concentrations of ubiquitous pigments (ß-carotene, Chl *a*, pheophytin *a*) all increased from minima deep in the core to historical maxima in the uppermost 20-25 cm. Both chemically-stable indicators of total algal abundance (ß-carotene, pheophytin *a*) exhibited marked increased in fossil concentration between 60 and 25 cm, followed by a plateau in more recent deposits. In contrast, labile indicator Chl *a* exhibited peaks at ~35 cm and in the uppermost 10 cm. Differences in timing of onset of increased fossil concentration may reflect minor differences in the preservation of individual biomarkers. For example, mid-core peaks in Chl *a* also correspond to maxima in okenone from sulfur bacteria, a reliable marker of intense deepwater anoxia and excellent pigment preservation. While changes in deepwater oxygen levels likely influence the relative preservation of labile and stable fossil pigments, the observation that both chemically-stable ß -carotene and easily-degraded Chl a exhibited similar increases in overall concentration during the core suggests that changes in fossil pigment concentrations reflect historical variations in algal abundance rather than artefacts of selective pigment preservation or deposition. Overall, analysis of wide-spread pigments suggests that total algal abundance since 1900 is approximately three-fold greater than historical (baseline) values.

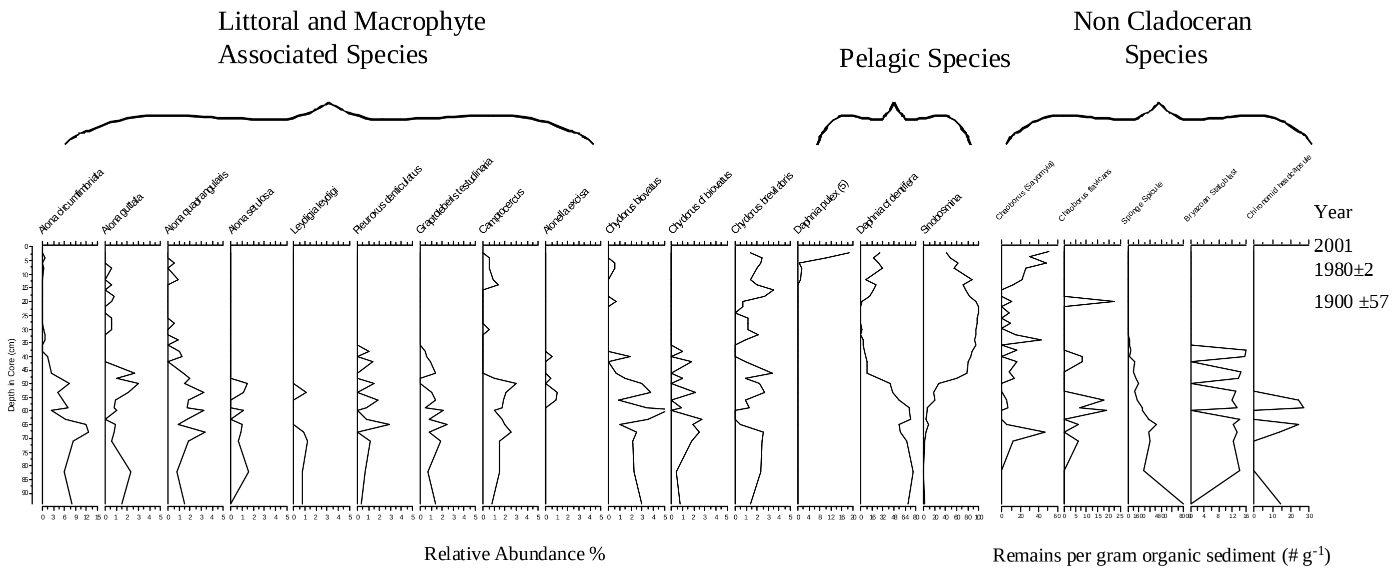

Figure 2. Invertebrate sedimentary remains. Cladoceran species composition is shown as relative abundance, while other species are shown in their absolute concentration.

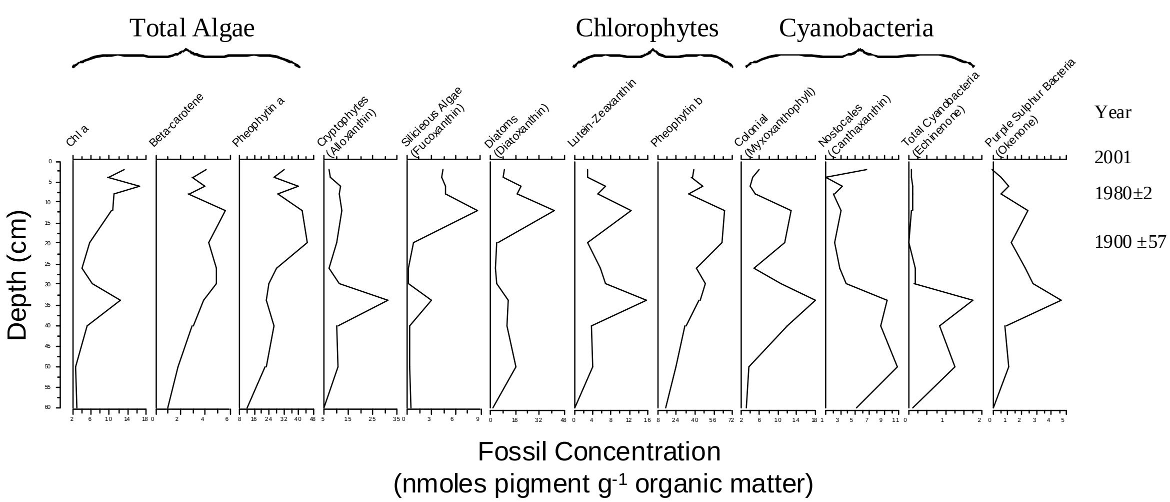

Figure 3. Sedimentary pigment concentrations. Note the reduced depth scale compared to figures one and two.

Despite our confidence in overall interpretations, changes in concentrations of fossil okenone from purple sulphur bacteria suggested that the stratification regime of Black Lake has varied in the recent past. For example, concentrations of okenone increased more than two-fold near 25 cm depth. Because these phototrophic bacteria require light for photosynthesis, yet are fatally poisoned by molecular oxygen, the presence of their pigments throughout the core suggests that light has always penetrated into anoxic bottom waters. Most commonly, this condition occurs when a lake is strongly or permanently stratified (meromictic), relatively transparent and when bottom waters are completely anoxic. However, increases in the deposition of okenone during 1960s-1980s suggest either that light penetration has recently improved, or that the lake has become more strongly stratified and that deepwater anoxia has become more profound. Presently, we cannot distinguish among these mechanisms. Regardless of the cause, we note that concentrations of okenone were always low when compared with values recorded from strongly stratified sites (e.g., Leavitt et al. 1989), suggesting that Black Lake exhibited only seasonal stratification.

Fossil pigment analyses suggested that the original algal communities were composed of mainly of chlorophytes (pheophytin *b*) and colonial cyanobacteria (myxoxanthophyll, canthaxanthin) (Figure 3; see also lutein-zeaxanthin). While siliceous algae (fucoxanthin, diatoxanthin) and cryptophytes (alloxanthin) are also present, fossil concentrations of these markers are low relative to those of bloom-forming green and blue-green algae. However, because the chemical stability in sediments varies among pigments, we suggest that these ratios should be interpreted with caution. Instead, trends of individual pigments should be interpreted with respect to the historical values observed for that compound alone (i.e., trends within pigment history). Regardless, the suite of fossil preserved in Black Lake is typical of those lakes in which cyanobacteria are abundant (e.g., Hall et al. 1999).

Concentrations of indicator pigments from siliceous algae (fucoxanthin, diatoxanthin) increased sharply in the uppermost 10-12 cm of sediment, consistent with elevated abundance of diatoms and possibly chrysophytes or dinoflagellates in the recent past (Fig. 1). The fact that labile fucoxanthin and chemically-stable diatoxanthin show very similar patterns suggests that fossil pigments are recording increased algal abundance, rather than changes in pigment preservation. This interpretation is further supported by the observation that this stratigraphic pattern is not seen with any other algae or bacterial compound. In contrast, pigments from chlorophyte algae (phaeophytin *b*) follow a pattern similar to that recorded by ubiquitous indicators of total algal abundance, with gradual increases in fossil concentration and inferred algal abundance from the base of the core to ~20 cm burial depth, followed by variable but high concentrations to the sediment-water interface.

In contrast to most other fossil pigments, carotenoids from cyanobacteria generally exhibited greatest values in deep or intermediate-level sediments, with lower concentrations of most compounds in the uppermost 25 cm. For example, echinenone, a chemically-stable indicator of total cyanobacterial abundance, was most abundant between 50 and 30 cm depth, with lower concentrations in both deeper and more recently deposited sediments. Similarly, myxoxanthophyll was most abundant at intermediate burial depths (40-15 cm), with distinctly lower concentrations in the uppermost 10-cm of sediment. Finally, while canthaxanthin from Nostocales cyanobacteria also exhibited recent increases in abundance in the uppermost sample, this pigment was also clearly more abundant in the past than at present. Because there is no clear association between inferred abundance of cyanobacteria and the presence of okenone, it can be deduced that the stratigraphic patterns of past cyanobacterial populations are not artefacts arising from changes in the sedimentary preservation environment (Leavitt 1993). Instead, analysis of the fossil pigment record suggests that present-day cyanobacteria, although possibly exhibiting extensive populations, are less abundant than in the more distant past.

Discussion

In general, our paleoenvironmental reconstructions for Black Lake suggest that the lake has always been somewhat productive and that cyanobacteria have always been present in the lake, even occurring at higher levels in the distant past. Organic-matter specific concentrations of most carotenoids were intermediate to low values recorded in unproductive alpine lakes and high concentrations characteristic of eutrophic systems (e.g., Leavitt and Findlay 1994, Vinebrooke et al. 1998). This finding strongly suggests that mesotrophic conditions occurred throughout Black Lake's history. However, significant alterations have been made to the Black Lake ecosystem, and the current lake is likely quite different in ecological function, i.e. pelagic food-chain driven, from the lake that existed pre-European settlement.

Initial conditions in Black Lake were likely clear water with abundant macrophyte growth around the shorelines, deep light penetration into the water column and moderate levels of algal productivity, including ubiquitous benthic blue-green algae. This interpretation is supported by the diverse population of littoral and macrophyte associated cladoceran species found in the lowermost sections of the core, along with large populations of filter-feeding sponges and bryazoans. During this same period, overall indicators of algal productivity (Chl-a, ß-carotene and pheophytin-a) are relatively low and suggest lake productivity approximately one third of that observed in more recent times. The elemental composition of the sediment core suggests that conditions were relatively stable in the lake pre-European settlement. Levels of C, N, inorganic content and the C/N ratio were all stable for the lower 45 cm or 500 years of the sediment core that represent pre-contact.

Sponge spicules begin to decrease in abundance by 55 cm in the core and are the first sign that the lake had begun to depart from the relatively stable, clear water conditions that had been observed previously. Sponges are highly responsive indicators of environmental change due to their sensitivity to silt or other particulates that can clog their filter-feeding systems (Harrison 1974). Shortly after sponge abundance begins to decrease, littoral species of cladocerans begin to decline, while large planktonic *Daphnia* species begin to be replaced by smaller *Sinobosmina* species. Between 55cm and 40 cm, macrophyte associated species of Cladocera decline in abundance and many disappear entirely by 40cm. Sponge spicules are also drastically reduced by 40 cm depth. During this same time period there is a gradual increase in the inorganic content and C/N ratio of the sediment which often accompanies increased erosion from a lakes catchment (Meyers and Teranes 2001). Although, the depth of these samples precludes direct dating (^{210}Pb reaches background levels by 20cm) extrapolated dates based on constant sedimentation would put the age of 40cm depth in the late 1800s or early 1900's. These observed changes are consistent with destabilization of soils around the lake due to land clearance and potentially the construction of a railway berm along the outlet of the lake in the 1880s. The punctuated change in inorganic content, C/N ratio and the complete disappearance of littoral cladoceran species at 40 cm most likely coincides with the constructions of the Post Falls Dam in 1906. Alteration of water levels can have strong negative effects on littoral macrophyte communities, and the combined effect of damming with other disturbances in the catchment appears to have been sufficient to greatly reduce the macrophyte coverage in the lake and cause a shift from initial clearwater conditions to turbid waters where pelagic phytoplankton dominate rather than littoral benthic macrophytes (eg. Moss 1998, Scheffer et al. 1993).

Above 40 cm in the core levels of Okenone pigment increase in the core suggesting enhanced deepwater anoxia and potentially greater phosphorus regeneration from anoxic lake sediments e.g. internal P loading. This nutrient release may have been further exacerbated by nutrients released from submerged terrestrial vegetation that often accompanies dam formation. During this time period the concentration of all algal pigments increases, consistent with higher levels of productivity. At the same time inorganic content of the sediment and the C/N continue to increase showing even higher levels of disturbance in the basins catchment and likely even further enhancement of nutrient conditions in the lake from higher external TP loads. This increase in productivity was likely further enhanced by prolonged periods of deepwater anoxia and thus higher rates of ‘internal’ P loading and heightened nutrient regeneration within the lake.

By 15 cm (late 1940’s, early 1950’s) the C/N ratio decreases to levels close to those seen lower in the core, suggesting that the level of import of terrestrial material into the lake had been reduced significantly. However, the inorganic content of the sediment remained elevated, until relatively recently, potentially a result of continued shoreline erosion. Most algal pigments were elevated leading up to and including the 1980s, but have declined in the last few decades. Similarly, planktonic cladoceran species composition is returning to a community that is more similar to ones seen before European settlement. Together these indicators suggest that, productivity may be decreasing in Black Lake albeit to levels that are still well above those that would have occurred in the undisturbed lake.

During the 20^{th} century, various fish introductions have taken place in or near Black Lake, including kokanee, cutthroat trout, largemouth and smallmouth bass and northern pike. The combined effects of these introductions are undoubtedly complex; and this complexity along with the chronological coarseness of that segment of the core sampled make it nearly impossible to determine the effect of individual fish species introductions to lake food-web structure. Overall, the changes between *Daphnia* and *Bosmina* dominance in the lake are consistent with moderate levels of planktivory in the lowermost sections of the core, with much increased levels of planktivory occurring between 50 and 15 cm and then reduction in planktivory above 15cm that appears to be even less intense (*D. pulex* is larger than *D.* c.f. *dentifera*) than in the lowermost sections of the core. This pattern is consistent with an initial population of coldwater piscivorous fish in the lake and moderate levels of planktivory exerted from juvenile fish and minnows kept in check by large piscivores. Increases in planktivory likely would have resulted from decreased populations of large piscivores potentially as a result of increased deepwater anoxia (as indicated by increased okenone levels in sediment during this period). Decreases in planktivory in the uppermost sections of the lake may indicate a reduction in planktivorous fish either through environmental stress, or through the introduction of warm-water piscivores tolerant of lower lake water oxygen levels.

Consistent with the findings of Kann and Falter (1987) it appears that Black Lake has always had relatively high nutrient levels, probably maintained by a combination of internal and external phosphorus loading. However, Kann and Falter (1987) concluded that internal loading of phosphorus was not enough to cause toxic blooms. The data from sedimentary pigments support the hypothesis that productivity in the lake is now likely about 300% higher than it was in the past and that much of this productivity is a result of external loading of phosphorus. The modest retraction in productivity seen in the topmost sections of the core suggests that rehabilitation of the lake may be possible. The large watershed to lake area ratio (28:1) leads to rapid flushing and diminished TP retention of the lake and likely contributes to the decreasing levels of nutrients. However, restoration efforts will also need to address the loss of macrophytes in the lake, which likely enhances the potential for algal blooms. Current levels of anoxia in the lake may also contribute to higher levels of internal P-loading than would have occurred in the past.

Literature Cited

Bos, D.G. 2001. Sedimentary cladoceran remains, a key to interpreting past changes in nutrients and trophic interactions. Ph.D. Thesis, Queen's University, Kingston Ontario, Canada

Dean, W.E. 1974. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: Comparison with other methods, J. Sediment Petrol. 44: 242-248.

Hall, R.I., P.R. Leavitt, R. Quinlan, A.S. Dixit, and J.P. Smol. 1999. Effects of agriculture, urbanization and climate on water quality in the northern Great Plains. Limnol. Oceanogr. 43: 739-756.

Harrison, F.W. 1974. Sponges (Porifera: Spongillidae). *In* Hart, C., W. Jr., Fuller, S.L.H. Eds., Pollution ecology of freshwater invertebrates. Academic Press, New York, NY, pp. 29-66.

Kann, J., and C.M. Falter. 1987. Development of toxic blue-green algal blooms in Black Lake, Kootenai County, Idaho. Research Technical Completion Report 14-08-0001-G1014-05. Submitted to the U.S. Geological Survey, United States Department of the Interior.

Leavitt, P.R. 1993. A review of factors that regulate carotenoid and chlorophyll deposition and fossil pigment abundance. J. Paleolimnol. 9: 109-127.

Leavitt, P.R., and D.L. Findlay. 1994. Comparison of fossil pigments with 20 years of phytoplankton data from eutrophic Lake 227, Experimental Lakes Area, Ontario. Can. J. Fish. Aquat. Sci. 51: 2286-2299.

Leavitt, P.R., S.R. Carpenter, and J.F. Kitchell. 1989. Whole-lake experiments: The annual record of fossil pigments and zooplankton. Limnol. Oceanogr. 34: 700-717.

Mantoura, R.F.C., and C.A. Llewellyn. 1983. The rapid determination of algal chlorophyll and carotenoid pigments and their breakdown products in natural waters by reversed-phase high-performance liquid chromatography. Anal. Chim. Acta 151: 297-314.

Moss, B. 1998. Shallow Lakes; biomanipulation, eutrophication. Scope Newsletter no. 29.

Meyers, P.A. and J.L. Teranes. 2001. Sediment Organic Matter *In* W.M. Last and J.P. Smol (eds.). Tracking environmental change using lake sediments. Volume 2: Physical and Geochemical Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Rowan, D.J., J. Kalff, and J.B. Rasmussen. 1992. Profundal sediment organic content and physical character do not reflect lake trophic status, but rather reflect inorganic sedimentation and exposure. Can. J. Fish. Aquat. Sci. 49: 1431-1438.

Scheffer, M., S.H. Hosper, M.L. Meijer, B. Moss, and E. Jeppesen. 1993. Alternative equilibria in shallow lakes. Trends in Ecology and Evolution 8: 275-279.

Vinebrooke, R.D., R.I. Hall, P.R. Leavitt, and B.F. Cummming. 1998. Fossil pigments as indicators of phototrophic response to salinity and climatic change. Can. J. Fish. Aquat. Sci. 55: 668-681.

Appendix F. Modeling Approaches – GWLF and BATHTUB

The modeling approach for this TMDL consisted of a combination of watershed model runs using GWLF (Generalized Watershed Loading Function) and a water quality model for Black Lake using BATHTUB. GWLF was run for each of the watersheds flowing to the lake (including the East and West Pastures) and the outputs were used to feed the BATHTUB model. The calibrated BATHTUB model was subsequently used for deriving the load allocation for nonpoint sources. The following sections describe in more detail the modeling activities.

F-1 GWLF Modeling

The Generalized Watershed Loading Function (GWLF) (Haith et al. 1992) is a mechanistic model that estimates dissolved and total nutrient loads in streamflow from complex watersheds. The model can account for nutrient loads from both point sources and septic systems, in addition to runoff loads. Rural nutrient loads are transported in runoff water and eroded soil from various source areas, each of which is considered to have uniform properties (soil and land cover). The model computes runoff using the Soil Conservation Service Curve Number Equation and erosion is estimated using the Universal Soil Loss Equation. Dissolved loads are then calculated as the product of runoff and dissolved concentrations, while solid-phase rural nutrient loads are computed by multiplying monthly sediment yield (erosion by delivery ratio) by average sediment nutrient concentrations.

For modeling purposes, the Black Lake watershed was divided into five subwatersheds that correspond to the three major tributaries and two pastures (Lamb Creek, Black Creek, Porter Creek, West Pasture, and East Pasture). The model was run for each subwatershed separately using a seven-year period, starting in January 1999 and ending December 2005. The first year results were ignored to eliminate effects of arbitrary initial conditions, as recommended in the GWLF Manual (Haith et al. 1992).

GWLF Input Data

The GWLF model requires three types of data: weather, transport, and nutrients.

Weather

Weather information required by the model includes daily precipitation and temperature data. Daily records for the period 1999-2005 for the Saint Maries 1W NOAA station were obtained from the Interactive Numeric and Spatial Information Data Engine of Idaho (http://inside.uidaho.edu/).

Transport

Transport parameters include areas, runoff curve numbers for antecedent moisture condition II, and the erosion product KLSCP (Universal Soil Loss Equation parameters) for each runoff source. Additional required watershed transport parameters are groundwater recession and seepage coefficients, available water capacity of the unsaturated zone, sediment delivery ratio, monthly values for evapotranspiration cover factors, average daylight hours, growing season indicators, and rainfall erosivity coefficients. Initial values must also be specified for unsaturated and shallow saturated zones, snow cover, and five-day antecedent rainfall plus snowmelt.

Parameters needed for land use were obtained from the State Soil Geographic (STATSGO) Database compiled by Natural Resources Conservation Service (NRCS) (Schwarz and Alexander 1995). For each land use area shown in Table F-1, NRCS Curve Number (CN), length (L), and gradient of the slope (S) were estimated from intersected electronic geographic information systems (GIS) land use and soil type layers. Soil erodibility factors (K_k) were obtained from the STATSGO database (Schwarz and Alexander 1995). Cover factors (C) were selected from tables provided in the GWLF manual and a supporting practice factor (P) of 0.4 was used for all source areas for lack of detailed data. Area-weighted CN and K_k, $(LS)_k$, C_k, and P_k values were calculated for each land use area.

Table F-1. Land Use Parameters for GWLF

Tributary	Land Use	Area (ha)	CN	K_f	LS	P	C
Lamb Creek	Bare Rock/Sand/Clay	0.3	100	0.476	0.493	0.4	0.01
	Bare Soil	154.1	94	0.548	1.232	0.4	0.01
	Deciduous Forest	4.3	79	0.523	1.720	0.4	0.001
	Deciduous Shrubland	74.1	77	0.534	4.365	0.4	0.001
	Emergent Herbaceous Wetlands	0.1	78	0.549	1.117	0.4	0.001
	Evergreen Forest	368.9	79	0.513	6.428	0.4	0.001
	Grassland/Herbaceous	175.7	84	0.542	1.826	0.4	0.001
	Mixed Forest	55.6	79	0.518	6.843	0.4	0.001
	Open Water	7.1	0	0.494	3.211	0.4	0
	Pasture/Hay	349.6	84	0.542	2.913	0.4	0.01
	Small Grains	207.0	88	0.547	1.620	0.4	0.01
	Commercial/Industrial-impervious	6.4	95	0.540	2.062	0.4	0
	Commercial/Industrial-pervious	9.6	84	0.540	2.062	0.4	0.001
	Residential-impervious	1.1	86	0.511	2.805	0.4	0
	Residential-pervious	4.3	84	0.511	2.805	0.4	0.01
Black Creek	Bare Rock/Sand/Clay	0.1	100	0.425	1.348	0.4	0.01
	Bare Soil	64.8	94	0.486	1.584	0.4	0.01
	Deciduous Forest	4.5	79	0.473	3.200	0.4	0.001

Tributary	Land Use	Area (ha)	CN	K_f	LS	P	C
	Deciduous Shrubland	153.9	77	0.409	5.314	0.4	0.001
	Emergent Herbaceous Wetlands	0.2	78	0.507	1.525	0.4	0.001
	Evergreen Forest	1019.2	60	0.379	6.492	0.4	0.001
	Grassland/Herbaceous	97.8	84	0.476	2.978	0.4	0.001
	Mixed Forest	168.0	60	0.362	6.181	0.4	0.001
	Open Water	23.6	0	0.446	3.780	0.4	0
	Pasture/Hay	291.4	84	0.459	2.138	0.4	0.01
	Small Grains	53.5	88	0.488	1.848	0.4	0.01
	Transitional	0.3	86	0.182	4.455	0.4	0.01
	Woody Wetlands	0.2	77	0.549	0.482	0.4	0
	Commercial/Industrial-impervious	5.7	95	0.487	3.037	0.4	0
	Commercial/Industrial-pervious	8.6	84		3.037	0.4	0.001
	Residential-impervious	2.2	72	0.394	2.597	0.4	0
	Residential-pervious	8.8	69		2.597	0.4	0.01
Porter Creek	Bare Soil	23.9	94	0.548	0.734	0.4	0.01
	Deciduous Forest	3.7	79	0.483	4.660	0.4	0.001
	Deciduous Shrubland	66.0	77	0.499	6.809	0.4	0.001
	Emergent Herbaceous Wetlands	0.1	58	0.425	0.000	0.4	0.001
	Evergreen Forest	306.9	79	0.515	7.333	0.4	0.001
	Grassland/Herbaceous	62.6	69	0.473	7.302	0.4	0.001
	Mixed Forest	58.1	79	0.509	7.518	0.4	0.001
	Open Water	3.8	0	0.440	6.192	0.4	0
	Pasture/Hay	237.1	84	0.525	4.656	0.4	0.01
	Small Grains	72.8	88	0.549	1.172	0.4	0.01
	Commercial/Industrial-impervious	6.4	95	0.520	3.070	0.4	0
	Commercial/Industrial-pervious	9.6	84	0.520	3.070	0.4	0.001
	Residential-impervious	1.1	86	0.497	3.971	0.4	0

Tributary	Land Use	Area (ha)	CN	K_f	LS	P	C
	Residential-pervious	4.3	84	0.497	3.971	0.4	0.01
West Pasture	Bare Rock/Sand/Clay	0.1	100	0.031	1.000	0.4	0.01
	Bare Soil	1.1	86	0.118	0.597	0.4	0.01
	Deciduous Forest	1.6	60	0.141	0.058	0.4	0.001
	Deciduous Shrubland	48.7	56	0.315	7.361	0.4	0.001
	Emergent Herbaceous Wetlands	0.7	58	0.031	0.054	0.4	0.001
	Evergreen Forest	254.0	79	0.401	12.592	0.4	0.002
	Grassland/Herbaceous	24.2	69	0.228	4.088	0.4	0.01
	Mixed Forest	38.9	79	0.410	11.388	0.4	0.001
	Open Water	20.9	0	0.052	0.753	0.4	0
	Pasture/Hay	164.8	79	0.177	2.161	0.4	0.01
	Small Grains	54.3	66	0.076	0.401	0.4	0.01
	Transitional	0.5	86	0.143	6.524	0.4	0.01
	Woody Wetlands	4.3	55	0.031	0.297	0.4	0
	Commercial/Industrial-impervious	1.2	92	0.131	0.497	0.4	0
	Commercial/Industrial-pervious	1.7	84	0.131	0.497	0.4	0.001
	Residential-impervious	1.4	72	0.059	0.602	0.4	0
	Residential-pervious	5.7	69	0.059	0.602	0.4	0.01
East Pasture	Bare Soil	1.9	94	0.549	4.378	0.4	0.01
	Deciduous Forest	3.3	60	0.421	2.414	0.4	0.01
	Deciduous Shrubland	30.7	56	0.449	4.262	0.4	0.001
	Emergent Herbaceous Wetlands	0.3	58	0.229	0.033	0.4	0.001
	Evergreen Forest	236.0	79	0.452	5.253	0.4	0.001
	Grassland/Herbaceous	31.0	69	0.455	3.553	0.4	0.001
	Mixed Forest	36.5	60	0.459	4.903	0.4	0.001
	Open Water	13.4	0	0.294	0.474	0.4	0.001
	Pasture/Hay	153.8	84	0.484	1.645	0.4	0
	Small Grains	20.9	88	0.474	2.569	0.4	0.01

Tributary	Land Use	Area (ha)	CN	K_f	LS	P	C
	Woody Wetlands	0.7	55	0.379	0.094	0.4	0.01
	Commercial/Industrial-impervious	3.3	92	0.486	2.661	0.4	0
	Commercial/Industrial-pervious	4.9	69	0.486	2.661	0.4	0.001
	Residential-impervious	2.2	72	0.447	2.687	0.4	0
	Residential-pervious	8.7	69	0.447	2.687	0.4	0.01

Monthly coefficients were assumed constant for all the subwatersheds as summarized in Table F-2. Coefficients for daily rainfall erosivity for non-growing and growing seasons were assumed as 0.03 and 0.15, respectively (coefficients provided in tables in the GWLF Manual). The growing season was assumed to go from April through October. Monthly average daylight hours for latitude of 42^o were obtained from the GWLF Manual (originally reported by Mills et al. 1985).

Table F-2. Monthly Coefficients for the GWLF Transport Dataset

Month	Evaporation Coefficient[a]	Mean daylight hours	Growing Season[b]	Erosivity Coefficient
January	1.0	9.3	0	0.03
February	1.0	10.4	0	0.03
March	1.0	11.7	0	0.03
April	1.0	13.1	1	0.15
May	1.0	14.3	1	0.15
June	1.0	15.0	1	0.15
July	1.0	14.6	1	0.15
August	1.0	13.6	1	0.15
September	1.0	12.3	1	0.15
October	1.0	10.9	0	0.03
November	1.0	9.7	0	0.03
December	1.0	9.0	0	0.03

[a] Assumed that foliage existed all year round due to the fact that the drainage areas are mainly forest

[b] 1 if the month corresponds to the growing season, 0 otherwise

Initial values for unsaturated and shallow saturated zones, snow cover, and five-day antecedent rainfall plus snowmelt were assumed within the ranges recommended in the GWLF Manual. It is noted, however, that because the first year of results was discarded, the effect of the initial conditions was eliminated.

Nutrients

Input data in this category include solid-phase nutrient concentrations in soil, dissolved P concentrations in groundwater, dissolved P concentrations in runoff for each individual non-urban land use, and P build-up rates for urban land uses. Because of lack of site-specific data for the previously mentioned parameters, the following assumptions were made:

- groundwater concentrations were assumed equal to the mean dissolved nutrient concentrations measured in streamflow by the National Eutrophication Survey (Omernik, 1977) and reported in the GWLF Manual;
- concentrations in soils and runoff were used as calibration parameters to match the observed TP concentrations and dissolved/total P ratios; the mass concentration of phosphorous in sediments was used in conjunction with the total suspended solids (TSS) concentrations in the ambient sampling to determine the particulate portion of the ambient TP attributable to suspended sediments; and
- nutrient build-up rates were assumed equal to those reported by Kuo et al. (1988) for Northern Virginia and included in the GWLF Manual.

A summary of the nutrient parameters is presented in Table F-3

Table F-3. Phosphorous Input Data for GWLF

Parameter	Lamb Creek	Black Creek	Porter Creek	West Pasture	East Pasture
Dissolved P in Runoff (mg/L)					
- Bare Rock/Sand/Clay	0.001	0.001	-	0.012	-
- Bare Soil	0.001	0.001	0.001	0.012	0.012
- Deciduous Forest	0.001	0.001	0.001	0.012	0.012
- Deciduous Shrubland	0.001	0.001	0.001	0.012	0.012
- Emergent Herbaceous Wetlands	0	0	0	0	0
- Evergreen Forest	0.001	0.001	0.001	0.012	0.012
- Grassland/Herbaceous	0.001	0.001	0.001	0.012	0.012
- Mixed Forest	0.001	0.001	0.001	0.012	0.012
- Open Water	0	0	0	0	0
- Pasture/Hay	0.15	0.15	0.2	0.3	0.3
- Small Grains	0.15	0.2	0.5	0.5	0.5
- Transitional	-	0.001	-	0.001	-
- Woody Wetlands	-	0	-	0	0
P Build-up Rates (kg/ha-day)					

Parameter	Lamb Creek	Black Creek	Porter Creek	West Pasture	East Pasture
- Commercial/Industrial Impervious			0.0112		
- Commercial/Industrial Pervious			0.0019		
- Residential-Impervious			0.0045		
- Residential - Pervious			0.0016		
P in Sediment (mg/kg)	14,000	13,000	8,000	1,000	1,400
P in Groundwater (mg/L)	0.0006	0.0006	0.0006	0.0006	0.0006

In addition to runoff loads, GWLF has the capability of including nutrient loads point sources and septic tanks in the subwatersheds. There are no point sources in the Black Lake watershed so none were included in the GWLF input. A number of septic tanks are located in the subwatersheds of the three tributaries and, thus, were included in the model. The number of septic tanks on each subwatershed was determined using the building shapefile provided by the Coeur d'Alene Tribe. The shapefile was processed to select one- and two-story buildings as well as mobile homes, all of which were assumed to have a septic tank. The shapefile was then intersected with a subwatershed shapefile to determine the number of septic tanks within each subwatershed. Septic systems can be input to GWLF under four different categories:

1. Short-circuited systems: located close enough to surface waters so that negligible adsorption of phosphorous occurs. Septic systems located within 20 meters of the streams (as determined using ArcGIS) were included in this category.
2. Normal systems: located within the subwatershed but outside of the 20-m buffer area and whose construction and operation conforms to recommended procedures.
3. Ponded systems: located within the subwatershed but outside of the 20-m buffer and exhibit hydraulic failure of the tank's absorption field resulting in surfacing of the effluent. Due to lack of site-specific data, failure rates were used as a calibration parameter (25% for Lamb Creek, 21% for Black Creek, and 100% for Porter Creek).
4. Direct discharge systems: illegal systems that discharge septic tank effluent directly into surface waters. It was assumed that there are no illegal systems in the Black Lake watershed.

Septic system input to GWLF include population served for each of the four categories, per capita tank effluent P load, and per capita growing season P uptake load. Table F-4 summarizes the septic tank data.

Table F-4. Septic Tank Data to GWLF

Parameter	Lamb Creek	Black Creek	Porter Creek
Total number of tanks	59	92	19
Total population served[a]	236	368	76
Effluent Flow (L/day)[b]	35,400	55,200	11,400
Population by category			
- Short-circuit systems	4	20	4
- Normal systems	172	272	0
- Ponding systems	60	76	72
- Direct discharge systems	0	0	0
Effluent P Concentration (mg/L)[c]	15		
Per capita P load (g/day)[d]	2.25		
Per capita growing season P uptake (g/day)[c]	0.5		

[a] Assuming 4 people/home
[b] Assumed system effluent flow 150 L/person/day (Woods 1991)
[c] From Woods (1991)
[d] 150 L/person/day * 15 mg/L = 2,250 mg/person/day

Input files for the five subwatershed models are included at the end of this Appendix.

GWLF Calibration and Output Data

The model was calibrated in three steps: flow, sediment yield, and P concentrations.

Flow

First, 6-year average runoff flows were compared to the average flows measured in 2004-2005 by the Coeur d'Alene Tribe and the transport parameters used for calibration were varied in a trial-and-error fashion, until the modeled flows reasonably matched the observed ones. Since there is no flow data for the Pastures the model was run assuming the calibrated transport parameters for the tributary subwatersheds. A comparison of average annual flow rates is shown in Figure F-1. It can be seen that the flow at Black Creek was slightly underestimated, while the flows at Lamb and Porter Creeks were overestimated. It is noted, however, that the flow data available for the different streams are very limited and do not include all the months of the year, while the GWLF model output considers monthly variation in flow based upon precipitation and evaporation data. Despite the limited data, it was concluded that the flow match was reasonable given the uncertainty in observed flows.

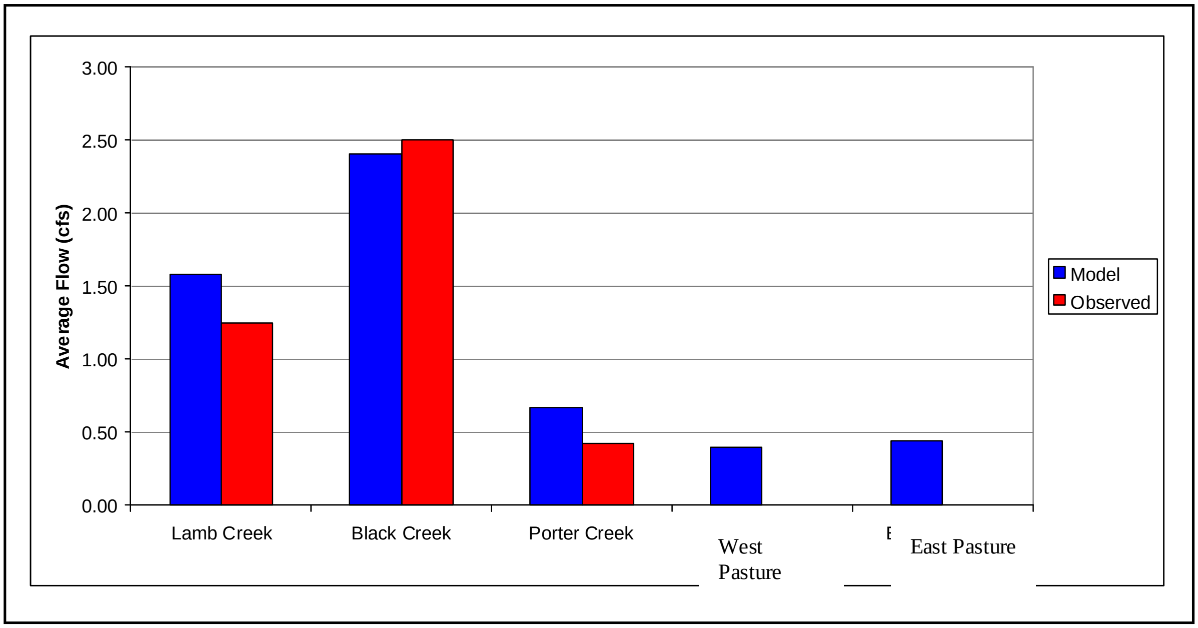

Figure F-1. Observed and Modeled Annual Average Flows

Sediment Yield

The GWLF model calculates sediment yield loads based on erosion and delivery ratios. Annual sediment yield loads for the various subwatersheds were converted to concentrations (using the calibrated flows). Subsequently, the 6-year averages were calibrated to the average TSS concentrations measured in the streams in 2004-2005 by changing the delivery ratios in a trial-and-error fashion. By making sure that the amount of sediment reaching the stream was within ranges comparable to observed data, the solid-phase P loads to the streams were considered within reasonable ranges. Figure F-2 shows a comparison of observed versus modeled TSS average concentrations. Total suspended concentrations were reasonably matched with errors less than 20% in all cases (errors varied from -9% to 17%).

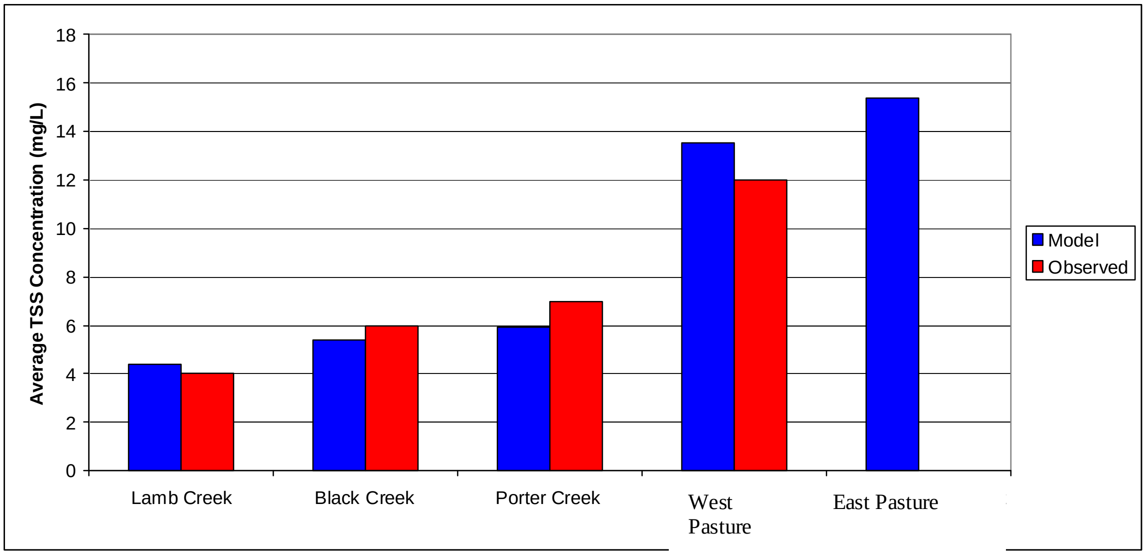

Figure F-2. Observed and Modeled Average TSS Concentrations

Phosphorous Concentrations

Six-year dissolved and total P concentrations were calibrated to average concentrations measured in 2004-2005 by the Coeur d'Alene Tribe. Soil concentrations were varied until the dissolved/total ratios matched those in the observed data. It is noted that the dissolved concentrations were assumed to be equal to the ortho-phosphorous concentrations. Figure F-3 depicts the TP results from the GWLF model. The model overpredicted the TP concentrations in all but one subwatershed, but model TP results were reasonable with errors between -8% and 26%.

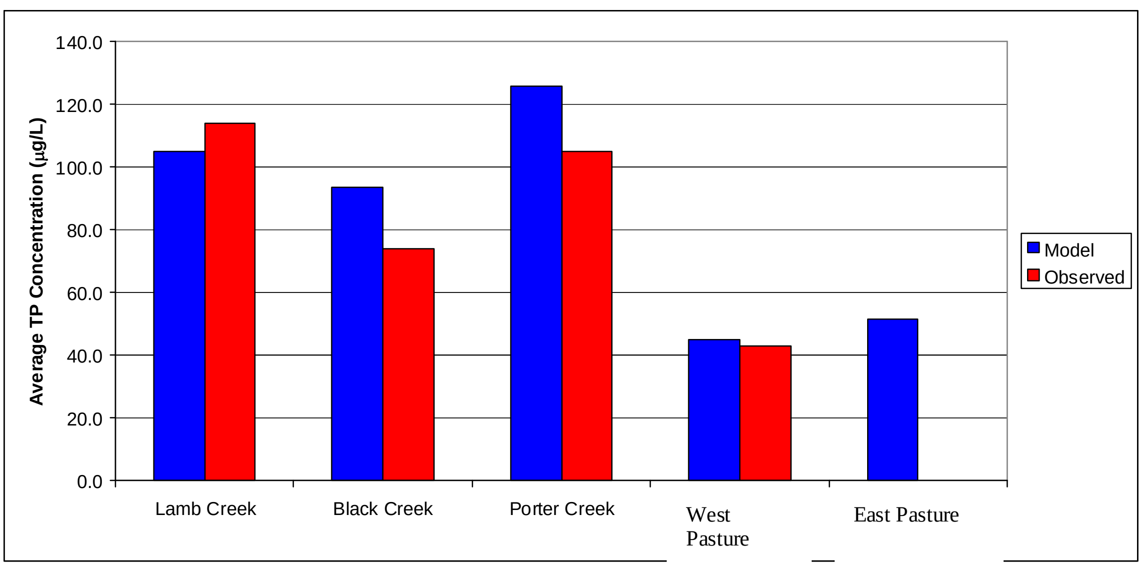

Figure F-3. Modeled and Observed TP Concentrations

Model output files for the five subwatersheds are included at the end of this Appendix.

Input to BATHTUB

As previously mentioned, the GWLF output data were used as an input to the BATHTUB water quality model for Black Lake. Data entered into BATHTUB included annual flow rates, dissolved P concentrations, and total P concentrations for the five subwatersheds. A summary of the GWLF results used to setup the BATHTUB model is included in Table F-5.

Table F-5. Annual Averages from Tributaries to Black Lake (from GWLF)

Subwatershed	Year	Flow (10^6 m^3/yr)	Concentrations (mg/L)	
			Dissolved Phosphorous	Total Phosphorous
Lamb Creek	2000	1.262	0.026	0.105
	2001	1.305	0.026	0.079
	2002	1.830	0.053	0.105
	2003	1.220	0.026	0.105
	2004	1.418	0.026	0.132
	2005	1.447	0.053	0.105
	6-yr Average	***1.414***	***0.035***	***0.105***
	CV[a]	***0.157***	***0.387***	***0.158***
Black Creek	2000	1.903	0.015	0.088
	2001	1.979	0.015	0.074
	2002	2.778	0.029	0.103
	2003	1.827	0.015	0.103
	2004	2.169	0.015	0.103
	2005	2.207	0.015	0.088
	6-yr Average	***2.144***	***0.017***	***0.093***
	CV[a]	***0.161***	***0.350***	***0.129***
Porter Creek	2000	0.565	0.044	0.133
	2001	0.540	0.089	0.089
	2002	0.771	0.089	0.133
	2003	0.497	0.044	0.133
	2004	0.591	0.089	0.133
	2005	0.634	0.089	0.133
	6-yr Average	***0.600***	***0.074***	***0.126***
	CV[a]	***0.160***	***0.310***	***0.144***

Subwatershed	Year	Flow (10^6 m^3/yr)	Concentrations (mg/L)	
			Dissolved Phosphorous	Total Phosphorous
West Pasture	2000	0.356	0.045	0.045
	2001	0.312	0.000	0.045
	2002	0.456	0.045	0.045
	2003	0.275	0.000	0.045
	2004	0.337	0.000	0.045
	2005	0.381	0.045	0.045
	6-yr Average	***0.353***	***0.023***	***0.045***
	CV[a]	***0.177***	***1.095***	***0.000***
East Pasture	2000	0.372	0.051	0.051
	2001	0.350	0.051	0.051
	2002	0.504	0.051	0.051
	2003	0.317	0.051	0.051
	2004	0.383	0.051	0.051
	2005	0.410	0.051	0.051
	6-yr Average	***0.390***	***0.051***	***0.051***
	CV[a]	***0.164***	***0.000***	***0.000***

[a] Coefficients of variation (CV) were calculated using the six annual values.

It is noted that the GWLF models were also calibrated to Total Nitrogen concentrations to obtain input data for BATHTUB that could aid in validating the calibration constants.

F-2 BATHTUB Modeling

BATHTUB is a U.S. Army Corps of Engineers model designed to simulate eutrophication in reservoirs and lakes. As a public domain model it has been applied to numerous lakes and reservoirs throughout the country, particularly in the Southeastern United States. BATHTUB has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited. The model incorporates several empirical equations of nutrient settling and algal growth to predict steady-state water column nutrient and chlorophyll-*a* concentrations based on water body characteristics, hydraulic characteristics, and nutrient loadings. The model allows diagnostic and predictive analysis on trophic state indicators in relation to user-defined reservoir framework and identification of factors controlling algal production. The Windows version of the BATHTUB model (V6.1) was used to predict water quality in Black Lake.

BATHTUB predicts steady-state concentrations of chlorophyll-*a*, Total Phosphorus (TP), Total Nitrogen (TN), transparency, and a conservative substance (e.g., chloride or a dye tracer) in a water body under various hydrologic and loading conditions. To do this, the model requires inputs that describe the physical characteristics of the water bodies (e.g., depth, surface area), tributary flow rates and loadings (which can be estimated by BATHTUB or input from another model), and observed water quality concentrations to use as calibration targets.

BATHTUB Model Setup and Input Data

The BATHTUB model relies on five key inputs: lake morphometry, weather data, inflows to the lake, atmospheric loads, and selection of empirical equations. For all numeric inputs, the model requires both a mean value and a coefficient of variation (CV). This is to express them in probabilistic terms to account for limitations in the data.

Lake Morphometry

BATHTUB allows the user to segment the reservoir or lake into a hydraulic network. The model requires basic lake morphometric data to access residence time and flow rate etc. In this TMDL study, a well-mixed lake of square shape was assumed. Based on availability of both flow and water quality data, a single segment was determined as sufficient. In addition, an averaging period of 1-year in the lake was used to depict the duration of mass-balance calculations (e.g. a single filling and emptying event in a year). The required morphometric information for BATHTUB model was derived from the volume-balance presented in Appendix C and summarized in Table F-6.

Table F-6. Annual Average Morphometric Characteristics of Black Lake

Year	Lake Volume (m^3)[a]	Surface Area (m^2)[a]	Mean Depth (m)[b]
2000	4,575,827	1,253,960	3.65
2001	**4,284,005**	**1,225,254**	**3.50**
2002	4,805,655	1,274,921	3.77
2003	4,475,438	1,243,739	3.60
2004	5,056,771	1,290,846	3.92
2005	4,964,505	1,285,607	3.86
6-YR AVG	***4,693,700***	***1,262,388***	***3.72***
CV	***0.064***	***0.020***	***0.044***

[a] Average of daily volumes for a given year as calculated using the volume-balance spreadsheet described in Appendix C

[b] Average of daily surface areas for a given year as calculated using the volume-balance spreadsheet described in Appendix C

[c] Annual average volume/Annual average surface area

Based on volume-balance calculations (Appendix C), the lowest annual flow from the Coeur d'Alene River to the Lake occurred in 2001. Thus, in order to be conservative in the overall TMDL calculation, the Coeur d'Alene River flow estimate for 2001 was used for BATHTUB modeling purposes because it represented the lowest dilution capacity during the available flow simulation period (2000 to 2005). Consequently, the average morphometry for 2001 was input to the model.

Weather Data

The BATHTUB model requires both precipitation and evaporation data. Precipitation data are available for both Saint Maries and Sand Point weather stations (Table F-7).

Table F-7. Annual Average Precipitation at Saint Maries and Sand Point Weather Stations

YEAR	TOTAL PRECIPITATION (m)	
	Saint Maries WS	Sand Point WS
2000	0.700	0.666
2001	**0.759**	**0.777**
2002	0.776	0.727
2003	0.773	0.855
2004	0.750	0.793
2005	0.675	0.673
6-yr Average	*0.739*	*0.748*
CV	*0.056*	*0.098*

Direct measurements of evaporation are available for Sand Point weather station (Table F-8), but not for Saint Maries weather station which is closer to Black Lake. Thus, lake evaporation rates for Saint Maries weather station were extrapolated from evaporation field measurements at Sand Point weather station by assuming the same ratio of evaporation to precipitation at both weather stations. Using this procedure, the annual mean evaporation for the Saint Maries weather station in 2001 was estimated as 0.718 meter.

Table F-8. Evaporation Measurement at Sand Point Weather Stations

YEAR	TOTAL EVAPORATION (m)
2000	0.557
2001	**0.735**
2002	0.743
2003	0.850
2004	0.564
2005	0.594
6-yr Average	*0.674*
CV	*0.178*

The coefficients of variation for both precipitation and evaporation were calculated using multi-year filed measurements.

Inflows to Black Lake

The mass-balance concept is fundamental to reservoir and lake eutrophication modeling. BATHTUB formulates water and nutrient balances by establishing a control volume, evaluating inflow, outflow, evaporation, and discharge, and by calculating the change in storage. In the BATHTUB model, the storage increase value is used only for completeness in the water and nutrient budgets. It does not influence predicted nutrient concentrations. In this TMDL model, lake inflow is assumed to be equal to outflow and, thus, there is no increase in storage.

The purpose of water quality modeling in BATHTUB is to provide a means of predicting ambient eutrophication response to nutrient concentrations from pollution sources. Three main sources of nutrients to Black Lake were identified: nonpoint sources from subwatersheds, loads from the Coeur d'Alene River, and septic systems in the vicinity of the lake. There are no point source discharges in the Black Lake watershed.

Nonpoint Loads from tributaries and Pastures

Nutrient nonpoint source loads from the three tributaries to the lake (Lamb Creek, Black Creek, and Porter Creek) and the two pastures were modeled as tributary inflows that discharge into Black Lake. The BATHTUB model was run using two completely different sources of data as inputs to develop a range for the load allocation and corresponding reduction goals. The two different data sources used are:

- Modeled annual average flows and concentrations from GWLF, and
- Annual average flows and back calculated concentrations from a 1987 report prepared by Jacob Kann and C. Michael Falter titled *"Development of Toxic Blue-Green Algal Blooms in Black Lake, Kootenai County, Idaho."* The values from this report are referred to as literature values or as Kann and Falter values.

Average annual flows and concentrations simulated using GWLF were used as inputs to the BATHTUB model which are summarized in Table F-9. In addition, the coefficient of variation of the annual GWLF results was calculated and input to BATHTUB.

Table F-9. Summary of Flow and Water Quality Data from GWLF Model Estimate

Year	Flow (million m^3/yr)	Concentrations (mg/L)			
		Total Phosphorous	Ortho-Phosphorous	Total Nitrogen	Inorganic Nitrogen
LAMB CREEK					
6-yr Average	*1.414*	*0.105*	*0.035*	*0.373*	*0.189*
CV	*0.157*	*0.158*	*0.387*	*0.113*	*0.137*
BLACK CREEK					
6-yr Average	*2.144*	*0.093*	*0.017*	*0.322*	*0.150*
CV	*0.161*	*0.129*	*0.350*	*0.114*	*0.097*
PORTER CREEK					
6-yr Average	*0.600*	*0.126*	*0.074*	*0.613*	*0.391*
CV	*0.160*	*0.144*	*0.310*	*0.133*	*0.132*
WEST PASTURE					

Year	Flow (million m^3/yr)	Concentrations (mg/L)			
		Total Phosphorous	Ortho-Phosphorous	Total Nitrogen	Inorganic Nitrogen
6-yr Average	*0.353*	*0.045*	*0.023*	*0.376*	*0.240*
CV	*0.177*	*0.000*	*1.095*	*0.124*	*0.153*
EAST PASTURE					
6-yr Average	*0.390*	*0.051*	*0.051*	*0.402*	*0.359*
CV	*0.164*	*0.000*	*0.000*	*0.149*	*0.156*

Key water quality parameters for BATHTUB input include TP, Ortho-P, TN, and inorganic N. BATHTUB model requires an estimate of inorganic nutrient factions for all nutrient loads to the lake. The inorganic nutrient factions for the sub-watershed loads were approximated from the ratios of dissolved nutrient load to total nutrient load predicted by GWLF for each year.

The literature values derived from the 1987 Kann and Falter report were used to establish an alternative BATHTUB model run are summarized in Table F-10. Only flow and concentration values were able to be deduced from the report for Black Creek, Lamb Creek and the East and West Pasture outfalls. Since TP and ortho-phosphorus values are necessary as inputs to BATHTUB and only TP values (expressed as annual average loads) were available in the Kann and Falter report, concentrations for both parameters were back calculated. An ortho-phosphorus to TP ratio of 0.3 was used to derive the ortho-phosphorus value.

Table F-10. Summary of Flow and Water Quality Data from Literature Values (1987 Kann and Falter Report)

	Annual Water Flow (million m3/yr)	Avg. TP Conc. (ug/L)	Avg. OP Conc. (ug/L) - 30%	Annual TP Loading (kg/yr)
Lamb Creek	2.362	87.6	26.3	206.8
Black Creek	4.523	48.2	14.5	218.1
West Pasture	1.059	120.0	36.0	127.1
East Pasture	0.824	259.8	77.9	214.1

Using these values it was possible to calculate a second pollutant load allocation scenario for some of the nutrient sources which presents a range for the load allocation and a range for the percent reduction goals for nonpoint sources to Black Lake.

Loads from the Coeur d'Alene River

As mentioned earlier, the lowest inflow from the Coeur d'Alene to Black Lake occurred in 2001. Thus, the 2001 flow was input to the model. In addition, average concentrations measured by USGS between 2003 and 2005 were used as model inputs. A summary of input parameters for the Coeur d'Alene River are provided in Table F-11.

Table F-11. Summary of Flow and Water Quality Data for Coeur D'Alene River

Annual Flow to the Lake (million m^3/yr)	Avg. Concentration (μg/L)	
	Total Nitrogen	Total Phosphorous
3.92	124	21

Septic tanks in the vicinity of Black Lake

Septic systems located within a 100-m buffer around Black Lake were assumed to be discharging directly to the lake and, thus, were input to the BATHTUB model as nutrient sources. Septic system input to BATHTUB includes total flow and dissolved P and N concentrations. The following assumptions were made to estimate the total direct septic system load to Black Lake:

- Septic systems located within 20 meters of the streams (as determined using ArcGIS) were assumed to be close enough to surface waters so that negligible adsorption of phosphorous occurs. Thus, the P load generated is directly discharged to the lake.
- 50% of the systems located within 50-m of the lake boundary but outside of the 20-m buffer were assumed to exhibit hydraulic failure of the tank's absorption field resulting in surfacing of the effluent and a load of P to the lake.
- The remaining 50% of the systems located within 50-m of the lake boundary but outside of the 20-m buffer area were assumed to have construction and operation that conform to recommended procedures, and, thus, they are no sources of P to the lake.
- The systems located within 100-m of the lake boundary but outside of the 50-m buffer area were assumed to be far enough from the lake that they do not represent a source of P to the lake.

Table F-12 summarizes the septic tank data.

Table F-12. Septic Tank Data to BATHTUB

Description	Phosphorous	Nitrogen
Number of septic tanks in the vicinity of Black Lake (100 m)	34	
Number of septic tanks discharging nutrients to the lake	15[a]	
Total Population	60[b]	
Total flow (million m^3/yr)	0.003[c]	
Per capita daily load (g/day)	2.25[d]	5.25[d]
Daily Uptake (g/day)	0.5[e]	1.6[f]
Total Load from Septics (kg/yr)	38.3[g]	79.9[g]
Concentration (mg/L)	11.7[h]	24.3[h]

[a] 9 systems located within 20 m of the lake boundary plus 50% of systems located between the 20-m and 50-m buffer lines (6 systems)

[b] Assuming 4 people/home

[c] Assumed system effluent flow 150 L/person/day (Woods 1991)
[d] 150 L/person/day * average concentration. Average concentrations are 15 mg/L for P and 35 mg/L for N.
[e] From Woods (1991)
[f] From GWLF Manual (Haith et al. 1992)
[g] Total population*(per capita daily load – daily uptake)/1000
[g] (per capita daily load – daily uptake)*1000/(150 L/person/day)
Highlighted rows correspond to BATHTUB input parameters

Internal loading rates reflect nutrient recycling from bottom sediments. Rates are normally set to zero in BATHTUB, since the pre-calibrated nutrient retention models already account for nutrient recycling that would normally occur. Nonzero values should be specified with caution and only if independent estimates or measurements are available. Because the sedimentation models within BATHTUB have been empirically calibrated, effects of internal loading or phosphorus recycling from bottom sediments are inherently reflected in the model parameter values and error statistics.

Atmospheric Loads

Atmospheric deposition can contribute some amount of TP and nitrogen load directly to a lake surface, particularly when the ratio of watershed area to lake surface area is low. Given the lack of site-specific data for TP and nitrogen from atmospheric deposition, default data from the BATHTUB model were used (Table F-13).

Table F-13. Estimate of Atmospheric Loads

Atmospheric Loads	Mean (mg/m^2-yr)	CV
Total P	30	0.5
Ortho P	15	0.5
Total N	1000	0.5
Inorganic N	500	0.5

Selection of Empirical Equations

BATHTUB consists of a series of empirical equations that have been calibrated and tested for reservoir application. These empirical relationships are used to calculate steady-state concentrations of TP, TN, chlorophyll-*a*, and transparency based on the inputs and forcing functions. To predict each output (e.g., TP concentration), one of several built-in empirical equations must be selected.

Based upon research results in BATHTUB User's Manual, a second-order decay model is the most generally applicable formulation for representing phosphorus and nitrogen sedimentation in reservoirs. There are two sub-models within the second-order decay model option for TP: (1) "*Second-Order, Available P*"; and (2) "*Second-Order Decay Rate Function*". Model 2 accounts for inflow nutrient partitioning by adjusting the effective sedimentation rate coefficient and is considered more physically reasonable. Therefore, the empirical equations selected for this TMDL modeling included "2nd order decay rate function" for phosphorus and nitrogen balance, "P, N, light, flushing" model for Chlorophyll-*a*, and "Secchi vs. Chlorophyll-*a* and turbidity" for transparency.

BATHTUB Output Data and Calibration Factors

Model Prediction of Water Quality Parameters for Black Lake

The predicted water quality concentrations by parameter are listed in Table F-14.

Table F-14. Summary of the Modeled Water Quality Parameters for Black Lake

Water Quality Parameter	Modeled Mean Concentration for Black Lake	CV
TOTAL P (µg/L)	36.3	0.16
TOTAL N (µg/L)	334	0.17
CHL-A (µg/L)	5.9	0.42
SECCHI (meter)	1.8	0.23

Application of Calibration Factors

As for field data that were used for calibration, TP and ortho-phosphorous were directly obtained from field measurements conducted between 2002 and 2006 by the Coeur d'Alene Tribe at both the top and bottom of the lake. TN and inorganic nitrogen concentrations were estimated based on other nitrogen species (nitrate plus nitrite, TKN and ammonia-N) also measured by the Tribe. The long-term average concentrations for these water quality parameters are shown in Table F-15.

Table F-15. Summary of Field Water Quality Parameters for Black Lake

Water Quality Parameter	Field Mean Concentrations for Black Lake
TOTAL P (µg/L)	41.6
TOTAL N (µg/L)	507
CHL-A (µg/L)	4.7
SECCHI (meter)	1.9

Since BATHTUB uses a set of generalized rates and factors, predicted concentrations versus actual field measurements may differ by a factor of two or more using the initial uncalibrated model. These differences reflect a combination of measurement errors in the inflow and outflow data, as well as unique features of the lake or reservoir being modeled.

In order to closely match actual in-lake condition with the predicted condition, BATHTUB allows the user to modify a set of calibration factors, which provide means for adjusting model predictions to account for site-specific conditions. Based on model prediction and actual field monitoring data, the calibration factor for TP is 1.15.

Conversion of Annual Average Loads (kg/yr) to Daily Loads (lbs/day)

BATHTUB was used to calculate and express the TMDL as an annual average phosphorus load (kg/yr) that if achieved should meet the water quality target. Given the transport, assimilation, and dynamics of nutrients both temporally and spatially, TP loading to Black Lake from a practical perspective must be managed on a long-term basis typically as pounds or kilograms per year. However, in response to a recent court decision often referred to as Anacostia decision which dictates that TMDLs include a "daily" load expression (*Friends of the Earth, Inc. v. EPA, et al.),* a method has been derived from the EPA 1991 Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001) (EPA 1991b) to address this concern. It is important to recognize that Black Lake's response to TP loading and the growing season is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response. As such it is important to note that expressing this TMDL in daily time steps could mislead the reader by implying a daily response to a daily load is practical from an implementation perspective.

As stated, the TMDL does set a total phosphorus allocation range of 617 to 1000 kg/year. To translate the long-term average to daily values the approach described in the Technical Support Document for Water Quality Based Toxics Control is provided below. The maximum daily load (MDL) equals the long term average (LTA) * exp(z*sigma-0.5*sigma^2). The data used in the TMDL has a coefficient of variation (CV) of 0.5. From the Technical Support Document, the 99th percentile occurrence probability for a CV of 0.5 is 2.68. Using these assumptions, the MDL = LTA*2.68. Therefore, the conversion of TP from an annual average load to a daily load would be:

Allocation Scenario 1: 220 kg/yr x 2.2 = 485 lbs/year ÷365 days/year * 2.68 = 3.6 lbs/day or
Allocation Scenario 2: 322 kg/yr x 2.2 = 708 lbs/year ÷365 days/year * 2.68 = 5.2 lbs/day

GWLF INPUT FILES

LAMB CREEK TRANSPORT PARAMETERS

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"NOV",1,9.7,0,0.03
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"Deciduous Forest",4.3,79,0.0004
"Deciduous Shrubland",74.14,77,0.0009
"Emergent Herbaceous Wetlands",0.13,78,0.0002
"Evergreen Forest",368.92,60,0.0013
"Grassland/Herbaceous",175.68,84,0.0004
"Mixed Forest",55.64,79,0.0014
"Open Water",7.14,6,0
"Pasture/Hay",349.57,84,0.0063
"Small Grains",206.97,88,0.0035
"Commercial/Industrial-impervious",6.42,95,0
"Commercial/Industrial-pervious",9.63,84,0
"Residential-impervious",1.08,86,0
"Residential-pervious",4.34,84,0

<u>LAMB CREEK NUTRIENT PARAMETERS</u>

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"Deciduous Forest",4.46,79,0.0006
"Deciduous Shrubland",153.87,77,0.0009
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"Small Grains",53.48,88,0.0036
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BLACK CREEK NUTRIENT PARAMETERS

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"Deciduous Forest",3.75,79,0.0009

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"Emergent Herbaceous Wetlands",0.13,78,0

"Evergreen Forest",306.89,60,0.0015

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"Mixed Forest",58.06,60,0.0015

"Open Water",3.82,6,0

"Pasture/Hay",237.05,84,0.0098

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PORTER CREEK NUTRIENT PARAMETERS

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"OCT",1,10.9,0,0.03
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"Bare Rock/Sand/Clay",0.06,100,0.0001
"Bare Soil",1.1,86,0.0003
"Deciduous Forest",1.62,60,0.0003
"Deciduous Shrubland",48.68,56,0.0009
"Emergent Herbaceous Wetlands",0.69,58,0.0007
"Evergreen Forest",253.99,79,0.004
"Grassland/Herbaceous",24.19,69,0.004
"Mixed Forest",38.94,79,0.0019
"Open Water",20.94,6,0
"Pasture/Hay",164.83,79,0.0015
"Small Grains",54.28,66,0.0001
"Transitional",0.45,86,0.0037
"Woody Wetlands",4.25,55,0
"Commercial/Industrial-impervious",1.16,92,0
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"Residential-impervious",1.43,72,0
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WEST PASTURE NUTRIENT PARAMETERS

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0,0,0,0

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0,0,0,0
0,0,0,0
5.2,2.25,1.6,0.5

EAST PASTURE TRANPORT PARAMETERS

```
11,4
0.1,0,0,0,0,0.3,10
0
0
0
0
0
"JAN",1,9.3,0,0.03
"FEB",1,10.4,0,0.03
"MAR",1,11.7,0,0.03
"APR",1,13.1,1,0.15
"MAY",1,14.3,1,0.15
"JUN",1,15,1,0.15
"JUL",1,14.6,1,0.15
"AUG",1,13.6,1,0.15
"SEP",1,12.3,1,0.15
"OCT",1,10.9,0,0.03
"NOV",1,9.7,0,0.03
"DEC",1,9,0,0.03
"Bare Soil",1.89,94,0.0096
"Deciduous Forest",3.33,60,0.0041
"Deciduous Shrubland",30.67,56,0.0008
"Emergent Herbaceous Wetlands",0.26,58,0
"Evergreen Forest",235.97,79,0.0009
"Grassland/Herbaceous",30.96,69,0.0006
"Mixed Forest",36.47,60,0.0009
"Open Water",13.37,0,0.0001
"Pasture/Hay",153.78,84,0
"Small Grains",20.93,88,0.0049
"Woody Wetlands",0.7,55,0.0001
"Commercial/Industrial-impervious",3.26,92,0
"Commercial/Industrial-pervious",4.89,69,0.0005
"Residential-impervious",2.16,72,0
"Residential-pervious",8.66,69,0.0048
```

EAST PASTURE NUTRIENT PARAMETERS

14000,1400,0.07,0.0006
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0.07,0.012
0.07,0.012
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0.07,0.012
0.07,0.012
0.07,0.012
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3,0.3
3,0.5
0,0
0.101,0.0112
0.012,0.0019
0.045,0.0045
0.012,0.0016
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0,0,0,0
0,0,0,0
5.2,2.25,1.6,0.5

GWLF OUTPUT FILES

LAMB CREEK

YEAR	PRECIP	EVAPOTRA	RUNOFF
	(cm)		
1	86.9	45.5	14.3
2	70	50.4	8.9
3	75.9	48.4	9.2
4	77.6	46.5	12.9
5	77.3	50.6	8.6
6	75	45.1	10
7	67.5	41.8	10.2

YEAR	EROSION	SEDIMENT	DIS.NITRTO	T.NITR	DIS.PHOS	TOT.PHOS
	(100Mg)		(Mg)			
1	0.1	0.01	0.7	1.3	0.2	0.4
2	0.2	0.02	0.7	1.4	0.1	0.4
3	0.1	0.01	0.6	1.2	0.1	0.3
4	0.2	0.02	0.9	1.6	0.2	0.4
5	0.2	0.02	0.7	1.4	0.1	0.4
6	0.2	0.02	0.7	1.6	0.1	0.5
7	0.1	0.01	0.7	1.3	0.2	0.4

<u>BLACK CREEK</u>

YEAR	PRECIP	EVAPOTRA	RUNOFF
	(cm)		
1	86.9	35.5	16.3
2	70	40.4	10
3	75.9	38.4	10.4
4	77.6	36.6	14.6
5	77.3	40.6	9.6
6	75	36.3	11.4
7	67.5	31.8	11.6

YEAR	EROSION	SEDIMENT	DIS.NITRTO	T.NITR	DIS.PHOS	TOT.PHOS
	(100Mg)		(Mg)			
1	0.2	0.044	1	2.3	0.2	0.7
2	0.1	0.022	0.9	2	0.1	0.6
3	0.1	0.022	1	1.9	0.1	0.5
4	0.2	0.044	1.1	2.3	0.2	0.7
5	0.2	0.044	1.1	2.5	0.1	0.7
6	0.2	0.044	1.1	2.4	0.1	0.7
7	0.2	0.044	0.9	2	0.1	0.6

PORTER CREEK

YEAR	PRECIP	EVAPOTRA	RUNOFF
		(cm)	
1	86.9	45.6	10.4
2	70	50.5	6.6
3	75.9	48.4	6.3
4	77.6	46.7	9
5	77.3	50.7	5.8
6	75	45.1	6.9
7	67.5	41.8	7.4

YEAR	EROSION	SEDIMENT	DIS.NITRTO	T.NITR	DIS.PHOS	TOT.PHOS
	(100Mg)			(Mg)		
1	0.1	0.01	1.1	1.5	0.2	0.3
2	0.1	0.01	0.8	1.3	0.1	0.3
3	0.1	0.01	0.8	1.2	0.2	0.2
4	0.1	0.01	1.1	1.7	0.2	0.3
5	0.2	0.02	0.8	1.3	0.1	0.3
6	0.2	0.02	0.9	1.5	0.2	0.3
7	0.1	0.01	0.9	1.3	0.2	0.3

<u>WEST PASTURE</u>

YEAR	PRECIP	EVAPOTRA	RUNOFF
	(cm)		
1	86.9	35.6	8.9
2	70	40.5	5.7
3	75.9	38.4	5
4	77.6	36.8	7.3
5	77.3	40.9	4.4
6	75	36.3	5.4
7	67.5	31.8	6.1

YEAR	EROSION	SEDIMENT	DIS.NITRTO	T.NITR	DIS.PHOS	TOT.PHOS
	(100Mg)		(Mg)			
1	0.1	0.03	0.8	1	0.1	0.1
2	0.1	0.03	0.5	0.8	0.1	0.1
3	0.1	0.03	0.5	0.7	0	0.1
4	0.1	0.03	0.7	1	0.1	0.1
5	0.1	0.03	0.5	0.8	0	0.1
6	0.1	0.03	0.5	0.9	0	0.1
7	0.1	0.03	0.5	0.8	0.1	0.1

EAST PASTURE

YEAR	PRECIP	EVAPOTRA	RUNOFF
	(cm)		
1	86.9	35.6	10.8
2	70	40.5	6.8
3	75.9	38.4	6.4
4	77.6	36.8	9.2
5	77.3	40.8	5.8
6	75	36.3	7
7	67.5	31.8	7.5

YEAR	EROSION	SEDIMENT	DIS.NITRTO	T.NITR	DIS.PHOS	TOT.PHOS
	(100Mg)		(Mg)			
1	0.1	0.03	1	1.1	0.1	0.1
2	0.1	0.03	0.6	0.7	0.1	0.1
3	0.1	0.03	0.7	0.7	0.1	0.1
4	0.1	0.03	0.9	1	0.1	0.1
5	0.1	0.03	0.6	0.7	0.1	0.1
6	0.1	0.03	0.7	0.8	0.1	0.1
7	0.1	0.03	0.7	0.8	0.1	0.1

BATHTUB OUTPUT FILES DERIVED FROM GWLF MODELING OUTPUTS

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 1 Black Lake

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	20.2	0.46	16.9%	41.6	0.48	43.8%
TOTAL N MG/M3	500.2	0.57	13.9%	507.3	0.26	14.4%
C.NUTRIENT MG/M3	16.6	0.40	17.0%	24.2	0.35	31.4%
CHL-A MG/M3	3.1	0.54	7.3%	4.7	1.42	18.4%
SECCHI M	2.1	0.24	80.1%	1.9	0.22	77.1%
ORGANIC N MG/M3	257.6	0.19	11.6%			
TP-ORTHO-P MG/M3	11.1	0.37	14.7%	12.4	0.48	17.6%
ANTILOG PC-1	49.9	0.61	11.2%	71.1	1.36	17.3%
ANTILOG PC-2	4.9	0.32	29.7%	6.4	0.97	49.1%
(N - 150) / P	17.3	0.93	51.0%	8.6	0.59	15.8%
INORGANIC N / P	26.4	1.58	45.3%			
TURBIDITY 1/M	0.4	0.26	32.6%	0.4	0.26	32.6%
ZMIX * TURBIDITY	1.4	0.29	15.5%	1.4	0.29	15.5%
ZMIX / SECCHI	1.7	0.27	3.8%	1.8	0.24	5.1%
CHL-A * SECCHI	6.3	0.53	24.7%	8.9	1.44	42.6%
CHL-A / TOTAL P	0.2	0.41	34.1%	0.1	1.49	19.3%
FREQ(CHL-a>10) %	1.3	2.30	7.3%	6.3	4.59	18.4%
FREQ(CHL-a>20) %	0.0	3.28	7.3%	0.4	7.10	18.4%
FREQ(CHL-a>30) %	0.0	3.89	7.3%	0.0	8.69	18.4%
FREQ(CHL-a>40) %	0.0	4.34	7.3%	0.0	9.87	18.4%
FREQ(CHL-a>50) %	0.0	4.69	7.3%	0.0	10.81	18.4%
FREQ(CHL-a>60) %	0.0	4.98	7.3%	0.0	11.59	18.4%
CARLSON TSI-P	47.5	0.14	16.9%	57.9	0.12	43.8%
CARLSON TSI-CHLA	41.6	0.13	7.3%	45.8	0.30	18.4%
CARLSON TSI-SEC	49.6	0.07	19.9%	50.8	0.06	22.9%

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Lamb Creek		1.4	4.93E-02	0.16	
2	1	1	Black Creek		2.1	1.19E-01	0.16	
3	1	1	Porter Creek		0.6	9.22E-03	0.16	
4	1	1	West Irrigation District		0.4	3.90E-03	0.18	
5	1	1	East Irrigation District		0.4	4.09E-03	0.16	
6	1	1	Coeur D'Alene River		3.9	1.54E-01	0.10	
7	1	1	Septic Tanks		0.0	0.00E+00	0.00	
PRECIPITATION				1.2	0.9	2.71E-03	0.06	0.76
TRIBUTARY INFLOW					8.8	3.39E-01	0.07	
***TOTAL INFLOW				1.2	9.8	3.42E-01	0.06	7.96
ADVECTIVE OUTFLOW				1.2	8.9	3.48E-01	0.07	7.24
***TOTAL OUTFLOW				1.2	8.9	3.48E-01	0.07	7.24
***EVAPORATION					0.9	5.99E-03	0.09	

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Lamb Creek	29.7	13.5%	4.37E+01	5.4%	0.22	21.0	
2	1	1	Black Creek	40.7	18.5%	7.06E+01	8.8%	0.21	19.0	
3	1	1	Porter Creek	15.0	6.8%	1.04E+01	1.3%	0.22	25.0	
4	1	1	West Irrigation District	3.2	1.4%	7.20E-01	0.1%	0.27	9.0	
5	1	1	East Irrigation District	3.9	1.8%	1.02E+00	0.1%	0.26	10.0	
6	1	1	Coeur D'Alene River	82.3	37.5%	3.39E+02	42.2%	0.22	21.0	
7	1	1	Septic Tanks	8.2	3.7%	0.00E+00		0.00	11700.0	
PRECIPITATION				36.8	16.7%	3.38E+02	42.1%	0.50	39.5	30.0
TRIBUTARY INFLOW				183.0	83.3%	4.65E+02	57.9%	0.12	20.7	
***TOTAL INFLOW				219.8	100.0%	8.03E+02	100.0%	0.13	22.5	179.4
ADVECTIVE OUTFLOW				179.6	81.7%	6.96E+03		0.46	20.2	146.6
***TOTAL OUTFLOW				179.6	81.7%	6.96E+03		0.46	20.2	146.6
***RETENTION				40.2	18.3%	6.66E+03		2.03		

Overflow Rate (m/yr)	7.2	Nutrient Resid. Time (yrs)	0.3950
Hydraulic Resid. Time (yrs)	0.4834	Turnover Ratio	2.5
Reservoir Conc (mg/m3)	20	Retention Coef.	0.183

Overall Mass Balance Based Upon Component: **Predicted TOTAL N** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Lamb Creek	527.4	14.6%	1.04E+04	2.5%	0.19	373.0	
2	1	1	Black Creek	690.4	19.2%	1.85E+04	4.4%	0.20	322.0	
3	1	1	Porter Creek	367.8	10.2%	5.86E+03	1.4%	0.21	613.0	
4	1	1	West Irrigation District	132.7	3.7%	8.23E+02	0.2%	0.22	376.0	
5	1	1	East Irrigation District	156.8	4.4%	1.21E+03	0.3%	0.22	402.0	
6	1	1	Coeur D'Alene River	486.1	13.5%	1.18E+04	2.8%	0.22	124.0	
7	1	1	Septic Tanks	17.0	0.5%	0.00E+00		0.00	24300.0	
PRECIPITATION				1225.3	34.0%	3.75E+05	88.5%	0.50	1317.5	1000.0
TRIBUTARY INFLOW				2378.2	66.0%	4.87E+04	11.5%	0.09	269.6	
***TOTAL INFLOW				3603.4	100.0%	4.24E+05	100.0%	0.18	369.5	2941.0
ADVECTIVE OUTFLOW				4437.5	123.1%	6.43E+06		0.57	500.2	3621.7
***TOTAL OUTFLOW				4437.5	123.1%	6.43E+06		0.57	500.2	3621.7
***RETENTION				-834.0		5.96E+06		2.93		

Overflow Rate (m/yr)	7.2	Nutrient Resid. Time (yrs)	0.5952
Hydraulic Resid. Time (yrs)	0.4834	Turnover Ratio	1.7
Reservoir Conc (mg/m3)	500	Retention Coef.	-0.231

East and West Irrigation Districts are identified as East and West Pastures in the main document.

Hydraulic & Dispersion Parameters

			Net	Resid	Overflow		Dispersion-------->		
		Outflow	Inflow	Time	Rate	Velocity	Estimated	Numeric	Exchange
Seg	Name	Seg	hm^3/yr	years	m/yr	km/yr	km^2/yr	km^2/yr	hm^3/yr
1	Black Lake	0	8.9	0.4834	7.2	2.3	98.0	1.3	0.0

Morphometry

		Area	Zmean	Zmix	Length	Volume	Width	L/W
Seg	Name	km^2	m	m	km	hm^3	km	-
1	Black Lake	1.2	3.5	3.5	1.1	4.3	1.1	1.0
Totals		1.2	3.5			4.3		

Segment & Tributary Network

--------Segment:	1	Black Lake		
Outflow Segment:	0	Out of Reservoir		
Tributary:	1	Lamb Creek	Type:	Monitored Inflow
Tributary:	2	Black Creek	Type:	Monitored Inflow
Tributary:	3	Porter Creek	Type:	Monitored Inflow
Tributary:	4	West Irrigation District	Type:	Monitored Inflow
Tributary:	5	East Irrigation District	Type:	Monitored Inflow
Tributary:	6	Coeur D'Alene River	Type:	Monitored Inflow
Tributary:	7	Septic Tanks	Type:	Monitored Inflow

East and West Irrigation Districts are identified as East and West Pastures in the main document.

Description:

Lake is modeled as one segment

Tributary flows / runoffs are modeled from GWLF

Atmospheric Loads are from default data

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.759	0.1
Evaporation (m)	0.718	0.1
Storage Increase (m)	0	0.3

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	2	2ND ORDER, DECAY
Nitrogen Balance	2	2ND ORDER, DECAY
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	2	CONCENTRATIONS
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Black Lake	0	1	1.225254	3.5	1.107	3.5	0.12	0	0	0.41	0.26	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	41.6	0.48	507.3	0.26	4.7	1.42	1.9	0.22	0	0	12.4	0.48	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1.147317	0	1.520306	0	0.428226	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Lamb Creek	1	1	0	1.414	0.157	0	0	21	0.158	373	0.113	7	0.387	189	0.137
2	Black Creek	1	1	0	2.144	0.161	0	0	19	0.129	322	0.114	3	0.35	150	0.097
3	Porter Creek	1	1	0	0.6	0.16	0	0	25	0.144	613	0.133	15	0.31	391	0.132
4	West Irrigation District	1	1	0	0.353	0.177	0	0	9	0.2	376	0.124	5	0.2	240	0.153
5	East Irrigation District	1	1	0	0.39	0.164	0	0	10	0.2	402	0.149	10	0.2	359	0.156
6	Coeur D'Alene River	1	1	0	3.92	0.1	0	0	21	0.2	124	0.2	10.5	0.2	62	0.2
7	Septic Tanks	1	1	0	0.0007	0	0	0	11700	0	24300	0	5850	0	12150	0

East and West Irrigation Districts are identified as East and West Pastures in the main document.

Appendix G. Unit Conversion Chart

Table G-1. Metric - English Unit Conversions

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Volume	Gallons (gal) Cubic Feet (ft^3)	Liters (L) Cubic Meters (m^3)	1 gal = 3.78 L 1 L= 0.26 gal 1 ft^3 = 0.03 m^3 1 m^3 = 35.32 ft^3	3 gal = 11.35 L 3 L = 0.79 gal 3 ft^3 = 0.09 m^3 3 m^3 = 105.94 ft^3
Flow Rate	Cubic Feet per Second (cfs)[a]	Cubic Meters per Second (m^3/sec)	1 cfs = 0.03 m^3/sec 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 3 m^3/sec = 105.94 ft^3/sec
Concentration	Parts per Million (ppm)	Milligrams per Liter (mg/L)	1 ppm = 1 mg/L[b]	3 ppm = 3 mg/L
Weight	Pounds (lbs)	Kilograms (kg)	1 lb = 0.45 kg 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 3 °C = 37.4 °F

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.
[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

Appendix H. Distribution List

Black Lake WAG participants:

Casey Amy, Kootenai School District #274

Tom Bell, Concerned Citizen/Landowner

John Katovich, Concerned Citizen/Landowner

Marianne and Larry Lariviere, Concerned Citizen/Landowner

Bob Martinson, Concerned Citizen/Landowner

Ken Ockfen, Idaho Department of Lands

Kenneth Osen, Concerned Citizen/Landowner

Sandy Watson, Concerned Citizen/Landowner

Appendix I. Public Comments

Comment 1: It may just be my software but the document I downloaded has a lot of errors in the tables that were not in the May 18th version. For instance in Table X, the load allocation for Porter Creek reads 17,4 77% and in Table 1 it gives the average January temperature as 722 degrees.

Response to comment 1: When the PDF document was indexed, the values for Porter Creek in table X were shifted, so the allocated load read 17.4 77%. The 77% belongs in the % load reduction table. This same thing happened with the temperature values in Table 1. These errors will be fixed in the final version.

Comment 2: In Table 8 only one value for orthophosphate in the Coeur d' Alene River was below 6 while in the May 18th version they all were. Which is correct?

Response to comment 2: Again, something happened with the PDF document was indexed and the values in the columns were shifted. This will be fixed in the final version.

Comment 3: The values given for Estimated Phosphorus Load in Table 9 are extremely misleading in that they give the loads to the septic tanks rather than to the environment. Septic systems which include the drainfield are normally reasonably efficient at retaining phosphorus in the soil. This Table deliberately misrepresents the probable impact of septic systems. It doesn't matter a lot because more reasonable values were used in the BATHTUB model to develop the TMDL but it doesn't help to establish credibility for the document.

Response to comment 3: The survey on which the load estimates in Table 9 were calculated said there were 34 homes within 100 meters of the lake, and there were 170 homes within 20 meters of Black Creek, Lamb Creek, and Porter Creek combined. Recent estimates indicate there are 52 homes within 100 meters of Black Lake, and 36 homes within 100 meters of Black Lake watershed streams. Therefore, the septic numbers will be updated in the final TMDL based on recent estimates. The load estimates as currently written in the TMDL are agreeably a misrepresentation of the *probable* impact to surface water. However, the TMDL states approximately 40 percent of the existing septic tanks were installed prior to 1979 and the steep slopes and soil types around Black Lake have poor suitability for septic tank absorption. As such, it is important to stress the high risk of septic tank pollution to Black Lake. Therefore, the final TMDL will print load estimates using the same assumptions (4 people per home, 150 L/person/day, 15 mg/L effluent) for informational purposes only to demonstrate that septic systems can be a significant source of nutrient loading should they fail or be working improperly. The TMDL does not use those numbers in modeling for load allocations. We will change the wording in the TMDL to better describe the purpose for publishing Table 9 and why those estimates weren't used for load allocation calculations.

Comment 4: I still do not believe the estimated inputs from the Coeur d'Alene River discussed on page 37 and shown in Table 10 are valid. The methodology discussed in Appendix C for developing a stage – flow relationship for the Harrison Gauging Station is certainly not correct. Again it doesn't matter very much because only the 2001 values were used in the BATHTUB Model and they show the minimum inflow.

Response to comment 4: We agree that actual measurements of discharge and total phosphorus concentrations used to develop the Total Phosphorus Loading from high flows of the Coeur d'Alene River would be preferred. Like many other portions of this TMDL, when faced with the paucity of data, the agency technical advisors (IDEQ, Coeur d' Alene Tribe, EPA) instructed and/or reviewed the consultants methods for best estimating values needed to establish load allocations. We are not aware of data or information that allows us to test validity, and dispute claims that the method selected is invalid. We queried the WAG and found that our estimates match the locals understanding of how the slough functions. The values in Table 10 and the methodology in Appendix C are reasonable. As you requested we tested the representativeness of the Harrison stage to another USGS station at Tubbs Hill and found consistent values. These findings were presented to the WAG.

Comment 5: My most serious concern is with the discussion of Internal Recycling on page 38. It says "In the 1987 Kann and Falter study, the percentage of TP estimated to be contributed by internal loading was relatively small at 9.3 percent (Kann and Falter 1987). As a result, the Kann and Falter study concluded that internal phosphorus loading does not appear to vary greatly from year to year and, therefore, this source of TP was not considered a significant source of loading contributing to impairment of Black Lake (Kann and Falter 1987)." I do not believe this statement accurately expresses what was said in the Kann and Falter Report. On page 21 through 23 Kan and Falter developed an estimated internal load of phosphorus of 117.9 kg/year or 78 mg/square meter/year. On page 25 Kann and Falter say "Because the variability of internal phosphorus loading does not appear to be great between bloom and non-bloom years, we have concluded that summer internal phosphorus alone could not explain annual bloom variations in Black Lake." They do not say the effects of internal loading are insignificant. On page 137 of the Draft TMDL in Table F-6 it gives the average Lake volume as 4,693.700 cubic meters. 117.9 kilograms of phosphorus dissolved in that volume is about 25 ppb. If the Kann and Falter internal loading estimate is correct then the TMDL target phosphorus concentration can not be met without considering the internal load to be another nonpoint source to be managed. Evidently the BATHTUB model does not show this but I am still unclear as to how the BATHTUB model handles internal loading. I think the Data Gaps Section on pages 31 and 32 should include gathering the data needed to understand the magnitude of internal loading as there are control strategies for this nonpoint load that may be more doable than some of the external load reductions.

It appears to me that the effects of internal loading may be more significant than previously considered because it is nearly all in the form of dissolved orthophosphorus and most of it is added to the water column in the summer months when it would have the most effect on algae growth. In contrast the total phosphorus loads from the streamflows enter the lake early in the year and a lot of that may settle out before the growing season.

Response to comment 5: Internal loading is discussed as a source of phosphorus to Black Lake throughout the document, and we agree it is not insignificant. Therefore, we will change the text on page 37 to reflect this opinion. We will also print in Table 12 on page 51 the internal load of TP as estimated by Kann and Falter (1987). However, because Kann and Falter estimated internal phosphorus loading with a nutrient budget based on data from 1984 and not from a sediment core taken from the lake, internal loading will not get a load allocation. Rather, we will emphasize that more data needs to be collected and modeling performed to better understand the TP contribution of the lake bottom sediments. Although it is stated in the data gaps section on page 38 and 39, we also need to make that statement in the data gaps section on page 31 and 32.

Internal loading may indeed need to be addressed at some point during the implementation of this TMDL. Like most lakes in this region the control of internal loading should only be considered after excess watershed nutrient inputs have been controlled or at least reduced. The Boos and Stockner report clearly shows that historic nutrient concentrations were significantly lower than those seen currently. Given this, it makes sense to first control watershed nutrients, monitor, and if water quality improvements are realized to the levels needed to achieve the goals of this TMDL then implement in-lake internal loading controls (such as alum treatment). Other lakes regional lakes such as Newman and Liberty lakes have attempted internal loading controls without first controlling watershed nutrients and these efforts have largely failed due to excess nutrients continuing to enter the lake. Once watershed nutrient reductions were put in place internal nutrient controls were again tried with much better success.

Comment 6: I read over the executive summary and large parts of the main document. It looks like the group did a lot of good work. Also it doesn't appear you offer any solutions to the problems, or did I misread it?

Response to comment 6: Implementation of the TMDL is discussed beginning on page 57. Once the TMDL is approved by the EPA, DEQ the Tribe, the WAG and other interested persons will author a TMDL implementation plan.