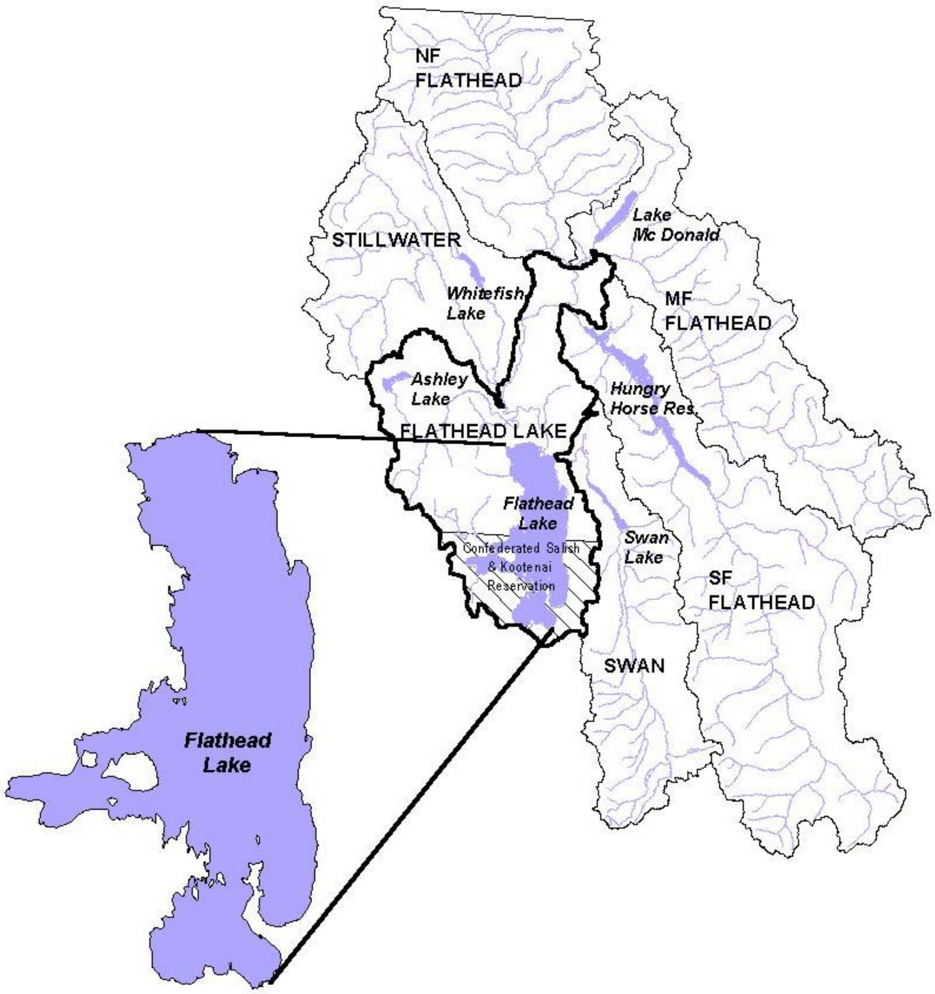
Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana



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Montana Department of Environmental Quality

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Waterbody Type:	Lake
Pollutant:	Nutrients (nitrogen and phosphorus) Siltation and suspended solids will be addressed concomitantly with nutrients
Impaired Uses:	Aquatic Life Support
Size of Waterbody:	191.5 $miles^2$
Size of Watershed:	7,093 $miles^2$
Water Quality Standards:	State of Montana narrative standards for A-1 waters applicable to nutrients and Confederated Salish and Kootenai Tribe Water Quality Standards for A-1 waters applicable to nutrients.

Targets:		
	Primary production	80 g C m^{-2} yr^{-1}
	Dissolved oxygen in the hypolimnion	No declining trend
	Blooms of Anabaena or other pollution algae	No measurable blooms
	Chlorophyll a	1.0 ug/L
	Algal biomass on near-shore rocks	Biomass remains stable or declining trend

Indicators		
	Total phosphorus (TP)	5.0 ug/L
	Soluble reactive phosphorus (SRP)	<0.5 ug/L
	Total nitrogen (TN)	95 ug/L
	Nitrite + Nitrate ($NO_{2/3}$ –N)	30 ug/L
	Ammonia (NH_3 – N)	<1.0 ug/l

TMDL: 15% nitrogen and phosphorus load reduction, plus 10% M.O.S.

Introduction and Purpose

Flathead Lake is an outstanding aquatic resource of international importance. However, despite basin wide efforts to reduce nutrient loading (e.g., phosphate detergent ban, increased municipal sewerage treatment efficiency, etc.) there has been a downward trend in water quality since 1977. Flathead Lake is listed on the 1996 and 2000 Montana 303(d) lists as impaired for the beneficial use of aquatic life support.

The purpose of this document is two-fold: 1) to fulfill the requirements of Section 303(d) of the Federal Clean Water Act and Montana Water Quality Act (Chapter 75, Part 7) regarding Total Maximum Daily Loads (TMDL); and 2) to provide a prioritized nutrient management plan for Flathead Lake. This document addresses those probable causes related to nutrients (i.e., nutrients, noxious aquatic plants, organic enrichment/low DO, and algal growth/chlorophyll a). Issues pertaining to potential sediment related impairments are also indirectly addressed by this plan. Flathead Lake is the focus of the TMDL, but the geographic scope of the Water Quality Restoration Plan includes the entire Flathead Basin.

The southern half of the lake and a portion of the lower basin are within the Confederated Salish and Kootenai Tribe (CKST) Reservation boundary. Thus, Flathead Lake is under the duel jurisdiction of both the State of Montana and the CSKT and this TMDL must satisfy the water quality standards of both the Montana Department of Environmental Quality and the CKST.

Adaptive Management Approach

While Flathead Lake and many of its tributaries have been the subject of extensive scientific research for many years, there is not sufficient data to specifically link all of the potential nutrient sources to the observed water quality problems. This and the fact that natural variables outside of man's direct control (e.g., weather patterns, internal lake dynamics, etc.) may also have an effect on the water quality of Flathead Lake necessitates an adaptive management and/or phased approach. In the context of this plan, adaptive management has been applied to first establish priorities for a short-term (one to three year) action strategy that will address known and readily controllable nutrient sources. This will provide a means to begin reducing nutrient loads immediately while additional data is collected to define measures for controlling all of the significant sources in the future.

Technical Basis

Much of the supporting technical data that has formed the basis for conclusions presented herein has been extracted from *Water Quality Data Analysis to Aid in the Development of Revised Water Quality Targets for Flathead Lake, Montana* (Stanford et.al., 1997). Additionally, data from over 50 technical reports/peer reviewed articles were consulted. Annual nutrient loads to Flathead Lake were estimated based on a long-term database extending from 1977 to the present. A synoptic study of many of the tributaries to Flathead Lake conducted in 1995 and 1996 provided a means to compare nutrient loading from one tributary to another and from one point along an individual tributary to another. And finally, an analysis was conducted wherein annual nutrient loading was estimated by source category (e.g., point source discharges, managed forestland, urban/agricultural land, etc.).

Targets

Targets are water quality goals used to measure the effectiveness of the restoration plan as it is implemented. The targets presented below represent the desired future water quality condition in comparison to current conditions.

Parameter	Target	Water Year 2000 data*
Primary production	80 g C m^{-2} yr^{-1}	108 g C m^{-2} yr^{-1}
Dissolved oxygen in the hypolimnion	No declining trend	79.5% of saturation at midlake deep site
Blooms of Anabaena or other pollution algae	No measurable blooms	Data not yet analyzed
Chlorophyll a	1.0 ug/L	1.0 ug/l
Algal biomass on near-shore rocks	Measured as Chl a per unit area, biomass remains stable or exhibits declining trend	Data collection effort just beginning
Total phosphorus (TP)	5.0 ug/l	5.9 ug/l
Soluble reactive phosphorus (SRP)	<0.5 ug/l	0.7 ug/l
Total nitrogen (TN)	95 ug/l	101 ug/l
Nitrite + Nitrate ($NO_{2/3}$ –N)	30 ug/l	43 ug/l
Ammonia (NH_3 – N)	<1.0 ug/l	5.1 ug/l

*From Ellis et al. 2000

TMDL

A 15 percent reduction in man-caused nitrogen and phosphorus loads, plus a 10 percent margin of safety is proposed as the TMDL. The margin of safety has been included to account for projected future increases in point source loads attributable to increased wastewater flows and a continuing upward trend in population growth in the unincorporated areas of the basin.

Allocation

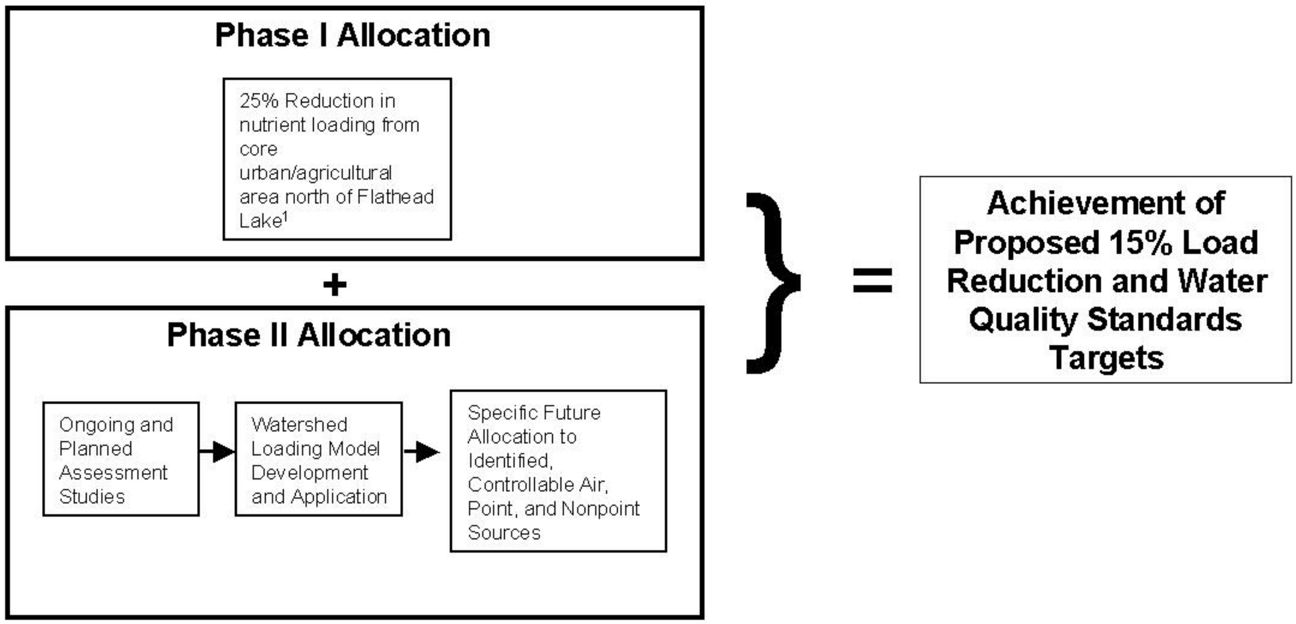
Using the available data, it is not possible in most cases to specifically allocate loads to individual sources or source categories. Further study is needed to fully allocate loads from all significant sources. For this reason, a phased approach is proposed for allocation.

The first phase, as presented herein, uses the available data to focus near-term (one to three year) implementation measures on those sources that:

1) appear to pose the greatest threat to Flathead Lake based on available data,
2) are known, based on the literature, to be significant sources of nutrients, and
3) are controllable in consideration of current technology.

A summary of the proposed Phase I and Phase II allocations or recommended allocation actions is presented below:

Figure 5-1. Allocation Plan.



The short-term goal set in Phase 1, 25% reduction in nutrient loading from the core urban/agricultural area north of the lake, will ensure that some of the most significant contributions to nutrient loading in the Lake will be curtailed in the near future. Phase II will concurrently collect additional data to support the evaluation of all significant sources of nutrients. The relative importance of all significant sources will be determined in Phase II and a final allocation plan will be developed using this information in 2006.

Monitoring and Adaptive Management Strategy

There are three basic components of the monitoring and adaptive management strategy: water quality monitoring, watershed modeling, and air quality monitoring. The purpose is to evaluate the progress and success or failure of the restoration efforts, to provide better resolution to quantification of nutrient loading from each source, and provide data upon which to make informed decisions about the management of Flathead Lake in the future.

The Flathead Lake Biological Station has monitored water quality in Flathead Lake and nutrient loading from the primary tributaries and from precipitation since 1977. Continuation of this ongoing monitoring program is proposed with the addition of several sample sites to better characterize nutrient loading to the lake and to evaluate the progress of restoration efforts. Additional synoptic tributary sampling (e.g., sampling multiple points along a single tributary during a single storm event) is also proposed in an effort to better characterize nutrient loading from specific sources.

Additional air monitoring is necessary to develop a better understanding of this potential source of nutrients to the lake by answering the following questions:

- Where is the airborne nutrient load coming from?
- Is it controllable?
- To what extent can it be controlled?

And finally, development of a watershed nutrient loading model is necessary to both better quantify loading from all sources under existing conditions and to allow for analysis of the potential impacts associated with future land management activities within the basin.

Restoration Strategy

As a parallel effort to the development of this plan, the Flathead Basin Commission (FBC) is developing an implementation plan to direct the activities of their Voluntary Nutrient Reduction Program. It is envisioned that the FBC will take the lead role in implementation. As a result, this plan does not present a detailed restoration or implementation strategy. Rather, the following recommendations are presented to provide direction for the FBC based on the results of this effort.

1. Given the results of this analysis, urban and agricultural land uses, primarily concentrated in the Flathead River valley north of the lake appear to pose the greatest immediate threat to Flathead Lake relative to nutrient loading. Controlling nutrient loading from the sources in this area should be the initial focus of efforts to restore Flathead Lake. Initial efforts in this regard will likely require a combination of implementation of on-the-ground restoration measures as well as more detailed analysis including: 1) a focused source assessment to locate specific agricultural and urban sources and, 2) a feasibility study to evaluate alternative control measures.

2. Growth in unincorporated areas throughout the basin has been shown to pose a future threat to the lake's water quality. Land use planning, education, and implementing BMP's (i.e., water quality best management practices) for all future development should also be a primary focus of the water quality restoration efforts.

3. The restoration strategy needs to include implementation of the adaptive management strategy and Phase II of the allocation plan as follows:

   - Trend monitoring needs to continue to track the success of current and future restoration efforts and the ongoing monitoring program should be expanded to include additional tributary and in-lake sites.
   - A watershed loading model should be developed to further refine the assessment and quantification of existing nutrient sources, allocate existing and future nutrient loads to each of the significant sources, and to evaluate, in a predictive mode, the potential impact of future land use actions.
   - Airborne sources need to be further investigated to determine if this source can be controlled and how.
   - Restoration targets and the TMDL (i.e., 25 percent reduction in nutrient loading) should be evaluated and modified as necessary to reflect the results of implementation of the adaptive management strategy.

4. Each of the sub-watersheds tributary to Flathead Lake are delineated as DEQ TMDL Planning Areas. All necessary TMDL's for those waters listed on the Montana 1996 303(d) List within the Swan, Flathead Headwaters, and Flathead-Stillwater TMDL Planning areas must be completed by 2002, 2003, and 2005, respectively. This provides an opportunity to focus assessment and restoration efforts on a smaller scale that may be more conducive to accurately evaluating the linkages between sources and impairments and, ultimately, to implementation of on-the-ground restoration actions. This will also likely be the most effective scale at which to address historical Forestry impacts that may be providing increased loads of both sediment and nutrients to the lake. Regardless of the listed impairments within these TMDL Planning Areas, future water quality restoration efforts should be coordinated with this plan in an effort to maximize potential nutrient load reductions.

SECTION 1.0
INTRODUCTION

1.1 Background and Purpose

Flathead Lake is an outstanding aquatic resource of international importance. The lake and its tributary rivers and streams are generally in good health with excellent water quality. However, there has been a downward trend in water quality since 1977 (Stanford et al., 1997). Declining water quality has been manifested by increased algal growth and decreased water clarity in the near shore environment. The downward trend in water quality is occurring despite basin-wide efforts to reduce nutrient loads in the lake. These efforts have included:

- Tertiary effluent treatment in upper basin sewage facilities,
- Increased municipal sewer hookups, notably in the Evergreen area,
- A ban on domestic use of phosphorus detergents,
- High compliance rates in the forest industry with best management practices, and
- A generally high level of awareness concerning the importance of good water quality in the basin.

These proactive steps may have been offset by a 42 percent increase in population from 1980-2000 (U.S. Census). Most of this growth has occurred outside of incorporated cities and towns.

Section 303 of the Clean Water Act requires states to submit a list of impaired and threatened water bodies to the U.S. Environmental Protection Agency (EPA) every two years. Impaired water bodies do not meet water quality standards and threatened water bodies are likely to violate standards in the near future. The 303(d) List identifies which beneficial uses are impaired and indicates the probable causes (i.e., the pollutant) and probable sources of impairment. A summary of the listing status for Flathead Lake is provided in Table 1-1.

Table 1-1. Flathead Lake 303(d) List Summary

303(d) List	Probable Uses Impaired	Probable Causes
1996	Aquatic life support	Flow alteration Noxious aquatic plants Nutrients Siltation Suspended Solids
2000	Aquatic life support	Nutrients Siltation Organic enrichment/low DO Algal growth/Chlorophyll a PCB's Metals Mercury

While the 2000 303(d) List is the most current approved list and is based on the most rigorous scientific analysis, a ruling by the U.S. District Court (CV97-35-M-DWM) on September 21, 2000 stipulated that the state of Montana must complete all necessary TMDL's, for all waters listed as impaired or threatened on the 1996 303(d) List. In accordance with this court order, all necessary TMDL's for Flathead Lake must be completed by December 31, 2001.

The purpose of this document is two-fold: 1) to fulfill the requirements of Section 303(d) of the Federal Clean Water Act and Montana Water Quality Act (Title 75, Chapter 7) regarding Total Maximum Daily Loads (TMDL); and 2) to provide a prioritized nutrient management plan for Flathead Lake. This document addresses those probable causes related to nutrients (i.e., nutrients, noxious aquatic plants, organic enrichment/low DO, and algal growth/chlorophyll a). Additionally, siltation and suspended solids will be addressed as a secondary outcome of this process (Appendix C). Phosphorus, in particular, is strongly associated with soil particulate matter (Reckhow et al., 1980). As a result, reducing non-point source phosphorus loads will, in many cases, involve employing measures to minimize sediment delivery to Flathead Lake and/or its tributaries. The probable causes of PCB's, metals and mercury appeared on the 303(d) list for the first time in 2000. Therefore, these probable causes are scheduled to be addressed by 2010.

Flathead Lake is the focus of the TMDL, but the geographic scope of the Water Quality Restoration Plan includes the entire Flathead Basin (Figure 1-1). Flathead Basin comprises five sub basins (i.e., 8 digit hydrologic unit code), virtually all of Flathead and Lake Counties, and a portion of Missoula County. The southern half of the lake (i.e., approximately 53 percent of the surface area of the lake) and a portion of the lower basin are within the Confederated Salish and Kootenai Tribe (CSKT) Reservation boundary (Figure 1-1). Thus, Flathead Lake is under the dual jurisdiction of both the State of Montana and the CSKT. The CSKT received treatment as a state authority to develop a water quality standards program in 1992 and the EPA approved the CSKT water quality standards in 1996. This TMDL must satisfy the water quality standards of both the Montana Department of Environmental Quality and the CSKT.

This document has been prepared by the Montana Department of Environmental Quality (DEQ), with the collaboration of the Flathead Basin Commission (FBC), the EPA, Confederated Salish and Kootenai Tribe (CSKT), and the University of Montana Flathead Lake Biological Station (FLBS). The Flathead Basin Commission was created by the State Legislature in 1983 to monitor and protect water quality in Flathead Lake. The commission has participated in the TMDL development process since 1997, including the preparation of two draft TMDL documents. These drafts are the foundation upon which this document has been constructed. Much of the supporting technical data in this report is from the FLBS's report "*Water Quality Data and Analysis to Aid in the Development of Revised Water Quality Targets for Flathead Lake, Montana*" (Stanford et al., 1997) which is incorporated herein by reference.

1.2 Adaptive Management Approach

This report makes several recommendations for reducing nutrient loads in Flathead Lake. Stakeholders would like assurance that these actions will restore and protect water quality. Land managers and water users would like to know the whole extent and precise cost of restoration measures. However, this is an extremely complex problem influenced by climate, stream flows, changes in land use and many other variables outside of our control.

Given the many uncertainties in the relationships between nutrient loading and response in Flathead Lake; the difficulties in completely characterizing the nutrient load to the lake, and limited site specific information regarding nutrient sources; a phased approach is proposed for the Flathead Lake Water Quality Restoration Plan and TMDL.

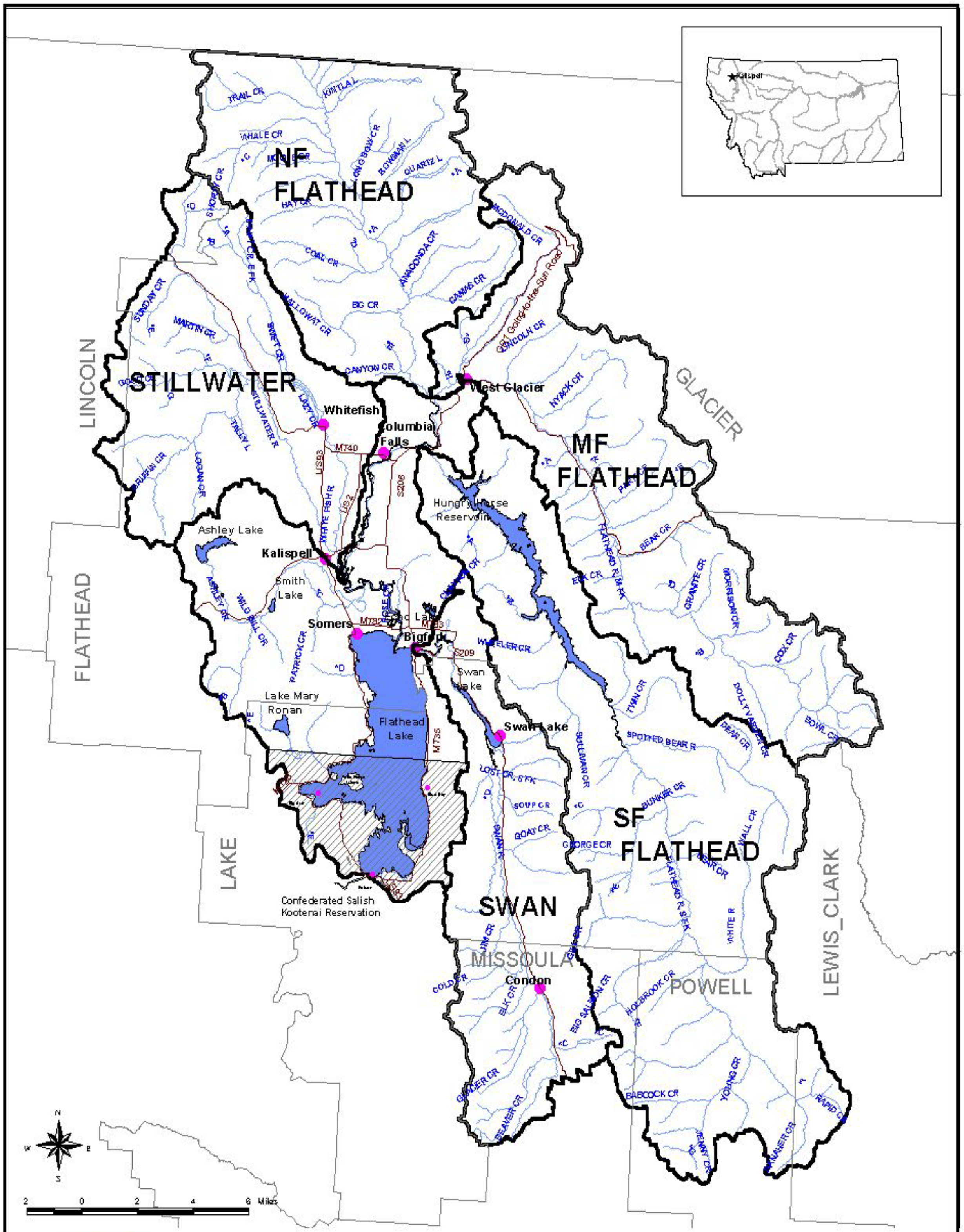


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Figure 1-1. Flathead Basin

Figure 1-1
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This document presents Phase I wherein the required elements of the TMDL (e.g., numeric targets, total maximum daily load, source characterization, etc.) are based upon the best available information and the hypothesis that implementing this plan will result in restoring all beneficial uses. A monitoring and adaptive management strategy, as conceptualized in Section 6.0, will be implemented in Phase II to test this hypothesis and provide information necessary to adaptively manage the system in the future. The phased approach is also proposed in recognition of a number of ongoing activities that may enhance our understanding of Flathead Lake (e.g., Groundwater Quality Assessment and Monitoring Plan for the North Flathead Valley and Flathead Lake Perimeter, a proposed airshed nutrient source assessment study, ongoing water quality trend monitoring conducted by the FLBS and FBC, etc.) and the fact that DEQ is currently in the process of developing statewide nutrient standards.

1.3 Document Contents

The following sections of the document have been organized to begin by presenting the reader with an understanding of the existing condition of Flathead Lake and its surrounding watershed in Section 2.0 – Watershed Characterization. This is followed by a detailed account of the water quality impairment status in Section 3.0 – Water Quality Concerns and Status. Potential sources of nutrient loading to Flathead Lake are discussed in Section 4.0 – Source Assessment. Numeric targets, the TMDL, and load allocations are presented in Section 5.0 – Water Quality Goals. Monitoring and adaptive management and restoration strategies are discussed in Sections 6.0 and 7.0, respectively, and Public Involvement is discussed in Section 8.0.

SECTION 2.0 WATERSHED CHARACTERIZATION

This section of the document sets the stage for subsequent discussions relative to management of the nutrient load to Flathead Lake by describing the current environmental conditions (i.e., those relevant to nutrient impairment) and the historic, current and projected anthropogenic forces underlying the identified water quality impairments.

2.1 Physical and Biological Characteristics

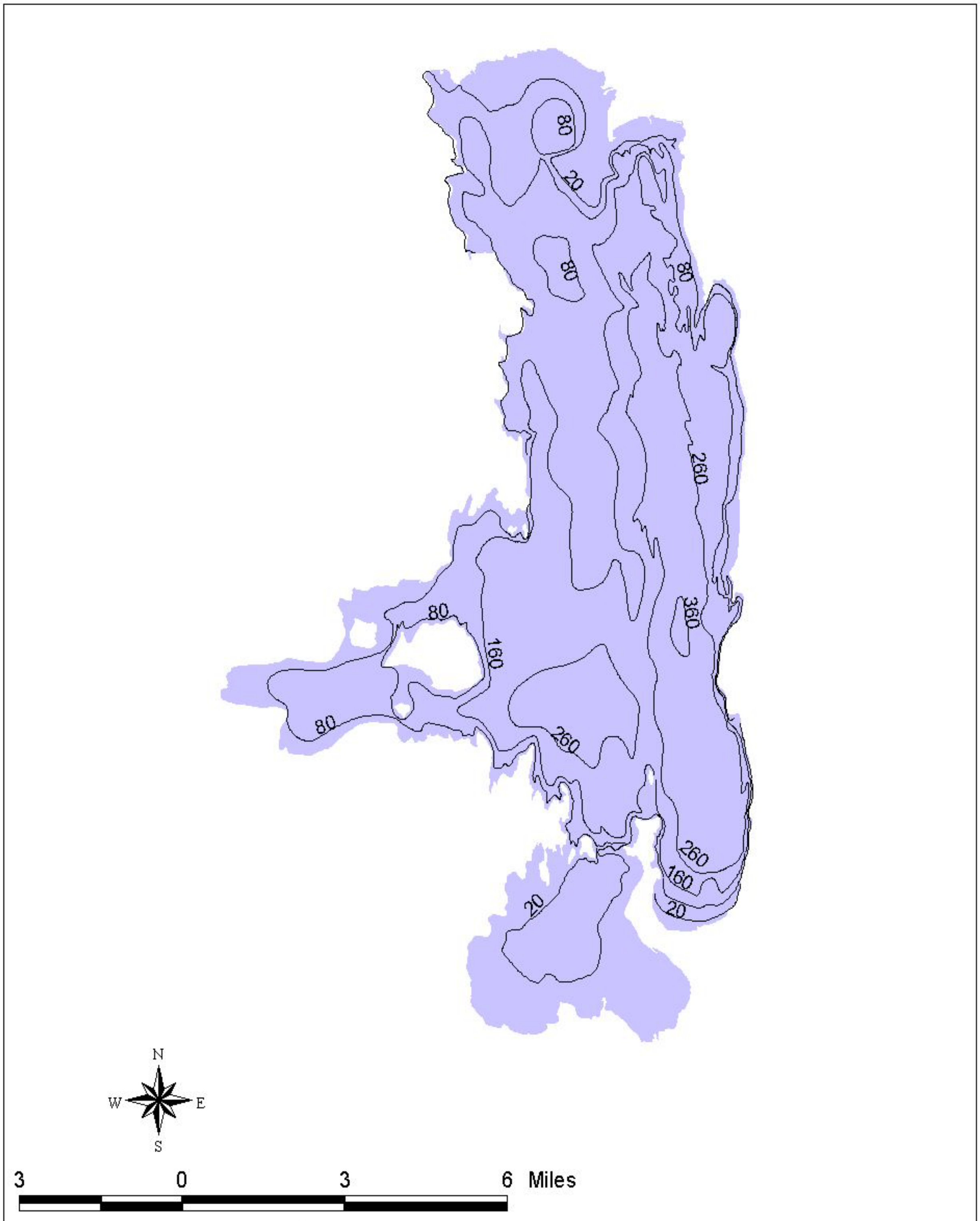
2.1.1 Hydrography

Flathead Lake has a surface area of approximately 191 square miles and more than 187 miles of shoreline (Table 2-1). Flathead Lake is deepest along the east shore and relatively shallow on the west side (Figure 2-1). The hydraulic residence time is 3.4 years (Flathead Lake Biological Station, 2001).

TABLE 2-1. LAKE CHARACTERISTICS

Maximum Length	27.3 miles
Maximum Breadth	15.5 miles
Maximum Depth	370.7 feet
Mean Depth	164.7 feet
Lake Surface Area	191.5 $miles^2$
Lake Volume	5.56 $miles^3$
Shoreline Length	187.6 miles

The Flathead basin comprises five sub-basins (i.e., 8-digit USGS Hydrologic Unit Codes) drained by seven major tributaries; the North, Middle, and South Forks of the Flathead River, Swan River, Stillwater River, Whitefish River, and Ashley Creek (Figure 1-1). The North, Middle, and South Forks join near the City of Hungry Horse to form the main-stem of the Flathead River. The Stillwater and Whitefish rivers and Ashley Creek discharge into the Flathead River in the vicinity of Kalispell. The Swan River discharges directly into Flathead Lake at Bigfork. The Flathead River provides approximately 85 percent of the water that enters Flathead Lake annually (Table 2-2). Of the remainder, the Swan River contributes approximately ten percent and the remaining five percent are delivered to the lake through a number of small drainages, overland flow directly into the lake, and from precipitation.



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Flathead Lake Bathymetry.
[Depth in feet]

Figure 2.1

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Table 2-2. Basin area and discharge characteristics of major tributaries contributing flow through Flathead Lake (Adapted from Stanford et al., 1994).

Tributary	Basin Area (Square Miles)	Average Annual Discharge (acre-feet x 106)	Average Annual Inflow (relative %)	Maximum Flow (cfs)	Minimum Flow (cfs)	Period of Record[a] (yrs)
South Fork	1,663	2.58	30.38	46,262	7[c]	53
North Fork	1,548	2.16	25.43	69,217	198	50
Middle Fork	1,128	2.13	25.05	139,846	173	42
Swan	726	0.84	9.90	8,899	193	29
Stillwater	338	0.24	2.87	4,344	40	29
Whitefish	170	0.14	1.64	1,589	38	30
Ashley Creek[b]	201	0.02	0.28			5
Flathead River at Outlet	7,093	8.51		82,636	5[c]	74
Other Inputs[d]		0.38	4.46			

[a] For calculation of average annual discharge
[b] Data collected by Flathead Lake Biological Station
[c] Due to dam closure
[d] Include other unspecified tributaries, direct overland flow, and precipitation estimated as the difference between the sum of the above specified inputs and the Flathead River at Outlet

Approximately 65 percent of the annual inflows occur between May 15 and June 10 as a result of snowmelt from the surrounding mountains (Stanford et al., 1994). Minimum flows generally occur in mid-winter. Annual flow patterns in the Flathead River, as well as Flathead Lake water surface elevations, are partly controlled by operations at the Hungry Horse dam facility, located on the South Fork of the Flathead River, and the Kerr Dam facility located on the main stem downstream of Flathead Lake.

Discharge rates from Hungry Horse Dam are constrained as follows (USFWS, 2000). Minimum flows in the South Fork of the Flathead River can range between 400 cfs and 900 cfs, depending on runoff forecasts. Minimum flows may be lowered to 145 cfs when the Flathead River at Columbia Falls reaches flood stage. Minimum flows at the Flathead River at Columbia Falls measurement site can range between 3,200 cfs and 3,500 cfs, depending on runoff forecasts. Ramping rates, or the rate of change in discharge magnitudes, can vary between 1,000 cfs/hr to 1,800 cfs/hr for increases in discharge from Hungry Horse and between 600 cfs/hr and 1,800 cfs/hr for decreases in discharge from Hungry Horse. Finally, use of Hungry Horse storage water to augment juvenile salmon flushing flows in the lower Columbia River during July and August will be minimized to the extent possible.

Minimum flows for releases from Kerr Dam range between 3,200 cfs and 12,700 cfs depending on seasonal conditions (FERC Section 4(e) conditions for Kerr Dam). Ramping rates may not exceed 250 cfs/hr for flows between 3,200 cfs and 7,500 cfs and ramping rates may not exceed 1,000 cfs/hr for flows greater than 7,500 cfs.

Target water surface elevations for Flathead Lake are bounded by flood control requirements imposed by the United States Army Corps of Engineers (USCOE) through memorandum to the Montana Power Company. By April 15, Flathead Lake elevation must be down from the full pool elevation of 2,893 feet to an elevation of 2,883 feet to allow storage for runoff. By June 15, Flathead Lake should be at full pool elevation.

2.1.2 Physical, Chemical and Biological Characteristics of Flathead Lake

The physical, chemical, and biological characteristics of Flathead Lake have been studied extensively (e.g., Gaufin et al., 1976; Ellis and Stanford, 1982; Flathead Basin Commission, 1989, 1991, 1993, 1995, 1997, 1999; Dodds et al., 1989; Dodds and Priscu, 1989, 1990; Perr and Stanford, 1982; Spencer and Ellis, 1990; Spencer, 1991; Spencer et al. 1991; Spencer and Ellis, 1998; Stanford et al., 1983; Stanford and Ellis, 1998; Stanford et al., 1990, 1994, 1995, 1997). Flathead Lake is one of the 300 largest lakes in the world and is renowned for its high water quality. The water column in the summer and fall is very transparent due to naturally low amounts of bio-available nitrogen and phosphorus entering the lake annually. Secchi disk readings in the summer and fall usually exceed 12 meters (Stanford et al., 1997). Average surface temperatures range from 36 degrees in mid-January, to 56 degrees in mid-June, to 68 degrees in mid-August. It is normal for many of the bay areas to freeze over on an annual basis, but due to its large volume and active winds the main lake basin does not freeze over most years.

Flathead Lake is considered oligotrophic (i.e., oligotrophic means being deficient in plant life or algae) and monomictic (i.e., one mixing period). While a distinct thermocline can be found in most areas of the lake each summer, there are several shallow bays (e.g., Polson Bay) which may not stratify. The depth and period of formation of the thermocline can vary considerably from year to year.

Following the discovery of declining oxygen levels in the hypolimnion of Big Arm Bay (Figure 2-1) in 1992, water column profiles of dissolved oxygen (DO) have been measured whenever possible (Ellis et al., 2000). The most recent data available regarding dissolved oxygen levels is from Water Year (WY) 1999 where percent oxygen saturation dropped to 79.5 percent (9.29 mg/l) near the bottom at the mid-lake deep site (Figure 2-2) in October 1999. The lowest observed DO concentration at this site was 70.1 percent in WY 1998. The lowest observed DO concentration at the Ross Deep site in WY 1999 was 65 percent (7.25 mg/l). The largest decline ever recorded at this site was from 102.4 percent at the surface to 50.7 percent (5.67 mg/l) at the bottom in WY 1998.

The fish community in Flathead Lake, the Flathead River and tributaries originally included ten native species with bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhyncus clarki lewisi*) as the dominant species in the upper trophic level of the lake ecosystem (Table 2-3). Eleven non-native fish species have been legally or illegally introduced into the system since the late 19th century (Table 2-3). The introduction of non-native fish coupled with the appearance of the non-native opossum shrimp (*Mysis relicta*) in Flathead Lake in 1981 have caused widespread changes in the lake's food web and ecosystem (Spencer et al., 1991). Lake trout are now the dominant predator fish species in the lake, the kokanee salmon population, which flourished through the late 1980's, has now crashed largely as a result of the appearance of opossum shrimp, and efforts are now underway to restore the bull trout fishery.

Bull trout were listed as threatened under the Endangered Species Act in July 1998. Both bull trout and westslope cutthroat trout are on the State of Montana's list of Animal Species of Special Concern (Roedel, 1999). The native Flathead Lake fishery is dependent on natural reproduction in the lake and recruitment from the tributary system above the lake. The lake and stream systems are dependent upon one another to provide the necessary environment for the sustenance of the fishery.

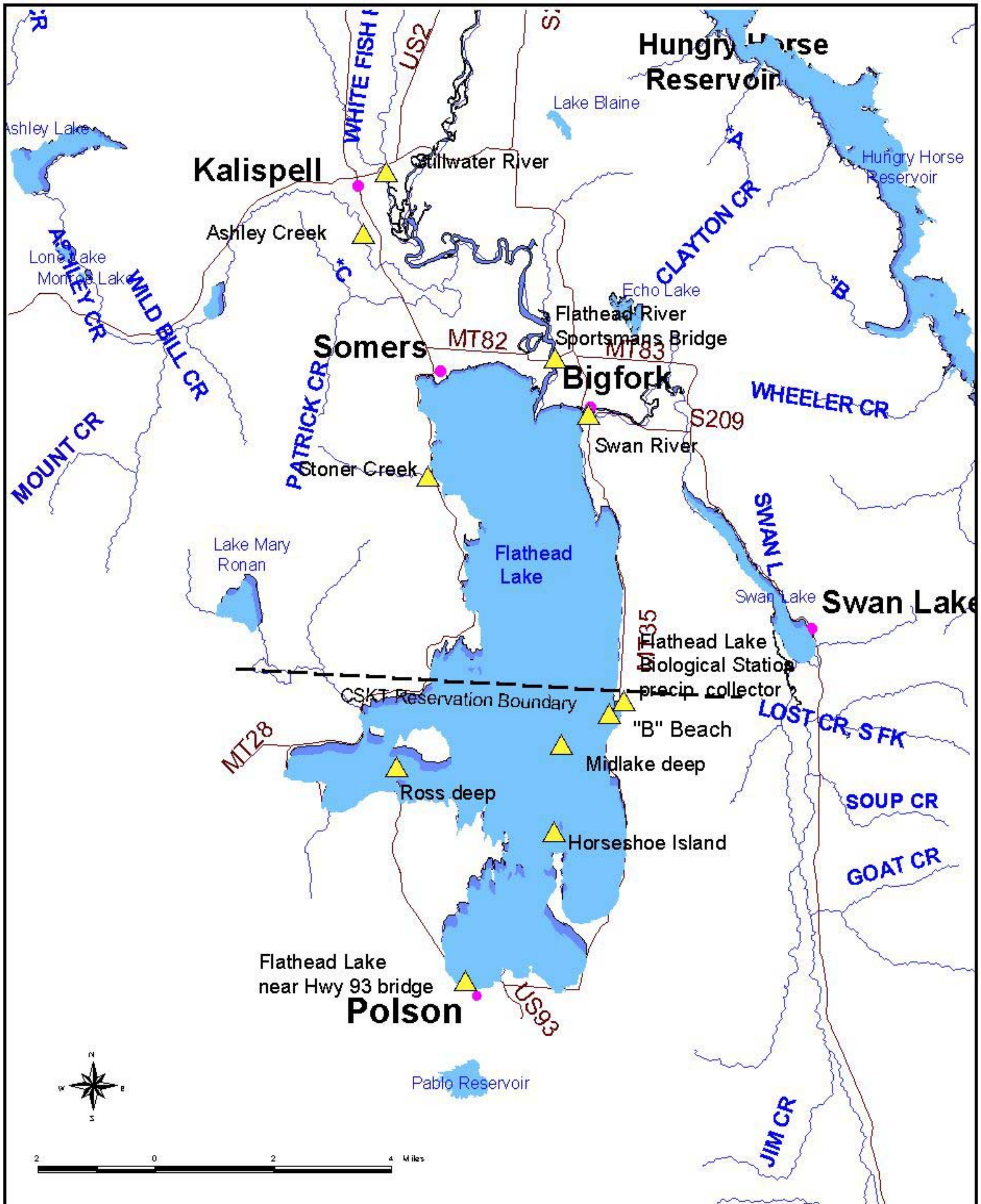

Figure 2-2. Flathead Lake Sampling Sites

Figure 2-2
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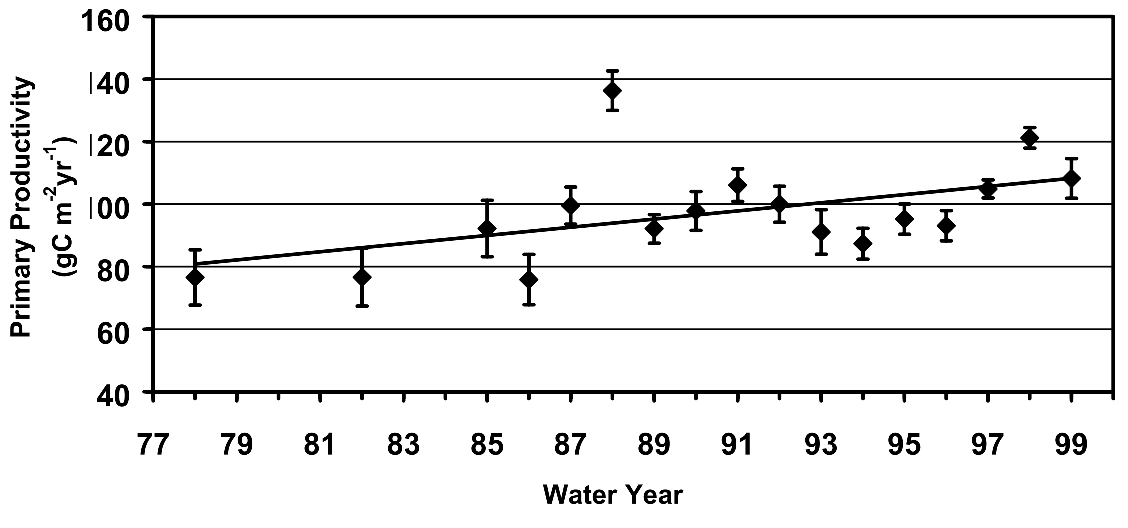
Table 2-3. Fish species of Flathead Lake, Flathead River and Tributaries

Native	Non-native
Bull trout	Lake trout (1905)
Westslope cutthroat trout	Lake whitefish (1890)
Mountain whitefish	Kokanee (1916)
Pygmy whitefish	Yellow perch (1910)
Longnose sucker	Northern pike (1960's – illegal introduction)
Largescale sucker	Rainbow trout (1914)
Northern pikeminnow	Brook trout (1913)
Peamouth chub	Largemouth bass (1898)
Redside shiner	Pumkinseed sunfish (1910)
Sculpin	Black bullhead (1910)
	Brown trout (1989 – unauthorized introduction)

Algal production in Flathead Lake is co-limited by low availability of both nitrogen and phosphorus, at least during the summer stratification period (Stanford et al., 1997; Spencer and Ellis, 1990). Since 1977 when the Flathead Lake Biological Station (FLBS) began focused water quality monitoring, open-water primary production (i.e., the rate of formation of organic plant material such as algae) has steadily increased (Figure 2-3). The FLBS long-term data bases show that production and standing crops of algae in the water column are influenced by the rate and timing of inputs of bioavailable nitrogen and phosphorus from the tributary watershed, including the lake shoreline and bulk precipitation on the lake surface (Stanford et al., 1997). Interannual variation in these data are high, due to year to year differences in temperature, light, mixing of the water column, internal nutrient cycling, water flux through the lake (e.g., as influenced by climate and operations of Kerr and Hungry Horse Dam (Stanford and Hauer, 1992; Stanford and Ward, 1992)), external nutrient loading and cascading effects associated with food web changes largely mediated by the population dynamics of *Mysis relicta*. The food web changes introduced significant variation into the expected relationship between primary production and nutrient loading. Nonetheless, primary productivity is at least partially linked to the nutrient load reaching Flathead Lake annually after the *Mysis*-mediated food web cascade stabilized (1989-present).

Profuse mats of algae have been observed along shoreline rubble adjacent to groundwater seeps and isolated portions of the lake (Hauer, 1988). As with primary productivity, shoreline periphyton is also responsive to changes in nutrient availability. However, sufficient time series data for periphyton biomass and productivity does not currently exist to link shoreline scums to external nutrient loading. Short term studies (Bauman, 1988; Marks and Lowe, 1993) show that Flathead Lake periphyton increases sharply if nutrients, especially phosphorus, are added. Shoreline surveys and previous work by Hauer (1988) clearly link localized scums to shoreline pollution sources. While it can be concluded that periphyton is a robust indicator of water quality, insufficient monitoring data exists to establish a relationship to annual nutrient load.

Figure 2-3. Primary Productivity Trends in Flathead Lake.



Like all large temperate lakes, Flathead Lake experiences an annual bloom of diatoms (phytoplankton) in the spring (April-May) associated with high nutrient concentrations in the water column, long day length and seasonal warming. Phytoplankton biomass (chlorophyll a) and primary production tend to reach an annual maximum at this time. The vernal diatom bloom expends the nutrient supply and crashes as the lake thermally stratifies in the summer. During stratification, algal growth is constrained by lack of nutrients and most years the stratified period is characterized by very small forms of algae that rapidly recycle nitrogen and phosphorus. Generally, biomass declines substantially in relation to the vernal bloom; but, primary production can remain fairly high due to rapid uptake and release of nutrients by these small sized microbes. Most years the lake appears very clear in late summer and fall because the water column is not producing a high biomass of algae; and, sediments from spring runoff have settled to the lake bottom. However, especially on wet years when external nutrient loading is high during summer, the pollution alga, *Anabaena flos-aquae*, has bloomed lake-wide (e.g., 1983 and 1993).

In lakes worldwide, *Anabaena* blooms and oxygen depletion during stratification are very well documented indicators of water quality deterioration associated with excess nutrient loading (Vallentyne, 1974; Cole, 1994; Wetzel, 2001). Water quality in Flathead Lake remains on or near a threshold with respect to nutrient loading and resulting water quality measured in terms of algal production and associated water clarity (Stanford et al., 1997).

2.2 Cultural Characteristics

2.2.1 Land Use

Current Land use Patterns

Land use patterns within the Flathead Basin were determined using the USGS National Land Cover Dataset (NLCD). The NLCD contains 21 categories of land cover determined based on 1992 Landsat imagery at a resolution of 30-meters. A summary of the land cover types within the entire Flathead Basin is presented in Table 2-4. Land cover maps for each of the six sub-watersheds are presented in Figures 2-4 through 2-9 (Appendix A). By far, the most prevalent cover type in the basin is evergreen forest (72 percent). The urban (i.e., low intensity residential, high intensity residential, commercial/industrial/transportation, and urban/recreation grasses) and agricultural land uses (i.e., pasture/hay, row crops, small grain) represent 0.3 and 2.9 percent of the total area, respectively, and are primarily confined to the Flathead, Stillwater, and Whitefish River valleys between Flathead Lake on the south and Whitefish Lake on the north.

Land use within close proximity to the shoreline of Flathead Lake is of particular importance relative to nutrient loading. Makepeace and Mladenich (1996) focused on the land area within one-half mile of the lake and determined homesite densities and land cover types based on interpretation of 1994 aerial photography (Figure 2-10 – Appendix A). The predominant land type along the lakeshore is forested, however, much of these lands have been subdivided for home sites. Grasslands comprise the second most common land cover type around the lake. This cover type is most prevalent along the west shore of the lake and, in many areas, is subdivided for home sites. Residential development occurs around the entire lake shoreline, the density of which is shown on Figure 2-11 (Appendix A).

Land Use Trends

Both Lake and Flathead Counties remain among the fastest growing in the state (Flathead Basin Commission, 2000). In Lake County, recent growth has largely been concentrated along the U.S. Highway 93 corridor, along the east shore of Flathead Lake, and in the lower Swan Valley. Eighty-nine subdivisions were created in 1998 and 1999, an increase of nine percent over the previous two-year period. The new subdivisions resulted in 275 lots. Through early December 2000, 300 new septic permits had been issued, compared to 204 in 1999 and 283 in 1998. Similar growth has been occurring in Flathead County where new subdivision lots increased from 490 in 1997 to 710 in 1999. Seventy-two percent of all types of new homes constructed in the county occurred outside the boundaries of the county's three incorporated areas (Flathead Basin Commission, 2000).

Table 2-4. Flathead Basin Land Cover Summary

COVER TYPE	ACRES	% OF TOTAL
Open Water	199,420	4.83%
Perennial Ice/Snow	2,818	0.07%
Low Intensity Residential	5,755	0.14%
High Intensity Residential	38	0.00%
Commercial/Industrial/Trans	7,027	0.17%
Bare Rock/Sand/Clay	110,441	2.69%
Quarries/Strip Mines/Gravel Pits	0	
Transitional	52,485	1.28%
Deciduous Forest	16,108	0.40%
Evergreen Forest	2,994,703	72.48%
Mixed Forest	2,204	0.06%
Shrubland	283,690	6.96%
Orchards/Vineyards/Other	36	0.00%
Grassland/Herbaceous	292,335	7.14%
Pasture/Hay	60,403	1.47%
Row Crops	0	
Small Grains	59,852	1.45%
Fallow	17,176	0.42%
Urban/Recreational Grasses	772	0.02%
Woody Wetlands	15,070	0.37%
Emergent Herbaceous Wetlands	2,089	0.05%

2.2.2 Land Ownership

Land ownership patterns within the Flathead Basin are summarized in Table 2-5 and depicted in Figures 2-12 through 2-17 (Appendix A). At 60 percent of the total land base within the basin, the United States Forest Service (USFS) is the single largest landowner. The National Park Service is the second largest landowner at 16 percent, with undifferentiated private at 13 percent, and the Montana Department of Natural Resources and Conservation and Plum Creek at five percent each.

Table 2-5. Flathead Basin Land Ownership Summary.

Ownership	Flathead Lake		Stillwtr/ Whtfish		North Fork		Middle Fork		South Fork		Swan		Total	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Bureau of Reclamation	0	0%	0	0%	0	0%	0	0%	85	0%	0	0%	85	0%
US Fish & Wildlife Service	3828	1%	0	0%	0	0%	0	0%	0	0%	1544	0%	5372	0%
National Park Service	1	0%	0	0%	278758	46%	340196	48%	0	0%	0	0%	618955	16%
US Forest Service	126144	21%	256014	49%	290158	48%	369518	52%	1044143	100%	280862	61%	2366839	60%
Department of Defense	34	0%	0	0%	0	0%	0	0%	0	0%	0	0%	34	0%
MT Department of Natural Resources and Conservation	20053	3%	101511	20%	19093	3%	351	0%	0	0%	45575	10%	186583	5%
MT Fish Wildlife & Parks	3015	1%	1550	0%	0	0%	103	0%	0	0%	83	0%	4751	0%
University System	68	0%	0	0%	0	0%	0	0%	0	0%	0	0%	68	0%
City	0	0%	154	0%	0	0%	0	0%	0	0%	0	0%	154	0%
BIA Trust	55538	9%	0	0%	0	0%	0	0%	0	0%	192	0%	55730	1%
Tribal Lands	22	0%	0	0%	0	0%	0	0%	0	0%	23	0%	45	0%
Private	309531	52%	133816	26%	16755	3%	5180	1%	79	0%	49901	11%	515262	13%
Plum Creek	76608	13%	24271	5%	0	0%	0	0%	0	0%	81511	18%	182390	5%
Nature Conservancy	101	0%	0	0%	156	0%	0	0%	0	0%	383	0%	640	0%

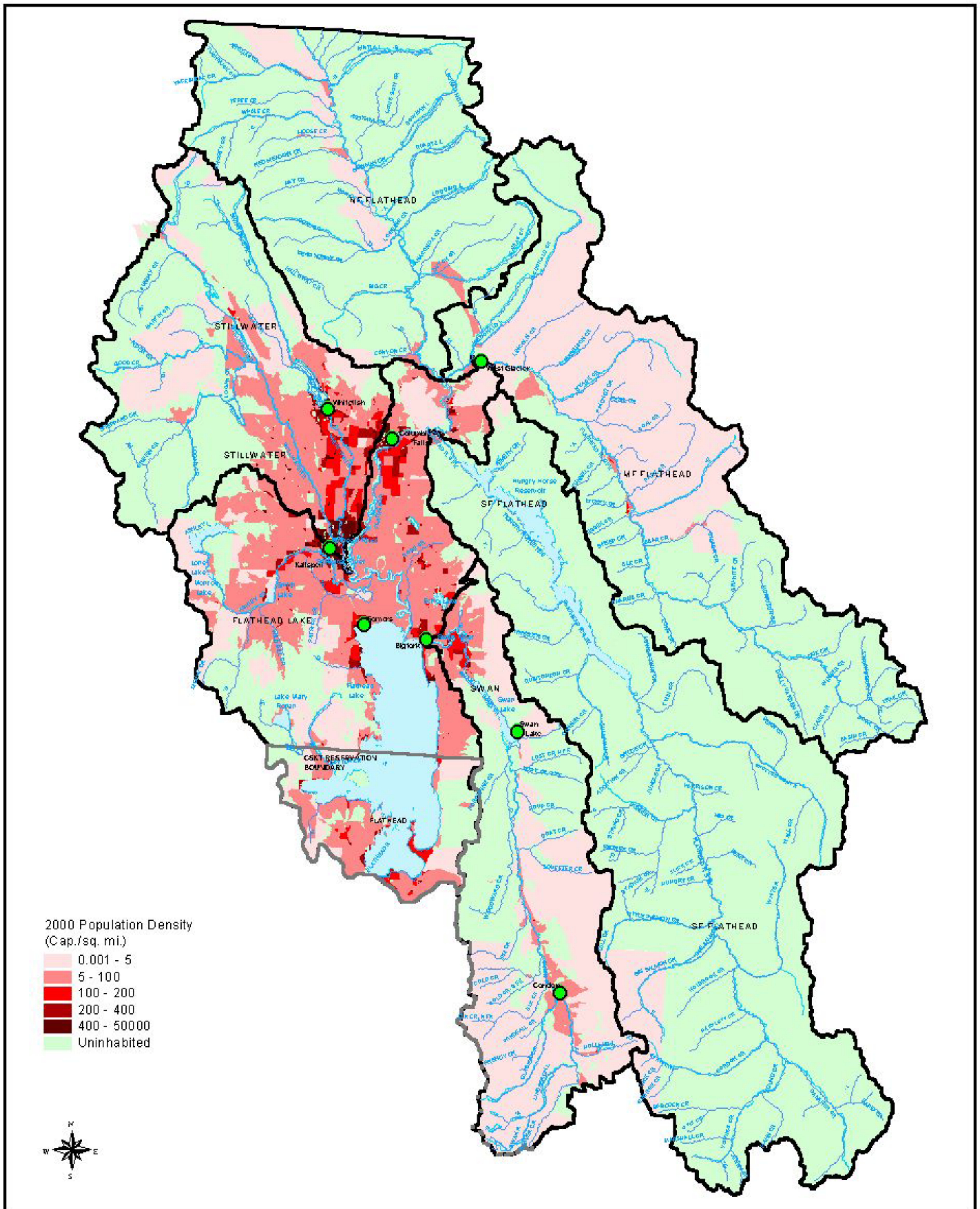
2.2.3 Population

Based on 2000 Census Block data obtained from the Montana State Library (2001), the 2000 population for the Flathead Basin was 93,052. That represents a 25.2 percent increase over the 1990 census. The distribution of the population is shown in Figure 2-18 and a summary by sub-basin is provided in Table 2-6.

The Flathead Lake and Stillwater/Whitefish sub-basins are, by far, the most densely populated areas within the Flathead Basin. The bulk of the population is concentrated in the area extending from the north shore of Flathead Lake to Kalispell, Whitefish and Columbia Falls. Another densely populated area exists in the vicinity of Polson. The majority of the periphery of the shoreline of Flathead Lake is populated with the highest concentrations along the northwest side.

Table 2-6. Sub-Basin Population Summary

Sub-Basin	1990 Population	2000 Population	% Increase
Flathead Lake	37660	49296	31
Stillwater/Whitefish	30079	36017	20
North Fork	273	414	52
Middle Fork	582	553	(5)
South Fork	1327	1311	(1)
Swan	4407	5461	24



Montana Department of Environmental Quality

Figure 2-18. Flathead Basin Population

Figure 2-18	
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SECTION 3.0
APPLICABLE WATER QUALITY STANDARDS

As shown in Figure 1-1, Flathead Lake is within the jurisdictional boundaries of both the State of Montana and CSKT Reservation and, thus, is subject to the water quality standards of both jurisdictions.

3.1 Montana Water Quality Standards

Subchapter 6 (title 17, chapter 30) of the Administrative Rules of Montana (ARM) describes Montana's surface water quality standards and procedures. Therein, Flathead Lake is classified as an A-1 waterbody (ARM 17.30.608{2}). This means that the lake should be suitable for drinking and food processing purposes, bathing, swimming, recreation, the growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers, and agricultural and industrial water supply (ARM 17.30.622{1-2}). Narrative and numeric water quality standards exist in order to protect these uses, and their legal foundation can be found (in addition to subchapter 6) in state statute. The Montana Water Quality Act begins by stating that: "*It is the public policy of this state to: …(2) provide a comprehensive program for the prevention, abatement, and control of water pollution*" (MCA §75-5-101{2}). Excess algae growth can negatively impact uses such as recreation and aquatic life (Biggs, 1996; Watson and Gestring, 1996), and nutrients have been cited as the cause of impairment to 40 percent of rivers and 50 percent of lakes according to the EPA report *National Water Quality Inventory: 1996 Report to Congress Executive Summary*. Numerous studies have shown that nutrients play a significant role in the propagation of benthic algae in streams (see review by Borchardt, 1996) and phytoplankton in lakes (Edmonson, 1970; Dillon and Rigler, 1974; Schindler, 1977; Sas, 1989; and others). Therefore, excess nutrients may be considered pollution, as pollution is defined in state statute as: "*a discharge, seepage, drainage, infiltration or flow of liquid, gaseous, solid, radioactive, or other substances into state water that will or is likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, or welfare, to livestock, or to wild animals, birds, fish, or other wildlife*" (MCA §75-5-103{25ii}).

Additional authority is found in ARM 17.30.637(1). According to this rule, "*State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: …(e) create conditions which produce undesirable aquatic life*". This statement is interpreted to mean that nutrients are the substances and excess algae are the undesirable aquatic life resulting from the condition of man-caused eutrophication. Further, these laws and regulations work in concert with the federal Clean Water Act (Section 101), whose stated goal is "*to restore and maintain the chemical, physical, and biological integrity of the nations waters*".

In the case of Flathead Lake, the use of these narrative standards is a matter of case-specific interpretation. A long-term data record collected by the University of Montana has documented a decline in the lake's water quality, a decline caused by excess algae resulting from increased human-caused nutrient loading (Stanford et al., 1997). Flathead Lake is among the cleanest large lakes in the northern temperate part of the world (Stanford et al., 1997). The lake is heavily used for recreation, and is known for its aesthetic beauty. Therefore, an increase in algae blooms, standing crop, and productivity is not desired. ARM 17.30.637 provides the legal authority to prevent this "*undesirable aquatic life*". As excess nutrient loading has been shown to be the cause of these negative changes, excess nutrients may be considered pollution (MCA §75-5-103{25ii}), which by state law we must prevent, abate or control (MCA §75-5-101{2}).

If it is determined that a water body does not meet its beneficial uses, Montana Department of Environmental Quality is required to list that water body as threatened or impaired (MCA Sect. 75-5-702) and to develop and implement a Total Maximum Daily Load (TMDL) (MCA Sect. 75-5-703).

Montana law requires that , "*Each TMDL must be established at a level that will achieve compliance with applicable water quality standards and must include a reasonable margin of safety that takes into account any lack of knowledge concerning the relationship between the TMDL and water quality standards*". The TMDL regulations further allow the department to establish waste load allocations for point sources and load allocations for nonpoint sources, and establish a requirement supporting a voluntary program of reasonable land, soil and water conservation practices for nonpoint source activities. Once a TMDL is adopted, point source discharges may continue if the discharge does not cause a decline in targeted water quality parameters, new and expanded nonpoint source activities continue using reasonable land, soil, and water conservation practices, and use of educational programs for voluntary nonpoint source control programs is employed.

3.2 Tribal Water Quality Standards

The Confederated Salish and Kootenai Tribes (CSKT) water quality standards were adopted by the Tribes in 1995 under the authority of Ordinance 89B, the CSKT Water Quality Management Ordinance, Sections 1-2-102, 1-2-201, 1-2-204, and 1-2-206. Tribal water quality standards are promulgated pursuant to Tribal Ordinance 86B, the Tribal Administrative Procedures Ordinance. Tribal authority to develop, adopt, and promulgate water quality standards stems from Federal authorities identified in the 1987 amendments to the Clean Water Act (The Water Quality Act of 1987), 33 USC §1377(e). A process is identified in §1377(e) for Indian Tribes to seek authority for "*treatment as a state*" for specific provisions of the Water Quality Act. One provision Tribes may seek authority for is 33 USC §1313, Water Quality Standards and Implementation Plans. The CSKT received treatment as a state authority to develop a water quality standards program in 1992 and the USEPA approved the CSKT Water Quality Standards in 1996.

Flathead Lake is designated with an A-1 classification in the CSKT standards and waters are intended to support a range of designated uses including drinking, culinary, and food processing uses; bathing, swimming, and recreation uses; wildlife uses; growth and propagation of salmonid fishes and associated life; and agricultural and industrial supply uses. Numeric and narrative water quality standards are identified which are protective of these designated uses.

"*Reservation waters,* in this specific instance Flathead Lake*, must be free from substances that are or may become injurious to public health, safety, welfare or any of the designated or existing beneficial uses. Such substances may or will create conditions that produce undesirable aquatic life*" (CSKT Water Quality Standards §1.3.13). Long-term primary productivity data (reported in Stanford et al., 1997) demonstrate a trend of increasing primary productivity in Flathead Lake and Stanford and others (1997) associate this increase with elevation in nutrient loads to the lake. Increases in aquatic plant life occur concurrently with increases in primary productivity and may impair recreational beneficial uses and, as the trend in dissolved oxygen profile information indicate (FBC Biennial Report, 1999–2000), may at some point lead to numeric water quality violations for dissolved oxygen concentration.

SECTION 4.0
SOURCE ASSESSMENT

This section presents a characterization of the type, magnitude, and location of sources of nutrient loading to Flathead Lake. Point sources, nonpoint sources, and airborne sources are discussed separately below.

4.1 Point Sources

In 1983 the Water Quality Bureau of the Montana Department of Health and Environmental Sciences (the predecessor to DEQ) estimated that point sources were discharging 45,760 pounds of phosphorous into Flathead Lake each year. The bureau predicted that, unchecked, the load would increase to 91,740 pounds by 2000. Even with treatment, it was estimated that municipal sewage plants would discharge 15,400 pounds of phosphorous into the lake in 2000 (DHES, 1983). In 1984 the Water Quality Bureau established a 1.0 milligram per liter limit on phosphorous discharges from municipal point sources in the Flathead Basin. Between 1984 and 2000 all the municipalities in the watershed replaced or upgraded their sewage treatment facilities. All plants now have phosphorous removal systems. Local residents have also helped reduce loads by using low or no phosphate products. As a result of these efforts the phosphorous load from permitted point sources in 2000 was just 2,329 pounds—15 percent of the most optimistic prediction 17 years earlier.

No comparable limits were established for nitrogen discharges. In the 1980s it was assumed that phosphorous availability was the determining factor in aquatic plant growth. Subsequent research has shown that nitrogen also plays an important role (Steg). The nitrogen limits contained in municipal permits are based on Montana's Nondegradation Rules (ARM 17.30.700). These limits are not tailored for Flathead Lake's specific water quality concerns. In 2000 municipal point sources discharged 56 metric tons of Total Nitrogen.

As shown in Table 4-1 and Figure 4-1, there are seven permitted nutrient point source dischargers within the Flathead Basin.

The Bigfork Sewer District serves 1200 people in an unincorporated area on the northeast side of Flathead Lake. The sewage treatment facility was built in 1988. It is designed for a population of 5,412. The plant is a trickling filter type secondary facility with tertiary phosphorous removal. Nitrogen and phosphorous discharges are monitored monthly. The district's MPDES permit was issued March 16, 2001 and expires July 31, 2006. In 1983 Bigfork's phosphorous discharge was 5,940 pounds per year. By 2000 the district had reduced phosphorous discharges to 110 pounds. In 2000, total nitrogen discharge was 4.3 tons.

The Whitefish sewage plant serves a city of 5,032 with a facility designed for a population of 10,000. The system consists of aerated lagoons followed by a flocculating clarifier for phosphorous reduction. The city's discharge permit was issued May 1, 2001 and expires April 30, 2006. The population of Whitefish increased 15 percent in the past decade. Nitrogen and phosphorous levels in discharge waters are monitored monthly. The 1983 phosphorous discharge for Whitefish was 12,760 pounds. The 2000 phosphorous discharge was 1,496 pounds. Total nitrogen discharge in 2000 was 22.7 metric tons.

Columbia Falls grew by 24 percent from 1990 to 2000. However, phosphorous discharges declined from 8,580 pounds in 1983 to 172 pounds in 2000. The city's sewage treatment facility serves a population of 3645. It is an activated sludge system with tertiary treatment. The plant was upgraded

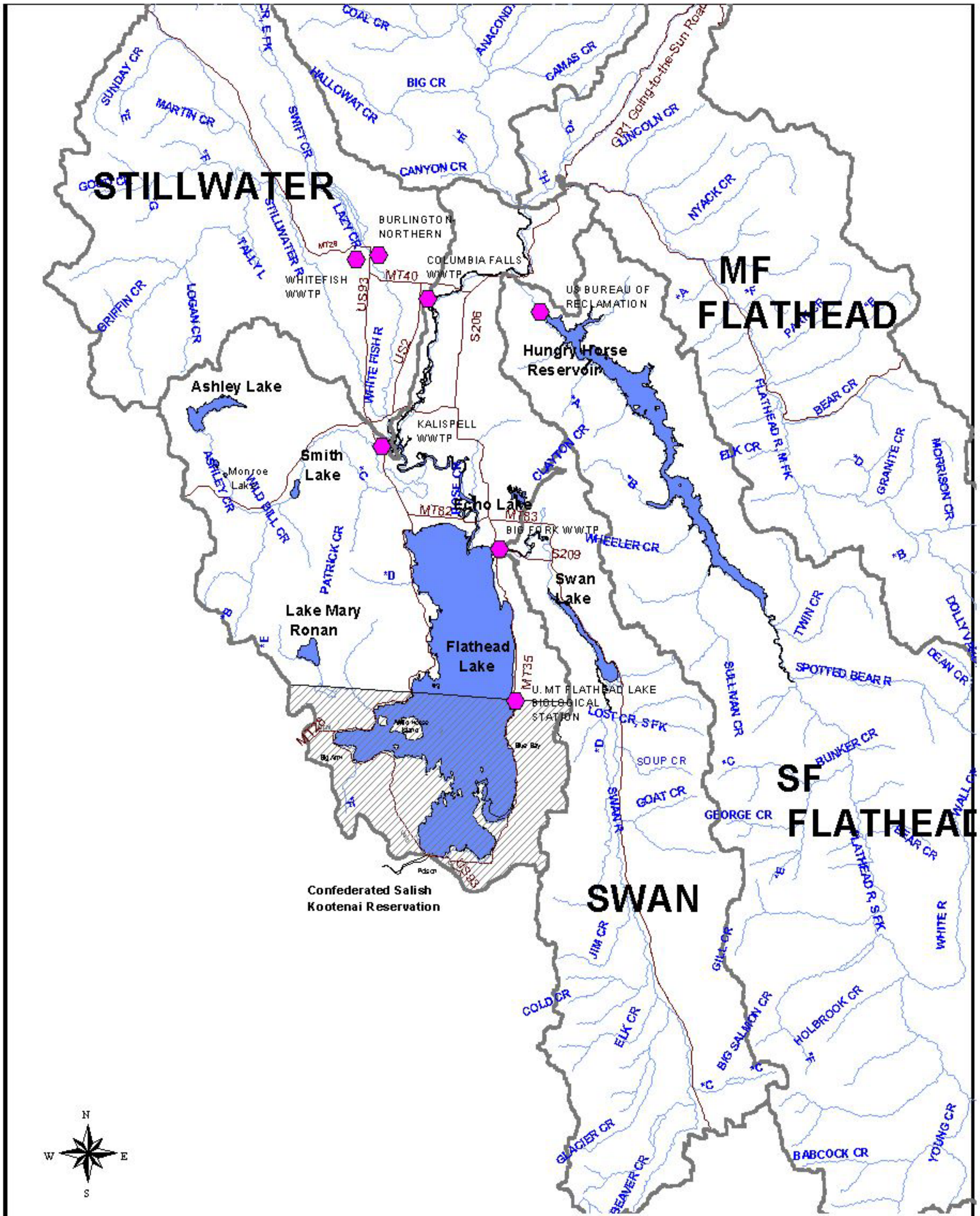

Figure 4-1. Point Source Discharge Locations	Figure 4-1
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in 2000. The MPDES discharge permit was issued on March 1, 1999 and expires August 31, 2003. The plant discharges into the Flathead River near Turnbull Creek. Phosphorous discharges are monitored weekly and nitrogen monthly. Total nitrogen discharge in 2000 was 3.65 metric tons.

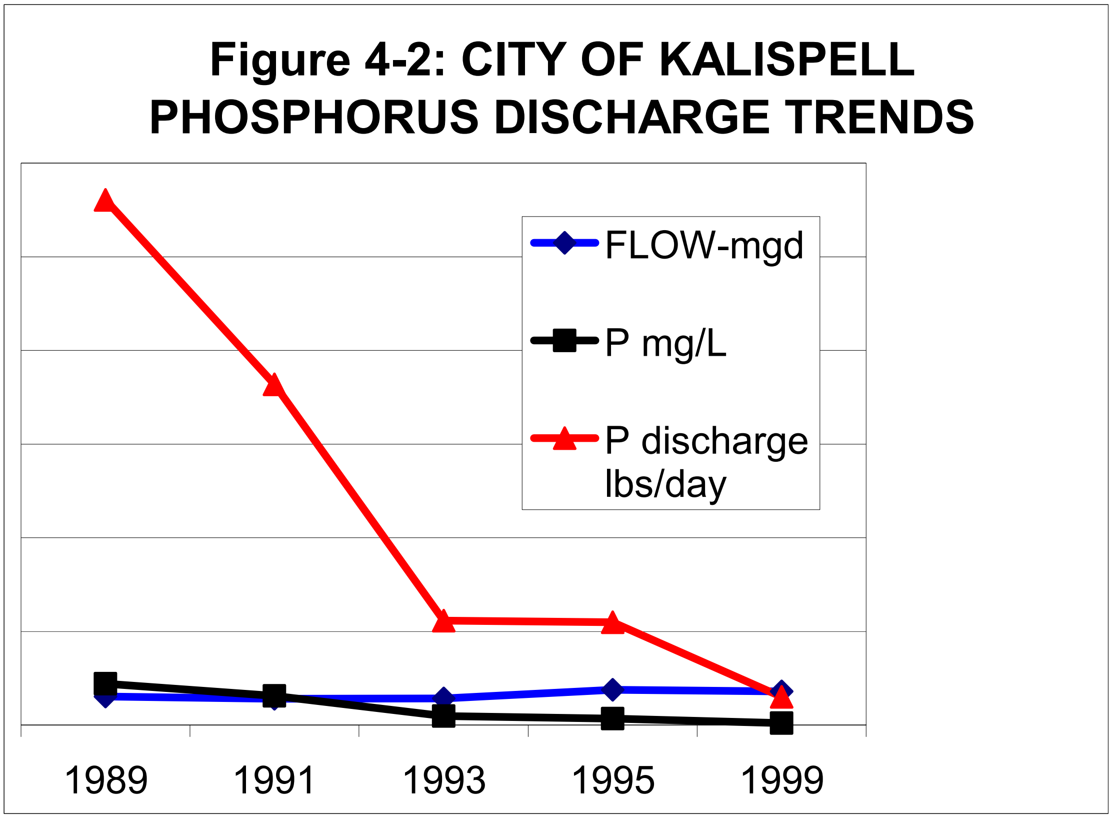
Kalispell accounts for 59 percent of the municipal load in the watershed. However, the city's discharges of nitrogen and phosphorous are well below permitted levels (Table 4-1).

The sewage treatment plant serves 14,223 with a facility designed for 31,800. The plant uses a biological nutrient removal process. Components include headworks, bar screen and solids separator units, two rectangular primary clarifiers, a flow equalization basin, eleven cell bioreactor to promote biological nutrient removal, back-up of chemical-precipitation phosphorous removal system, two circular secondary clarifiers, four effluent sand filters, effluent re-aeration basin, primary sludge fermenter, two dissolved air flotation sludge thickeners, two belt filter press units and three anaerobic sludge digesters. Phosphorous discharges dropped significantly when the new plant came on line in 1992 (Figure 4-2). Operators monitor nitrogen levels monthly and phosphorous levels twice a week. The city's current permit expires August 31, 2003. Kalispell grew by almost 20 percent in the 1990s. In 1994 the City of Kalispell signed an agreement with Evergreen Sewer District to provide sewer service to the district's 2000 customers. In 1983 the city discharged 18,480 pounds of phosphorous; in 2000 547 pounds. Discharge phosphorous concentrations dropped from 4.7 mg/l in 1983 to 0.1 mg/l in 2000. In 2000 Kalispell's total nitrogen discharge was approximately 25 metric tons.

TABLE 4-1. Point Source Nutrient Discharges

FACILITY NAME	RECEIVING WATER	PERMITTED LOAD*		ACTUAL LOAD*		% DESIGN CAPACITY†
		N	P	N	P	
Bigfork Sewer District	Flathead Lake	152	4.2	26	.3	38
Whitefish	Whitefish R.	280	10.4	137	4.1	64
Columbia Falls	Flathead River		6	26	.47	65
Kalispell	Ashley Creek	890	26	167	1.8	69
Burlington-Northern	Whitefish R.	27	.80	NA	NA	8
Flathead Lake Biological Station	Flathead Lake	7.9	2	.167	.002	7
U.S. Bureau of Reclamation	South Fork Flathead R.	3.1	.8	.45	.009	29
TOTALS		1500	50.2	372	6.89	

* Pounds per day †Based on flow.



Burlington-Northern (B-N) has an industrial permit to discharge into the Whitefish River. B-N's average daily discharge is 8 percent of its permitted discharge. Many months the facility has no discharge to report. The treatment facility, built in 1988, is a two-cell facultative/settling pond system. Nitrogen and phosphorous levels in discharge waters are monitored monthly. B-N's permit was issued October 1, 1999 and expires June 30, 2004.

The University of Montana Flathead Lake Biological Station has a permitted sewage treatment system that discharges into Flathead Lake. It is an extended aeration system with tertiary sand filtration. Permitted discharge is 35,000 gallons/day. Phosphorous discharges are monitored weekly and nitrogen monthly.

The U.S. Bureau of Reclamation has a permitted sewage treatment facility at Hungry Horse Dam on the South Fork of the Flathead River. The 9000 gallon/day system serves Bureau employees and dam visitors. It is an extended aeration system with tertiary sand filtration. Phosphorous discharges are monitored weekly and nitrogen monthly.

4.1.1 Point Source Loading Summary

Municipal point sources contributed between one and two percent of the total nutrient load to Flathead Lake in WY 1993 (Figures 4-9 through 4-11). At current discharge rates, with all of the facilities at less than 69 percent design capacity, municipal point sources do not appear to be significant sources of nitrogen or phosphorus to Flathead Lake at this time. However, if all of the municipal point source facilities were to discharge at their permitted discharge limits, nitrogen and phosphorus loads from these sources could increase by approximately 4.6 and 7.8 times, respectively. The total nitrogen load would increase from 1.39 percent (based on WY 1993 – Table 4-2) to 14.2 percent of the total load to Flathead Lake. For total phosphorus, the load would increase from 1.62

percent to 11.7 percent of the total load, provided other sources did not also increase nutrient discharges.

4.2 Nonpoint Sources

The following source assessment summary for nonpoint sources is based on three separate studies: 1) a long-term tributary nutrient loading analysis, 2) synoptic tributary sampling, and 3) a loading analysis by source category.

4.2.1 Long-term Tributary Loading

Methods

Loading of nitrogen and phosphorus to Flathead Lake from the primary tributaries was determined by Stanford et al. (2001) from a long-term database electronically archived at the Flathead Lake Biological Station. The database was derived from measurements of nitrogen and phosphorus forms made by the Biological Station from time-series collections on the major tributaries to the lake and the airshed (bulk precipitation at the Biological Station). Monitoring sites where long-term phosphorus and nitrogen data were obtained are shown on Figure 2-2 and include:

- Ashley Creek below the Kalispell sewage treatment plant outfall;
- Stillwater River in Evergreen below the confluence of the Whitefish River;
- Flathead River near Holt (Sportsmen Bridge), the primary upstream tributary;
- Swan River at Bigfork, upstream from the outfall of the sewage treatment plant;
- Flathead Lake at the outlet sill near the Highway 93 bridge in Polson;
- The bulk precipitation collector located on the dock at the Flathead Lake Biological Station;
- Midlake deep (110 m depth) ca. 1 mile west of Yellow Bay Point in a pelagic area of Flathead Lake;
- Stoner Creek near Lakeside.

Stream discharge data were obtained from the U. S. Geological Survey (USGS), except on Ashley and Stoner Creeks, where flow data was obtained from the Biological Station using USGS procedures. All analytical data collected at all sites in the Flathead Basin since 1977 are included in the master Flathead database at FLBS. Loading estimates have been made only through the 1996 water year, although the monitoring program has continued to date (see Ellis, 1998 #18915; Ellis, 1999 #18918; Ellis, 2000 #19345).

Daily loading estimates were made by interpolating between known concentrations of nutrients in river and bulk precipitation. Measured daily river-flow and precipitation values were multiplied by nitrogen and phosphorus concentrations to estimate load. Nitrate plus nitrite concentrations in the Flathead River at Holt were independent of river discharge and therefore linear interpolation was used. However, total phosphorus concentrations were related to river flow (Stanford et al., 1994; Stanford et al., 1995); during spring runoff the forks and mainstem of the Flathead River contain variable amounts of inorganic particulates (eroded sediments) that contain high amounts of non-labile phosphorus. Ellis and Stanford (1986) showed that only ten percent of the total phosphorus entering the lake in association with inorganic sediments during high flow events is biologically stimulatory to phytoplankton in the lake. Therefore, during base flow, when little or no inorganic sediments were present in the samples, interpolations between known points were weighted by flow and, during high flow events when sediments were present in samples, total phosphorus concentration was predicted as a function of discharge. High flow events were identified when total suspended solids exceeded 10 mg/l; for all TP data obtained during high flow events the load was corrected for bioavailability by reducing the measured amount by 90 percent.

Estimates of input of phosphorus from the atmosphere on to the surface of the lake were obtained from collections of bulk precipitation at FLBS. Loads were calculated by multiplying the concentrations of N and P forms in bulk collections by precipitation volumetrically and distributing the inputs lakewide.

Shoreline septic system loading was based on Makepeace and Mladenich (1996) which is incorporated herein by reference.

Tributary Nonpoint Source Loads

The main-stem Flathead River delivers the largest load of bioavailable phosphorus (60.28 percent), total nitrogen (69.90 percent), and nitrate/nitrite (75.13 percent) to Flathead Lake (Table 4-2). This is not surprising given that the Flathead River also delivers the greatest hydrologic load to the lake on an annual basis (approximately 85 percent of the total inflow). Of the remaining tributaries to Flathead Lake for which data is currently available, the Stillwater/Whitefish basin delivers the second largest nutrient load followed by the Swan River, Ashley Creek, Stoner Creek and other shoreline tributaries combined. The loads of bioavailable phosphorus and nitrate/nitrite from shoreline septic systems comprise 2.59 and 3.86 percent, respectively, of the total loads.

Table 4-2. Summary of nitrogen and phosphorus loads to Flathead Lake (adapted from Stanford and Ellis, 2001).

Watersheds	BioTP load MT/yr	%	TN load MT/yr	%	NO2/3 load MT/yr	%
Main-stem Flathead(1)	85.96	60.28%	1067.15	69.90%	545.41	75.13%
Swan	7.09	4.97%	108.44	7.10%	30.84	4.25%
Stillwater/Whitefish	12.73	8.93%	119.72	7.84%	48.29	6.65%
Ashley Creek	6.12	4.29%	66.3	4.34%	22.14	3.05%
Stoner Creek	0.15	0.11%	1.04	0.07%	0.11	0.02%
Other shoreline creeks(2)	1.57	1.10%	11.42	0.75%	4.45	0.61%
Shoreline septic (3)	3.7	2.59%		NA	28	3.86%
Precipitation	22.97	16.11%	131.34	8.60%	40.28	5.55%
Point Sources	2.309	1.62%	21.21	1.39%	6.393	0.88%
Total Load	142.599		1526.62		725.913	

(1) Excluding loads from the Stillwater/Whitefish and Ashley Creek Basins.
(2) Estimated using nutrient data from Yellow Bay Creek (n=24) and estimated annual discharge from 20 of the larger shoreline creeks (see Stanford et al. 1983 and Potter 1978). This is likely an underestimate.
(3) From Makepeace and Mladenich, 1996.

The nutrient loads presented in Table 4-2 are a function of the hydrologic load commensurate with each tributary system. Mean annual areal nutrient loading was calculated for each of the tributary systems to compare nutrient loading from one basin to another on a relative basis (Table 4-3). On an acre-by-acre basis, the Ashley Creek basin produces the greatest unit areal load of nutrients with one exception. The highest unit aerial load of nitrate/nitrite was observed in the main-stem Flathead Basin.

Table 4-3. Mean annual unit areal loading expressed as metric tons/km^2/year (adapted from Stanford and Ellis, 2001).

Watersheds	BioTP load	TN load	NO2/3 load
Ashley Creek	0.012	0.127	0.043
Stillwater/Whitefish	0.010	0.091	0.037
Main-stem Flathead	0.007	0.089	0.046
Swan	0.004	0.058	0.016
Stoner Creek	0.003	0.018	0.002

4.2.2 Synoptic Sampling

A synoptic study of many of the Flathead Basin tributaries was conducted in 1995 and 1996 in an attempt to further refine the assessment of nonpoint sources of nutrients to Flathead Lake (Stanford et al., 1997). Grab samples were collected during base flow conditions in 1995 and 1996 and during a runoff event produced by a 0.75 to 0.86-inch precipitation event in April 1996.

Examination of the data collected through this effort revealed that the largest percentage of the total nutrient load delivered to Flathead Lake was from the most developed portions of the tributary watersheds. Table 4-4 presents the results of an analysis of the synoptic data conducted by Stanford and Ellis (2001) in which nutrient loading from the more developed portions (i.e., upper basins as shown on Figure 4-3) of the Stillwater River, Whitefish River, and Ashley Creek Basins were compared to nutrient loading for the less developed portions of these basins (i.e., lower basins as shown on Figure 4-3). For a single storm event in April 1996, a disproportionate share of the total phosphorus and nitrate/nitrite loads were produced within the most developed portions of the Stillwater River, Whitefish River, and Ashley Creek watersheds (Figure 4-3). With the exception of Ashley Creek, the same is true for total nitrogen. An upstream/downstream land use comparison is presented in Figure 4-4.

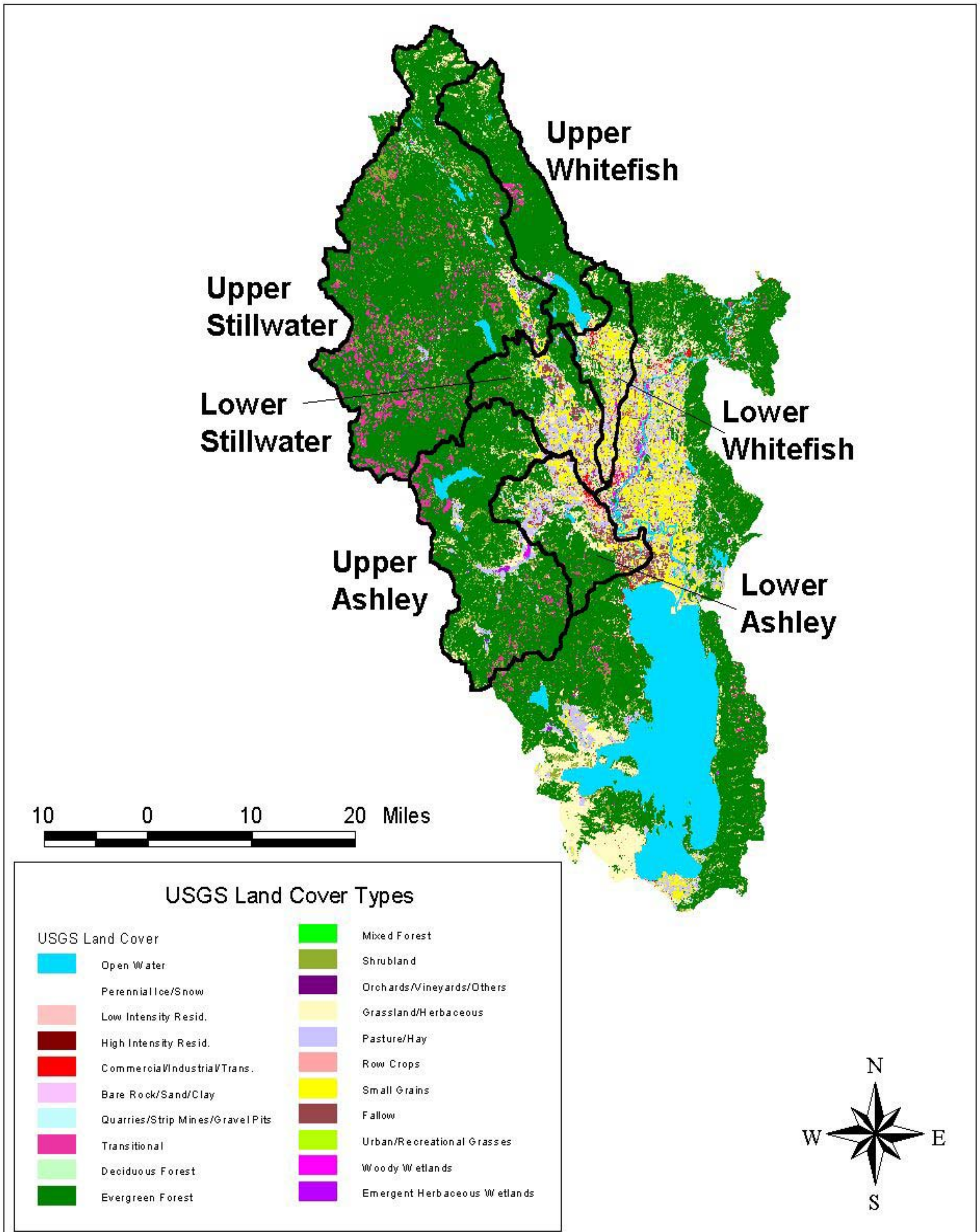
Table 4-4. Percent of total nutrient load from the more populated portions of the watersheds of three major Flathead Lake tributaries (adapted from Stanford and Ellis, 2001).

Sample Site	Date	Hydrograph	% of Total Load		
			TP	$NO_{2/3}$	TN
Stillwater R. (below Twin Bridges)	Apr-96	Runoff	71.1	66.2	42.2
	Aug-95	Base flow	13.2	95.0	16.4
	Aug-96	Base flow	11.0	92.8	31.8
Whitefish R. (below Whitefish L.)	Apr-96	Runoff	78.0	98.9	79.3
	Aug-95	Base flow	36.7	96.5	6.0
	Aug-96	Base flow	34.3	97.6	49.4
Ashley Creek (below Smith Lake)	Apr-96	Runoff	62.4	96.0	26.8
	Aug-95	Base flow	81.8	99.8	80.4
	Aug-96	Base flow	0.0	94.9	60.1

While these results are from a single storm event, when combined with the general scientific literature regarding export of nutrients from various land use types it is possible to conclude that the urban and agricultural land uses produce the greatest load of nutrients to Flathead Lake on an acre for acre basis. Reckhow et al. (1980) conducted an extensive literature search regarding the export of nutrients from various land uses. Data from this literature search clearly supports the conclusion that phosphorus and nitrogen export from urban and agricultural land uses, with the exception of pasture, is significantly greater than from forested land uses (Figures 4-5 and 4-6).

4.2.3 Annual Loading Analysis by Source Category

Stanford et al. (2001) attempted to put this into perspective on an annual basis by conducting an analysis of nutrient loading in relation to land use/land activity categories for the 1993 water year.



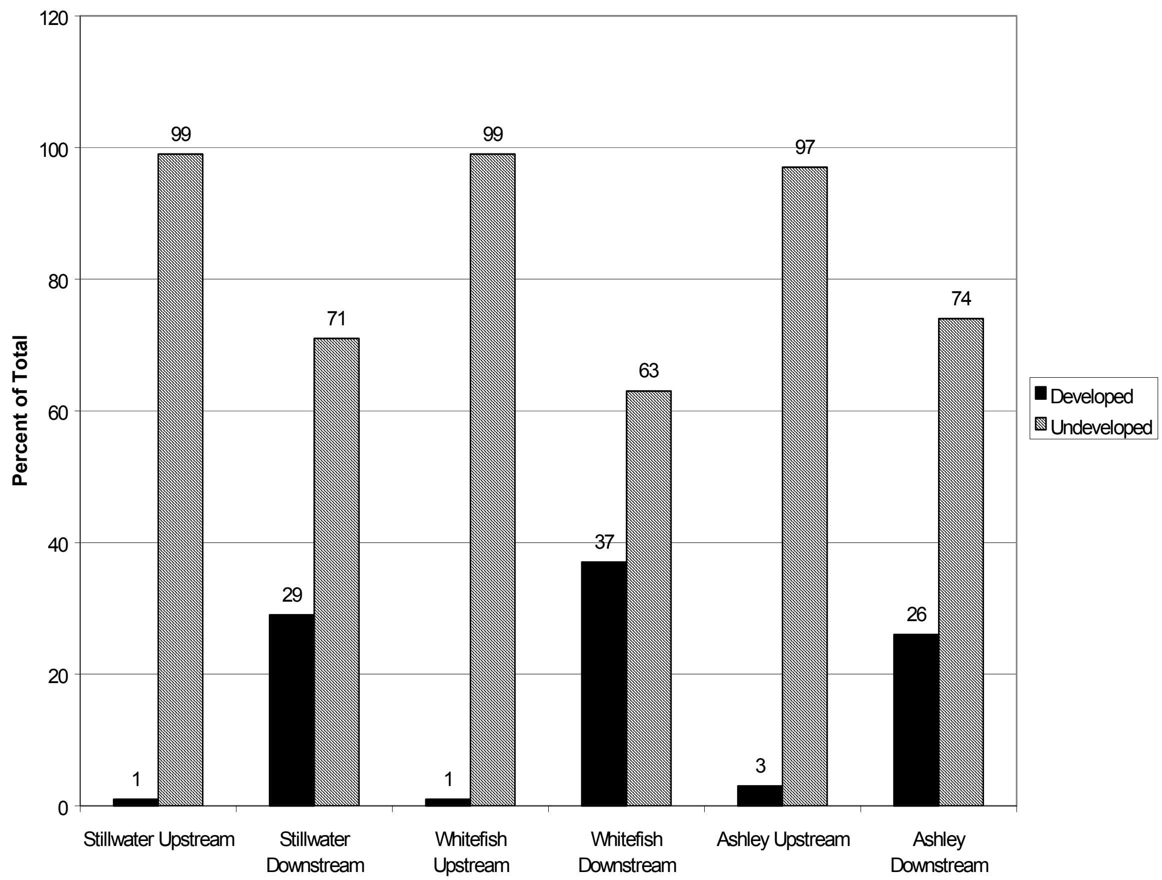
Montana Department of Environmental Quality

Figure 4-3. Landuse characteristics adjacent to synoptic monitoring sites.

Figure 4-3
By: MTDEQ
Date: Aug. 2001

The results of this analysis are presented in Figures 4-7 through 4-9. Given that the forestland cover type dominates the watershed (i.e., approximately 80 percent of the total land area, see Table 2-4), it is no surprise that managed and unmanaged forests produce the greatest nutrient loads (an historical perspective on harvest trends and application of best management practices on managed forest land is presented in Appendix B). By far, the single greatest loads of bioavailable phosphorus, total nitrogen and nitrate/nitrite are from unmanaged forest (i.e., natural background). For nitrate/nitrite and total nitrogen, managed forests were the next largest source followed by agriculture/urban and precipitation. For bioavailable phosphorus, precipitation was estimated to be the second largest source followed by agriculture/urban and managed forest. Shoreline septic systems, sewage treatment plants, and the evergreen aquifer were estimated, for all studied nutrients, to individually contribute five percent or less of the total nutrient load.

Figure 4-4. Upstream/downstream Land Use Analysis for Selected Sample Points.



Note: Developed includes the following land cover types: low intensity residential, high intensity residential, commercial/industrial/transportation, quarries/strip mines/gravel pits, orchards/vineyards/other, pasture/hay, row crops, small grains, and urban/recreational grasses.

Undeveloped includes open water, perennial ice/snow, bare rock/sand/clay, transitional, deciduous forested, evergreen forested, mixed forest, shrubland, grassland/herbaceous, fallow, woody wetlands, and emergent herbaceous wetlands.

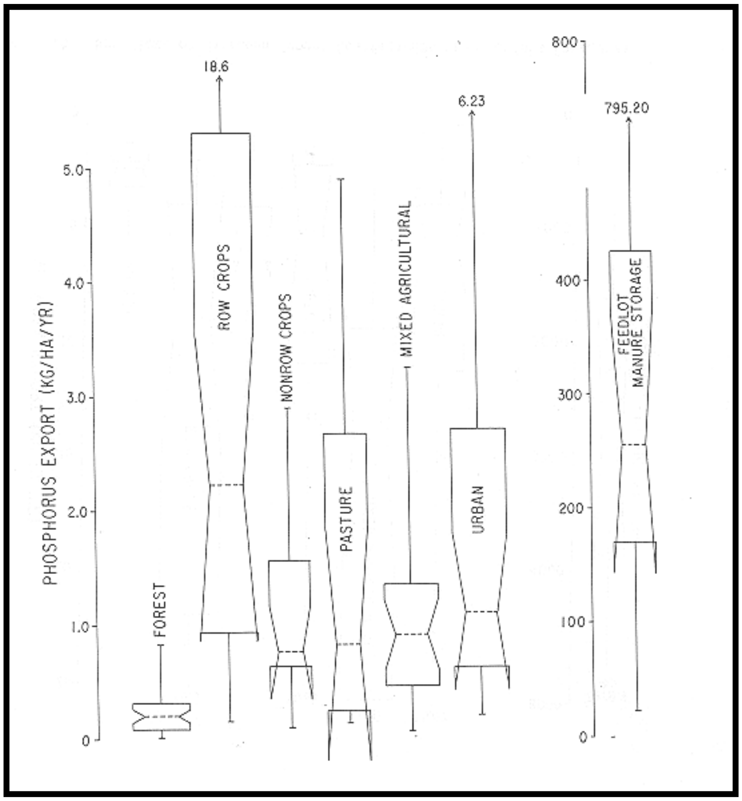


Figure 4-5. Box Plots of Phosphorus Export Coefficients from Various Land Uses.

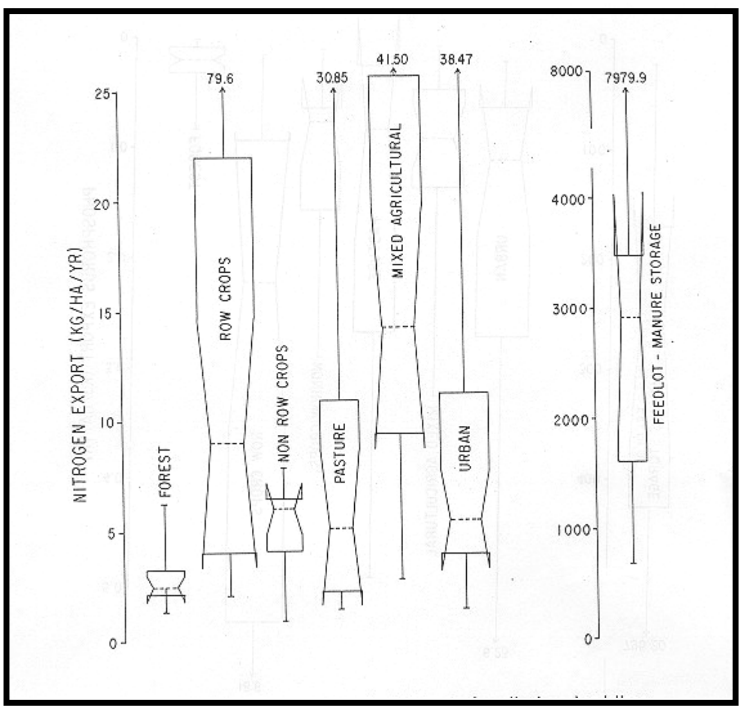


Figure 4-6. Box Plots of Nitrogen Export Coefficients from Various Land Uses

Figure 4-7. Phosphorus Load by Source Category.

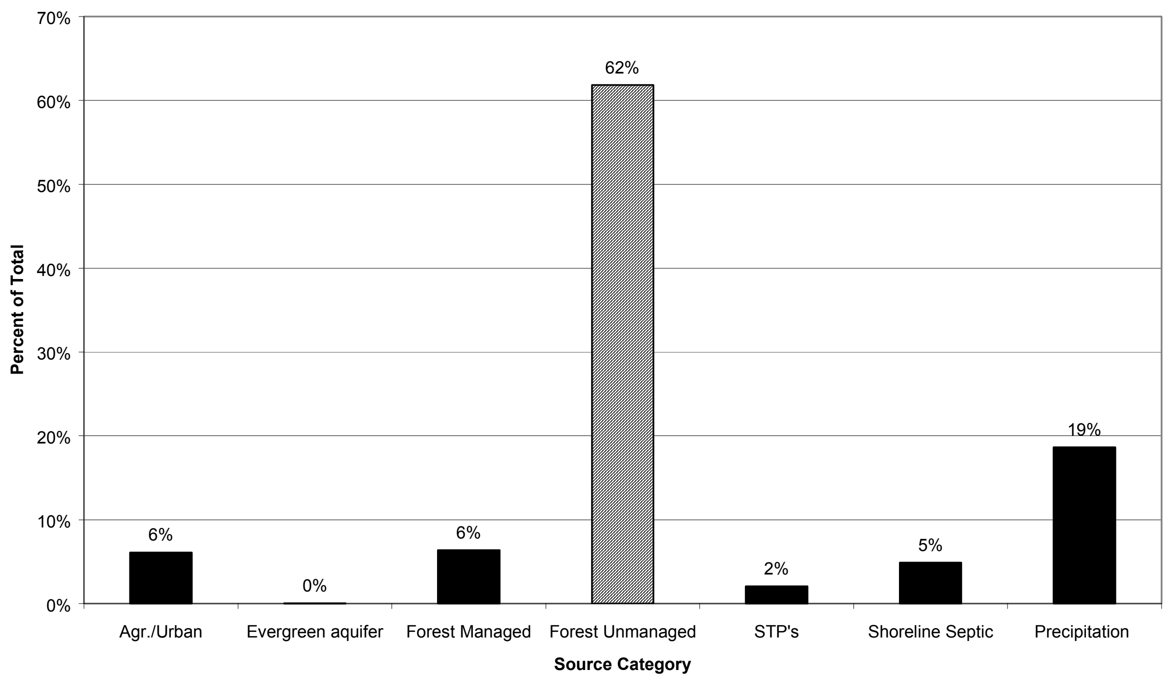
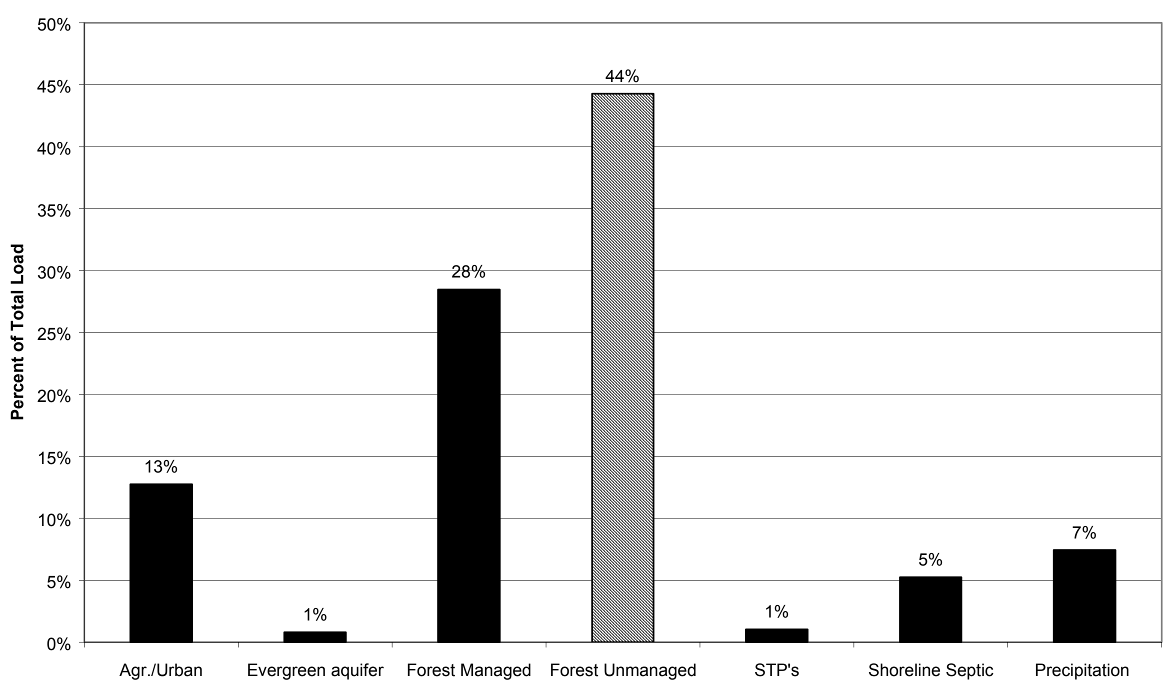


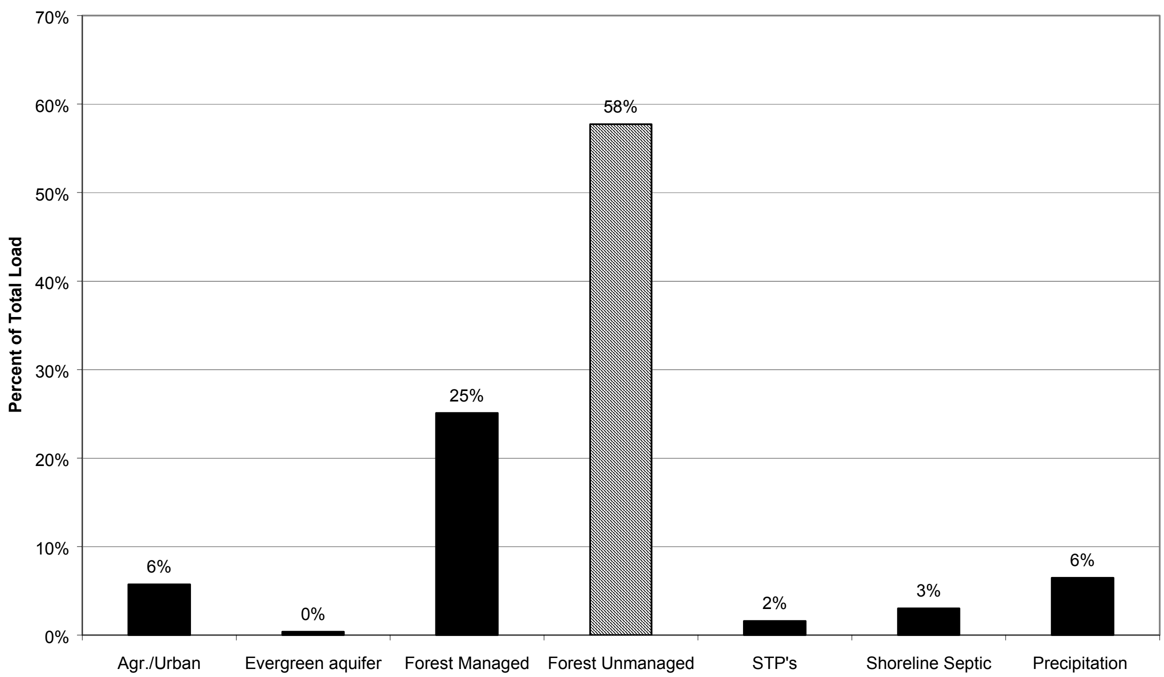
Figure 4-8. Nitrate/Nitrite Load by Source Category



4.2.4 Nonpoint Source Loading Summary

The Flathead River delivers 74 percent of the bioavailable total phosphorus load, 82 percent of the total nitrogen load, and 85 percent of the nitrate/nitrite load to Flathead Lake. Of the studied tributary watersheds, Ashley Creek and the Stillwater/Whitefish Basins deliver the highest bioavailable total phosphorus and total nitrogen loads per acre. The Flathead River basin, excluding inputs from the Stillwater/Whitefish and Ashley Creek watersheds, delivers the highest nitrate/nitrite load per acre. The results of a synoptic study of a single storm event, revealed that the largest nutrient loads were delivered from the lower, and most developed portions of the studied watersheds. The results from this one storm event suggest that loading from agricultural and urban lands may be having the greatest impact on Flathead Lake.

Figure 4-9. Total Nitrogen Load by Source Category.



The loading analysis by source category is somewhat contradictory indicating that, by far, the single greatest loads of bioavailable phosphorus, total nitrogen and nitrate/nitrite are from forest lands. Given that forest dominates the watershed, this makes sense even in consideration of the fact that forestlands contribute significantly less nitrogen and phosphorus on an acre-by-acre basis when compared to most other land use types (Figures 4-5 and 4-6). What the loading analysis by source category may have failed to consider is the potential presence of natural nutrient sinks within the tributary watersheds that trap nutrients from the headwaters regions of the watershed well before they ever reach Flathead Lake. Many of the tributaries to Flathead Lake contain lakes and/or wetlands (e.g., Ashley Lake, Smith Lake, Hungry Horse Reservoir, etc.) that may trap and/or assimilate nutrients transported from areas upstream. This theory further supports the premise that the lower, more developed portions of the watershed may be the most important in terms of nutrient delivery to Flathead Lake.

4.2.5 Uncertainty and Adaptive Management

The analysis presented above is based on the best available information. While a basic understanding of the most important nonpoint sources of nutrient loading to Flathead Lake have been identified, insufficient monitoring data exists to specifically identify and quantify the relative importance of each source of nutrients. The analysis of synoptic data presented above is based on a single storm event. Additional synoptic data are necessary to more accurately define the spatial and temporal characteristics of nutrient loading and the relationships between nutrient loading and current land use. The analysis of nutrient loading by source category is a "best estimate" based on extrapolations from available monitoring data and may be misleading given the potential for nutrient retention in lakes and wetlands in areas upstream of Flathead Lake. Insufficient data is available to specifically allocate loads using this data. All of the point and nonpoint sources will be further evaluated, as described in Section 5.3, in an effort to quantify the relative importance of all sources.

4.3 Airborne Sources

Atmospheric nutrient deposition is derived from both natural and anthropogenic sources. Natural sources may include wind-blown dust, wildfires, volcanoes, oil and gas seeps, non-domestic animals, sea spray, vegetative emissions, and decomposition processes. Although these sources are not controllable, they contribute to the natural 'baseline' condition. Anthropogenic sources may be categorized as point, area or mobile sources. Point sources generally include major and minor industrial processes. Area sources include a broad range of activities such as agricultural and wildland burning, residential wood stoves, and small business activities such as dry cleaners, graphic art studios, asphalt operations, petroleum operations, and incinerators. Mobile sources include all transportation-related activities such as aircraft, boats, trains, motor vehicles, and non-road equipment. As a result of either incomplete combustion or atmospheric chemistry, emissions from natural and anthropogenic sources contribute to the process of atmospheric nutrient deposition.

Atmospheric concentrations of emissions are influenced by meteorological conditions both locally and regionally. The physical and chemical state of the atmosphere determines pollutant transport, dilution, chemical transformation, and ultimately nutrient deposition. In many cases, meteorology is more important than atmospheric chemistry in controlling location and form in which nutrients are deposited (Cape and Unsworth 1987). The prevailing winds in the vicinity of Flathead Lake vary, however the general trend as indicated by data from a monitoring station in Kalispell is from the south by south east to the west (Figure 4-10).

4.3.1 Airborne Load to Flathead Lake

According to Stanford et al. (1997) the contribution of airborne nitrogen and phosphorus to Flathead Lake were investigated through bulk precipitation sampling (wet plus dry) collected at the Flathead Lake Biological Station grounds adjacent to Flathead Lake. Results for the period 1991 through 1995 are presented in Table 4-5. For this time period, the percentage of phosphorus contributed by precipitation varied from approximately 3 to 38 percent of the total load to Flathead Lake, with a 16 percent average. The percentage of wet deposition of nitrogen varied from approximately 4 to 8 percent of the total load to Flathead Lake, with a 7 percent average for the corresponding years.

Figure 4-10. Seasonal Wind Roses for Kalispell International Airport, 1997 – 2001.

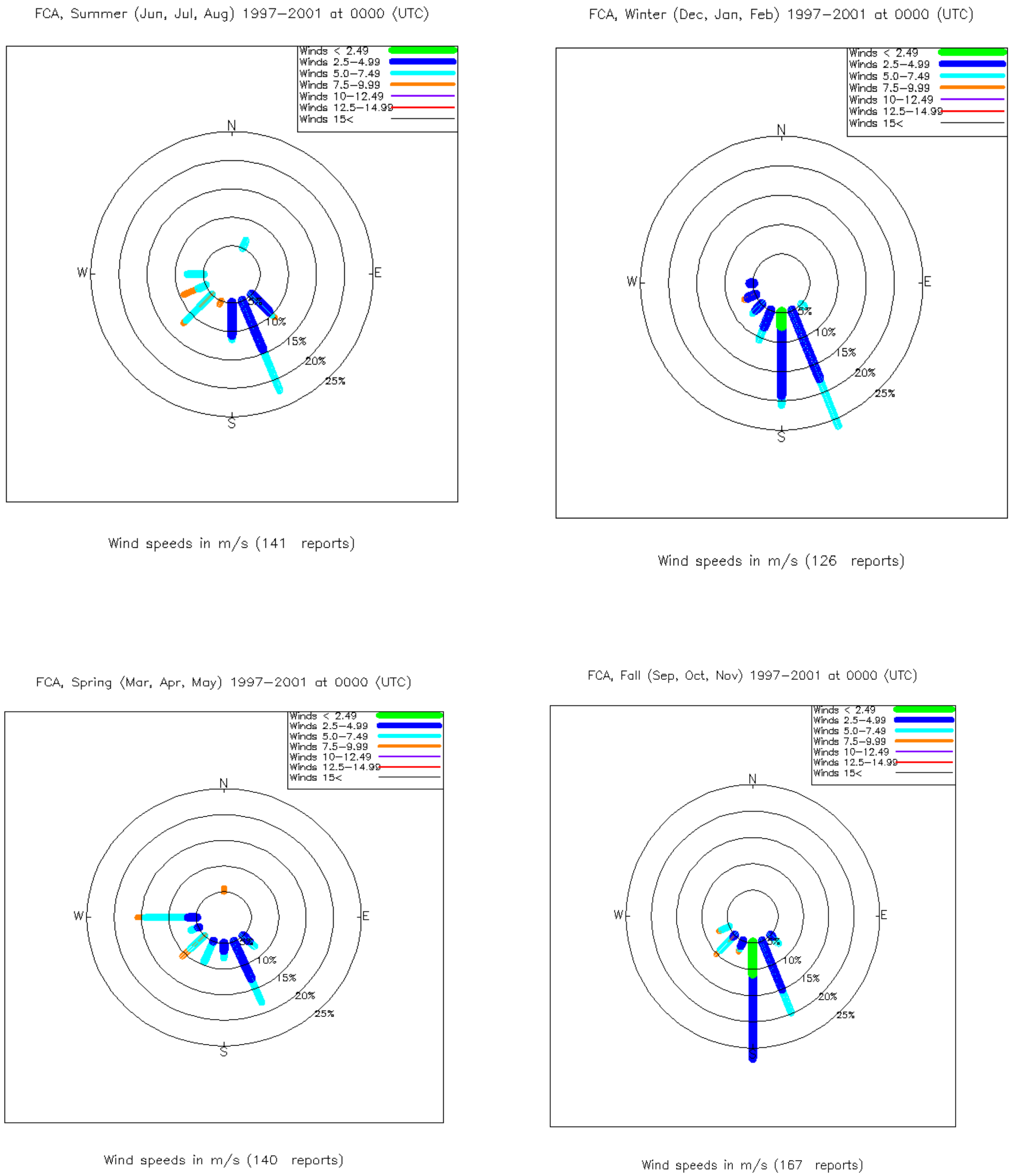


Table 4-5. Precipitation nutrient loading to Flathead Lake.

Year	Phosphorus MT/yr[1]	%	Nitrate+Nitrite MT/yr[1]	%
1991	36	14.4	40	3.6
1992	43	38.4	40	8.0
1993	20	19.0	44	7.5
1994	4	5.7	36	6.3
1995	4	2.7	50	8.1

[1]The nutrient loading information in Stanford et al. (1997) is presented only in bar graphs (Figures 15, 16 and 17). These values are estimates from the bar graphs.

4.3.2 Potential Airborne Sources

Airborne nutrients may remain suspended in the atmosphere for periods of time ranging from a few seconds to several months, depending upon their size and the altitude at which they are exhausted from a convection column. This suggests that Flathead Lake may be receiving nutrients from sources located both locally and regionally; perhaps crossing state or national borders. Unfortunately, insufficient data is currently available to pinpoint sources (i.e., types of activities producing the nitrogen and phosphorus) of nutrients entrained in the atmosphere or their location. The following presents summaries of studies that, individually, provide some limited information regarding potential airborne sources of nutrients.

Chemical Mass Balance Receptor Modeling Studies

The Montana Department of Environmental Quality (DEQ) has conducted several Chemical Mass Balance (CMB) receptor-modeling studies in the Flathead Valley. This type of modeling can be used to qualify and quantify the source contributions to the particulate matter in the atmosphere within an airshed. Particulates are collected on filters and the chemical composition (species of elements, ions, organic and elemental carbon) of the suspended particulates on the filters are analyzed and quantified. Particulates are collected on filters to capture two different sized particulates: PM-2.5 (particulates with a diameter less than or equal to 2.5 microns, also called “fine” particulates) and PM-10 (particulates with a diameter less than or equal to ten microns, also called “coarse” particulates). The chemical composition and corresponding mass of the particulate matter emitted by the potential sources are also known by direct collection and analysis, or from the literature (EPA, 1984). To identify the sources, a statistical comparison of the chemical profile of each potential source with the chemical profile of the particulate samples is performed. Meteorological information such as wind speed and direction, temperature, and atmospheric condition (stagnation, smoke, etc.) is collected during the day of sampling.

The following CMB studies were performed for communities in the Flathead Valley: Columbia Falls (Patterson et al., 1991), Kalispell (Raisch and Jeffry, 1988), and Whitefish (TRC Environmental Corporation, 1995). The potential sources in the airshed were identified by DEQ through reviewing air quality permits and previous emissions inventories of these communities (Carlin, 1996; Raisch and Schneider, 1991; Clavin and Carlin, 1995), and consulting local air quality agencies. Typical sources that emitted particulate matter in the Flathead Valley were road dust, vehicle exhaust, wood-burning stoves, and industrial hog fuel boilers. The sampling periods for these studies were Columbia Falls (9/16/89 – 3/30/90), Kalispell (9/1/86 – 8/30/87), and Whitefish (1/1/93 – 3/30/94). The particulates were collected on filters over a 24-hour (standard day) period on generally every third day. In all of the studies, the filters were analyzed for elemental phosphorus, but not nitrogen. These studies are relatively old so any new source of particulates that moved into the Valley after 3/30/94 would not have been part of the analyses.

The particulate phosphorus levels on the filters were predominantly below the analytical detection limits and therefore, were not included in the statistical analysis to determine the sources. Even when the concentrations were above the detection limits, phosphorus was rarely used as an indicator chemical species to determine the source of the particulates. However, this fact was not surprising considering that the sources in the airshed that emitted phosphorus had very low percentages of phosphorus in their aerosol mass including the local road silt samples (0.05 percent of aerosol mass). The majority of sources that released particulates in the Valley had less than 0.1 percent of phosphorus in their aerosol mass and all of the sources emitted particulates with less than 1.6 percent of phosphorus. Industrial fuel boilers represented the source with the greatest concentration of phosphorus (i.e., 1.6 percent). These studies coupled with Stanford et al. (1997) research suggest long-distance transport of phosphorus.

Chemical Mass Balance Receptor Modeling Studies

Sources of nutrients attributable to biomass burning in the Flathead Basin include wildland and agricultural burning, wildfires, and residential woodstoves. Many chemical elements are found in biomass. Those occurring in fairly large quantities include nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur (Tangren et al., 1976). Biomass burning emits hundreds, if not thousands of chemicals into the atmosphere. Carbon monoxide and carbon dioxide are the major carbonaceous gases produced during the combustion of biomass fuels. Smoke from biomass burning also contains nutrient sources that may affect Flathead Lake such as nitrogen oxides (NO_x) and, to a lesser extent, phosphorus (Ward, 1990). Biomass burning produces copious amounts of cloud condensation nuclei, which may influence the amount of wet deposition (Radke et al., 1991).

In wildland fires, small amounts of NO_x are produced primarily from oxidation of the nitrogen contained in the fuel. Thus, the highest emissions of NO_x occur from fuels burning with a high nitrogen content. Most fuels contain less than one percent nitrogen. Of that, about 20 percent is converted to NO_x when burned (Ottmar, 2000). Oxides of nitrogen take the form of nitrate particles that may be deposited locally or regionally. However, deposition rates are not well established.

Phosphorus and potassium contents of forest soils were found to increase following a prescribed burning experiment west of Olney, Montana. This increase was attributed to ash-fall from burned logging debris (DeByle and Packer, 1981). Wind-blown soil/ash from burned sites in close proximity to Flathead Lake may be a source of airborne nutrient deposition. Smoke plumes from wildland burning studies in the Flathead Basin also indicated heavy concentrations of particulate matter existing 30 miles from the fire. These plumes also exhibited a southerly flow toward Flathead Lake (Adams, Robinson et al., 1981).

Clayton (1976) determined the concentration of nutrients in precipitation falling through smoke plumes from wildland burning may be 20 to 70 times greater than normal. This study concluded the transfer of plant nutrients in smoke from wildland burning to be statistically significant. Nutrients lost in smoke particulates from burned sites become nutrient additions in downwind locations.

Snowpack Chemistry Studies

Chemical composition of annual snowpack represents a record of atmospheric deposition of airborne pollutants throughout the winter and has been used to identify nearby emission sources. Elevated levels of pollutants from atmospheric deposition held in seasonal snowpacks have been associated with watershed acidification (including nitrates) at alpine and subalpine sites (Story, 1999).

The United States Geological Survey monitors snowpack chemistry in Montana at several sites within the Flathead Basin. However, results available from the Big Mountain and Glacier National Park monitoring sites do not indicate elevated levels of nitrates (Acheson, 2001).

High elevation forests typically receive more precipitation than forests at low elevations. Solubility of most pollutants differs in ice, snow, and rain; therefore, the form and amount of precipitation may influence the concentrations of ions deposited. This is an important consideration when extrapolating from data collected at high elevations to areas such as Flathead Lake located in lower elevation (Finlayson-Pitts, 1986).

NADP Monitoring

The National Atmospheric Deposition Program (NADP) is a nationwide network of precipitation monitoring sites. The purpose of the network is to collect data on the chemistry of precipitation for monitoring of geographic and temporal trends. Deposition takes two forms, wet and dry. Dry deposition involves the transfer of gases and particles from the atmosphere to the ground via atmospheric turbulence and diffusion without the intervention of precipitation. Dry deposition of nitrogen occurs in the form of both gas-phase (HNO_3 and NH_4), and particulate form (NO_3 and NH_4) in both small and coarse aerosols.

Wet deposition involves the removal of pollutants during precipitation events. Wet deposition rates of nitrate and ammonium are measured in rain and snow samples at a NADP site located in West Glacier. Monitoring results indicate no elevated levels of nitrates at this site (Michels, 2001).

AQRV Monitoring

The Federal Clean Air Act (CAA), 42 U.S.C. §7401, *et seq*. provides for the protection of certain national parks and wilderness areas classified as "Class I" areas. Water in Class I areas is considered an AQRV ("Air Quality Related Value") and is protected by the Prevention of Significant Deterioration (PSD) provisions of CAA for potential anthropogenic point source impacts. However, CAA makes no provisions to remedy existing anthropogenic point source impacts.

The portion of Glacier National Park west of the Continental Divide is the only Class I area inside the Flathead Basin. To date, no AQRV monitoring studies for water quality has been conducted in Class I areas within the Flathead Basin (Michels, 2001). Furthermore, Flathead Lake is not classified as a Class I area. Therefore, CAA does not authorize AQRV monitoring studies for purposes of regulating to protect Flathead Lake.

4.3.3 Uncertainty and Adaptive Management

Stanford et al. (1997) have documented that precipitation falling on the lake may contribute a substantial portion of the total nutrient load to Flathead Lake on an annual basis. However, sources of atmospheric nutrient deposition, the relationship between natural and anthropogenic sources, the relative contribution from each source, or seasonal/temporal deposition rates into Flathead Lake are not currently well understood. These factors are necessary to accurately quantify atmospheric nutrient deposition. These factors are also necessary in ultimately defining a strategy to control potential airborne sources of nutrient deposition to Flathead Lake. A conceptual strategy to collect the necessary data is outlined in Section 6.2

SECTION 5.0
WATER QUALITY GOALS

5.1 Water Quality Restoration Targets

Considerable research and effort has gone into the development of the water quality restoration targets for Flathead Lake summarized in Table 5-1. The basis for these targets will be detailed in Section 5.1.2. Among the targets, five may be considered "effect" variables and are the primary targets. Specifically, these are: annual primary production; chlorophyll *a*; "no measurable blooms of *Anabaena* (or other pollution algae)"; "no oxygen depletion in the hypolimnion"; and "no increase in algal biomass on near-shore rocks". Measurable changes in these parameters have been linked to nutrient loading in the lake (Stanford et al., 1997). Therefore, suggested targets for in-lake nutrients ("cause" variables) are also shown in Table 5-1. However, due to uncertainties in the cause-effect relationships, these parameters should be viewed as indicators, whereas the effect variables are desired levels or conditions for the lake.

While it is the goal of the Flathead Basin Commission (1998) to achieve these targets within a five-year period, it is anticipated that it may take considerably longer given the complexities associated with implementing effective nutrient loading reduction measures on a scale as large as that of the Flathead Basin. It should also be noted that, given the high annual variability in nutrient loading and in the primary numeric targets (Stanford and Hauer, 1992; Stanford and Ward, 1992), it is unlikely that a steady, decreasing trend in primary productivity will be observed. Year to year differences in temperature, light, mixing of the water column, internal nutrient cycling and water flux through the lake will likely result in significant year to year differences in primary productivity.

Table 5-1. Flathead Lake Numeric Water Quality Targets.

Parameter	Type of Variable	Target
Primary production	Effect	80 g C m^{-2} yr^{-1}
Dissolved oxygen in the hypolimnion	Effect	No declining trend in oxygen concentrations
Blooms of Anabaena or other pollution algae	Effect	No measurable blooms
Chlorophyll a	Effect	1.0 ug/L
Algal biomass on near-shore rocks	Effect	Measured as Chl a per unit area, biomass remains stable or exhibits declining trend
Total phosphorus (TP)	Cause	5.0 ug/l
Soluble reactive phosphorus (SRP)	Cause	<0.5 ug/l
Total nitrogen (TN)	Cause	95 ug/l
Nitrite + Nitrate ($NO_{2/3}$ –N)	Cause	30 ug/l
Ammonia (NH_3 – N)	Cause	<1.0 ug/l

Although all five effect variables are important, three stand out as being particularly critical. Primary productivity directly influences the dissolved oxygen (DO) decline in the hypolimnion, therefore both of these parameters are strong indicators of undesirable lake changes. The goal of "no nuisance algal blooms" is of equal importance, as blooms of *Anabaena flos-aquae* are an indicator of declining water quality and have only been noted in the lake since the 1980's, commensurate with increasing nutrient loads from human sources (Stanford et al., 1997). Chlorophyll *a* is also important, however there is considerable variability in the primary production-chlorophyll *a* relationship for Flathead Lake (r^2= 0.19; Stanford et al., 1997). For example, the chlorophyll *a* target was achieved in 1999, however primary productivity was still well above the desired target level (Ellis et al., 2000).

The target for near-shore algae is somewhat more problematic to use as an indicator of overall lake health. Periphyton growth tends to be site specific, and long-term periphyton monitoring only began in 1999. Presently, there is only a small amount of data from the 1980's with which to make comparisons. This target will be more valuable in the future as the size of the database increases.

5.1.1 Comparison of Numeric Targets to Current Conditions

Table 5-2 compares the targets to the current conditions in the lake, as reported by Ellis et al. (2000). Primary production currently exceeds the target by 35 percent, and exceeded it by 50 percent in 1998. Total P, SRP, and total N slightly exceeded the targets, however $NO_{2/3}$ surpassed the target by 43 percent. Dissolved oxygen in the hypolimnion is lower than desired and further, some of the lowest dissolved oxygen levels in the hypolimnion have been measured in the past few years.

Table 5-2. Comparison of Targets to Current Conditions in Flathead Lake.

Parameter	Target	Water Year 2000 data*
Primary production	80 g C m^{-2} yr^{-1}	108 g C m^{-2} yr^{-1}
Dissolved oxygen in the hypolimnion	No declining trends in oxygen concentrations	79.5% of saturation at midlake deep site
Blooms of Anabaena or other pollution algae	No measurable blooms	Data not yet analyzed
Chlorophyll a	1.0 ug/L	1.0 ug/l
Algal biomass on near-shore rocks	Measured as Chl a per unit area, biomass remains stable or exhibits declining trend	Data collection effort just beginning
Total phosphorus (TP)	5.0 ug/l	5.9 ug/l
Soluble reactive phosphorus (SRP)	<0.5 ug/l	0.7 ug/l
Total nitrogen (TN)	95 ug/l	101 ug/l
Nitrite + Nitrate ($NO_{2/3}$ –N)	30 ug/l	43 ug/l
Ammonia (NH_3 – N)	<1.0 ug/l	5.1 ug/l

*From Ellis et al. 2000

5.1.2 Basis for the Targets

The targets in Table 5-1 were developed as result of extensive scientific research, followed by considerable debate and discussion. Scientists at the Flathead Lake Biological Station have been measuring depth-integrated primary productivity consistently since the late 1970's, as well as chlorophyll *a*, nutrients, and algae populations. Then, from 1992-1998, a TMDL Team (supported by the Flathead Basin Commission) met in a series of meetings and proposed in-lake targets as part of a Voluntary Nutrient Reduction Strategy. The Team was composed of local, state, federal, and tribal agency representatives, scientists, and other stakeholders (Flathead Basin Commission, 1998). The targets that they originally proposed are shown in Table 5-1, with one change.

The TMDL Team originally suggested that the primary productivity target be set at 70 g C m^{-2} $year^{-1}$, as this value corresponded closely to the lake's production at the time that the Flathead Basin Commission was created. According to the 1983 statute that created it, the purpose of the Flathead Basin Commission is to "protect the existing high quality of the Flathead Lake aquatic environment…" (MCA §75-7-302). It appears that the TMDL team felt that this statute provided a legal foundation for their decision that was, in essence, a no-net increase/hold-the-line approach (Flathead Basin Commission, 1998). Subsequently, the Flathead Basin Commission met and decided to increase this target value to 80 g C m^{-2} $year^{-1}$. The Commission felt that the target was really an "interim" value, and could be adjusted if other TMDL targets (i.e., no *Anabaena* or other pollution algae blooms) were not being met (Flathead Basin Commission meeting, 2/18/98). This conclusion was considered reasonable by the Technical Committee, given the uncertainty in the data.

The targets for "cause" variables shown in Table 5-1 were also recommended by the TMDL Team (Ellis et al., 2000). These values were based on long-term records of nutrient loading to the lake and have been included as they are useful indicators of lake water quality that have been, and will be, monitored with equal intensity as the other parameters.

5.1.3 Collection Locations and Seasonal Considerations for the TMDL Targets

In their 1998 report, the TMDL Team indicated that all targets are annual averages, and for consistency their protocols will continue to be used. The depth-integrated samples (primary productivity, chlorophyll *a*, TP, SRP, TN, $NO_{2/3}$, and NH_3) will be collected at the Biological Station's midlake deep site (Fig. 2-2) and must be in the photic (light penetrated) zone. Valid annualized sample averages will be composed of at least 12 samples collected during all four seasons. Further, at least one sample will be collected during the rising and one during the falling limb of the Flathead River hydrograph. Values reported as annual means must meet these requirements in order to be included in the long-term data set. The lake is stratified in the summer, and it is during this period, in late summer and into fall, that water column dissolved oxygen profiles will be measured at the Ross and midlake deep sites (Ellis et al., 2000). While individual dissolved oxygen profiles will be evaluated, the intent with this target is to observe trends over time.

Sampling of periphyton will be undertaken at two locations, the "B" beach site and on Horseshoe Island (Fig.2-1). Both sites are Biological Station property and therefore no future, localized pollution sources should interfere with the long-term data record being developed. Sampling will follow protocols found in Stanford et al. (1997), except that sample replication will be increased to 10 at a depth of 5 m only (Ellis et al., 2000).

5.1.4 Uncertainty and Adaptive Management

The restoration targets have been established based on the best available information and the current understanding of the relationship between external nutrient loading and primary productivity. The monitoring strategy described in Section 6.0 will be implemented on an annual basis. Additionally, the relationship between external nutrient loading and primary productivity will continue to be evaluated. The University of Montana Flathead Lake Biological Station is currently working on the development of a model to assist in the explanation of this relationship (Levitan, 2001 see section 5.2). It is anticipated that these targets will be modified as more and better information becomes available.

The primary effect target (primary productivity) will be initially evaluated at the Mid-lake Deep site (Figure 2-2). While it is thought that this site adequately represents the entire main lake basin, there are discrete areas of the lake that possess unique morphological characteristics that may necessitate the development of regionalized targets. For example, Big Arm Bay is shallower, freezes over regularly, is potentially isolated from main lake circulation patterns, and also has a significantly reduced wind fetch. Similarly unique areas exist in Polson Bay and other near shore, shallower, isolated bays within the lake basin. Additional monitoring sites are proposed in Section 6.0 to address the uncertainties associated with the appropriateness of the targets to the entire lake basin.

5.2 Total Maximum Daily Load

5.2.1 Load Reduction Goal

The Clean Water Act requires states to identify waters not meeting water quality standards and to develop plans for cleaning them up. The framework for these plans is the Total Maximum Daily Load (TMDL) program. A TMDL is essentially a prescription designed to restore the health of the polluted body of water by indicating the amount of pollutants that may be present in the water and still meet water quality standards. The restoration targets presented in Section 5.1, particularly the primary "effect" target for primary productivity (i.e., 80 g C m^{-2} yr^{-1}), provide the endpoint water quality goal. The TMDL provides a quantification of the means to achieve this goal. Based on an ongoing modeling study conducted by Chuck Levitan (using the "Flathead Lake Model") at the Flathead Lake Biological Station (unpublished results, 2001), reducing the current nutrient loads by approximately 16 percent would result in achievement of the restoration target. This assumes a reduction of primary productivity from the current level of approximately 110 g C m^{-2} yr^{-1} to the target value of 80 g C m^{-2} yr^{-1}.

The Flathead Lake Model simulates the biology of the actual lake ecosystem: phytoplankton growth, their consumption by zooplankton, and Mysis shrimp and fish preying in turn on zooplankton. Masses of plants, animals, and nutrients are calculated as the sums of losses (e.g. respiration) and gains (e.g. feeding) over time. These loss and gain processes are modeled as numeric descriptions of the interactions from the literature or measured in the lake. For example, nutrient uptake by phytoplankton is modeled as obeying Michaelis-Menton enzyme dynamics. These ecosystem processes all run in a simulated physical arena which features nutrient exchanges, lake mixing, river flows, atmospheric input, losses by sinking, and seasonal changes in the weather. The model uses all these to forecast the next day's plant and animal populations, then recalculates a new day's set of gains and losses.

Interestingly, the model results closely approximate Flathead Lake Biological Station's statement that "*a 15 percent or so reduction in non-points during the summer of 1993 would have approximated loads on drier years when Anabaena did not bloom*" (Stanford et. al., 1997).

A 15 percent reduction in nitrogen and phosphorus loads, plus an additional 10 percent load reduction for a margin of safety, is proposed as the TMDL. The TMDL applies to the entire basin and all anthropoginic sources, as appropriate. The 10 percent margin of safety has been included to account for projected future increases in point source loads attributable to increased wastewater flows (see Section 5.3.1) and a continuing upward trend in population growth in the unincorporated areas of the basin (see Section 5.3.2).

5.2.2 Uncertainty and Adaptive Management

While a link clearly exists between external nutrient loading and the increasing trend in primary productivity, internal food web dynamics also appear to play a substantial role in controlling primary productivity. It is possible; therefore, that achieving the TMDL may not result in achieving the restoration targets. However, this is not suggested to imply that reducing external loading should not be pursued. External loading is the only factor over which we have management control. This uncertainty will be addressed by continued monitoring of both cause and effect variables (Section 6.0).

Also, as with the restoration targets, the TMDL presented herein may not be appropriate for the entire lake basin for the same reasons described in Section 5.1.4. Isolated bays and near shore areas of the lake may be uniquely affected by localized sources of nutrient loading. If this is the case, increased local load reductions from sources specifically contributing to these isolated areas of the lake may be required. The additional in-lake monitoring sites and watershed modeling described in Section 6.2 will provide the necessary information to adapt the TMDL as appropriate.

In accordance with the Montana Water Quality Act (MCA 75-5-703 (9)), DEQ will reevaluate the condition of Flathead Lake relative to both the TMDL and the targets in five years (2006). If, after five years, the targets have not been achieved, the Act provides a mechanism for adaptive management. This could include implementation of a new or improved phase of voluntary management practices or allowing more time to pass for the system to respond to those management practices that may have been implemented. Alternatively, if future data indicate that the targets or TMDL is unachievable, the targets and/or TMDL can be revised to achieve applicable water quality standards.

5.3 Allocation

EPA's Protocol for Developing Nutrient TMDLs defines allocation as *"the portion of a receiving water's loading capacity attributed to one of its existing or future pollution sources (nonpoint or point) or to a natural source"* (EPA, 1999). In simple terms allocation refers to apportioning the total nutrient load to each of the significant sources. From a practical management perspective, the allocation step provides a means to prioritize future management activities such that limited resources can be maximized as well as focused on those sources over which controls are most likely to be effective at achieving the restoration targets.

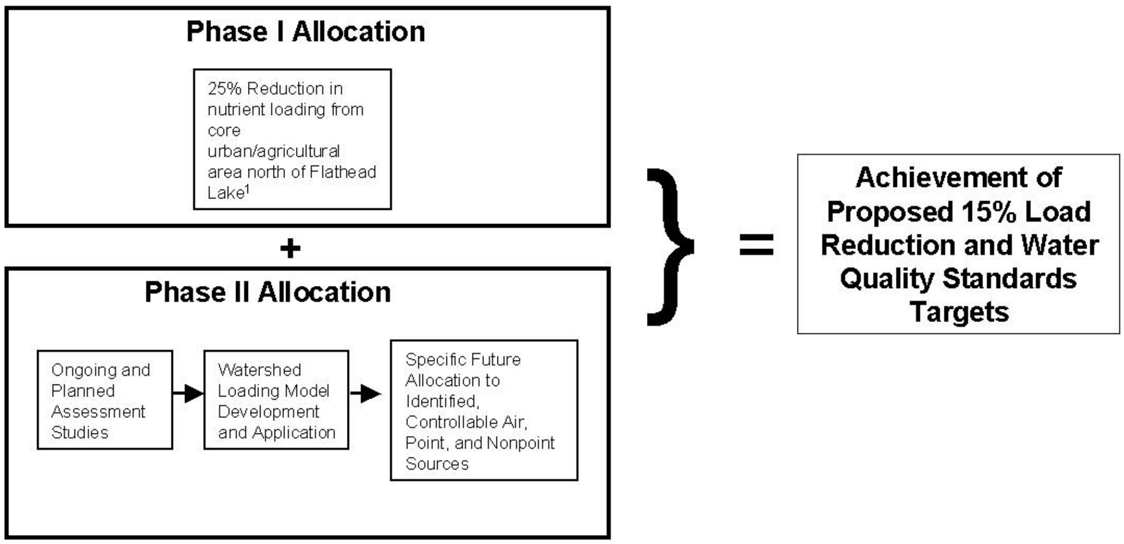
While a very complete record of nutrient loading into Flathead Lake is available for each of the major tributaries, little data is available that would assist in quantifying the relative importance of each of the potential sources of nutrients to Flathead Lake. Further, little data is available to assist in differentiating between the natural and anthropogenic nutrient loads on a sub-basin basis. Both are necessary to accurately apportion loads to each of the identified sources. Thus, **it is not possible in most cases, using the available data, to specifically allocate loads to individual sources or source categories**. Further study is needed to fully allocate loads from all significant sources. For this reason, a phased approach is -necessary for allocation.

The first phase, as presented herein, uses the available data to focus near-term (one to three year) implementation measures on those sources that:

4) appear to pose the greatest threat to Flathead Lake based on available data,
5) are known, based on the literature, to be significant sources of nutrients, and
3) are controllable in consideration of current technology.

A summary of the Phase I and Phase II allocations, and/or recommended actions, with a demonstrated link to achievement of water quality restoration targets is presented in Figure 5-1. The basis for the phase I allocations is presented in Section 5.3.1. The Phase II allocation actions are described in Section 5.3.2.

Figure 5-1. Allocation Plan.



[1]The short-term goal set in Phase 1, 25% reduction in nutrient loading from the core urban/agricultural area north of the lake, will ensure that some of the most significant contributions to nutrient loading in the Lake will be curtailed in the near future.

5.3.1 Phase I Allocations

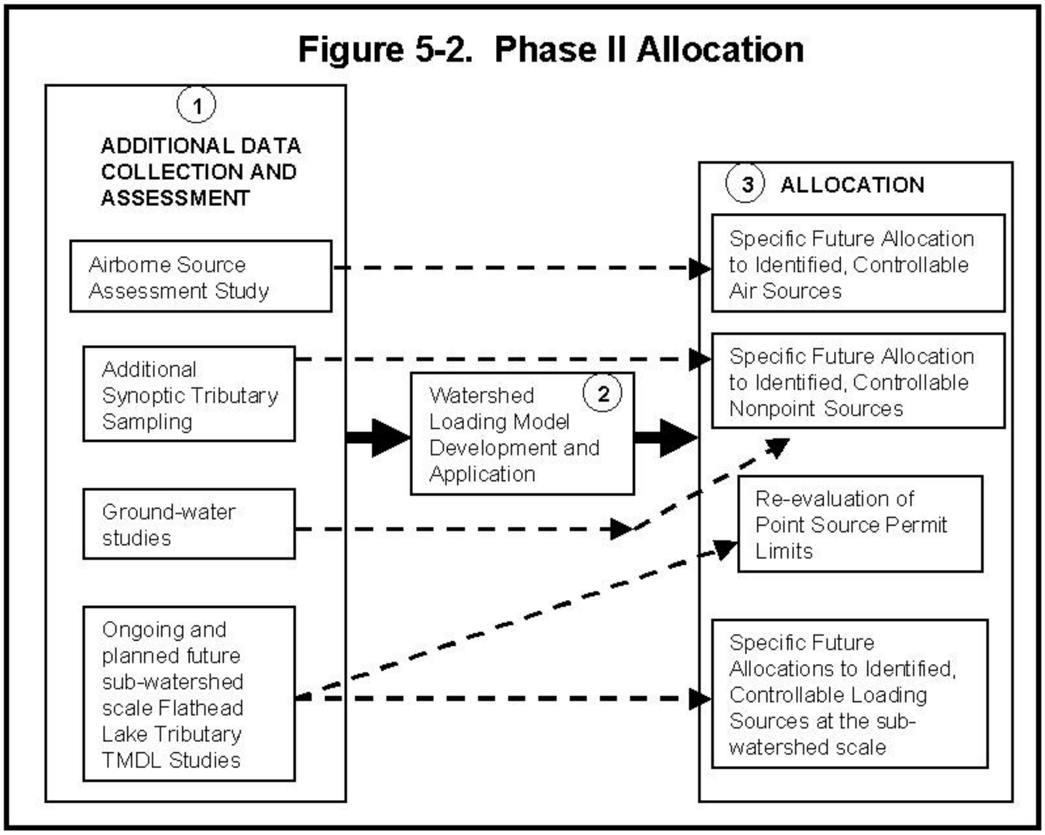
It is not possible at this time to specifically quantify the relative importance of the nutrient load from the most concentrated area of urban/agricultural land uses shown in Figure 5-2. However, the analysis summarized in Section 4.0 of this document suggests that this area poses the greatest immediate threat to Flathead Lake and, therefore, is the focus of the Phase I allocations. Phase I provides an opportunity to focus on-the-ground implementation activities, and educational activities to facilitate implementation, on an area that is know to pose a threat to water quality. This area includes the communities of Kalispell, Whitefish, Columbia Falls, Bigfork, Evergreen, Somors and Creston and also contains the highest population density and the highest density of urban and agricultural land uses. On a single storm event basis, this area produced a significantly higher load than all other source categories (see Table 4-4). As shown in Figure 4-7 and 4-8, agricultural and urban land uses also have the potential for producing among the highest loading rates of any land use type. Relative to other land use types in the basin, these land use types also tend to occur in close proximity to the lake and major tributaries. At the same time, the technology for control of urban and agricultural nonpoint source runoff has been well developed for over 20 years. For example, properly designed urban Best Management Practices (BMPs) such as wet detention basins, infiltration trenches, infiltration basins, and vegetated filter strips have exhibited removal efficiencies of 40 to 80 percent for total phosphorus and total nitrogen (Schueler, 1987). For agriculture, systems of BMPs have been shown to result in greater than 50 percent reductions in total phosphorus concentrations (Osmond et al., 1995).

A Phase I nutrient reduction target of 25 percent is established for this area. It is not envisioned that achieving a 25% load reduction from this single area will result in achieving the overall 15% basin wide load reduction. Rather, this is an interim load reduction goal for an area known to be an immediate threat to Flathead Lake (i.e., an area know n to deliver relatively high nutrient loads for which the technology exists to achieve load reductions). This source area will be further evaluated in context with all other potential significant sources in Phase II. A revised allocation plan for this area, and all other areas of the basin, will be determined based on the results of Phase II. Modification of this allocation may occur using the adaptive management strategy outlined in Section 6.0.

5.3.2 Phase II Allocation Strategy

The intent of this allocation approach is to begin taking actions toward reducing pollutant loads, as described above in Phase I, while concurrently collecting additional information in Phase II. This additional information will ultimately allow for fair and equitable allocation of the total anthropogenic load.

The organizational structure of Phase II is shown in Figure 5-2. Phase II basically includes three steps. The first ("box 1") includes the assessment actions necessary to compile sufficient data to quantify the relative importance of each significant nutrient source and fill current data gaps. This step will provide the data necessary to load and calibrate a watershed nutrient loading model ("box 2"). The watershed nutrient loading model will allow for evaluation of all the nutrient sources in context with one another and will be used to define the appropriate load allocations for all sources, including the core urban/agricultural area in the Flathead Valley. It should be noted that, in some cases (indicated by the dashed arrows on Figure 5-2), the assessment actions in Box 1 may provide sufficient information to allow for allocation without the use of the watershed loading model. Phase II allocation steps are discussed in detail in the following paragraphs. The final step will be defining allocations to all significant sources.



Airborne Source Assessment Study

For the time period 1991 through 1995, the percentage of phosphorus contributed by precipitation varied from approximately 3 to 38 percent, with a 16 percent average. The percentage of wet deposition of nitrogen varied from approximately 4 to 8 percent of the total load to Flathead Lake, with a 7 percent average for the same time period. While airborne sources constitute a significant source of nutrients to the lake, insufficient data is available to identify specific controllable sources. A monitoring strategy to collect the data necessary to identify potentially controllable sources is provided in Section 6.2. The Flathead Basin Commission submitted a 319 Grant Application to the DEQ in September 2001 requesting funding for an airborne nutrient monitoring study that fulfills most of the goals of the monitoring strategy outlined in Section 6.2. The 319 Grant request has preliminary DEQ approval and the study is envisioned to begin during the summer of 2002 with a targeted completion in the summer of 2004. It is envisioned that the data collected through this study will provide the information necessary to make allocation decisions regarding airborne sources. This study will also likely provide input and calibration data for the watershed loading model described below.

Groundwater Studies

The Flathead Basin Commission applied for, and received, a 319 grant to develop, and implement, a groundwater monitoring strategy for the Flathead Basin. In general, this project will compile and evaluate all available ground water data for the five primary aquifers existing within, and adjacent to, the Flathead River Valley to the north of Flathead Lake as well as the surficial aquifers surrounding Flathead Lake itself. These areas will be prioritized by their relative importance to potential nutrient contributions to Flathead Lake. A monitoring strategy will then be developed and implemented for a period of one year. This project will be completed in 2003. The intent of this project is to develop a better understanding of the groundwater contributions of nutrients to Flathead Lake. It is anticipated that this effort will establish priorities relative to nutrient contributions to Flathead Lake from groundwater and will, in and of itself, provide much of the information necessary for allocating to groundwater sources. The information compiled through this effort will also be used to refine/ calibrate the watershed loading model.

Synoptic Tributary Sampling

As described in Section 4.2.2, a synoptic study of many of the Flathead Basin tributaries was conducted in 1995 and 1996 in an attempt to further refine the assessment of nonpoint sources of nutrients in Flathead Lake. While this study provided valuable information, additional information is necessary to better define the contribution of nonpoint source nutrient loading from all of the potential sources in the basin. At this time, two studies are currently in the planning stages wherein additional synoptic sampling has been proposed. The Flathead Lake Biological Station has been funded to conduct additional synoptic sampling in the Whitefish River Basin. This study will be conducted in 2002 and 2003 and will include the collection of surface water quality samples at strategically located sites along the entire Whitefish River during spring runoff, summer storm events and base flow conditions. The intent of this study is to identify the significant sources of nutrient loading in the Whitefish River basin. It has also been designed to investigate the hypothesis that Whitefish Lake may be a sink for nutrients from headwater sources.

The Flathead Basin Commission has proposed a similar, but more comprehensive study for the Stillwater River Basin. As proposed, this study would include additional synoptic sampling as well as the development of a Water Quality Restoration Plan for the Stillwater River Basin. Funding for the Stillwater River Basin study has not yet been secured. However, this study has been identified as a critical need by the DEQ. For the purposes of this document, it is assumed that this study will be at least partially funded allowing for, at a minimum, the synoptic sampling to proceed.

These two studies will provide the means to better quantify the relative importance of nutrient sources and will allow for the development of load allocations within their respective watersheds. The relationships between land use and nutrient loading developed within these sub-watersheds will also be used to refine/calibrate the watershed loading model described below, which will ultimately facilitate the development of an overall allocation plan for the entire Flathead Basin.

Ongoing and Planned Future Sub-Watershed Scale TMDL Studies

Each of the sub-watersheds tributary to Flathead Lake are located within DEQ TMDL Planning Areas (Figure 7-1). All necessary TMDL's for those waters listed on the Montana 1996 303(d) List within the Swan, Flathead Headwaters, and Flathead-Stillwater TMDL Planning areas must be completed by 2002, 2003, and 2005, respectively. This provides an opportunity to focus assessment and restoration efforts on a smaller scale that may be more conducive to accurately evaluating the linkages between sources and impairments and, ultimately, to implementation of on-the-ground restoration actions. This will also likely be the most effective scale at which to address historical Forestry impacts that may be providing increased loads of both sediment and nutrients to the lake.

These sub-watershed studies will result in sub-watershed allocations for both nonpoint and point sources (where point sources exist) relative to impairments within the listed streams in each watershed. As appropriate, these sub-watershed specific allocations will be further evaluated in context with their overall contribution to Flathead Lake to ensure that they are appropriate at both the sub-watershed and Flathead Basin scale. Additionally, information compiled through the sub-watershed scale studies will likely be useful as both input and calibration data for the watershed loading model described below.

Watershed Loading Model

The development of a basin-scale watershed loading model is proposed to further refine the assessment and quantification of existing nutrient sources, allocate existing and future nutrient loads to each of the significant sources, and to be used as a tool to evaluate, in a predictive mode, the potential impact of future land use actions. A simple loading model is proposed to simulate seasonal loading of nutrients as a function of land use, atmospheric fluxes, and point source information.

This model would be developed by the DEQ, with direction provided by a technical advisory committee. Assuming funding is available, model development would begin in 2002. Validation/calibration of the model would begin as data from Box 1 (Figure 5-2) becomes available. It is envisioned that the model would be developed, tested, validated, and calibrated by 2005. At that point, in combination with the data from Box 1, it would be applied to develop an overall allocation plan for all point and nonpoint sources.

Allocation and Allocation Schedule

Allocations to point and nonpoint sources will be devised through the actions defined above and shown in Box 1 and 2 in Figure 5-2. While it will likely be possible to define some allocations directly through the actions in Box 1, the final allocation plan will be developed with the assistance of the watershed loading model. The model will allow for the development of alternative allocation scenarios by evaluating all potential nutrient sources in context with one another to facilitate the most equitable and feasible allocation of point and nonpoint source loads.

The final allocation plan will be prepared in 2006. This will provide adequate time for the completion of all proposed assessment activities and for development and testing of the watershed loading model. Sub-watershed and source specific allocations may be developed earlier, as appropriate, based on the results of the sub-watershed scale TMDL efforts and assessment studies.

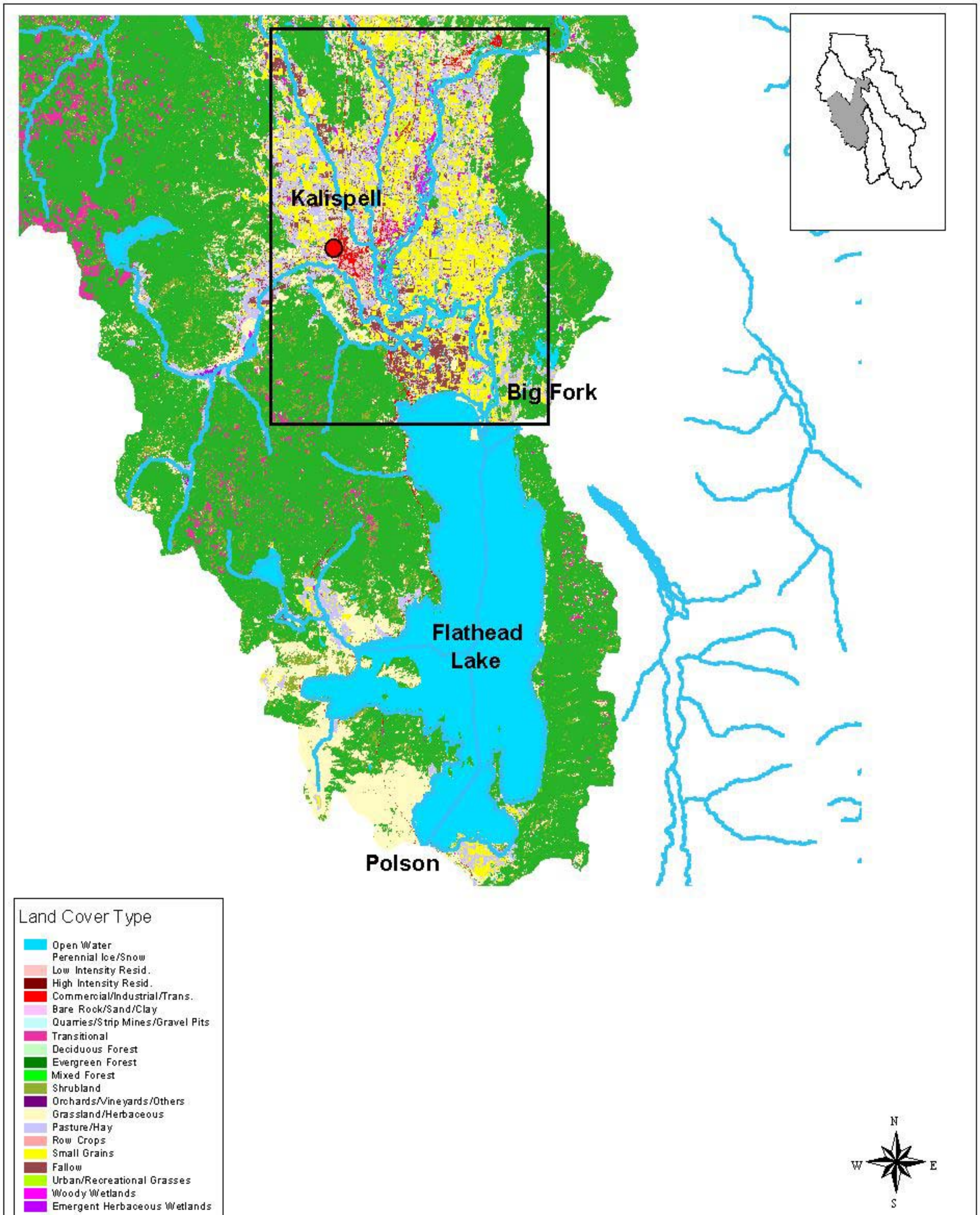


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Figure 5-3. Highest Density Urban and Agricultural Land Uses.

Figure 5-3

By: MT DEQ

Date: 8/21/01

Source: USGS National Land Cover Dataset, 1992.

SECTION 6.0

MONITORING AND ADAPTIVE MANAGEMENT STRATEGY

6.1 Current Flathead Lake Monitoring Program

The Flathead Lake Biological Station has monitored water quality in Flathead Lake continuously since 1977. From 1977 to 1982, baseline limnological data was collected as a part of the Flathead River Basin Environmental Impact Study. Thereafter, the lake was monitored with funds obtained through a cooperative agreement between Flathead Lake Biological Station and a consortium of management agencies. The Flathead Basin Commission coordinates the cooperative agreement.

The following sites have been included in the Flathead Lake Biological Station's monitoring program (Figure 2-2):

- Midlake Deap (110 m depth) located approximately one mile west of Yellow Bay Point in a pelagic are of Flathead Lake (#FBC05014)
- Flathead Lake at the outlet sill near the Highway 93 bridge in Polson (#FBC05021)
- Stoner Creek near Lakeside, a small lakeshore tributary stream (#FBC05018)
- Ashley Creek below the Kalispell sewage treatment plant outfall, a tributary to the Flathead River (#FBC05023)
- Swan River in Bigfork, a large tributary to Flathead Lake (#FBC06009)
- Stillwater River in Evergreen, a tributary to the Flathead River (#FBC04022)
- "Sportsman's Bridge" on the Flathead River near Holt, the primary tributary to Flathead Lake (#FBC05012)
- Bulk precipitation collected at the Flathead Lake Biological Station on the east shore of the lake (#FBC05016)
- "B" Beach, a shoreline periphyton monitoring site located at the Flathead Biological Station on the west side of Cape Montana (#TMP00884)
- Horseshoe Island, a shoreline periphyton monitoring site with a westerly aspect (#TMP00885)

Depth-integrated samples (primary productivity, chlorophyll *a*, TP, SRP, TN, $NO_{2/3}$, and NH_3) are collected at the Midlake deep site within the photic (light penetrated) zone. An attempt is made to collect at least 12 samples during all four seasons. At least one sample is to be collected during the rising and one during the falling limb of the Flathead River hydrograph. Since approximately 1992, dissolved oxygen profiles have been measured at the Ross and midlake deep sites. Sampling of periphyton was undertaken since 1999 at two locations, the "B" beach and Horseshoe Island site.

Loading of phosphorus and nitrogen to Flathead Lake is monitored at the above listed tributaries. Stream discharge data is obtained from the U.S. Geological Survey, except on Ashley and Stoner Creeks, where the Flathead Lake Biological Station monitors flow.

This monitoring program has allowed for annual comparisons between the rate of primary productivity, and mean concentrations of the TMDL target parameters, with the long-term averages for the midlake deep site in Flathead Lake. A complete summary of the current monitoring program is provided in Appendix C.

6.2 Proposed Flathead Lake Monitoring and Adaptive Management Program

Continuation of the ongoing Flathead Lake monitoring program, as summarized above and described in detail in Appendix B, will provide sufficient data to evaluate whether or not the restoration targets proposed in Section 5.1 are met. However, additional tributary monitoring sites are proposed to enhance the resolution of the monitoring program relative to future quantification of nutrient loads from the various sources. The following additional tributary monitoring sites are proposed (see Figure 6-1):

- Whitefish River immediately upstream of the confluence with the Stillwater River
- Stillwater River immediately upstream of the confluence with the Whitefish River
- South Fork Flathead River at Hungry Horse
- North Fork Flathead River immediately upstream of the confluence with the Middle Fork
- Middle Fork Flathead River immediately upstream of the confluence with the North Fork

Additional in-lake monitoring is also proposed to assist in both developing a better understanding of the lake system as well as providing early identification of localized problems that may be significant signs of overall lake health deterioration. Two additional lake monitoring sites are proposed; one in Big Arm Bay and the other in South Bay. The standard sampling protocol defined in Appendix B should be followed at these two additional sites.

These two areas of the lake are distinctly different from the main lake basin in that they are both somewhat protected from wind action and circulation patterns, they are shallower than the main lake basin, and they tend to freeze over on a more regular basis. In the absence of monitoring data in these locations, it is possible that localized problems could be overlooked. Additionally, given the relatively unique characteristics of these areas, this data may be useful in establishing localized restoration targets that are more representative.

The synoptic tributary studies conducted in 1995 and 1996 were very useful in beginning to understand the relationship between sources and loads. However, additional comparable data is necessary to accurately define this relationship. Additional synoptic monitoring, during spring runoff, summer storm events, and baseflow conditions is proposed as a method to further refine the understanding of potential nutrient sources. Tentative arrangements have been made for the Flathead Lake Biological Station to collect additional synoptic samples in representative tributaries in 2002.

Watershed Modeling

Sufficient monitoring data will never be available to fully identify all of the potential nutrient sources and to quantify the relative importance of each of the sources within a basin the scale of the Flathead Basin.

As described in Section 5.3.2, development of a basin-scale watershed nutrient loading model is proposed. The purpose of this exercise is to develop a tool to:

1) further refine the assessment and quantification of existing nutrient sources,

2) allocate existing and future nutrient loads to each of the significant sources, and

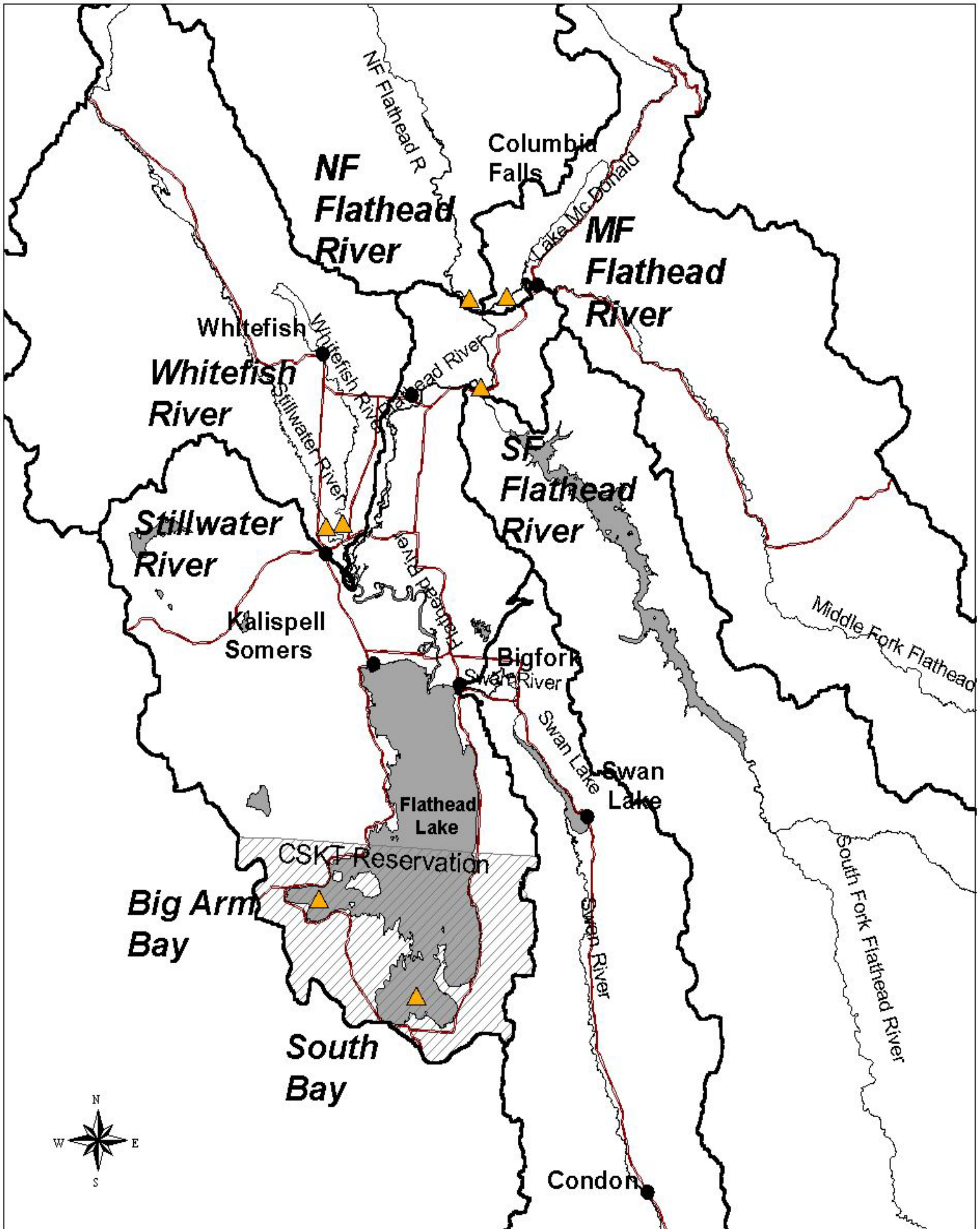

Figure 6-1. Proposed Additional Monitoring Sites

Figure 6-1	
By: MT DEQ	
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Montana Department of Environmental Quality

3) to evaluate, in a predictive mode, the potential impact of future land use scenarios and the effectiveness of proposed management practices on water quality within the basin.

In the later mode, this model could be used as a tool to assist in making land use planning decisions.

The "Flathead Lake Model" that is currently under development (see Section 5.2) simulates the response of the lake to internal and external changes within the lake, but does not estimate external nutrient loading from within the basin. The proposed basin-scale watershed loading model could be coupled with the "Flathead Lake Model" to evaluate both cause (e.g., where is the nutrient load coming from?) and effect (e.g., to what extent and how does that load change the biological characteristics of the lake?).

While these models can never replace "real monitoring data", they could become invaluable tools to assist in both managing existing nutrient loading problems as well as in preventing future problems.

Airborne Monitoring Strategy

Stanford et al.(1997) documented that precipitation falling on the lake may contribute a substantial portion of the total nutrient load to Flathead Lake on an annual basis. However, the atmospheric contribution of nutrients to Flathead Lake due to dry deposition (settling) has not been estimated. Likewise, sources of atmospheric nutrient deposition, the relationship between natural and anthropogenic sources, the relative contribution from each source, and seasonal/temporal deposition rates into Flathead Lake are not currently well understood. Answering these questions is necessary to quantify atmospheric nutrient deposition and to ultimately define a strategy to control potential airborne sources of nutrient deposition to Flathead Lake. A conceptual strategy to collect the necessary data is outlined in the following paragraphs.

The monitoring strategy should continue to focus on deposition monitoring. The deposition sampler used in the National Acid Deposition Program is recommended for this project because it is field-tested and provides data for both wet and dry deposition. Dry deposition may be a significant source of nutrients during certain events such as ash fall from forest fires or wind blown dust from agricultural fields. Flathead is a large lake with lakeshore activities ranging from recreation homes and cherry orchards to livestock and agricultural production. Wet/Dry deposition monitoring will be necessary at several locations (3-10) around the lake to address precipitation patterns and the effect of local sources on dry deposition. The shoreline sites should be selected to represent all of the major land uses around the lake. Consideration should be given to a monitoring site that is remote from local shoreline sources such as on one of the less developed islands within the lake. Such a site would be indicative of nutrient deposition in the large open water area of the lake. A second remote site located at high elevation (above 6500 ft MSL) and immediately up or downwind of the lake is also recommended. A remote high elevation site would be largely free of local sources (except for nearby forest prescribed fires and wildfires) and primarily impacted by nutrients associated with long-range transport from Western Montana or emission sources in other states. It is estimated that virtually all of the deposition due to long-range transport will be in the form of wet deposition.

The deposition monitors should be operated to collect samples on a precipitation event basis and/or on a pre-established schedule such as weekly. Temporal resolution is important for correlating nutrient deposition rates with specific events (i.e., major forest fires or dust storms) or to eliminate sources such as dust from dirt roads when the roads are snowpacked. The wet and dry deposition samples should be analyzed for a wide range of elemental and ionic constituents including all ionic forms of nitrogen and phosphorus. A comprehensive chemical analysis can provide clues to the sources of deposition. The researcher should evaluate the feasibility of using receptor-modeling techniques such as microscopy or chemical mass balance modeling directly on the deposition samples to identify sources. These techniques have been used successfully on air sample to determine the contributions from various emission sources and may be adaptable to deposition samples.

Meteorological stations capable of measuring wind speed, direction and temperature should be collocated at each of the wet/dry deposition sites. Wind direction and strength information would facilitate back-trajectory analyses to identify possible sources of nutrients. Such analyses would be particularly useful for identifying wind-related sources such as dust storms or in the case of the remote high elevation site the general region that is the origin of nutrients from long-range transport.

Serious consideration should be given to locating the remote high elevation deposition monitor at an existing IMPROVE air monitoring site. The IMPROVE sites are long-term sites (10-60 years) that are designed to collected fine particulate data, analyze it for numerous elemental and ionic constituents, calculate their impact on visibility, and use the data to determine the sources of the particulate. The IMPROVE data could be used to verify the data from the wet/dry deposition monitors or substitute for the wet/dry deposition data if an adequate relationship can be established. Although it is a reasonable assumption that the chemistry of fine particulate concentrations and wet/dry deposition at high elevation is similar, it is by no means a certainty.

The researchers should also investigate the usefulness of locating airborne particulate monitors (PM-2.5 and/or Total Suspended Particulate) at each of the low elevation wet/dry deposition sites. Although it is very expensive to analyze the air sampling filters for a spectrum of chemical constituents, the data could be used similar to the IMPROVE data to identify sources.

The monitoring study should extend for at least one full year. Several years would be preferable in order to address changing weather patterns and fluctuations in economic output that affects industrial emissions.

Section 7.0
Restoration Strategy

As a parallel effort to the development of the Flathead Lake Water Quality Restoration Plan, the Flathead Basin Commission is currently developing an implementation plan to direct the activities of their Voluntary Nutrient Reduction Strategy (VNRS). The FBC will take the lead role in implementation. As a result, a detailed restoration strategy is not presented herein. Rather, this document presents recommendations based on the results of this effort that may enhance the FBC's future efforts to reduce nutrient loading to Flathead Lake.

The results of this effort have highlighted what we know, what we suspect, and what we don't know relative to nutrient loading to Flathead Lake. It has been clearly demonstrated that there is an increasing trend in primary productivity. This increase is at least partially controlled by external nutrient loading. Internal lake dynamics associated with an altered food web may also play a role in the increase in primary productivity. However, external loading is the only factor over which we have direct management control. Therefore, the means to reverse the increasing trend in primary productivity is through control of external nutrient loading. Five basic water quality restoration priorities are presented below:

5. Given the results of this analysis, urban and agricultural land uses, primarily concentrated in the Flathead River Valley north of Flathead Lake (Figure 5-2) appear to pose the greatest immediate threat to Flathead Lake relative to nutrient loading. Controlling nutrient loading from the sources in this area should be the initial focus of efforts to restore Flathead Lake. Initial efforts in this regard will likely require a combination of implementation of on-the-ground restoration measures as well as more detailed analysis including: 1) a focused source assessment to locate specific agricultural and urban sources and, 2) a feasibility study to evaluate alternative control measures.

6. Growth in unincorporated areas throughout the basin has been shown to pose a future threat to the lake's water quality. Land use planning, education, and implementing BMPs for all future development should also be a primary focus of the water quality restoration efforts.

7. The restoration strategy needs to include implementation of the Phase II allocation plan and the adaptive management strategy as follows:

    - Trend monitoring needs to continue to track the success of current and future restoration efforts and the ongoing monitoring program should be expanded to include additional tributary and in-lake sites.
    - Additional tributary synoptic sampling should be conducted to further refine the characterization of nutrient sources.
    - A watershed loading model should be developed to further refine the assessment and quantification of existing nutrient sources, allocate existing and future nutrient loads to each of the significant sources, and to evaluate, in a predictive mode, the potential impact of future land use actions.
    - Airborne sources need to be further investigated to determine if this source can be controlled and how.
    - Restoration targets and the TMDL (i.e., 25 percent reduction in nutrient loading) should be evaluated and modified as necessary to reflect the results of implementation of the adaptive management strategy.

8. Each of the sub-watersheds tributary to Flathead Lake are located within DEQ TMDL Planning Areas (Figure 7-1). All necessary TMDL's for those waters listed on the Montana 1996 303(d) List within the Swan, Flathead Headwaters, and Flathead-Stillwater TMDL Planning areas must be completed by 2002, 2003, and 2005, respectively. This provides an opportunity to focus assessment and restoration efforts on a smaller scale that may be more conducive to accurately evaluating the linkages between sources and impairments and, ultimately, to implementation of on-the-ground restoration actions. This will also likely be the most effective scale at which to address historical Forestry impacts that may be providing increased loads of both sediment and nutrients to the lake. Regardless of the listed impairments within these TMDL Planning Areas, future water quality restoration efforts should be coordinated with this plan in an effort to maximize potential nutrient load reductions.

   The FBC's VNRS Coordinator presented a draft of a VNRS Implementation Plan at a December 2001 FBC meeting. Having worked closely with the DEQ for several years regarding Flathead Lake water quality issues, the FBC's draft plan contained most of the suggested restoration strategy elements presented above. Through a formal vote at this meeting, the FBC reiterated their support in implementing the VNRS and, thereby, provided reasonable assurance that the above listed elements of this restoration strategy will be implemented through the FBC's continued efforts.

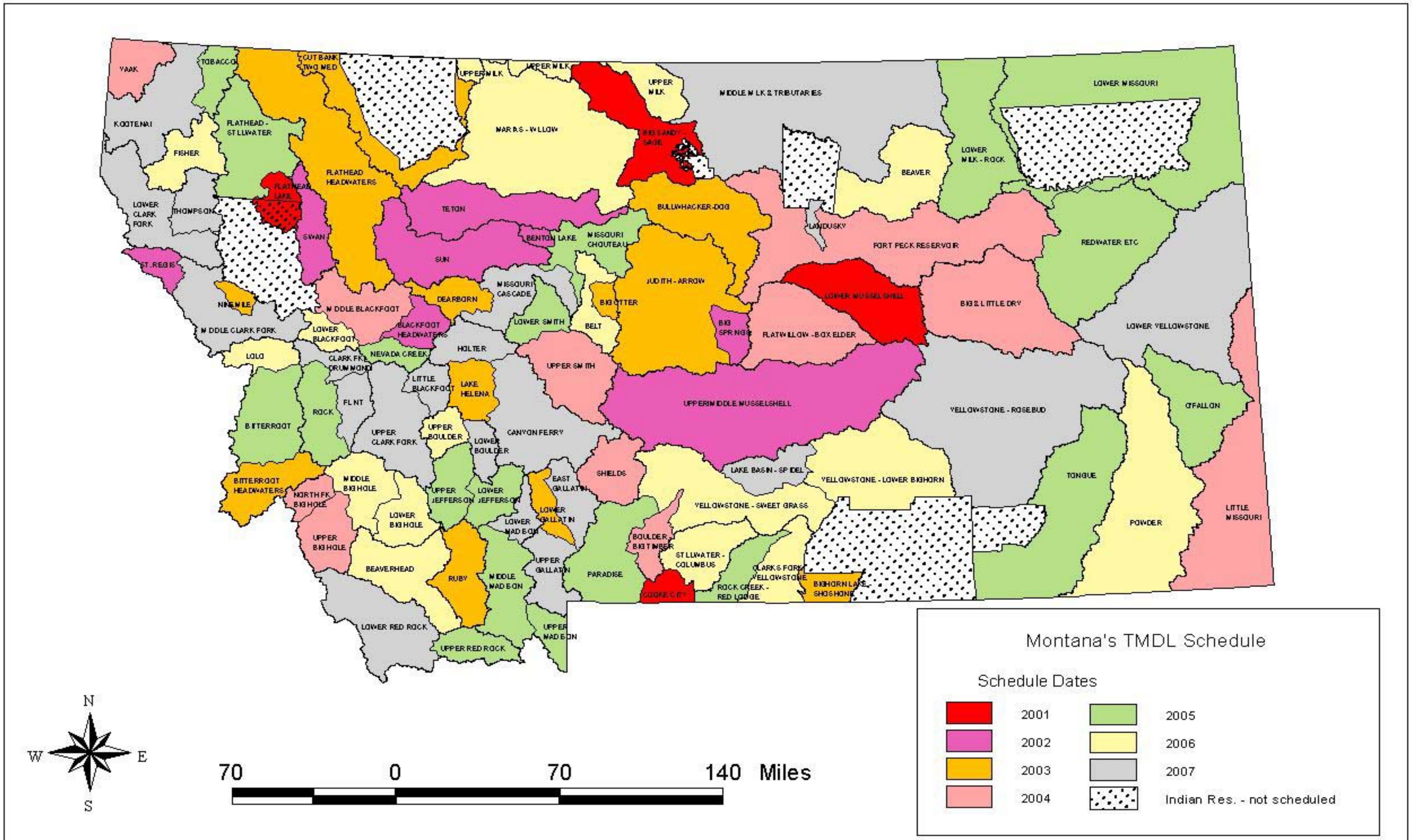
Section 8.0
Public Involvement

A draft **Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana** was released for public comment on October 30, 2001. Paid announcements appeared the week of October 29-November 1 in the classified sections of the Missoula **Missoulian**, Kalispell **Inter-lake**, Bigfork **Eagle** and **Polson Advertiser**. A press release was sent to all area newspapers, radio and television stations on October 29, 2001. The document was made available for public review on the Department of Environmental Quality website www.deq.state.mt.us and at public libraries in Kalispell, Bigfork and Polson.

DEQ and the Flathead Basin Commission hosted two open houses to provide information to the public and answer questions. The first open house was November 6th at the Polson City Library and the second was on November 7th at the Flathead Valley Community College cafeteria in Kalispell. Opportunities for written and verbal public comment were provided at both meetings. The public comment period closed at 5 p.m. November 30, 2001.

A separate meeting, hosted by DEQ, was also held in Kalispell, Montana on November 29, 2001 to specifically discuss issues pertaining to point source discharges. Additionally, this document was discussed at two FBC meetings, one on August 30 and the other on December 17, 2001. Both FBC meetings were open to, and attended by, the public. In addition to numerous verbal comments received during the above listed meetings, a total of 10 written comment letters were received by DEQ.

This final draft document reflects modifications made in response to the written and verbal comments received throughout the public comment period. DEQ's responses to written comment are provided in Appendix D.



	State of Montana's TMDL Planning Area scheduled completion dates. NOTE: states do not have jurisdiction on tribal lands, thus waters therein are not included in Montana's TMDL schedule.	**Figure 7-1** By: MTDEQ Date: Oct. 2001

Montana Department of Environmental Quality

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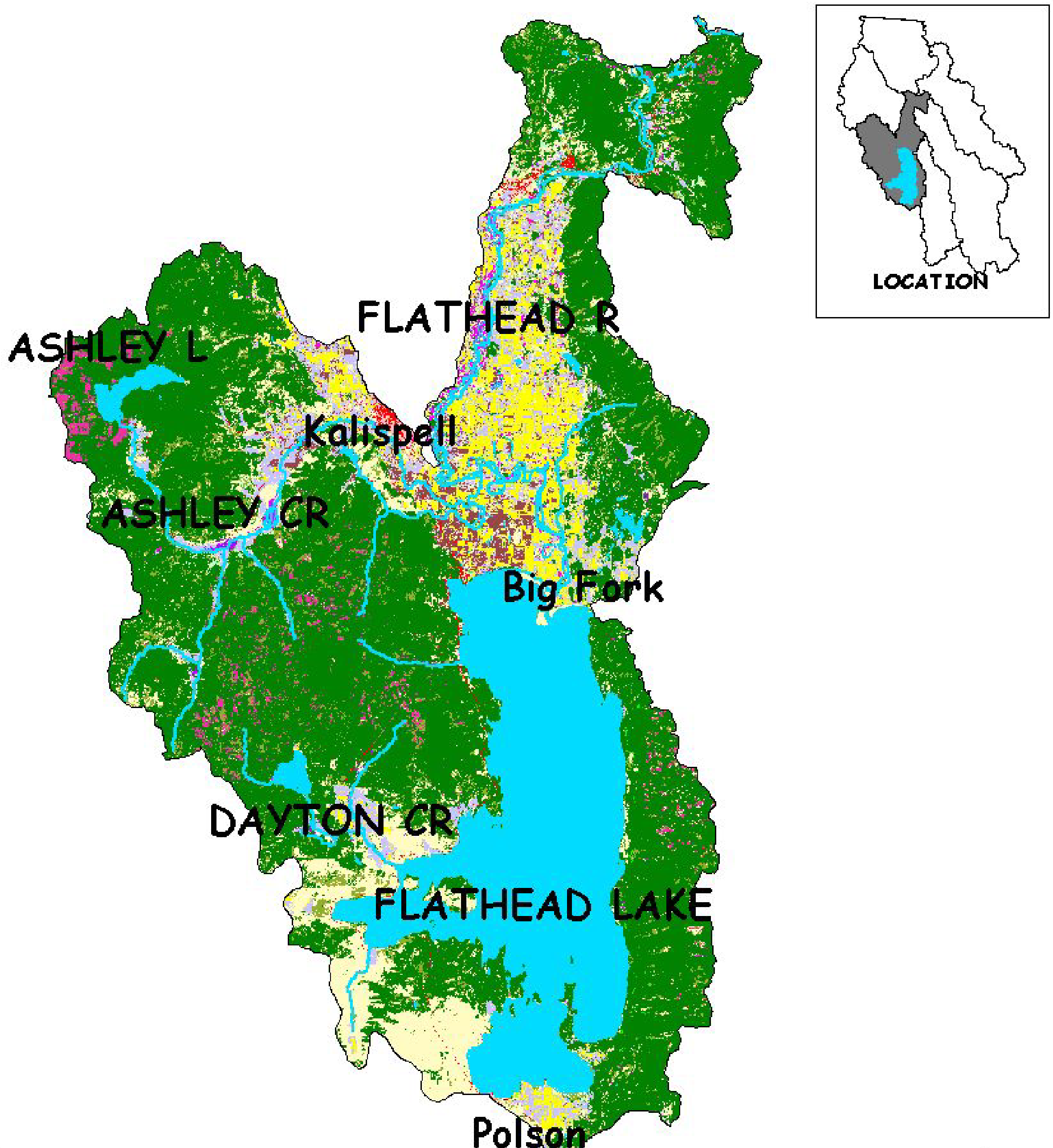
APPENDIX A
ADDITIONAL FIGURES



Land Cover Type	Acres	%	Land Cover Type	Acres	%
Open Water	135246	18.57	Shrubland	36785	5.05
Perennial Ice/Snow	48	0.01	Orchards/Vineyards/Others	0	0.00
Low Intensity Resid.	2494	0.34	Grassland/Herbaceous	72186	9.91
High Intensity Resid.	22	0.00	Pasture/Hay	38022	5.52
Commercial/Industrial/Trans.	3264	0.45	Row Crops	0	0.00
Bare Rock/Sand/Clay	748	0.10	Small Grains	37127	5.10
Quarries/Strip Mines/Gravel	0	0.00	Fallow	11354	1.56
Transitional	9978	1.37	Urban/Recreational Grasses	273	0.04
Deciduous Forest	3764	0.52	Woody Wetlands	4319	0.59
Evergreen Forest	371483	51.01	Emergent Herb. Wetland	928	0.13
Mixed Forest	273	0.04			

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Figure 2-4. Land Cover - Flathead Lake Basin.

Source: USGS National Land Cover Dataset based on 1992 Landsat Thematic Mapper Imagery.

By: RFS

Date: 2/5/01

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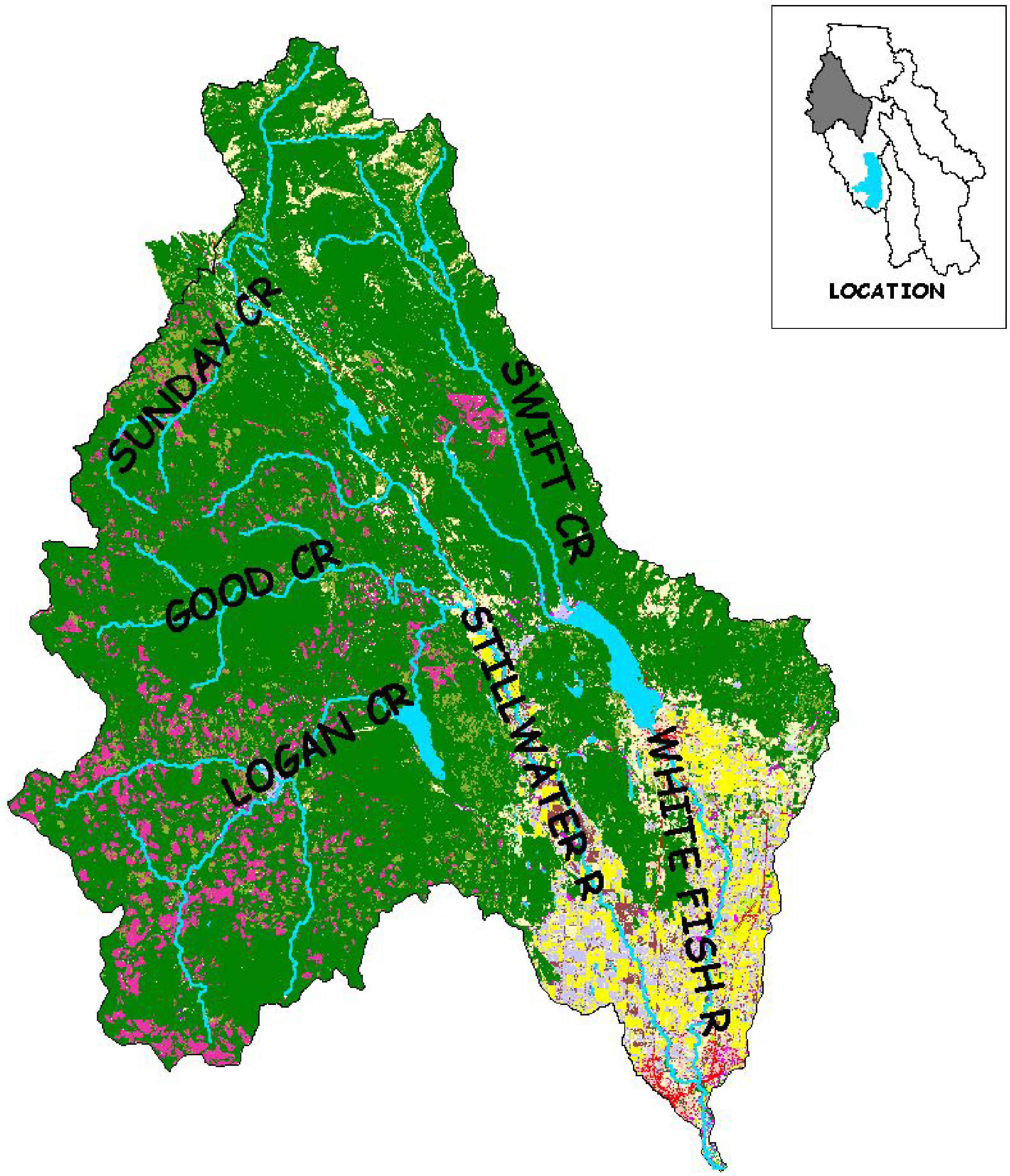

Land Cover Type	Acres	%	Land Cover Type	Acres	%
Open Water	7709	1.47	Shrubland	30805	5.89
Perennial Ice/Snow	8	0.00	Orchards/Vineyards/Others	0	0.00
Low Intensity Resid.	3143	0.60	Grassland/Herbaceous	27709	5.29
High Intensity Resid.	13	0.00	Pasture/Hay	17887	3.42
Commercial/Industrial/Trans.	2500	0.48	Row Crops	0	0.00
Bare Rock/Sand/Clay	552	0.11	Small Grains	21760	4.16
Quarries/Strip Mines/Gravel	0	0.00	Fallow	5789	1.11
Transitional	27496	5.25	Urban/Recreational Grasses	460	0.09
Deciduous Forest	4219	0.81	Woody Wetlands	3214	0.61
Evergreen Forest	369836	70.67	Emergent Herb. Wetland	215	0.04
Mixed Forest	1	0.00			

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Figure 2-5. Land Cover - Stillwater Basin.

Source: USGS National Land Cover Dataset based on 1992 Landsat Thematic Mapper Imagery.

By: RFS

Date: 2/5/01

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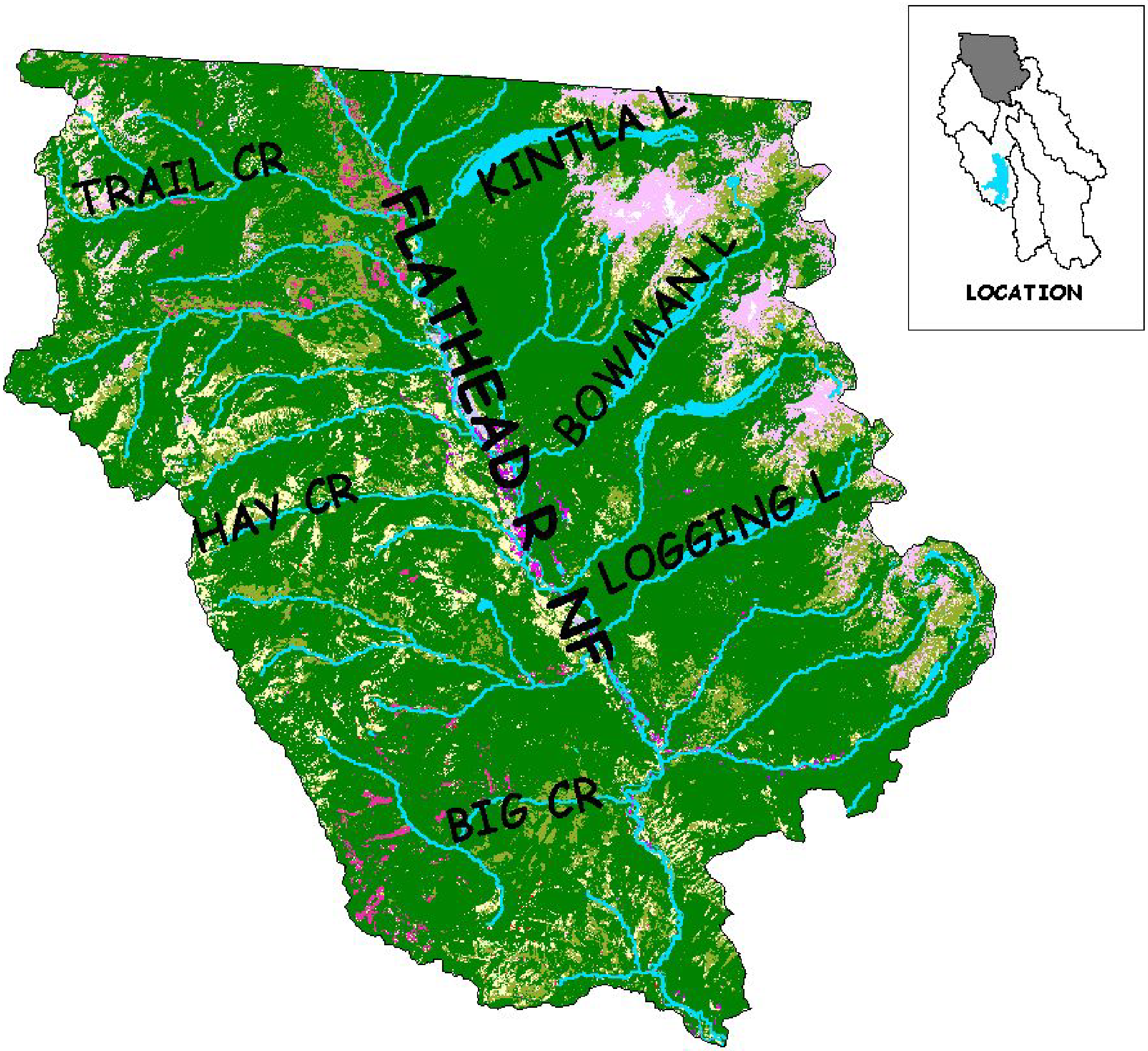

Land Cover Type	Acres	%	Land Cover Type	Acres	%
Open Water	10,863	1.77	Shrubland	59,924	9.79
Perennial Ice/Snow	1,152	0.19	Orchards/Vineyards/Others	0	0.00
Low Intensity Resid.	10	0.00	Grassland/Herbaceous	36,910	6.03
High Intensity Resid.	0	0.00	Pasture/Hay	1,230	0.20
Commercial/Industrial/Trans.	238	0.04	Row Crops	0	0.00
Bare Rock/Sand/Clay	26,487	4.33	Small Grains	0	0.00
Quarries/Strip Mines/Gravel	0	0.00	Fallow	0.2	0.00
Transitional	5,110	0.84	Urban/Recreational Grasses	6	0.00
Deciduous Forest	2,354	0.38	Woody Wetlands	2,586	0.42
Evergreen Forest	464,498	75.89	Emergent Herb. Wetland	589	0.10
Mixed Forest	89	0.01			

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Figure 2-6. Land Cover - North Fork Flathead Basin.

Source: USGS National Land Cover Dataset based on 1992 Landsat Thematic Mapper Imagery.

By: RFS

Date: 2/2/01

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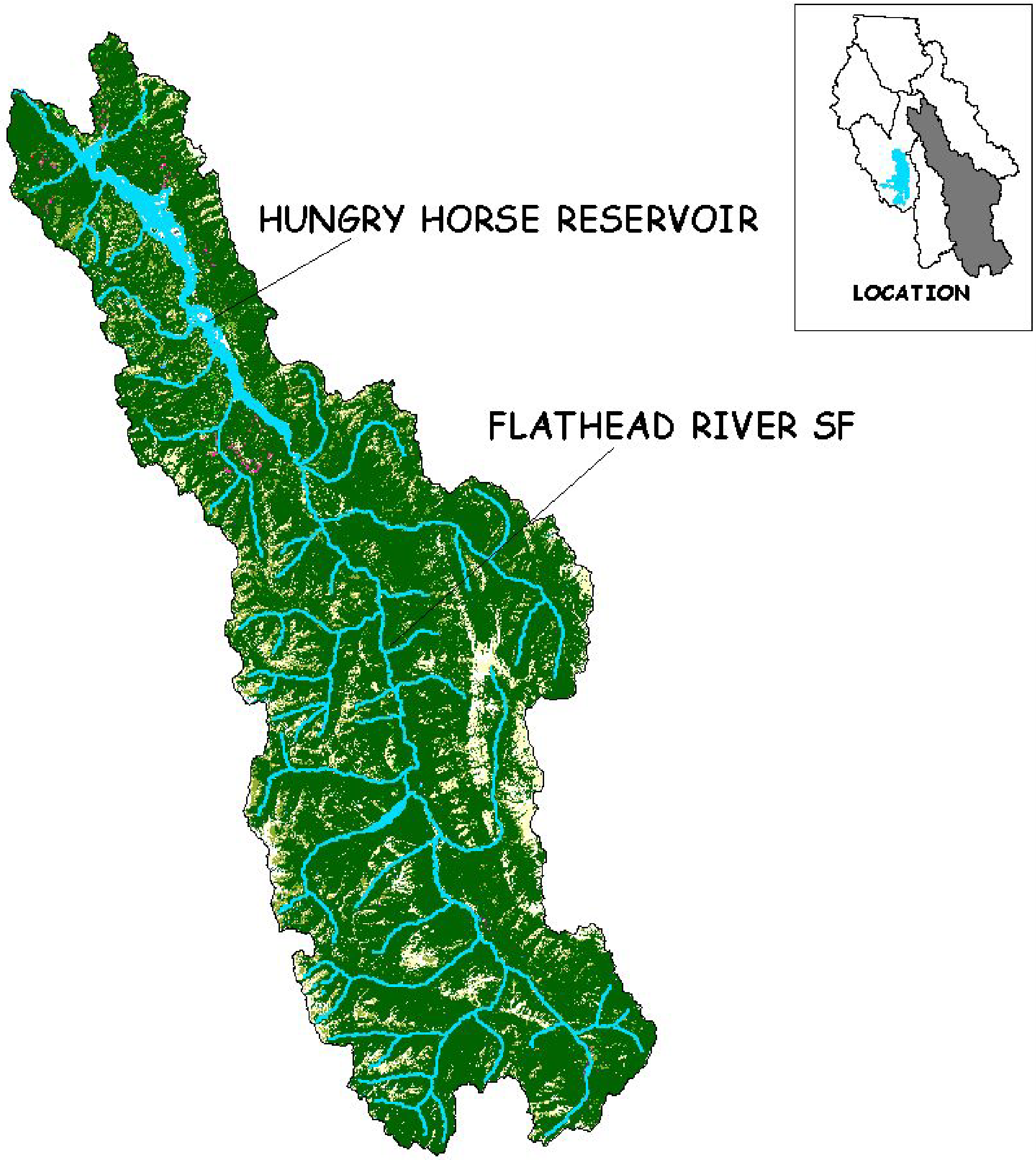

Land Cover Type	Acres	%	Land Cover Type	Acres	%
Open Water	24095	2.26	Shrubland	67113	6.28
Perennial Ice/Snow	531	0.05	Orchards/Vineyards/Others	28	0.00
Low Intensity Resid.	59	0.01	Grassland/Herbaceous	81145	7.60
High Intensity Resid.	0	0.00	Pasture/Hay	11	0.00
Commercial/Industrial/Trans.	109	0.01	Row Crops	0	0.00
Bare Rock/Sand/Clay	34455	3.23	Small Grains	0	0.00
Quarries/Strip Mines/Gravel	0	0.00	Fallow	3	0.00
Transitional	1997	0.19	Urban/Recreational Grasses	2	0.00
Deciduous Forest	1299	0.12	Woody Wetlands	1042	0.10
Evergreen Forest	855122	80.06	Emergent Herb. Wetland	46	0.00
Mixed Forest	1024	0.10			

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Figure 2-7. Land Cover - South Fork Flathead Basin

Source: USGS National Land Cover Dataset based on 1992 Landsat Thematic Mapper Imagery.

By: RFS

Date: 2/5/01

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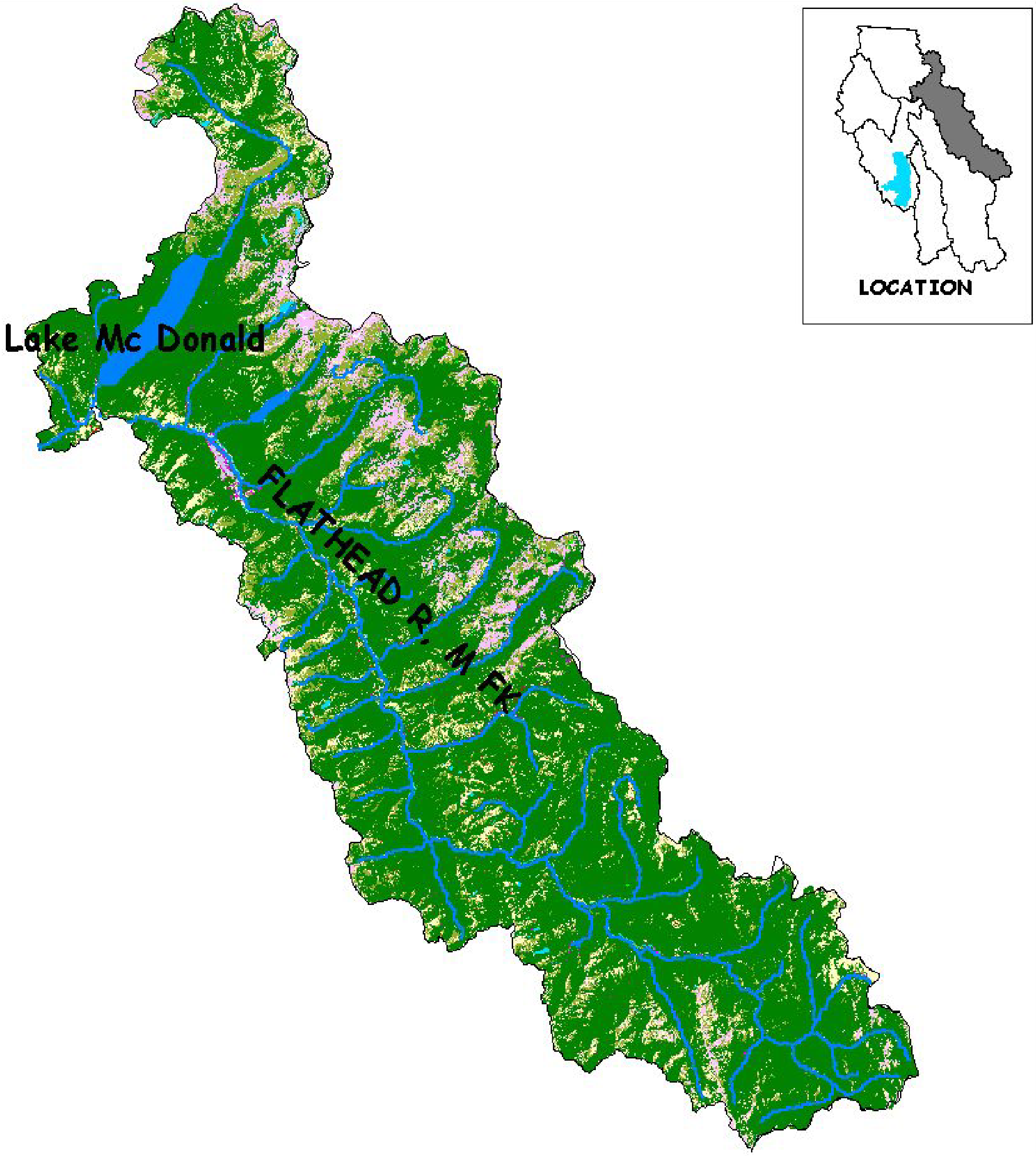

Land Cover Type	Acres	%	Land Cover Type	Acres	%
Open Water	11657	1.61	Shrubland	68253	9.45
Perennial Ice/Snow	924	0.13	Orchards/Vineyards/Others	0	0.00
Low Intensity Resid.	20	0.00	Grassland/Herbaceous	48013	6.65
High Intensity Resid.	0	0.00	Pasture/Hay	490	0.07
Commercial/Industrial/Trans.	847	0.12	Row Crops	0	0.00
Bare Rock/Sand/Clay	39311	5.44	Small Grains	0	0.00
Quarries/Strip Mines/Gravel	0	0.00	Fallow	0	0.00
Transitional	0	0.00	Urban/Recreational Grasses	3	0.00
Deciduous Forest	3688	0.51	Woody Wetlands	2266	0.31
Evergreen Forest	546407	75.62	Emergent Herb. Wetland	112	0.02
Mixed Forest	535	0.07			

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Figure 2-8. Land Cover - MIDDLE FORK FLATHEAD BASIN

Source: USGS National Land Cover Dataset based on 1992 Landsat Thematic Mapper Imagery.

By: RFS

Date: 2/5/01

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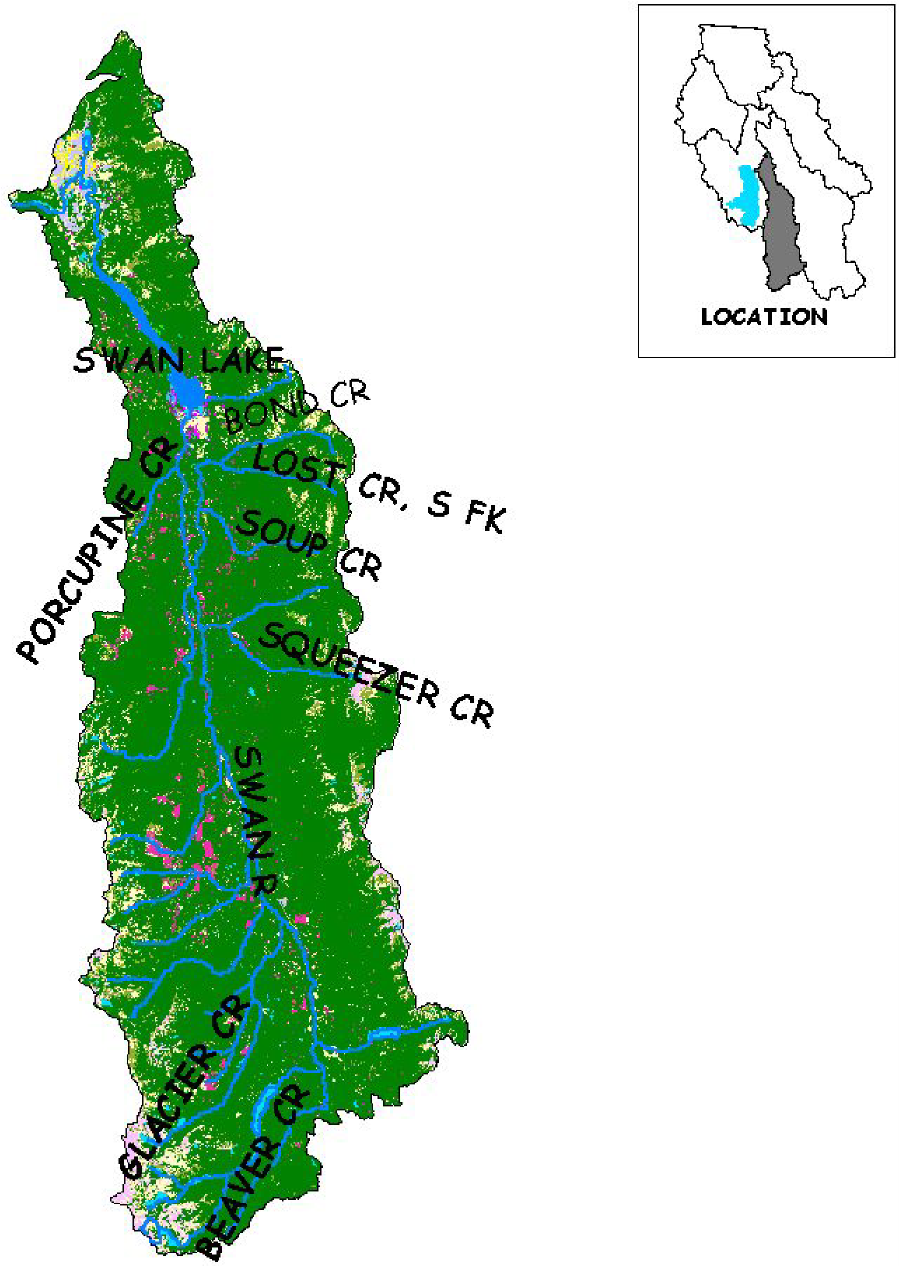

Land Cover Type	Acres	%	Land Cover Type	Acres	%
Open Water	9,848	2.10	Shrubland	20,808	4.45
Perennial Ice/Snow	154	0.03	Orchards/Vineyards/Others	7.6	0.00
Low Intensity Resid.	28	0.01	Grassland/Herbaceous	26,370	5.63
High Intensity Resid.	3.4	0.00	Pasture/Hay	2,760	0.59
Commercial/Industrial/Trans.	67	0.01	Row Crops	0	0.00
Bare Rock/Sand/Clay	8,886	1.90	Small Grains	963	0.21
Quarries/Strip Mines/Gravel	0	0.00	Fallow	29	0.01
Transitional	7,902	1.69	Urban/Recreational Grasses	26	0.01
Deciduous Forest	781	0.17	Woody Wetlands	1,640	0.35
Evergreen Forest	387,355	82.75	Emergent Herb. Wetland	196	0.04
Mixed Forest	281	0.06			

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Figure 2-9. Land Cover - Swan Basin.

Source: USGS National Land Cover Dataset based on 1992 Landsat Thematic Mapper Imagery.

By: RFS

Date: 2/5/01

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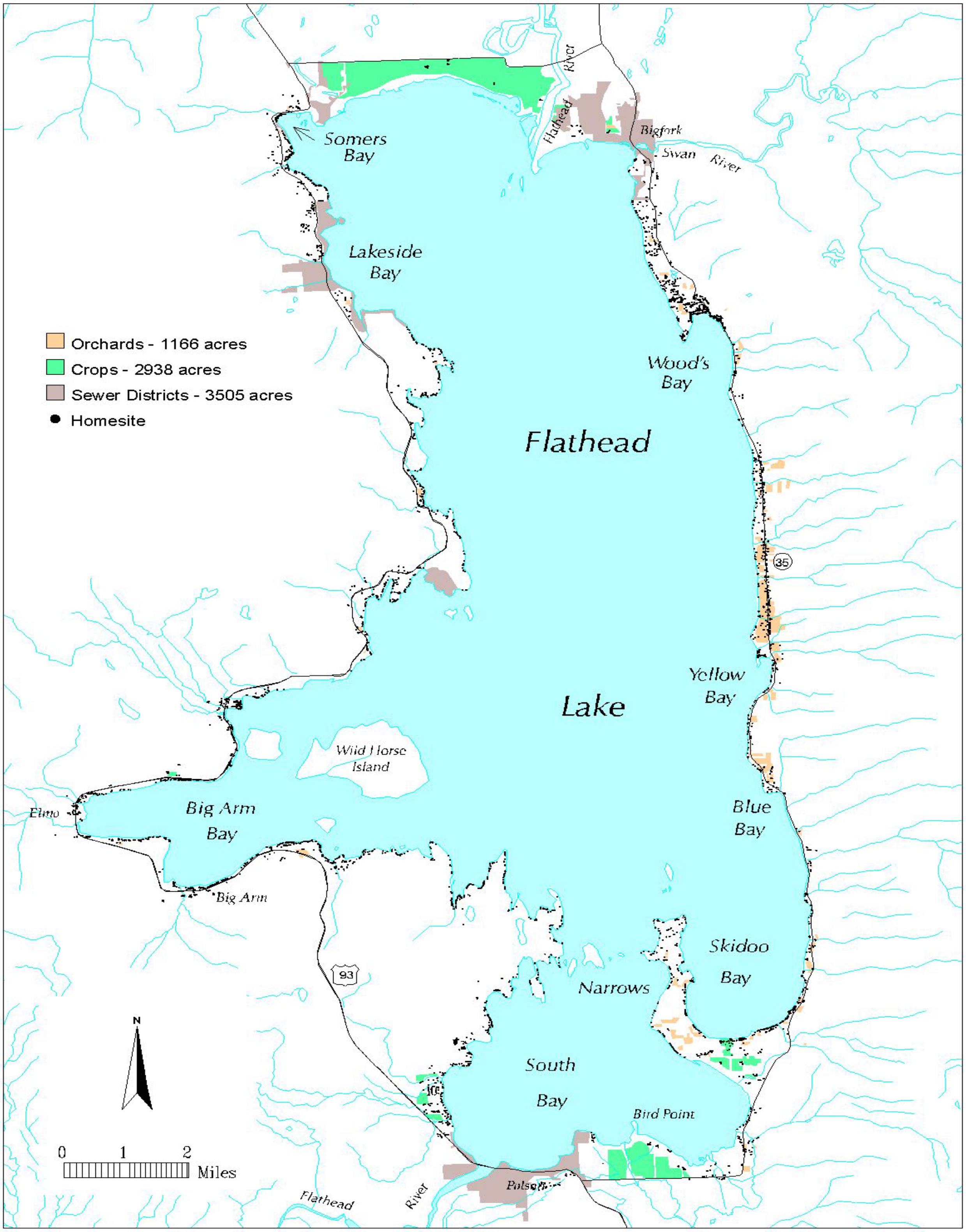

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Figure 2-10. Flathead Lake Land Use - June 1994

Source: Makepeace and Mladenich, 1996.

Figure 2-10	
By: MT DEQ	
Date: 1996	
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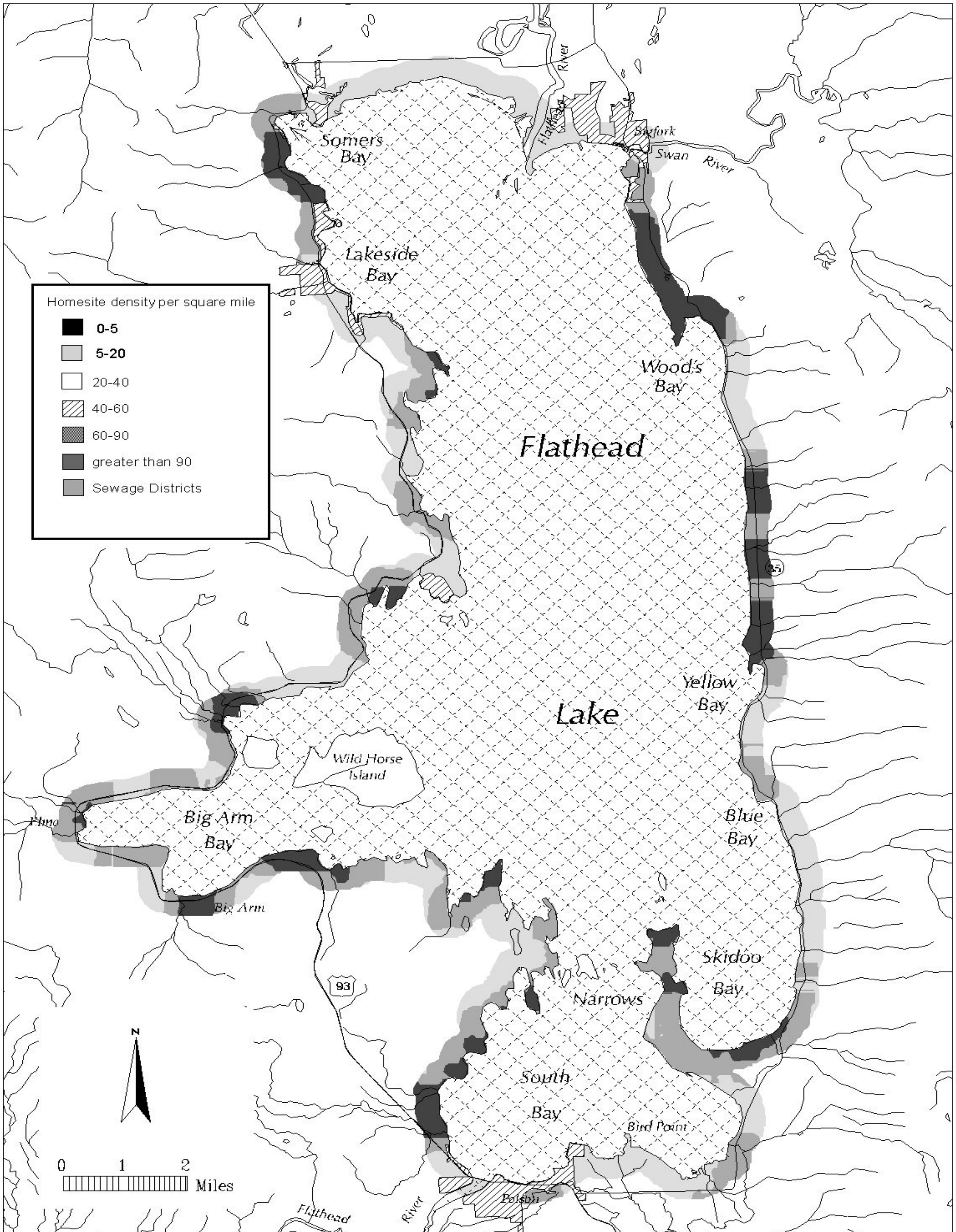

Figure 2-11. Flathead Lake Homesite Density - June 1994

Source: Makepeace and Mladenich, 1996.

Montana Department of Environmental Quality

Figure 2-11
By: MT DEQ
Date: 1996
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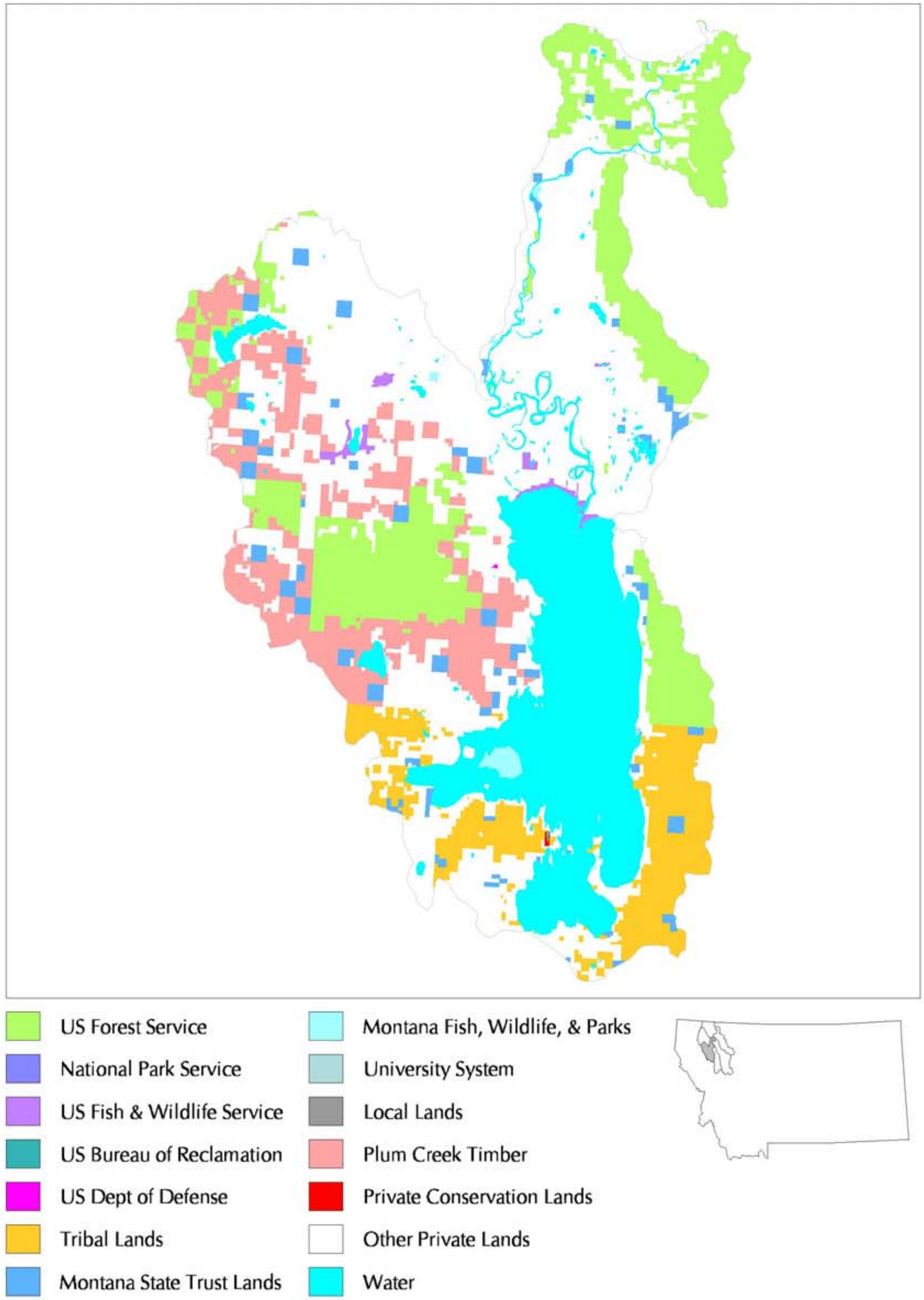

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Figure 2-12. Land Ownership
Flathead Lake Basin

Source: Land Ownership and Managed Areas of Montana available from Montana Natural Resource Information System.

Montana Natural Resource Information System
Montana State Library – 1515 East 6th Avenue
Helena, Montana – (406) 444-5357

NRIS Map # 01nris365 - 10/3/2001

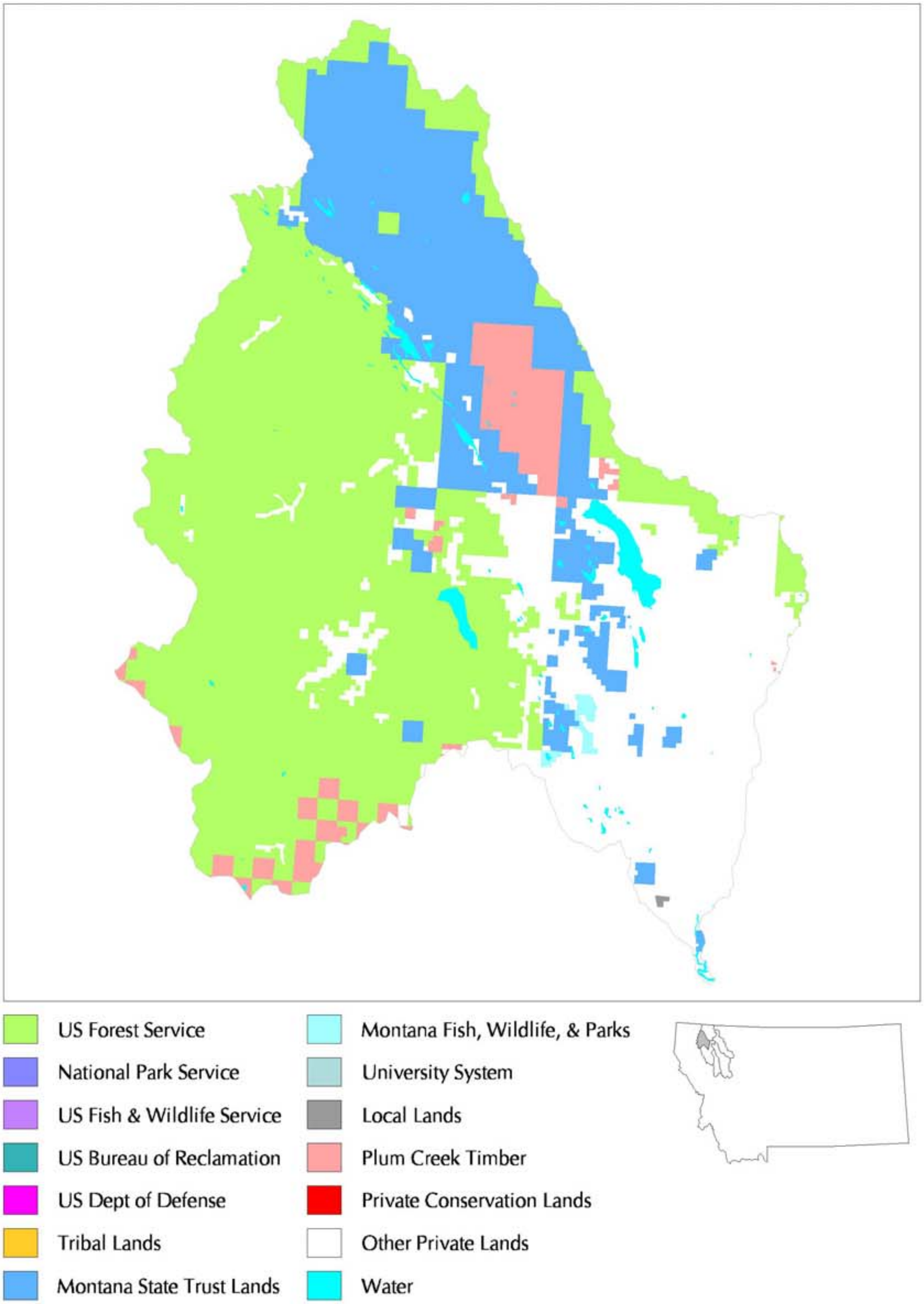

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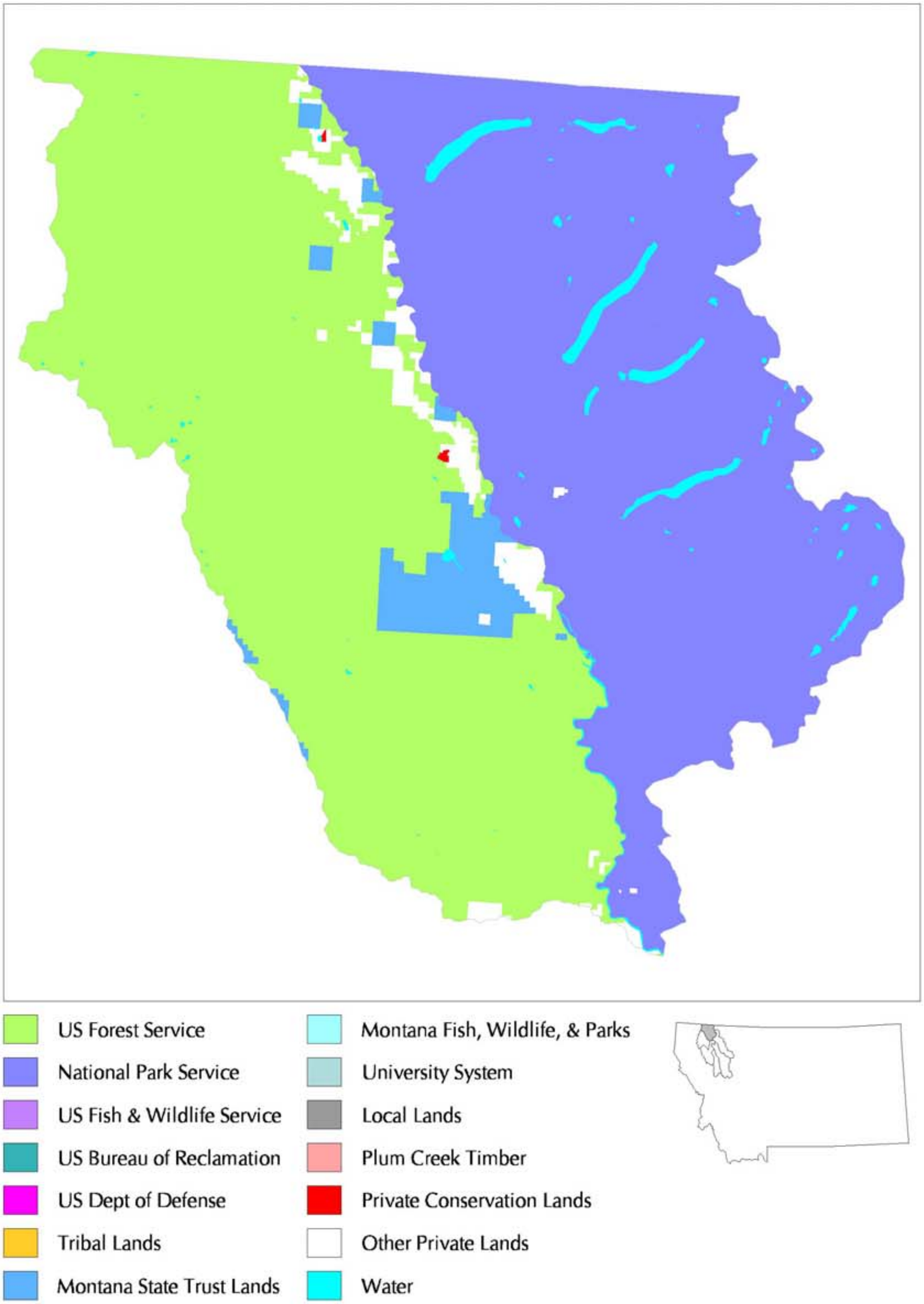
Figure 2-13. Land Ownership Stillwater/Whitefish Basin

Source: Land Ownership and Managed Areas of Montana available from Montana Natural Resource Information System.

Montana Natural Resource Information System

NRIS Map # 01nris365 - 10/3/2001



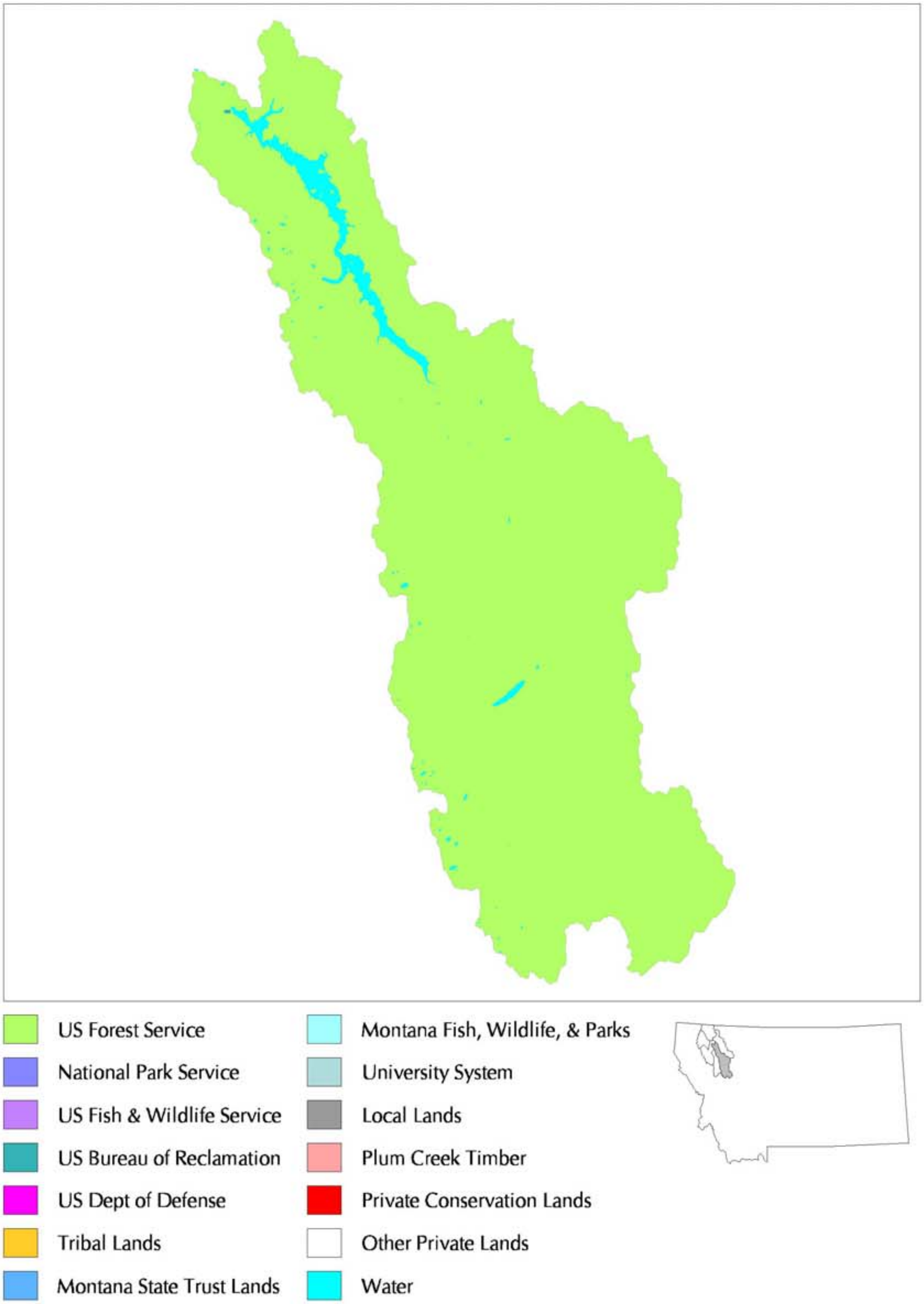
Montana Department of Environmental Quality

Figure 2-14. Land Ownership North Fork Basin

Source: Land Ownership and Managed Areas of Montana available from Montana Natural Resource Information System.

Montana Natural Resource Information System
Montana State Library – 1515 East 6th Avenue Helena, Montana – (406) 444-5357

NRIS Map # 01nris365 - 10/3/2001



Montana Department of Environmental Quality

Figure 2-15. Land Ownership
South Fork Basin

Source: Land Ownership and Managed Areas of Montana available from Montana Natural Resource Information System.

MONTANA Natural Resource Information System
Montana State Library – 1515 East 6th Avenue Helena, Montana – (406) 444-5357

NRIS Map # 01nris365 - 10/3/2001

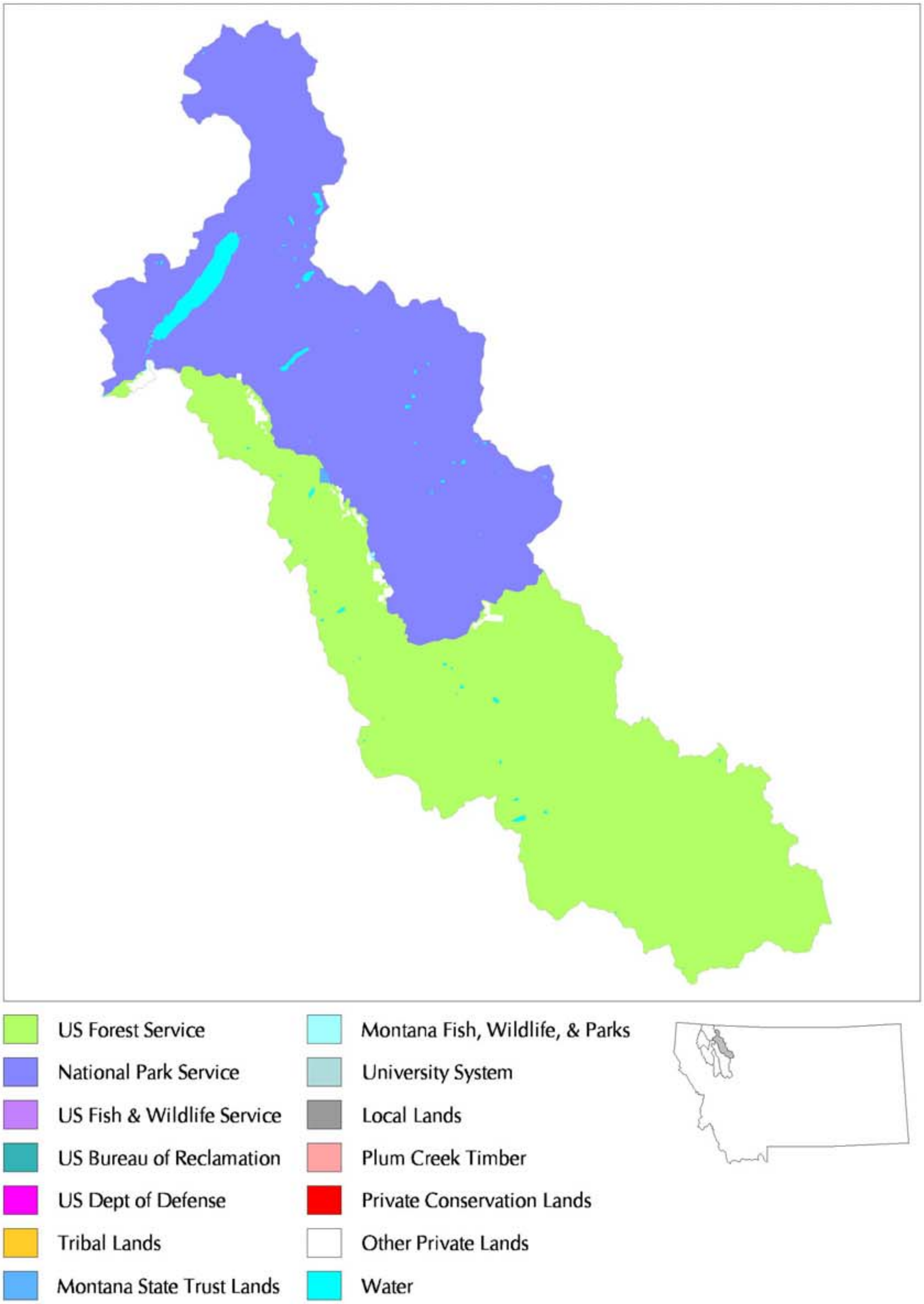


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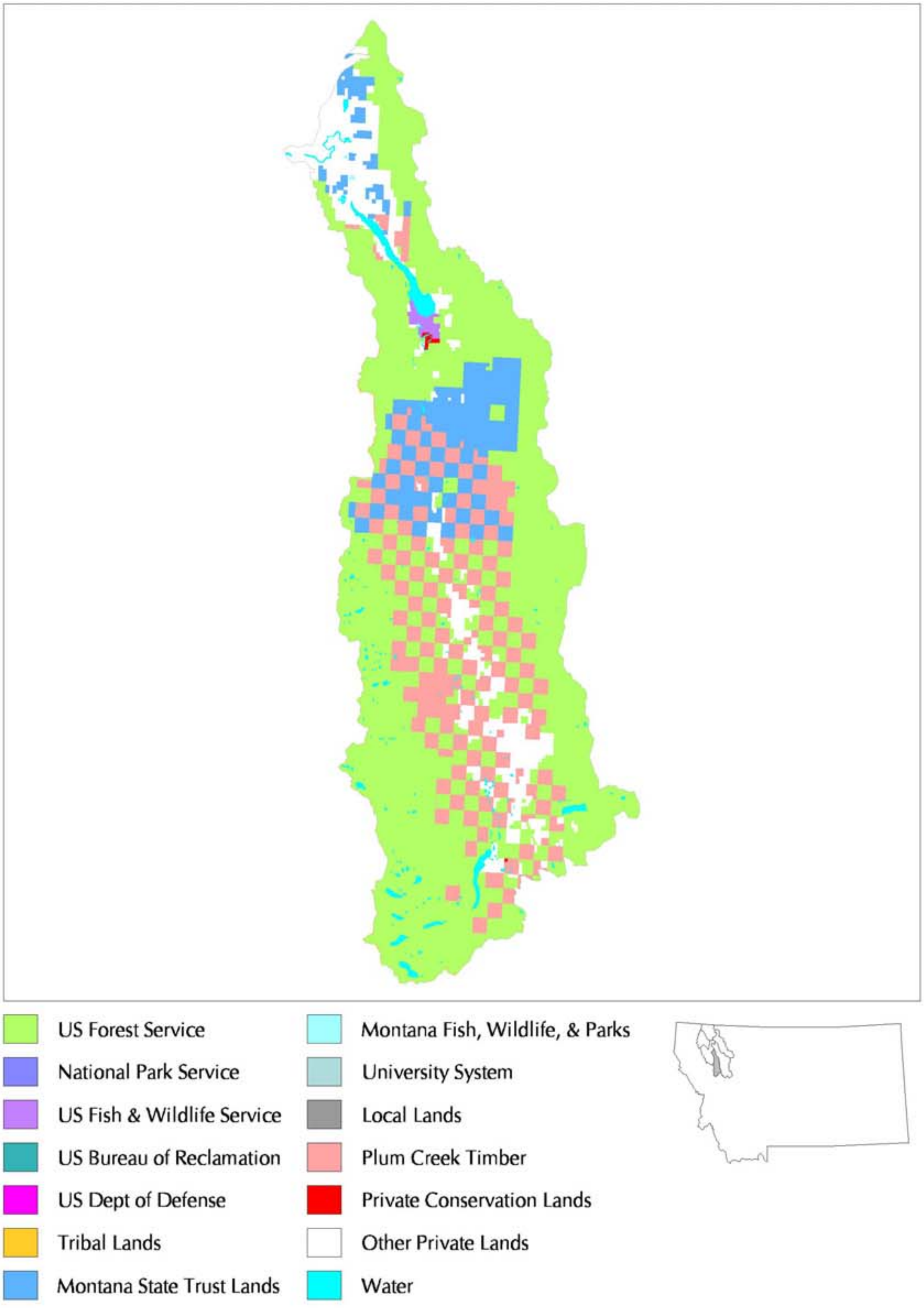
Figure 2-16. Land Ownership Middle Fork Basin

Source: Land Ownership and Managed Areas of Montana available from Montana Natural Resource Information System.

Montana Natural Resource Information System
Montana State Library -- 1515 East 6th Avenue Helena, Montana -- (406) 444-5357

NRIS Map # 01nris365 - 10/3/2001



Montana Department of Environmental Quality

Figure 2-17. Land Ownership Swan Basin

Source: Land Ownership and Managed Areas of Montana available from Montana Natural Resource Information System.

Montana Natural Resource Information System
Montana State Library – 1515 East 6th Avenue Helena, Montana – (406) 444-5357

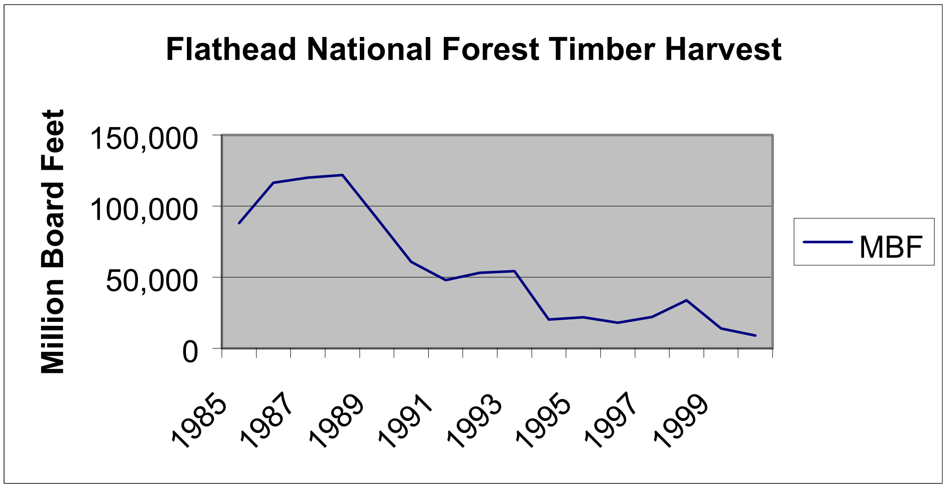
NRIS Map # 01nris365 - 10/3/2001

Appendix B
HISTORICAL PERSPECTIVE ON MANAGED FOREST LANDS

Historical Perspective on Managed Forest Lands

Based on a nutrient loading analysis conducted by source category (Section 4.2.3), forested lands comprise the greatest single source of nutrients to Flathead Lake. At the same time, timber harvest on National Forest lands fell from a high of 122,000,000 board feet in 1988 to less than 9,000,000 board feet in 2000 (See Figure B-1). The National Forest comprises 60 percent of the land base of the watershed. While timber harvest has not declined similarly on state and private forest lands, the increased implementation of forestry best management practices has reduced the impacts of all logging operations.

Figure B-1. Flathead National Forest Timber Harvest Trends.



Statewide Best Management Practices for forestry were adopted in 1987. These practices are described and illustrated in the **Forestry BMPs** handbook, a publication developed by the Department of Natural Resources and Conservation, Montana State University Cooperative Extension Service and the Montana Logging Association. In 1989 the Montana legislature required landowners who were planning to harvest a significant amount of timber to notify the state. Under this law best management practice information is sent to the landowner. BMPs are also promoted at industry meetings, workshops and conferences. Each year DNRC and the Montana Logging Association conduct workshops for timber harvest operators, road builders, private landowners and other interested parties to improve the effectiveness and application of BMPs.

Since 1990, biennial audits have tracked the progress of BMP implementation. These audits show considerable progress in BMP application over the past decade (Table B-1). The 2000 audit found that forestry best management practices are correctly applied 96 percent of the time. The 1991 Streamside Management Zone (SMZ) law regulates forest practices in riparian areas. Since 1994, the BMP audits have also evaluated compliance with SMZ. The 2000 audit found SMZ rules were correctly applied 96 percent of the time. Of 17 departures from the rules, 14 were considered minor and three major. SMZ effectiveness was rated very high--over 99 percent.

Plum Creek Timber, the watershed's largest private forest landowner, signed a Habitat Conservation Plan (HCP) agreement with the U.S. Department of Interior in November 2000. The agreement, which covers 1.5 million acres in western Montana, specifies measures to conserve 17 native fish species, including eight species that are threatened or endangered. The Native Fish HCP adopts a multi-species aquatic ecosystem approach, spanning all watersheds within the project area. All of Plum Creek's land management activities, including timber harvesting, road building, and land sales are governed by the plan. The HCP will help minimize impacts to water quality in watersheds where Plum Creek Timber is a major landowner.

While managed forest lands may continue to provide a source of nutrients to Flathead Lake from a legacy of historic management practices, this contribution has likely decreased significantly in the last 10 to 15 years as a result of declining timber harvest levels, implementation of voluntary BMP's, and the SMZ law. This source category will be reevaluated in context with all other potential significant sources as described in Section 5.3.

TABLE B-1. Comparison of Audit Results 1990-2000 (statewide results)

	2000	1998	1996	1994	1992	1990
Application of practices that meet or exceed BMP requirements	96%	94%	92%	91%	87%	78%
Application of high risk practices that meet or exceed BMP requirements	92%	84%	81%	79%	72%	53%
Percentage of sites with at least one major departure in BMP application.	9%	17%	27%	37%	43%	61%
Average number of departures in BMP application, per site.	1.4	2	3	3.9	5.6	9
Percentage of practices providing adequate protection.	98%	96%	94%	93%	90%	80%
Percentage of high risk practices providing adequate protection	93%	89%	86%	83%		58%
Percentage of sites having at least major/ temporary or minor/prolonged effectiveness departure.	21%	26%	34%	28%	37%	64%
Average number of effectiveness departures per site.	1	1.5	2.3	3	4.6	8

APPENDIX C
CURRENT FLATHEAD LAKE MONITORING PROGRAM

MONITORING WATER QUALITY IN FLATHEAD LAKE, MONTANA
2000 PROGRESS REPORT

Submitted to:

Montana Department of Environmental Quality
P. O. Box 200901
Helena, MT 59620-0901

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INTRODUCTION

The Flathead Lake Biological Station (FLBS) has monitored water quality in Flathead Lake continuously since 1977. From 1977 to 1982, baseline limnological data were collected as a part of the Flathead River Basin Environmental Impact Study. Thereafter, the lake was monitored with funds obtained through a cooperative agreement between the Flathead Lake Biological Station and a consortium of management agencies. The Flathead Basin Commission (FBC) coordinates the cooperative.

Monitoring results and basic limnological features of Flathead Lake have been reported in biennial technical reports and journal publications (e.g., Ellis and Stanford 1982; Flathead Basin Commission 1989, 1991, 1993, 1995, 1997, 1999; Dodds et al. 1989; Dodds and Priscu 1989, 1990; Perry and Stanford 1982; Spencer and Ellis 1990; Spencer 1991; Spencer et al. 1991; Spencer and Ellis 1998; Stanford et al. 1983; Stanford and Ellis 1988; Stanford et al. 1990). In recent years, the long-term data on nutrient loading and attendant responses in the lake have been supplemented with additional studies that examined cause and effect (Stanford et al. 1994, 1995, 1997).

These studies have been funded by the Environmental Protection Agency (EPA) and are the technical background for development of a Total Maximum Daily Load (TMDL) allocation for the purpose of managing nutrient loads reaching Flathead Lake. Based on these studies, the Flathead Basin Commission TMDL Technical Committee recommended the following interim targets for the protection of water quality in Flathead Lake:

1) no increase in the biomass of lakeshore periphyton,
2) no measurable blooms of *Anabaena flos-aquae* (or other pollution algae),
3) no declining trend in oxygen concentrations in the hypolimnion, and

4) average annual concentrations of the following variables in the photic zone of the midlake deep site in Flathead Lake will not exceed the values indicated:

primary production - 70 gC m^{-2} yr^{-1}

chlorophyll *a* - 1.0 μg/L

soluble reactive phosphorus - <0.5 μg/L

total phosphorus - 5.0 μg/L

total nitrogen - 95 μg/L

ammonium - <5.0 μg/L

nitrate + nitrite - 30 μg/L

After reviewing the recommendations, the Flathead Basin Commission opted not to accept the committee's recommendation of 70 gC m^{-2} yr^{-1} as the primary productivity target for Flathead Lake and increased the interim target to 80 gC m^{-2} yr^{-1}. The FBC also did not adopt the interim targets for soluble reactive phosphorus, total phosphorus, total nitrogen, ammonium and nitrate plus nitrite.

Herein we provide a progress report pertaining to the primary objectives that are crucial to the monitoring of TMDL targets for Flathead Lake. The report summarizes the annual rate of primary production and mean concentrations of the TMDL target parameters (i.e., recommended targets and adopted targets) for the 1999 water year (WY) in comparison to long-term averages for the midlake deep site in Flathead Lake. Nutrient loading to Flathead Lake from the major tributaries and precipitation is also presented for WY 1999. Additional monitoring funds made available by the 1999 Montana State Legislature will allow completion of phytoplankton and zooplankton community analysis as well as the annual loading record for the period during which funds were lacking (i.e., 1996-1998). Those results will be included in the final report due November 2001.

STUDY SITES

Monitoring sites discussed herein include:

- midlake deep (110 m depth) ca. 1 mile west of Yellow Bay Point in a pelagic area of Flathead Lake (site number: FBC05014);
- Flathead Lake at the outlet sill near the Highway 93 bridge in Polson (FBC05021);
- Stoner Creek near Lakeside, a small lakeshore tributary stream (FBC05018);
- Ashley Creek below the Kalispell sewage treatment plant outfall, a small upstream tributary (BSC05023);
- Swan River in Bigfork, a large upstream tributary (FBC06009);
- Stillwater River in Evergreen, a large upstream tributary (FBC04022);
- Flathead River near Holt (Sportsmen Bridge), the primary upstream tributary (FBC05012);
- the bulk precipitation collector located at the Flathead Lake Biological Station on the east shore of the lake (BSC05016);
- "B" Beach, a shoreline periphyton monitoring site located at the Flathead Lake Biological Station on the west side of Cape Montana (TMP00884); and,
- Horseshoe Island, a shoreline periphyton monitoring site with a westerly aspect (TMP 00885).

A description of Flathead Lake and its catchment basin can be found in the following publications: Stanford et al. (1983, 1992, 1994, 1995 and 1997).

METHODS

All tributary sites were sampled 15-17 times during the funding period (i.e., July 1, 1999 – June 30, 2000) and the lake site was sampled 15 times. Additional tributary samples were collected at some sites to examine changes in nutrient concentrations during rain events. Bulk precipitation was sampled after every major precipitation event (29 times).

The sampling protocol for each date was as follows:

-- Midlake sampling:

- discrete samples for chemistries (Table 1) at 5 and 90 m;
- one integrated (0 - 30 m) sample for chemistries (Table 1);
- integrated (0 - 30 m) samples, subsampled for chlorophyll *a*;
- duplicate chlorophyll *a* samples from the depth of maximum fluorescence (as determined *in situ* using a shipboard fluorometer);
- depth profiles: primary productivity, photosynthetically-active radiation, specific conductance, pH, temperature, dissolved oxygen and secchi depth.

-- Lake shoreline sampling:

- ten periphyton samples from 5 m depth analyzed for chlorophyll *a*.

-- Watershed sampling:

- analyses of chemistries (Table 1) in shoreline grab samples or mid-channel collections with Van Dorn water bottle deployed from bridges;
- field metering of specific conductance, pH, dissolved oxygen, and temperature at all sites (lab meters are used for bulk precipitation), and flow calibration of data loggers at Stoner Creek and Ashley Creek; and,
- a continuous record of air and water temperatures, photosynthetically-active radiation, wind speed and direction are obtained with a data logger maintained on Yellow Bay point.

Methods for all of these analyses are referenced in Table 1. Every tenth field sample for chemistries was duplicated to obtain a variance estimate.

Following the discovery in 1992 of declining oxygen in the bottom waters of Big Arm Bay, water column profiles of dissolved oxygen were measured whenever possible (funding not available after 1993) during late summer and early fall. To aid in the monitoring effort, the Confederated Salish and Kootenai Tribes (CSKT) agreed to monitor dissolved oxygen and other physico-chemical variables throughout the water column at the Ross Deep site in Big Arm Bay and to collect the water sample from the Polson outlet site for chemical analysis. Physico-chemical variables were also measured at the Polson outlet.

Long-term monitoring of periphyton biomass in Flathead Lake was initiated in 1999 when additional funds became available. The two sites selected for monitoring were the "B" Beach site on the east shore (located on the lake side of Yellow Bay Point) and a site on Horseshoe Island. Both sites are adjacent to Flathead Lake Biological Station property, assuring no future pollution in the local area. The "B" Beach site is the location of the first periphyton study on Flathead Lake (Bauman 1988); thus, data from 1987 is available for comparison. Methods of periphyton biomass collection and analysis followed those given in Stanford et al. (1997), with the modification of increased replicates (i.e., 10) at a depth of 5 m only.

Loading of nitrogen and phosphorus to Flathead Lake for WY 1999 was determined from measurements of nitrogen and phosphorus forms made by the Biological Station from time-series collections on the major tributaries to the lake (Flathead River at Holt, Swan River at Bigfork, Stoner Creek at Lakeside, Ashley Creek below Kalispell STP, Stillwater River below Whitefish River confluence in Evergreen) and the airshed (bulk precipitation at the Biological Station). Stream discharge data were obtained from the U. S. Geological Survey (USGS), except on Ashley and Stoner Creeks, where flow is monitored by the Biological Station using USGS procedures. Precipitation volume was determined from the National Weather Service (National Oceanic and Atmospheric Administration) Monitoring Station located at the Biological Station.

Methods of calculating loading estimates from nutrient concentrations and discharge or precipitation volume are given in Stanford et al. (1997).

Analytical Quality Control

Precision of the analytical analyses of water samples is determined by ±1 SD of replicated analyses on individual samples, whereas accuracy is determined by 110% > x > 90% recovery of a known addition of standard solution to selected samples. These quality control criteria are tested on approximately 1 out of every 15 samples run in the Freshwater Research Laboratory at the Biological Station. Analytical performance of lab personnel is also evaluated about every 6 months by analyses of quality control samples (unknown concentrations) from Inorganic Ventures IV Lab (NIST traceable). These performance evaluations are on file at the Biological Station. All sample data, laboratory standard curves and quality control information are electronically archived by the FLBS Data Manager in the Biological Station's data storage and retrieval system (FLATDAT).

Physical variables (e.g., temperature, secchi disk depth; Table 1) were determined with electronic meters or other standard limnological gear. Meters were calibrated with ASTM standards prior to each sampling period, and calibration records for all meters and analytical instruments are maintained at the Biological Station.

RESULTS AND DISCUSSION

Mean annual discharge in the Flathead River at Columbia Falls in WY 1999 was similar to that in WY 1998 (i.e., 9,149 versus 8,092 cfs) and similar to the long-term mean (i.e., 9,695 cfs for 1928-present) (U.S. Geological Survey, National Water Information System Files, Helena).

Results of chemical analysis of samples collected from the tributary and bulk precipitation sites during WY 1999 are shown in Table 2. As was observed in WY 1998, total nitrogen (TPN) values for the Stillwater River at Conrad Drive were higher than the long-term mean (i.e., 1977-1992) reported in Stanford et al. (1992). Although the mean TPN in WY 1999 was not as high as that reported for 1998, it was 56 µg/L higher than the long-term mean. Mean TPN for WY 1999 was 349 µg/L compared to 293 µg/L for the 1977-1992 period of record. In addition, a comparison of nitrate nitrogen (NO_3-N) data from 1977-1992 to nitrate plus nitrite ($NO_{2/3}$-N) data from WY 1999 indicated higher levels of inorganic nitrogen in the Stillwater River during the last sampling period; the mean $NO_{2/3}$-N for WY 1999 was 251 µg/L compared to a mean of 164 µg/L NO_3-N for the 1977-1992 period. Although NO_2-N data were not reported for the Stillwater River for the 1977-1992 period, additional data indicated that >98% of the nitrogen in $NO_{2/3}$-N was in the form of NO_3-N. The mean concentration of $NO_{2/3}$-N was also higher in the mainstem Flathead River at Holt for WY 1999 than for the 1977-1992 period (i.e., 81 µg/L $NO_{2/3}$-N compared to 69 µg/L NO_3-N, respectively).

Mean total phosphorus (TP) and soluble reactive phosphorus (SRP) concentrations in the Stillwater River were much lower for WY 1999 than for the 1977-1992 period. Mean TP in WY 1999 was 15 µg/L compared to 25 µg/L for the long-term mean, while mean SRP for 1999 was 1.4 µg/L compared to the long-term mean of 8.9 µg/L. The mean 1999 TP concentration in the Flathead River at Holt was also lower than the long-term mean (i.e., 14 versus 23 µg/L, respectively).

Mean and maximum concentrations for all nutrients in Ashley Creek exceeded values observed in all the other tributaries (see Table 2). Although nutrient concentrations in Ashley Creek were lower than the long-term means reported by Stanford et al. (1992), the long-term average for Ashley Creek included very high values associated with discharges from the Kalispell Sewage Treatment Plant before it was upgraded to tertiary treatment. However, $NO_{2/3}$-N concentrations in WY 1999 were not much lower than the long-term average, suggesting that any reduction in this labile form of nitrogen from the upgrading of the sewage treatment plants was offset by increased transport in the catchment upstream of the plant. In comparison to the 1998 mean, average $NO_{2/3}$-N concentrations in WY 1999 were about 200 μg/L higher (i.e., 753 μg/L in WY 1998 versus 968 μg/L in WY 1999).

In general, mean nutrient concentrations in Stoner Creek and the Swan River were similar to the long-term means reported by Stanford et al. (1992) (see Table 2). Total phosphorus values in Stoner Creek remain quite high compared to other streams in the Flathead Basin (see Stanford et al. 1997). The maximum TP concentration of 80 μg/L recorded during WY 1999 was outside the long-term range for Stoner Creek (i.e., 77 μg/L for 1985-1992 period). Additional work is needed in the Stoner Creek catchment to determine the source of relatively high phosphorus and total nitrogen concentrations. In addition to the primary tributary sites, approximately 43 streams (perennial and intermittent) flow directly into Flathead Lake and little is known about the transport of nutrients from these sites. Although the flow is small in comparison to the major tributaries that are regularly monitored, localized impacts may occur, particularly in areas of reduced circulation.

Total phosphorus and $NO_{2/3}$-N concentrations in bulk precipitation samples were similar to concentrations from previous years, but SRP, TPN and NH_4-N concentrations were considerably higher during WY 1999 (see Stanford et al. 1992; Table 2). The mean concentration of TPN for WY 1999 was almost twice the mean for the 1982-1992 period (i.e., 2,345 μg/L versus 1,216 μg/L, respectively), while the 1999 mean NH_4-N concentration was more than twice the 1982-1992 mean (i.e., 1,301 μg/L versus 574 μg/L, respectively). Increased concentrations of some nutrient forms during WY 1999 could be due to many factors, such as a change in weather patterns that facilitated air inversions in the Flathead valley, an increase in wildfires and slash burning or more road dust due to a drier summer and/or fall. However, the data will be investigated further by comparisons to State air quality data collected during the same time period in Polson and Kalispell. State air quality data were still unavailable at the time of this report.

Nutrient loads reaching Flathead Lake are primarily controlled by water yield within the watershed (i.e., flows in the Flathead and Swan Rivers). However, precipitation on the lake surface can be a major source of both nitrogen and phosphorus. Preliminary data from WY 1999 indicated that the load of total nitrogen from precipitation was higher than normal and accounted for about 17% of the total annual load (Figure 1). However, the bulk precipitation loading estimates remain preliminary until comparisons to State air quality data can be made. Total nitrate plus nitrite nitrogen loading was relatively high in WY 1999 in comparison to years of similar total discharge at Holt (i.e., 1979, 1986 and 1989; see Figure 2). The annual total phosphorus load, adjusted for bioavailability (see Stanford et al. 1997), was mid-range between the loads observed during high and low water years (Figure 3).

For the TMDL target variables, mean concentrations were determined for the 1999 water year (October 1, 1998 – September 30, 1999) for 0 to 30 m integrated samples collected from the midlake deep site in Flathead Lake (Figure 4). The higher inorganic nitrogen concentrations that were measured in the Stillwater River and the mainstem Flathead River were also mirrored at the midlake deep site in Flathead Lake and the lake outlet site at Polson (Tables 2 and 3; Figure 4). Means for WY 1999 were compared to WY means for the period of record (i.e., integrated samples collected from 1987-1998). The mean $NO_{2/3}$-N for WY 1999 was at the very upper limit of previous annual means (Figure 4). This was not too surprising given the relatively high

$NO_{2/3}$-N loading to Flathead Lake in WY 1999. As was observed in 1997 and 1998, concentrations of $NO_{2/3}$-N as well as TPN were higher than the recommended TMDL targets for midlake deep (Table 4).

Concentrations of SRP and chlorophyll *a* in 0-30 m samples from the midlake deep site were close to the long-term means and the TMDL interim targets (Figure 4; Table 4). The mean concentration of TP was somewhat higher than the 1977-1992 mean and the TMDL interim target, but was well within the range of previously reported means.

In 1998, the annual rate of primary production at the midlake monitoring site was the second highest value ever recorded (i.e., 120 gC m^{-2} yr^{-1}; see Figure 5) and exceeded the TMDL interim target by 40 gC m^{-2} yr^{-1} (Table 4). Mean primary productivity in 1999 was considerably lower than the WY 1998 mean, but was still higher than the TMDL interim target by 28 gC m^{-2} yr^{-1}. Our long-term record of primary productivity in Flathead Lake is a robust indicator of water quality that is strongly influenced by external nutrient loads (Stanford et al. 1997). Experiments strongly support the conclusion that growth of algae in Flathead Lake is controlled by nitrogen and phosphorus supply (Dodds and Priscu 1989, 1990; Spencer and Ellis 1990). However, it is important to remember that under certain conditions, food web changes may also influence primary production by altering the density of organisms that cycle these nutrients within the lake. The annual survey of *Mysis* in 1999 revealed a mean density almost identical to that for 1998; the 1999 mean was 44 organisms/m^2 (unpublished data) compared to 45 organisms/m^2 in 1998. These are some of the higher densities recorded since the major peak in 1986-87. Clearly, alterations in the lake food web will continue as *Mysis* densities fluctuate so dramatically. Experiments have shown that if nutrient levels in Flathead Lake increase, organisms such as *Mysis* will become more important in regulating primary production; but, at current nutrient levels, nitrogen and phosphorus appear to be more important in controlling the algal community in the lake (Spencer and Ellis 1998).

Oxygen in oligotrophic lakes does not vary much from saturation in the epilimnion or hypolimnion (10 $\pm$ 10%) (Horne and Goldman 1994). Thus, one of the TMDL interim targets states that there shall be no declining trend in oxygen concentrations in the hypolimnion of Flathead Lake. Profiles of dissolved oxygen at the midlake deep site during the late summer and fall of 1999 revealed a decline in oxygen concentrations with depth as the period of thermal stratification in the lake continued through early fall. Percent oxygen saturation dropped to 79.5% (9.29 mg/L) near the bottom at midlake deep by 21 October 1999. The lowest oxygen concentration observed at the midlake site was 70.1% in WY 1998. At the time of this report, CSKT physical-chemical profiles of the Ross Deep water column were unavailable. The lowest oxygen concentration measured by FLBS personnel at Ross Deep during WY 1999 was 65% (7.25 mg/L) on 15 September. The largest decline in oxygen ever measured in Flathead Lake was at the Ross Deep site on 16 September 1998 (i.e., % saturation of oxygen decreased from 102.4% at the surface to 50.7% (5.67 mg/L) at the bottom).

The TMDL interim targets recommend no measurable blooms of *Anabaena flos-aquae* (or other pollution algae) at the midlake deep site. Surface algal scum was not visually observed at the midlake deep site during WY 1999, but surface samples collected during the late summer have not been analyzed microscopically. Additional funds will allow complete analysis of the algal community by project end in November 2001.

The TMDL interim targets also state that there shall be no increase in the biomass of lakeshore periphyton. Long-term monitoring of periphyton biomass began in 1999. The mean chlorophyll *a* concentration ($\pm$ 1 standard deviation) at the “B” Beach site was 6.9 $\pm$ 1.3 $\mu g/cm^2$ when measured on August 5th. The mean for the Horseshoe Island site on the same date was 2.2

$\pm$ 0.6 μg/cm^2. Periphyton biomass at the "B" Beach site was significantly higher in August 1999 than in August 1987 (i.e., 6.9 versus 1.2 μg/cm^2, respectively; $p<0.0001$, independent-samples t test). At this early stage of monitoring, with means from 1987 and 1999 only, it is not possible to determine a trend in periphyton biomass. Continued monitoring is needed to assess natural interannual variation.

The significantly higher periphyton biomass at "B" Beach than at Horseshoe Island in 1999 suggests that access to nutrients was greater at the "B" Beach site than the Horseshoe Island site. Both sites have very similar aspects; thus, the insolation to both shorelines should be quite similar. The prospect of regionally higher nutrient concentrations in the "B" Beach area is worthy of additional investigation. One possibility is that upwelling currents on the east shore bring higher nutrient concentrations from the hypolimnion to the upper waters during the growing season. It is also possible that groundwaters, which are typically higher in nutrients, are influent in the area of the "B" Beach. Increased nutrient pollution in the east shore area is also a potential concern. Additional sampling of nutrients and other physico-chemical parameters will be proposed at both sites during the 2001 growing season to provide more insight into the observed differences.

During the 1999 water year, the Flathead Lake Biological Station was able to assess all interim TMDL targets established for the protection of water quality in Flathead Lake, except the periphyton biomass and algal bloom targets. Analysis of surface samples for any evidence of algal blooms will be completed by project end (November 2001). Long-term periphyton biomass monitoring just began and data must be collected over many years before any determination of trends can be made. The mean chlorophyll *a* concentration in WY 1999 was right on the target value, but the dissolved oxygen target was not met (i.e., a decline in oxygen was observed) and primary production at midlake deep exceeded the target value by 35%. Three of the targets that were recommended by the FBC TMDL Technical Committee also were exceeded (i.e., TPN, $NO_{2/3}$-N and TP), but only the $NO_{2/3}$-N mean was substantially higher than the target (i.e., exceeded target by 43%).

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Table 1. Biophysical variables, methods and sites used in monitoring water quality in Flathead Lake. Abbreviations are as follows: MLD, midlake deep site 2 km west of Yellow Bay Point; TRIBS, all river and creek sites; H&P TRIBS, Flathead River at Holt and Polson only; PREC, bulk precipitation collected on the weather tower on Yellow Bay Point.

Variable (units)	Method (references)	Detection limit	Sites
Analyses of water samples			
phosphorus (µg/L-P)			
total (TP)	persulfate digestion; modified automated ascorbic acid (1)	0.4	MLD, TRIBS, PREC
soluble total (SP)	filtration; persulfate dig.; mod. auto. ascorbic acid (1)	0.4	MLD, TRIBS
soluble reactive (SRP)	filt.; mod. auto. ascorbic acid (1)	0.4	MLD, TRIBS, PREC
nitrogen (µg/L-N)			
total persulfate (TPN)	persulfate digestion (2); auto. cadmium reduction (1)	20.0	MLD, TRIBS, PREC
nitrite + nitrate ($NO_{2/3}$-N)	auto. cadmium reduction (1)	0.6	MLD, TRIBS, PREC
ammonium (NH_4-N)	auto. phenate (1)	5.0	MLD, TRIBS, PREC
sulfate (mg/L-$S0_4$)	ion chromotography (1)	0.05	PREC
dissolved silica (mg/L-SiO_2)	auto. molybdate-reactive silica (1)	0.2	MLD
carbon (mg/L-C)			
non-dissolved (NDOC) and dissolved organic (DOC)	persulfate dig.; infrared CO_2 detection (3)	0.03	MLD, H&P TRIBS
dissolved inorganic (DIC)	acid liberation; infrared CO_2 detection	0.03	MLD, H&P TRIBS
carbonate alkalinity (mg/L-$CaCO_3$) (Alk)	titration (1)	0.5	MLD
turbidity (NTU) (Turb)	nephelometry (1)	0.10	MLD, H&P TRIBS
total suspended solids (mg/L) (TSS)*	filt.; gravimetric (1)	0.5	MLD, TRIBS
Biological analyses			
chlorophyll *a* (mg/m^3) (Chl *a*)	acetone extraction (1,4)	1.00	MLD
relative fluorescence (units)	continuous flow *in situ* fluorometry (5)	0.05	MLD
photosynthetically active radiation (µEinsteins/m^2/sec)	submarine/deck quantum meter (6)	0.01	MLD
phytoplankton primary productivity	^{14}C uptake in light and dark bottles; acid-bubbling technique (7)		MLD

Table 1 (continued).

Variable (units)	Method (references)	Detection limit	Sites
Physical profiles			
temperature (°C)	thermistor (9)	0.15	MLD, TRIBS
dissolved oxygen (ppm)	electrode (9)	0.20	MLD, TRIBS
pH (units)	electrode (9)	0.1	MLD,TRIBS, PREC
conductivity (µmhos/cm)	electrode (9)	1.5	MLD, TRIBS
secchi depth (m)	secchi disk (8)	0.25	MLD

[1]APHA, 1985

[2]D'Elia *et al.*, 1977

[3]Menzel and Vaccaro, 1964

[4]Marker *et al.*, 1980

[5]Turner Designs, 1981

[6]Licor 188 integrating quantum meter

[7]Theodorssen and Bjarnason, 1975; Wetzel and Likens, 1991

[8] Wetzel and Likens, 1991

[9]measured *in situ* using Hydrolab Surveyor III and SeaBird CTD systems

*TSS run when turbidity exceeds 0.3 NTU

Table 2. Mean, minimum and maximum values for chemical analysis of grab water samples at five tributary sites and the outlet site for Flathead Lake for the 1999 water year (i.e., October 1, 1998 to September 30, 1999). Results from the analysis of bulk precipitation samples collected at the Flathead Lake Biological Station point for the same period are also presented. See Table 1 for a description of variable abbreviations.

site		pH	*Cl	*SiO_2	*SO_4	*DIC	DOC	*NDOC	*TURB	**TSS
		units	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(NTU)	(mg/l)
Ashley Creek below	mean						7.36			
Kalispell STP	min			0.2	11.65	22.7	3.89		2.0	2.8
	max			4.6	12.50	27.1	9.39		4.5	38.9
Flathead River	mean					18.7	1.87	0.27	9.8	
at Holt	min			4.0	3.17	12.0	1.13	0.16	1.4	1.9
	max			4.1	3.23	25.0	3.65	1.32	73.7	101.2
Stillwater River at	mean						2.61			
Conrad Drive	min			7.9	2.27	18.8	1.40	0.27	3.2	2.6
	max			8.3	2.89	21.5	4.48	0.47	4.8	45.3
Stoner Creek at	mean						3.18			
Flathead Lake	min			13.3	2.40	24.3	1.54	0.16	1.0	0.5
	max			14.4	2.70	27.7	5.68	0.49	2.0	77.5
Swan River at	mean						1.83			
Bigfork	min			5.6	1.19	13.2	1.13	0.24	1.2	<0.5
	max			5.9	1.31	15.6	3.02	0.26	1.3	1.9
Bulk Precipitation at	mean	5.7	0.28		0.89					
Yellow Bay point	min	4.6	<0.04		0.10					
	max	6.7	1.20		4.82					
Flathead Lake	mean					18.4	1.64	0.24	1.1	
outlet at Polson	min			4.4	2.89	15.0	1.43	0.14	0.7	0.6
	max			4.7	2.99	22.2	1.84	0.36	2.3	1.3

Table 2. (continued)

site		TPN (μg/l)	*NH_4-N (μg/l)	$NO_{2/3}$-N (μg/l)	TP (μg/l)	SP (μg/l)	SRP (μg/l)
Ashley Creek below	mean	1428	34	968	47.9	24.0	7.0
Kalispell STP	min	771	6	249	24.0	12.7	1.3
	max	2263	126	1689	97.0	36.3	17.1
Flathead River	mean	138	8	81	13.5	3.8	1.5
at Holt	min	83	5	30	5.6	2.4	0.5
	max	314	14	177	88.3	7.1	11.0
Stillwater River at	mean	349	19	251	14.9	5.6	1.4
Conrad Drive	min	148	<5	35	8.2	4.4	0.9
	max	569	57	461	41.9	7.4	2.6
Stoner Creek at	mean	130	5	25	20.0	13.2	5.4
Flathead Lake	min	72	<5	<0.6	12.8	10.6	3.0
	max	368	6	115	80.4	18.4	10.6
Swan River at	mean	104	6	29	6.1	3.5	1.0
Bigfork	min	71	<5	5	4.1	2.4	0.6
	max	178	13	70	8.7	4.9	1.5
Bulk Precipitation at	mean	2345	1301	290	197		147
Yellow Bay point	min	164	85	74	2.1		<0.4
	max	9622	5077	558	1979		1560
Flathead Lake	mean	103	5	26	6.1	3.3	0.9
outlet at Polson	min	80	<5	<0.6	4.1	1.8	0.5
	max	143	10	61	8.4	4.8	1.9

* Due to lack of funding prior to July 1, 1999, range represents July - September period only,
except when means are given (e.g., Holt and Polson sites).
** Analysis only run during spring runoff (i.e., March through June).

Table 3. Mean, minimum and maximum values for chemical analysis of integrated (0-30 m) and
discrete grab (5 m and 90 m) samples collected during the 1999 water year (i.e., October 1, 1998
to September 30, 1999) at the midlake deep site (MLD) on Flathead Lake. See Table 1 for description of variable
abbreviations.

site		ALK (mg/l $CaCO_3$)	SiO_2 (mg/l)	*SO_4 (mg/l)	DIC (mg/l)	DOC (mg/l)	NDOC (mg/l)	TURB (NTU)	**TSS (mg/l)
MLD 0-30 m	mean		5.0		17.8	1.75	0.17	1.1	
	min		4.6	2.91	13.6	1.06	0.13	0.4	<0.5
	max		5.4	3.12	23.0	2.96	0.21	2.3	0.7
MLD 5 m	mean	89.9	5.3		18.4	1.78	0.19	0.9	
	min	84.3	4.3	2.81	15.0	1.28	0.13	0.4	<0.5
	max	98.6	6.8	3.05	23.1	2.52	0.26	3.2	1.5
MLD 90 m	mean		5.5		18.5	1.79	0.11	1.2	
	min		5.1	3.03	12.5	1.19	0.08	0.4	<0.5
	max		6.1	3.30	21.9	2.88	0.13	2.4	0.5

site		TPN (mg/l)	NH_4-N (mg/l)	$NO_{2/3}$-N (mg/l)	TP (mg/l)	SP (mg/l)	SRP (mg/l)	CHL *a* (mg/l)
MLD 0-30 m	mean	101	5.1	43.4	5.9	3.5	0.7	0.988
	min	79	<5.0	28.4	4.2	1.8	<0.3	0.634
	max	137	5.6	60.4	12.5	13.6	2.4	1.506
MLD 5 m	mean	95	6.0	35.8	5.3	2.8	0.7	
	min	63	<5.0	1.4	3.9	1.6	<0.3	
	max	143	20.4	64.4	6.8	3.5	1.6	
MLD 90 m	mean	114	5.5	66.9	5.4	3.1	0.7	
	min	78	<5.0	52.5	3.9	1.6	0.3	
	max	147	8.4	90.6	8.6	8.0	1.5	

* Analyses run as additional money became available during the year.
** Analysis only run during the lake plume from spring runoff (i.e., ~April through July).

Table 4. Interim numeric TMDL targets for the midlake deep site (0–30 m integrated water column) in Flathead Lake and mean concentrations of those target variables for the 1997, 1998 and 1999 water years. All nutrient and chlorophyll *a* concentrations are in µg/l and primary productivity is given in gC m^{-2} yr^{-1}. Targets shown in the lower half of the table were recommended by the FBC TMDL Technical Committee but were not accepted by the FBC.

target variable	TMDL target value	WY1997 mean	WY1998 mean	WY1999 mean
chlorophyll *a* (Chl *a*)	1.0	0.7	0.8	1.0
primary productivity	80	101	120	108
no declining trend in oxygen concentrations in the hypolimnion		X	XX	XXX
no increase in the biomass of lakeshore periphyton		*	*	
“B” Beach site				6.9
Horseshoe Island site				2.2
no measurable blooms of *Anabaena flos-aquae* (or other pollution algae)		*	*	**
total nitrogen (TPN)	95	117	100	101
nitrate + nitrite nitrogen ($NO_{2/3}$-N)	30	44	46	43
ammonium nitrogen (NH_4-N)	5.0	6.4	*	5.1
total phosphorus (TP)	5.0	5.4	5.3	5.9
soluble reactive phosphorus (SRP)	0.5	0.6	0.5	0.7

X Decline in DO down to 70.6% at Ross Deep and 77.1% at midlake in 1997.
XX Decline in DO down to 50.7% at Ross Deep and 70.1% at midlake in 1998.
XXX Decline in DO down to 65.0% at Ross Deep and 79.5% at midlake in 1999.
* Funding not available for monitoring.
** Analysis to be completed November 2001.

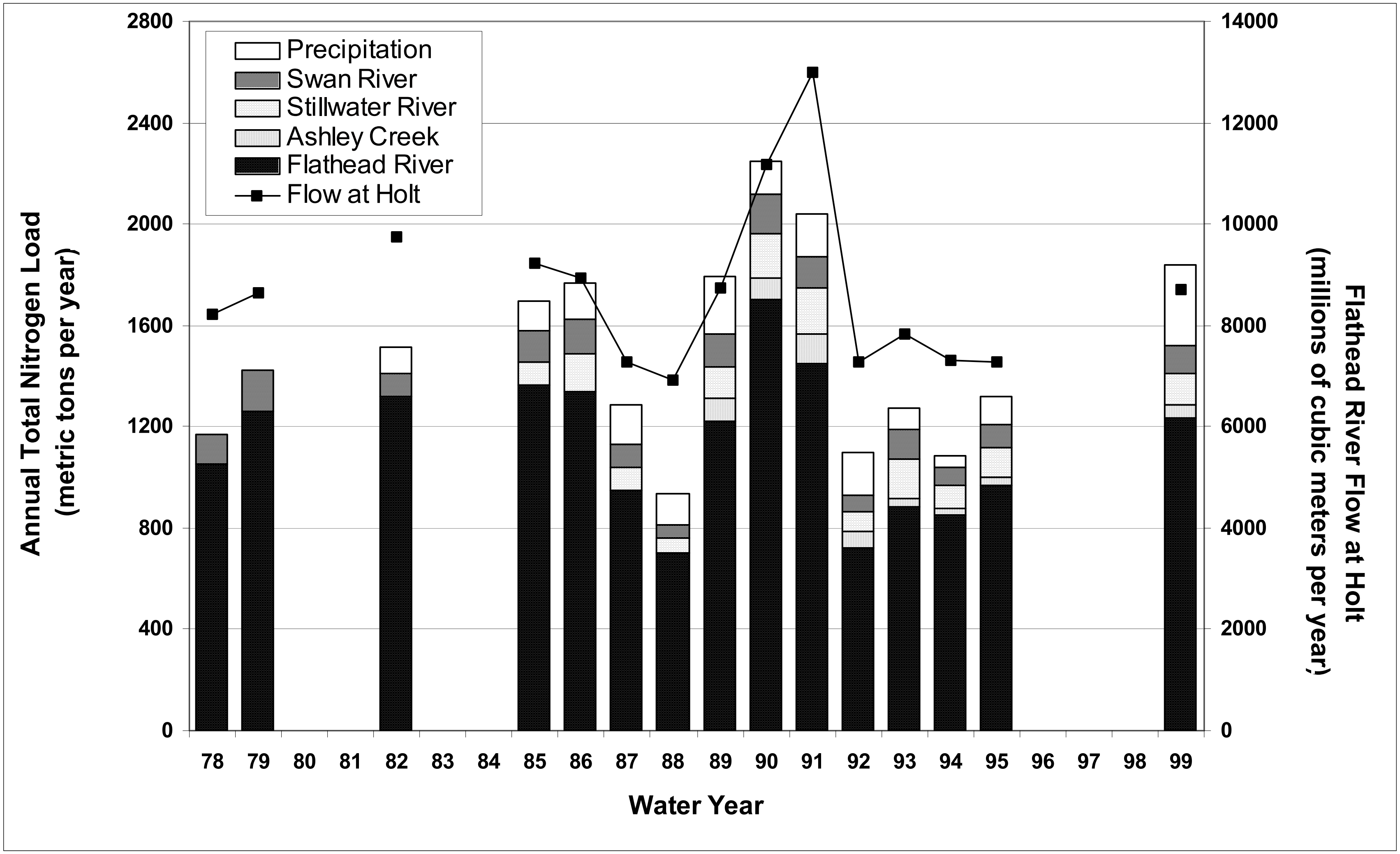

Figure 1. Mass of total nitrogen by source reaching Flathead Lake annually in relation to annual inflow from the Flathead River (closed squares). Precipitation data were not available in 1978-79. Prior to 1985, Ashley and Stillwater River (below confluence with the Whitefish River) are included in the Flathead River. Prior to 1989, Ashley included in Flathead River. Stoner Creek load too small to be visible.

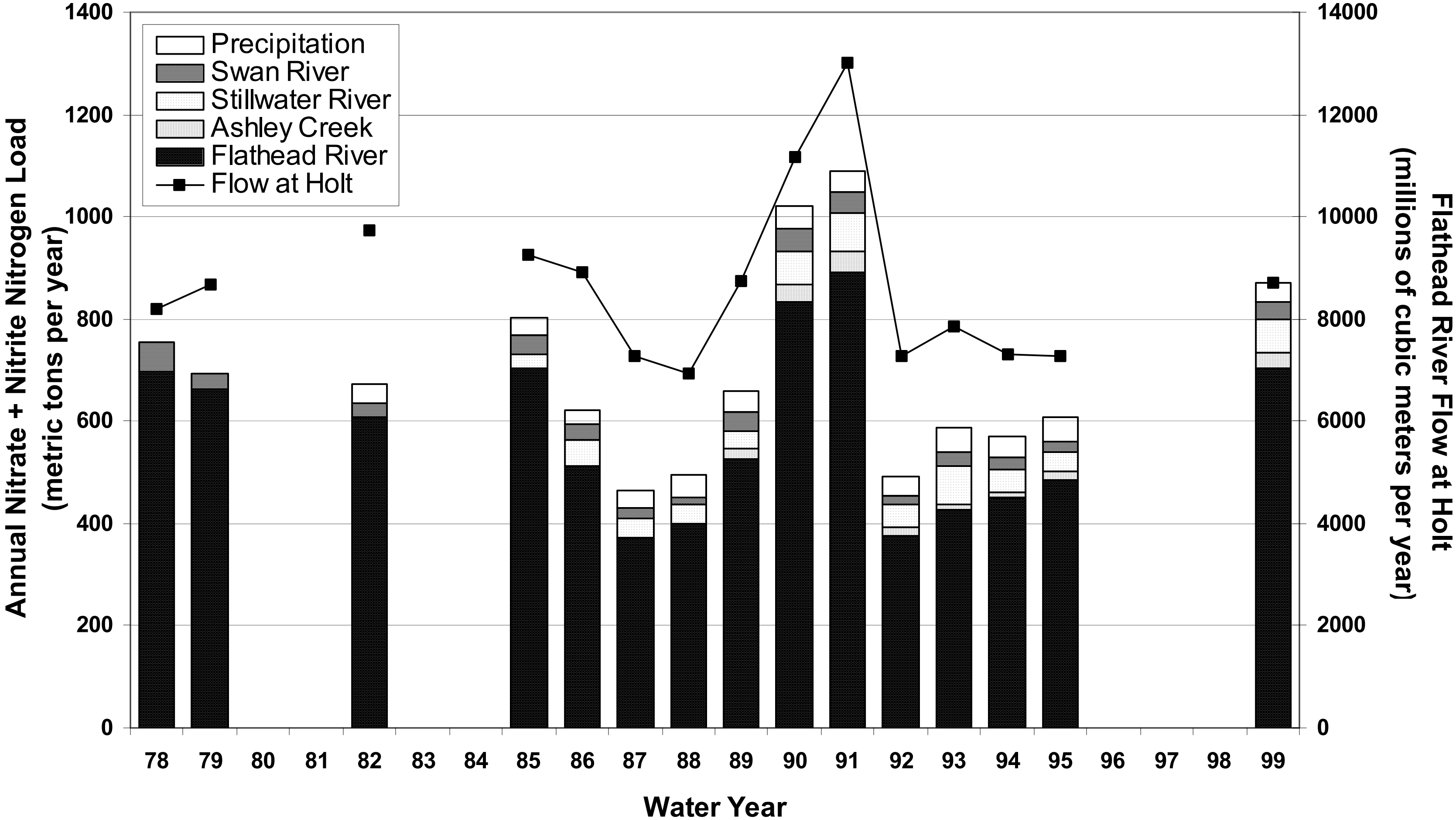

Figure 2. Mass of nitrate plus nitrite nitrogen by source reaching Flathead Lake annually in relation to annual inflow from the Flathead River (closed squares). Precipitation data were not available in 1978-79. Prior to 1985, Ashley and Stillwater River (below confluence with the Whitefish River) are included in the Flathead River. Prior to 1989, Ashley included in Flathead River. Stoner Creek load too small to be visible.

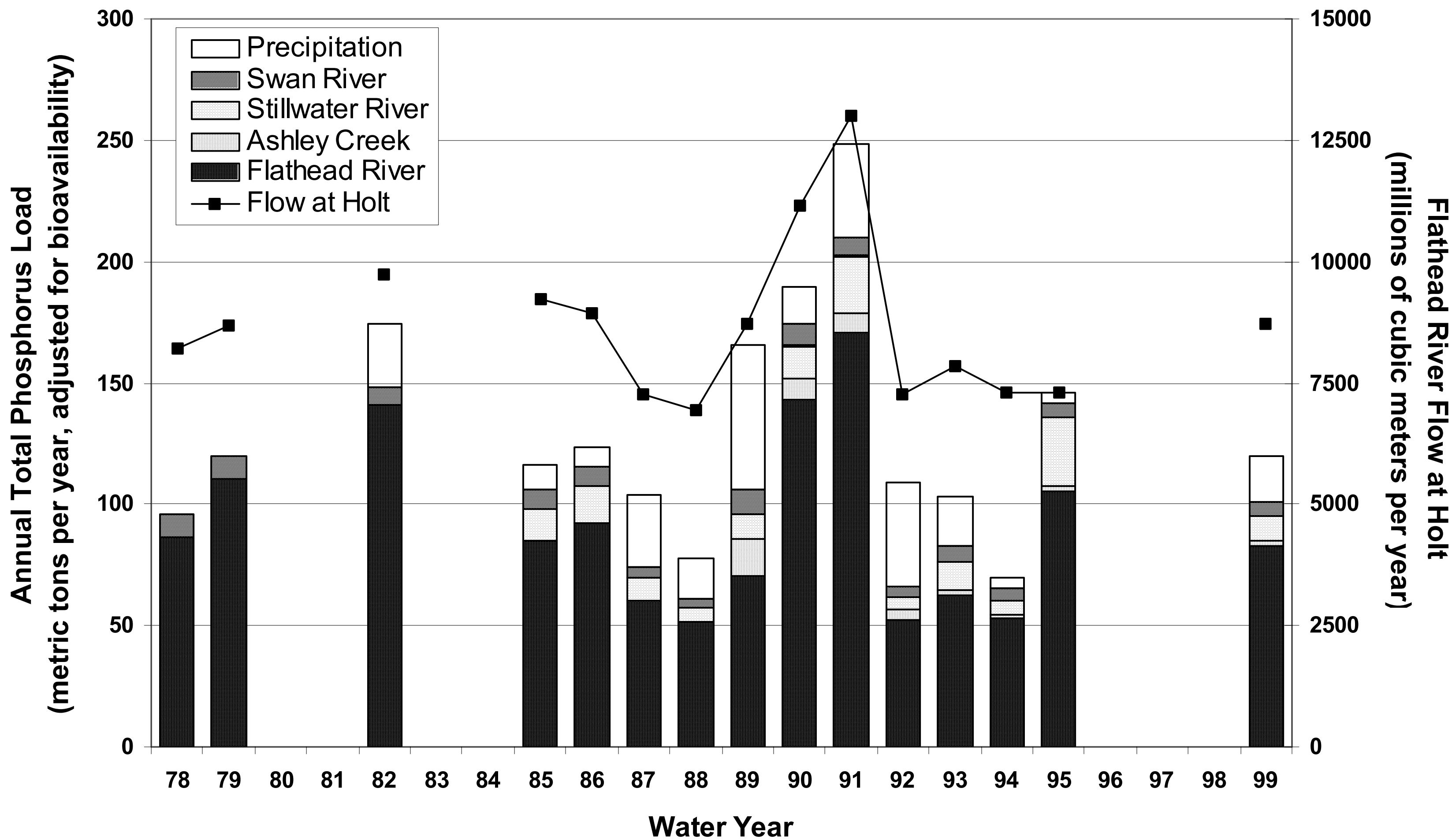

Figure 3. Mass of biologically available phosphorus by source (histograms) reaching Flathead Lake annually in relation to annual inflow from the Flathead River (closed squares). Precipitation data were not available in 1978-79. Prior to 1985, Ashley and Stillwater River (below confluence with the Whitefish River) are included in the Flathead River. Prior to 1989, Ashley included in Flathead River. Stoner Creek load is too small to be visible.

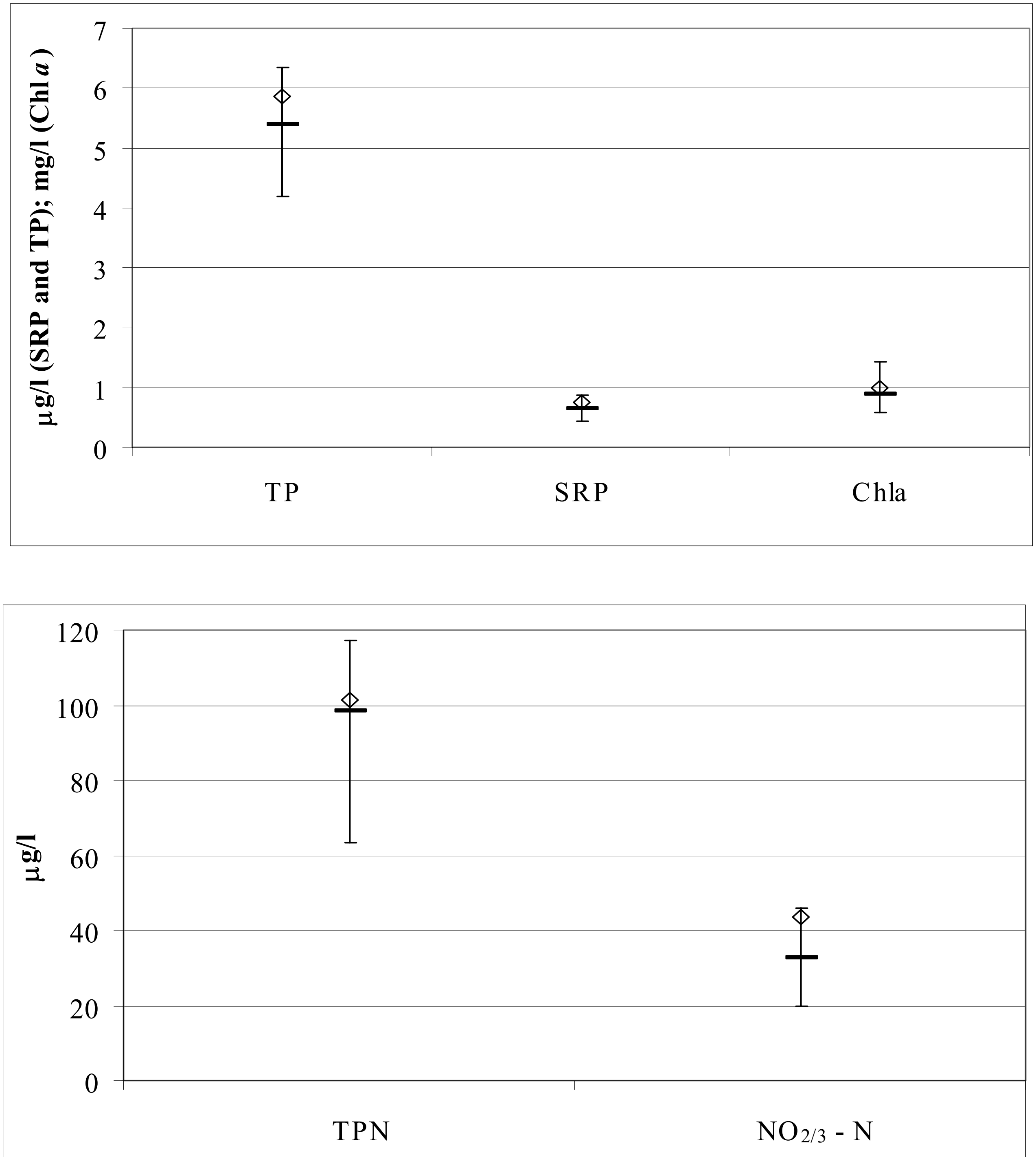

Figure 4. Long-term mean (thick bar) and range of means (thin bars) for nutrient and chlorophyll *a* concentrations of 0-30 m integrated samples collected from 1987 to 1998 at the midlake deep site on Flathead Lake. Means were calculated for each water year (i.e., October 1 - September 30). Mean concentrations for the 1999 water year, October 1, 1998 to September 30, 1999, (diamonds) are also presented for comparison.

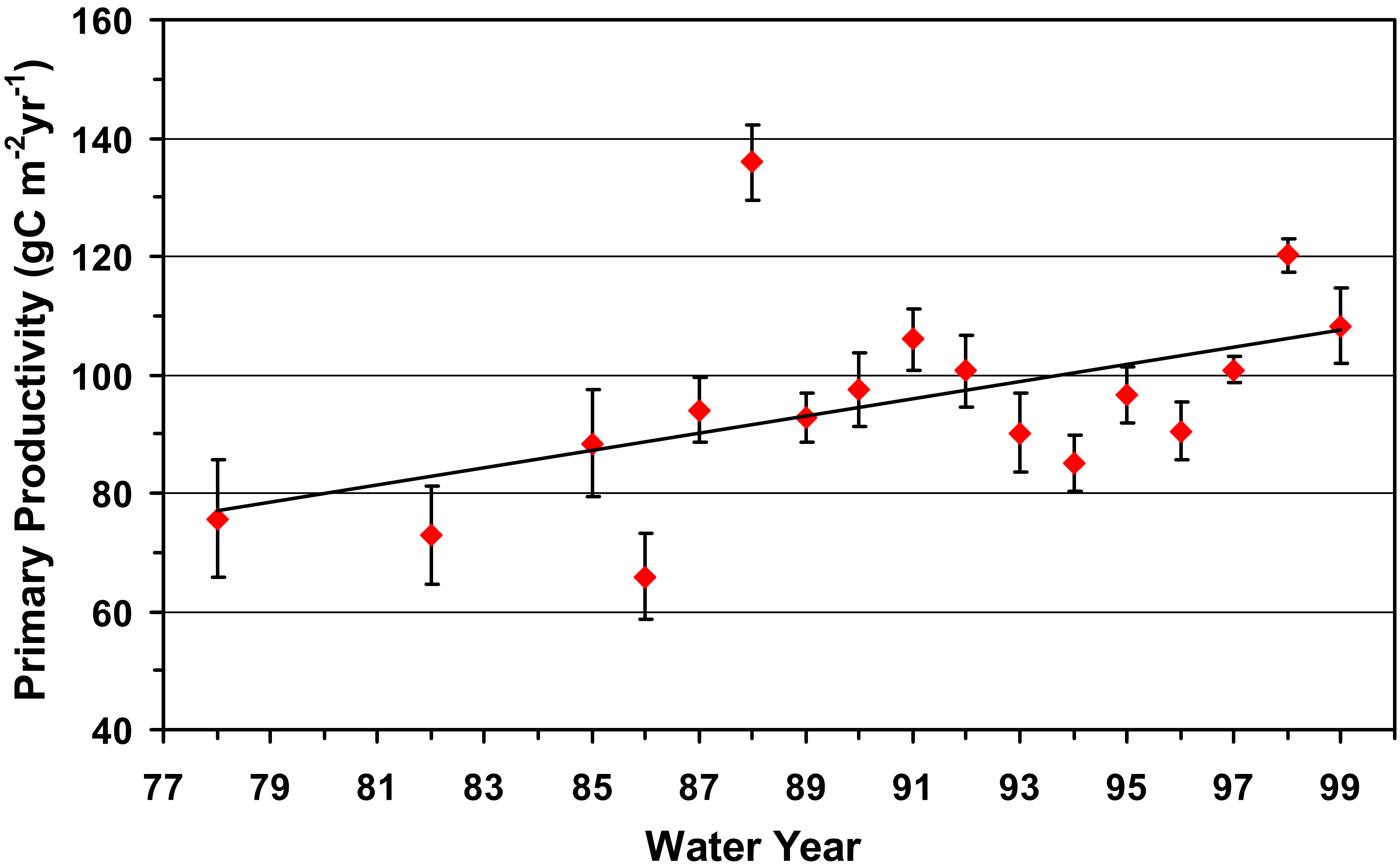

Figure 5. Mean annual pelagic primary productivity (gC m^{-2} yr^{-1}) at the midlake deep site for Flathead Lake from 1978 to 1999. Bars represent minimum and maximum yearly estimates.

Appendix D
DEQ RESPONSES TO WRITTEN PUBLIC COMMENT

DEQ Responses to Written Public Comment

COMMENT: The Executive Summary states the proposed TMDL is a "25% *nitrogen and phosphorus load reduction*."This statement implies that this is a reduction from the existing total load, not simply a *25%* reduction in the "human-caused" component of the total load. At a Flathead Basin Commission meeting this past summer, DEQ stated that the *25%* reduction TMDL is based on just the human-caused portion of the loading and not the total existing load (which would include natural background as well). To be consistent with DEQ's earlier statements, we suggest that the TMDL be changed as follows: "A 25% *reduction in human caused loading of* ***nitrogen and phosphorus."*** If in Department misspoke at the meeting in Kalispell, we suggest that the TMDL document disclose what the actual reduction would be for the human-caused component as well.

> **DEQ RESPONSE**: The TMDL is expressed in Section 5.2.1 as follows: "*A 15 percent reduction in nitrogen and phosphorus loads (i.e., basin wide and from all anthropogenic sources as appropriate), plus a 10 percent load reduction for a margin of safety, is proposed as the TMDL. The TMDL applies to the entire basin and all anthropogenic sources, as appropriate.*"

COMMENT: The last paragraph of Section 1.2 states: *"DEQ is currently in the process of developing statewide nutrient standards."* It is our understanding that these statewide standards already exist for protection of human health. Standards also exist in narrative form for protection of aquatic life in ARM 17.30.637. DEQ should clarify the intent of the statement in Section 1.2.

> **DEQ RESPONSE**: The sentence has been removed from the final draft.

COMMENT: The data fails to establish for the reader a clear and direct cause-effect relationship between increasing levels of nitrogen and phosphorus and algae. While these connections may exist, in fact, the text, and other cited references, repeatedly acknowledges great uncertainty in the critical areas needed to firmly establish this connection. More work is needed to support sweeping recommendations with such profound and far reaching impacts on local communities.

> **DEQ RESPONSE**: The observed water quality impairments in Flathead Lake are described in Section 2.1.2 and the conclusions reached are based on over 20 years of data collected by the Flathead Lake Biological Station. As shown in Figure 2-3, primary productivity (a commonly used lake water quality indicator) has increased since the 1970's. The pollution algae *Anabeana flos-aqua* has bloomed lake-wide during wet years when external nutrient loading is high and hypolimnetic oxygen depletion has been observed during stratification. All these factors point to declining water quality. Based on the available information, the cause of the decline is a combination of in-lake food web dynamics and external nutrient loading.

COMMENT: Page 2-7 "However, especially on wet years when external nutrient loading is high during summer, the pollution alga, *Anabaena fos-aquae,* has bloomed lake-wide." This fact could lead one to conclude that the loadings from the wastewater plants would have little impact on the production of pollution algae since those external loadings remain relatively constant on an annual basis.

> **DEQ RESPONSE**: The relative importance of all of the potential nutrient sources (point, nonpoint, airborne, natural) will be evaluated as described in the Phase II allocation plan (Section 5.3).

COMMENT: Page 3-1 The *"undesirable aquatic life"* that the department has the legal authority to prevent (identified by Dr. Stanford and included in the water quality targets for Flathead Lake) is *Anabaena fos-aquae.* Blooms of these nuisance algae have been associated with wet years with high external nutrient and localized shoreline pollution sources. This again should lead one to the conclusion that it is the departments' obligation and duty to develop strategies that address this problem and not just exercise authority because the court demands it.

> **DEQ RESPONSES**: The TMDL process is the mechanism currently available to the DEQ through which to develop such a strategy. In fact, the intent of the program, and this plan, is to develop strategies to restore water quality.

COMMENT: On page 4-3 it states that the Columbia Falls WWTP discharges to Turnbull Creek. This is incorrect. It discharges to the main stem of the Flathead River.

> **DEQ RESPNSE**: The final document has been revised to reflect this comment.

COMMENT: On page 4-1 of the document there is a statement: The population of the [Bigfork] area remained constant from 1990 to 2000. Big Fork *did* grow between 1990 and 2000.

> **DEQ RESPNSE**: The final document has been revised to reflect this comment.

COMMENT: Page 4-1 A flocculating not *fluctuating* clarifier is used for phosphorus reduction at the Whitefish sewage plant.

> **DEQ RESPNSE**: The final document has been revised to reflect this comment.

COMMENT: Page 4-3 Phosphorus levels are monitored weekly not monthly.

> **DEQ RESPNSE**: The final document has been revised to reflect this comment.

COMMENT: Little mention was given to clear reduction achieved by phosphate ban in detergents and reduction from improved sewage treatment plants. We have already made major improvements, not to say more shouldn't be done!

> **DEQ RESPNSE**: The positive gains at reducing nutrient loads by improved sewage treatment is acknowledged (Figure 4-2) and appreciated. Point sources will be re-evaluated in context with all other sources (nonpoint, airborne, natural) as described in the Phase II allocation plan to ensure that the final load allocation developed in 2006 is equitable and addresses all source categories appropriately.

COMMENT: Figures 4-7 (Phosphorus Load by Source Category), 4-8 (Nitrate/Nitrite Load by Source Category) and 4-9 (Total Nitrogen Load by Source Category) are misleading in their present form because they do not quantify on a per acre basis the nutrient loads between managed and unmanaged forests. The narrative attempts to explain that because forests represent 80% of the land area they account for the greatest nutrient loading, which is understandable. However, from the graph it appears that the unmanaged forests are the greatest polluters to the watershed because there is no acreage loading calculation that shows how much phosphorus, nitrate/nitrite and nitrogen is being generated from managed forests vs. unmanaged forests on a per acre basis. There are substantial scientific studies that conclude unroaded forests provide the greatest protection for water quality, fisheries and wildlife that these graphs appear to contradict.

> **DEQ RESPNSE**: The loading analysis by source category summarized in Figures 4-7 through 4-9 is but one piece of the puzzle that was available at the time this document was prepared. Insufficient data is currently available to clearly define the relative contribution from these two source categories. As described in the Phase II allocation plan (Section 5.3), all sources (including managed and unmanaged forest land) will be further evaluated to determine their relative importance in terms of nutrient delivery to Flathead Lake. Specifically, forested lands will be evaluated: 1) at a smaller scale (sub-watershed scale) in each of the TMDL studies to be completed within the Flathead Basin between

2002 and 2005; 2) through additional synoptic sampling in the Stillwater and Whitefish River Basins; and 3) through use of the proposed basin-scale watershed loading model.

COMMENT: There is also no narrative that explains that unmanaged forest's phosphorus, nitrate/nitrite and nitrogen contributions are a natural baseline "condition". This statement is made for airborne sources on page 4-13 but not for unmanaged forests.

DEQ RESPNSE: The final document has been revised to reflect this comment.

COMMENT: Work by Makepeace and Mladenich, *1996* quantified the contribution of shoreline septic systems to the nutrient loading to Flathead Lake. This information was included in Table *4-2* along with a summary of other loading from other sources. This information attributes between *0.88%* and *1.62%* of the total nitrogen and phosphorus loads to Flathead Lake to point sources while attributing between *2.59%* and *3.86%* of those loads to shoreline septic systems. If you would take this information and look at the entire basin and the hundreds of miles of other lakeshores, rivers and streams with septic systems in close proximity, you could easily conclude that a very significant loading could be attributed to septic systems.

DEQ RESPNSE: As described in the Phase II allocation plan (Section 5.3), all sources (including the load from septic systems) will be further evaluated to determine their relative importance in terms of nutrient delivery to Flathead Lake. Specifically, septic system loads will be evaluated through the groundwater studies and through the use of the proposed basin-scale watershed loading model.

COMMENT: Page 4-7 Your adaptation and conclusions concerning the synoptic studies conducted on the storm water outfalls of the urban areas are baffling. In the text of the study I find statements like ". . . ***storm water runoff from the 4 major urban areas in the Flathead Basin would have accounted for only*** *0.5%* ***and 0.9% of the total load of nitrate+nitrite nitrogen and phosphorus, respectively to Flathead Lake in 1995"*** and ". . . ***the nutrient load from urban storm water appears to be a minor load to Flathead Lake...".*** Contrary to the statements contained in the study, you conclude ***"a disproportionate share of the total phosphorus and nitrate/nitrite loads were produced in the most developed portions of the ... watersheds..."*** It appears that you are misinterpreting or misrepresenting the data analysis and providing your own conclusions to further your own agenda? You cannot base your assumptions on comparisons of unrelated data (base flow compared to storm event) to determine percentage of contribution. To do so you would have to assume that the storm event had no impact on the nutrient load from any other sources.

DEQ RESPONSE: The storm event nutrient loads captured during the synoptic study included runoff from all developed lands within their respective watersheds (see Table 4-4). A disproportionate share of the total load was delivered from the most developed portions of the studied watersheds. The nutrient load from the most developed portions of the studied watersheds certainly included urban stormwater loads, but urban stormwater comprises only one component of total load. The remainder was thought to be attributable to the predominance of developed lands within the lower portions of these watersheds (see Figure 4-4). As described in Section 5-3, additional synoptic sampling will be conducted to better define the relative nutrient contribution from all sources.

COMMENT: Page 4-12 Again your interpretation of the results of the synoptic storm water study, which I might add was based on only one storm event, is contrary to the data analysis provided by the scientists involved in the study. How can anyone looking at the study with an open mind come to the conclusion that you offer. Especially considering the fact that the synoptic study was limited to one storm event. You have demonstrated a serious bias by your misrepresentation of the study data.

DEQ RESPONSE: As described in Section 5-3, additional synoptic sampling will be conducted to better define the relative nutrient contribution from all sources.

COMMENT: Page 4-12 ***"What the loading analysis by source category may have failed to consider is the potential presence of natural nutrient sinks within the tributary watersheds that trap nutrients from the headwaters regions of the watershed well before they ever reach Flathead Lake."*** This statement should be continued to note that the natural nutrient sinks could definitely trap nutrients, but not indefinitely. The literature cites several conditions that can and do exist whereby the normally insoluble forms of nitrogen and phosphorus (those nutrients trapped in sediments) are released into the water column. This fact would alter you assumption that these nutrients remain trapped and never reach Flathead Lake. Your false assumptions should not be used to lend support to your theory that the lower portions of the watershed may be the most important in terms of nutrient delivery to Flathead Lake. You should stick to the conclusions of the scientific community that has studied the Flathead Basin and not interject your own half-baked assumptions into the plan.

> **DEQ RESPONSE**: As described in Section 5-3, additional synoptic sampling will be conducted to better define the relative nutrient contribution from all sources as well as to test the hypothesis that natural nutrient sinks exist within the tributary watersheds.

COMMENT: The Water Quality Targets remain on interesting discussion as well irregardless of the level of information on which they are based. Under Section 5.2.1 P 5-4 it calls for "reducing the current nutrient loads by approximately 16 % " to achieve target loads while the assumption used assumes a 27.27% reduction (110 - 80 = 30; 30 - 110 = 27.27 %), which incidentally does not include the "plus 10 % growth factor" mentioned for nitrogen and phosphorous loads, but most certainly also requires that consideration on the overall productivity figure.

> **DEQ RESPONSE**: The TMDL is expressed in Section 5.2.1 as follows: "*A 15 percent reduction in nitrogen and phosphorus loads (i.e., basin wide and from all anthropogenic sources as appropriate), plus a 10 percent load reduction for a margin of safety, is proposed as the TMDL. The TMDL applies to the entire basin and all anthropogenic sources, as appropriate.*"

COMMENT: Page 4-16 - 4-17 The plan documents the impact of biomass burning. ***"Biomass burning emits hundreds, if not thousands of chemicals into the atmosphere"*** and "This ***study concluded the transfer*** of ***plant nutrients in smoke from wildland burning to be statistically significant. Nutrients lost in smoke particulates from burned sites become nutrient additions in downwind locations.".*** How can you then state that ***"...sources of atmospheric nutrient*** *deposition... are not currently well understood"* What is understood and well documented in the literature is that biomass burning from open burning and wildland fires is a significant source of nutrients. It should be easy to conclude that a strategy to (1) reduce the risk of wildland fires, (2) limit controlled burning on private, state and federal forest lands, except to reduce risk of wildland fires, (3) limit or ban any open burning of biomass fuels including agricultural burns, (4) require use of only efficient residential wood stoves, could all lead to a significant reduction of nutrient loading in the basin. Since data collection began in 1977 on Flathead Lake most, if not all of the spikes in nutrient loading to the lake are directly attributable to wildland fire events here or in Idaho and Washington. What more evidence is needed to assume that burning of biomass is a source of nutrient load that can be mitigated, even on an interim basis?

> **DEQ RESPONSE**: The relative importance of all of the potential nutrient sources (point, nonpoint, airborne, natural) will be evaluated as described in the Phase II allocation plan (Section 5.3). All significant sources will then be evaluated in context with one another to develop the final allocation plan.

COMMENT: There was little mention of the combined effects of forest fires, controlled burns, dust from roads and farmers plowing fields.

> **DEQ RESPONSE**: The relative importance of all of the potential nutrient sources (point, nonpoint, airborne, natural) will be evaluated as described in the Phase II allocation plan (Section 5.3). All

significant sources will then be evaluated in context with one another to develop the final allocation plan.

COMMENT: The strength of the Plan lies in its two-phase structure. The short-term goal it sets for Phase 1, 25% reduction in nutrient loading from the core urban/agricultural area north of the lake and revised point source permit limits, will ensure that some of the most significant contributions to nutrient loading in the Lake will be curtailed in the near future. The adaptive management approach embodied in Phase Ii, which calls for continued monitoring of nutrient sources and adaptation of nutrient load allocations in response to the results of this monitoring, gives reasonable expectation of also reaching the long-term goal set by the Plan: 25% load reduction overall.

DEQ RESPONSE: The two-phased approach remains intact in this final document. However, the evaluation of point source limits has been moved into Phase II such that this source is considered in context with all other potentially significant sources when the final allocation is developed.

COMMENT: On page 5-3 remove "but were not accepted by the Flathead Basin Commission."

DEQ RESPNSE: The final document has been revised to reflect this comment.

COMMENT: Goals can easily be set oblivious to other influences, but when other influences are taken into account those same goals can be found to be inappropriate. To suggest goals without a discussion in how they will be obtained or what programs can or should be implemented, and a potential cost/affect to the taxpayers is not in the public interest. Any restorative strategy must include the "how to accomplish" not simply a "need to accomplish" based on incomplete data.

DEQ RESPNSE: As required by both the Clean Water Act and the Montana Water Quality Act, this plan establishes measurable water quality goals (i.e., water quality restoration targets in Section 5.1), and a means to achieve these goals (i.e., the TMDL presented in Section 5.2). Both the water quality restoration targets and TMDL are based on over 20 years of data collected by the Flathead Lake Biological Station and were established by the FBC's TMDL Technical Advisory Committee. The "how to accomplish" is articulated in the two-phased allocation plan (Section 5.3), the monitoring and adaptive management strategy (Section 6.0), and the restoration strategy (Section 7.0).

COMMENT: By far and away the largest percentage of land mass providing a natural base for nutrient loading is left out of the discussion of target goals. This has as its consequence the elimination of all federal and state lands producing nutrient load being eliminated. It is grossly negligent to eliminate 85% of the public lands in Flathead County from any goal discussion in this regard. This also has as a consequence the ability of the federal government and the State of Montana having not to follow any discourse or assume any liability for nutrient loading in Flathead Lake. This is patently wrong.

DEQ RESPONSE: No sources are being eliminated from consideration. The relative importance of all of the potential nutrient sources (point, nonpoint, airborne, natural) will be evaluated as described in the Phase II allocation plan (Section 5.3). All significant sources will then be evaluated in context with one another to develop the final allocation plan.

COMMENT: There seems to be some confusion with the TMDL target that states there shall be "No declining trend in oxygen levels in the hypolimnion." In reading Appendix B, it appears that Biostation researchers are interpreting this target as being based on evaluation of individual DO profiles rather than a comparison of hypolimnetic DO levels recorded over time (i.e., over a period of years). It is our belief that this target is only meaningful when compared over a period of years. For example, at a given site in Flathead Lake, annual minimum hypolimnetic DO concentrations would be plotted over time and this would be the basis for the trend determination.

DEQ RESPNSE: The final document has been revised to reflect this comment.

COMMENT: Related to [the above] Comment, we believe the Department should compile the historic data on dissolved oxygen levels in the lake, at both the Midlake Deep site and in Big Arm Bay prior to finalization of the TMDL. While the draft document states that oxygen levels have been declining over time, we have not seen data presented in a way that supports these statements. Compiling these historic data will also be essential for future "trend determinations" to evaluate attainment of the targets.

DEQ RESPNSE: Dissolved oxygen trend data will be evaluated in five years at which point in time the DEQ will be required to evaluate the success of this plan.

MULTIPLE SIMILAR COMMENTS REGARDING POINT SOURCE LIMITS: Multiple comments were received suggesting that it was inappropriate to include revised point source limits in the Phase I allocation plan.

DEQ RESPONSE: Revised point source limits have been removed from the Phase I allocation plan. The relative importance of all of the potential nutrient sources (point, nonpoint, airborne, natural) will be evaluated as described in the Phase II allocation plan (Section 5.3). All significant sources will then be evaluated in context with one another to develop the final allocation plan.

COMMENT: The section Forested Land on pages 5-8 through 5-10 appears to rely on Best Management Practices to protect water quality. We believe there needs to be a quantitative measurement of BMPs that actually measures Nitrogen and Phosphorus to evaluate their true effectiveness. To our knowledge, BMPs have been evaluated for their application in the audit reports not their effectiveness in limiting nutrient loading. As an example, a project in the Swan Valley called the Hemlock Access Project would allow Plum Creek to build 8 miles of road in one steep square mile section with 18 stream crossings. This road construction is expected to increase sediment by 1,000% in Windfall Creek with the application of "enhanced" BMPs. This road construction is also expected to eliminate any cutthroat trout population in the stream. Obviously the application of BMPs in this case does not protect the beneficial uses of this stream.

DEQ RESPONSE: As described in the Phase II allocation plan (Section 5.3), all sources (including managed and unmanaged forest land) will be further evaluated to determine their relative importance in terms of nutrient delivery to Flathead Lake. Specifically, forested lands will be evaluated: 1) at a smaller scale (sub-watershed scale) in each of the TMDL studies to be completed within the Flathead Basin between 2002 and 2005; 2) through additional synoptic sampling in the Stillwater and Whitefish River Basins; and 3) through use of the proposed basin-scale watershed loading model.

COMMENT: We fully support the additional monitoring proposed on page 6-2 but would like to see the funds allocated to make sure this monitoring is done. The Master Monitoring Plan for the Flathead Basin has never been fully implemented due to funding constraints and we are concerned that without an allocation of funds to actually conduct this monitoring it will also languish. Monitoring these additional sites is critical to fully implementing the TMDL so funding sources should be identified.

DEQ RESPONSE: Much of the additional monitoring and assessment work recommended in this plan is already funded and ongoing, or funding sources have been identified (see Section 5.3.2).

COMMENT: We have concerns about monitoring of the TMDL target that states there shall be "No measurable blooms of *Anabaena fos-aquae* or other pollution algae." It is unclear to us how this TMDL target will be "measured" based on our review of the document and the monitoring report in Appendix B. *Anabaena fos-agttae* have been noted as a component of the Flathead Lake algal biomass dating back to the early 1900's (see review in Stanford et al. 1997). The final document should clarify how this target will be measured for compliance determination.

DEQ RESPONSE: The target "No measurable blooms of *Anabaena fos-aquae* or other pollution algae" is but one of a suite of targets that will be evaluated collectively in an effort to observe long-term water quality trends in Flathead Lake.

COMMENT: We are pleased to see that the draft TMDL recognizes the significant progress made by the timber industry in implementing forestry Best Management Practices (BMPs) over the past decade. Audits conducted biannually by the Montana DNRC since 1990 clearly demonstrate that logging activities conducted in compliance with modern forestry BMPs (including retention of Streamside Management Zones) have a negligible effect on water quality. Additionally, when old roads constructed prior to the advent of BMPs are re-used, forest landowners commonly upgrade these roads to meet current standards, thereby resulting in net improvements to water quality. As Plum Creek implements it's Native Fish Habitat Conservation Plan (NFHCP), these sorts of road improvements will continue until all old roads are either upgraded or reclaimed. While the draft TMDL did not propose a specific allocation for forestry activities at this time, Plum Creek is committed to conducting our activities in ways that minimize impacts on water quality. To the extent that historic forestry activities are contributing to current water quality degradation in the basin, we support the Departments decision that they are better addressed during restoration planning for headwater basins (e.g., Swan, North Fork Flathead, etc.). This will allow for a much more appropriate scale of analysis.

DEQ RESPONSE: Acknowledged.

COMMENT: Page 5-11 At the time of the synoptic studies of storm water outfalls the City of Whitefish had already begun a program of BMP's to deal with nonpoint sources of runoff. Within our City limits we have 25 specific drainage basins with storm water collection systems. Of those, 19 are now equipped with properly designed treatment facilities. Of the six uncontrolled discharge points two belong to the MDOT. Of the four remaining outfalls only one has a drainage area that exceeds 9,000 square feet. Once again we can demonstrate that we as stakeholders have stepped up to the plate and made significant improvements to help mitigate nutrient loadings. I'm confident that the other municipalities have similar efforts to report. The information contained in the synoptic studies and your assumptions based on that data does not take into consideration improvements installed since that time. All of the outfalls studied in Whitefish in 1995 and 1996 have been upgraded to include combination wet detention basin and infiltration basin treatment technologies.

DEQ RESPONSE: Acknowledged.

COMMENT: If you truly want to make a positive impact on the quality of Flathead Lake, impose an interim moratorium on septic systems within one thousand feet of any body of water or watercourse. You could then refine the limits on location and design of the systems to a point that they would not significantly increase the nutrient load to the basin. Limitation of septic system installation could easily be implemented on an interim basis and achieve significant results.

DEQ RESPONSE: As described in the Phase II allocation plan (Section 5.3), all sources (including the load from septic systems) will be further evaluated to determine their relative importance in terms of nutrient delivery to Flathead Lake. Specifically, septic system loads will be evaluated through the groundwater studies and through the use of the proposed basin-scale watershed loading model.

COMMENT: The short comment period leaves us unable to prepare a thorough and complete set of comments and as a result we request that the comment period be extended to allow for a more comprehensive review.

DEQ RESPONSE: The public involvement process is described in Section 8.0 of this document. There are no state regulatory or statutory requirements for public comment regarding TMDL documents. In addition to the 30 day public comment period, several meetings were held to provide the public with opportunity to discuss the document, including: two public informational meetings hosted by the DEQ and FBC; two FBC meetings (both open to the public); and a meeting with the wastewater treatment plant operators to discuss point source limits. Further, although the official public comment period was only 30 days, most of the technical elements of this document were developed over a period of several years in concert with the FBC and their TMDL Technical Advisory Committee. The targets and TMDL were originally adopted by the FBC in 1998. The FBC includes representatives from a variety of stakeholder/interest groups including the forest industry, agriculture, environmental concerns, and local, state, tribal and federal land management agencies. Given that the development of the document included a process involving a broad array of stakeholder representatives and the fact that the 30 public comment period solicited numerous comments covering virtually every chapter of the document, it is felt that an adequate level of public involvement was achieved.