Little Bitterroot Lake
Water Quality Monitoring Program
2014 Annual Report

Little Bitterroot Lake

Marion, MT

June 2015

Prepared For:
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Glossary of Terms

Benthic – the bottom region of a lake including the sediment surface

Bloom – a significant increase in algae population triggered by favorable conditions for growth

Chlorophyll-*a* – a green pigment found in photosynthetic plants and algae

Depth profile – a chart showing a water chemistry parameter at various depths within a lake

Epilimnion – the uppermost portion of a stratified lake

Eutrophic – having high biological productivity (meso-eutrophic is moderately high), high productivity is commonly an indicator of high nutrients and poor water quality

Hypolimnion – the bottom layer of a stratified lake

Mesotrophic – having moderate biological productivity

Metalimnion – the middle (transitional) layer of a stratified lake

Oligotrophic – having low biological productivity (meso-oligotrophic is moderately low), low productivity is an indicator of low nutrient concentrations and good water quality

Trophic – relating to available nutrients (ex. trophic status)

Trophic status – a lake's ability to produce and sustain populations of algae in response to available nutrients, also referred to as lake productivity or biological productivity

List of Acronyms

CFS – cubic feet per second
DEQ –Montana Department of Environmental Quality
DO – dissolved oxygen
FLBS – Flathead Lake Biological Station
GPM – gallons per minute
LBLA – Little Bitterroot Lake Association
SAP – sampling and analysis plan
SC – specific conductance
TN – total nitrogen
TP – total phosphorus
TSI – trophic state index
WET – Water & Environmental Technologies
WLI – Whitefish Lake Institute

Executive Summary

Little Bitterroot Lake was sampled on August 11, 2014, which was the 15th sampling event since 1999. Six lake locations were sampled for field parameters, nutrients, and chlorophyll-a, and 2 stream sites were sampled for field parameters and nutrients. Depth profiles were recorded at the lake center on August 11 and November 5, 2014, by Whitefish Lake Institute.

Water quality was very good in Little Bitterroot Lake in 2014. Average total nitrogen was the 4th lowest on record, and average total phosphorus was the lowest on record. Nitrogen concentrations were highest in Herrig Creek Bay, and phosphorus concentrations were highest in Slaughter House Bay, although little variation occurs around the lake. Little Bitterroot Lake continues to be phosphorus limited, meaning that algae blooms are most likely to occur with additional inputs of phosphorus.

Near surface lake temperatures in August were around 22°C (72°F), which was the highest average since sampling began in 1999. Homeowners noted increased algae on rocks (benthic) near the shoreline in 2014, which may have been a result of high lake temperatures. One benthic algae sample was collected in 2014, but chlorophyll-a concentrations were quite low and likely did not represent the peak concentration. Additional sampling for benthic algae is planned for 2015 to collect baseline data and monitor changes in algae concentration.

The lake was thermally stratified in August 2014, with an epilimnion from 0 to 21 feet, a metalimnion from 21 to 100 feet, and a hypolimnion below 100 feet, which is typical for mid-summer in Little Bitterroot Lake. Chlorophyll-a in the water column peaked at a depth of approximately 70 feet, and dissolved oxygen peaked at approximately 40 to 60 feet. Algae concentrations in the water column did not reach nuisance levels, and were comparable to data from previous sample years.

The trophic state index for Little Bitterroot Lake was oligotrophic based on concentrations of chlorophyll-a and phosphorus, meaning the lake has low primary productivity and good water quality. Total nitrogen concentrations indicate the lake has potential to be eutrophic, but the lake is phosphorus limited and the low concentrations of available phosphorus help prevent nuisance algae blooms.

Some concerns of homeowners around Little Bitterroot Lake include high or fluctuating water levels, increased algae on shoreline rocks, effects of fire ash, and disturbance from vegetation removal. High water levels have the potential to introduce lake water to nutrient sources, such as lawn fertilizer, shoreline sediment, and septic systems. Fluctuating water levels can also increase erosion and introduce nutrients and sediment. Fire ash is likely to have little direct effect on lake water quality; however, fires in the watershed have the potential to increase runoff and contribute nutrients and sediment to the lake, especially in years immediately after fire. Furthermore, any disturbance which introduces sediment or vegetative debris into the water has the potential to increase nutrient concentrations and promote algae growth. Efforts should be made to reduce potential sources of nutrients, such as limiting application of fertilizer to lawns, maintaining septic systems, keeping a buffer area around the lake, and reducing shoreline erosion. Because Little Bitterroot Lake is phosphorus limited, fertilizers with little or no phosphorus are recommended to help maintain good water quality. This can be accomplished by selecting fertilizers with a zero as the middle value (i.e. 16-0-0).

Water quality monitoring will continue in 2015 with the support of a grant from Montana DEQ. Sampling in 2015 will include the traditional field and nutrient parameters, but additional samples will be collected for benthic algae from shoreline rocks.

1.0 Introduction

Little Bitterroot Lake is the headwaters for the Little Bitterroot River located southwest of Kalispell near the community of Marion at an elevation of approximately 3900 feet (**Attachment A**, **Figure 1**). The lake has a maximum depth of 260 feet, a surface area of approximately 4.6 square miles (2,950 acres) and a drainage area of 34.4 square miles (22,000 acres). The area exists within the Salish Mountains Ecoregion with a humid continental climate (Köppen classification Dfb) and an average annual precipitation of 21 inches. The geology of the watershed is primarily sedimentary rocks of the Belt series. The lake outlet is controlled by an earthen dam built in 1918, and is managed by the Flathead Irrigation Project for downstream irrigators. Herrig Creek is the only perennial stream flowing into the lake, although seven intermittent or ephemeral streams contribute seasonally. Groundwater contributes a substantial portion of water to the lake, especially from the Salish Mountains to the west and northeast. Local uses of the lake include water supply for domestic use, irrigation, fishing and recreation.

The Little Bitterroot Lake Association (LBLA) began in 1988 with the purpose of "preserving the high recreational value of Little Bitterroot Lake, maintaining its aesthetic integrity, and to educate the public and others as to the value of Little Bitterroot Lake as a recreational resource." Water quality monitoring has been conducted on the lake since 1999. The purpose of the monitoring program is to establish a water quality and nutrient baseline for the inflow, outflow, and lake water in conjunction with prior water quality projects. Information from this monitoring program may be used to make management decisions to help maintain the aesthetic and recreational conditions of the lake and surrounding drainages, and to help prioritize future monitoring efforts.

This report outlines the history of the monitoring program and presents water quality results from 2014 and past monitoring events. Long term trends in nutrient concentrations and trophic status are provided for locations that have been sampled consistently since 1999.

2.0 Monitoring Program History

Water & Environmental Technologies (WET) have conducted 15 sampling events on Little Bitterroot Lake since 1999 with assistance from the Little Bitterroot Lake Association. Data collected during sampling helps document existing water quality, track changes in nutrient concentrations over time, and to characterize the lake's productivity and trophic status. Additional data have been collected by the Flathead Lake Biological Station, Flathead Basin Commission, Flathead High School, Montana DEQ, University of Montana, and Whitefish Lake Institute. Laboratory analyses in 2014 were funded by a grant from the Volunteer Monitoring Support Program administered by Montana DEQ.

Past monitoring events conducted on Little Bitterroot Lake include:

November 30, 1999
May 24, 2000
September 27, 2004
September 1, 2005
September 25, 2006
October 8, 2007
October 13, 2008
October 5, 2009
June 3, 2010
August 23, 2010
September 20, 2011
September 10, 2012
May 20, 2013
August 29, 2013
August 11, 2014.

Little Bitterroot Lake was also sampled on November 5, 2014, by the Whitefish Lake Institute which oversees the Northwest Montana Lakes Volunteer Monitoring Network. For comparison, results from sampling conducted by Whitefish Lake Institute in 2014 are included within this report. A summary of the monitoring program was presented by WET staff at the annual meeting on July 23, 2014, and members of LBLA fielded many questions and comments regarding water quality on Little Bitterroot Lake which are addressed within this report.

3.0 Field and Analytical Methods

The 2014 sampling events were conducted by WET on August 11 and by Whitefish Lake Institute on November 5 with assistance from members of LBLA. Sampling was conducted at 6 lake locations, the inlet stream (Herrig Creek) and the outlet stream (Little Bitterroot River) (**Figure 1**). Sampling includes direct measurements of field parameters, collection of samples for laboratory analysis, and depth profile monitoring at the lake center. Methods of each component of the monitoring program are summarized in the following sections. A complete description of field and analytical methods are provided in the project Sampling and Analysis Plan (SAP) (WET, 2014) which is provided to Montana DEQ to procure funding from the grant program.

3.1 Field Parameters

Field parameters including water temperature, dissolved oxygen, specific conductance and pH are monitored using a portable water quality meter at each sample location. The instrument is calibrated during the day of sampling. Water clarity is evaluated at the lake center using a Secchi disc, and stream flow is measured at the inlet and outlet streams using an electronic flow meter.

3.2 Samples for Laboratory Analysis

Samples are collected for laboratory analysis of nutrients at each location, and additional samples are collected from lake sites for analysis of chlorophyll-a concentration in water. Sample bottles are filled from moving water at the inlet and outlet streams, and from just below the surface at lake sites. At the lake center, several samples are collected at depth using a Van Dorn type sampler. Samples are filtered or preserved if necessary, and stored in a cooler on ice until delivery to the laboratory. Samples for Chlorophyll-a are wrapped in aluminum foil to prevent exposure to light which can degrade samples. Nutrient parameters analyzed at the laboratory include various forms of nitrogen (nitrate+nitrite, ammonia, total Kjeldahl, organic, total) and phosphorous (dissolved ortho and total). All laboratory analyses use standard analytical methods, which are described in more detail in the project SAP.

One sample of attached (benthic) algae was collected from shoreline substrate in 2014. Ten large rocks were selected from the wadeable portion of the lake that represents typical algae growth for the shoreline area. A template is placed on the rock, and algae are removed from inside the template by scraping and brushing. The removed algae are placed in a centrifuge tube and wrapped in aluminum foil for delivery to the laboratory.

3.3 Depth Profile Sampling

Depth profile sampling was conducted at the lake center to evaluate changes in field and nutrient parameters at depth, which indicate whether or not the lake is stratified during sampling. Depth profile sampling was conducted by Whitefish Lake Institute using a portable Hydrolab water quality meter which measures depth, chlorophyll-a, temperature, specific conductance, dissolved oxygen, and pH. The Hydrolab has a maximum sampling depth of 140 feet, which is sufficient to monitor for stratification in Little Bitterroot Lake.

4.0 2014 Monitoring Results

Results from the 2014 sampling events are provided in **Attachment A** and summarized in the following sections below.

4.1 2014 Field Parameter Results

Field parameter results from 2014 are provided in **Table 1**. During the August 2014 sampling event the lake had a uniform surface temperature around 22°C (72°F). Herrig Creek was contributing cooler water around 12°C (54°F) at a low flow of approximately 0.5 CFS (200 GPM). The Little Bitterroot River at the outlet had a flow of 2.7 CFS (1200 GPM). pH at the lake sites varied from 7.2 to 7.9, and pH measured 5.4 in the inlet stream. Biological activity by plants and algae raise pH during daytime hours when photosynthesis is occurring, which may attribute to the higher pH measurements in the lake when compared to the inlet stream. Dissolved oxygen (DO) varied from 7.4 to 7.9 mg/L in the lake, and DO measured 9.7 in the inlet stream. Specific conductance was quite low in the inlet stream (47 µS/cm) but uniformly around 117 µS/cm at the lake sites. These results are comparable to field parameters measured during previous sample years, and are indicative of good water quality and oligotrophic conditions.

4.2 2014 Nutrient and Chlorophyll-a Results

Results from August 2014 are provided in **Table 1**, and data for total nitrogen and total phosphorus are shown spatially in **Figure 2**, organized left to right from the lake inlet (Herrig Creek) to the lake outlet (Little Bitterroot River).

In 2014, total nitrogen concentrations were highest at Herrig Creek Bay in the north portion of the lake (0.170 mg/L) and lowest in the northwest bay (0.090 mg/L). The measured concentration for total nitrogen at the outlet stream was near the average of all measurements within the lake.

Concentrations of total phosphorus were very low throughout the lake in 2014, with just 4 of 10 samples above the analytical detection limit. The highest concentrations were recorded at the lake inlet (0.009 mg/L) and at the lake center at a depth of 20' (0.005 mg/L). Total phosphorus at the outlet stream was below the analytical detection limit (0.003 mg/L), which suggests that available phosphorus is likely consumed by algae within the lake before reaching the outlet. Little Bitterroot Lake has typically been described as "phosphorus-limited" in previous years, so any addition of phosphorus will promote algae growth.

In August 2014, the highest concentrations of chlorophyll-a occurred from 60 to 80 feet below lake surface, and the highest concentration of dissolved oxygen occurred between 40 and 60 feet. Elevated chlorophyll-a concentrations often correlate with higher concentrations of dissolved oxygen, which is produced by photosynthetic algae in the water column. Dissolved oxygen concentrations are well above the threshold for aquatic life (5 mg/L) throughout the water column, which is typical of an oligotrophic lake with good water quality and low biological productivity.

During the annual meeting in July 2014, attached algae on rocks appeared to be at near nuisance levels, and several homeowners around the lake noted increased algae near the shoreline as compared to previous years. The 2014 sampling program did not originally include sampling for attached algae; however, one benthic algae sample was collected in an attempt to document algae conditions in 2014. The benthic algae sample was collected during the August sampling event near the dock of the Engel residence at Slaughter House Bay. The sample results reported the chlorophyll-a concentration at 0.1 mg/m^2 and ash free dry weight at 7.75 g/m^2. Recent studies (Suplee et al, 2009) report that chlorophyll-a concentration of 150 mg/m^2 is generally considered a nuisance level of algae. The measured concentration of Chlorophyll-a was well below the nuisance level during sampling; however, algae conditions were not as prolific in August as noted in July, and much of the algae remaining in August was likely decadent and the chlorophyll-a was degraded. Future sampling for benthic algae will attempt to capture conditions near the peak in order to better quantify algae growth and chlorophyll-a concentration and compare to standards for nuisance growth.

4.3 2014 Depth Profile Results

Depth profile sampling was conducted in August and November 2014 to show changes in water chemistry at depth. Results from the depth profile sampling are shown in **Figure 3**, including charts for water temperature, dissolved oxygen, pH, and chlorophyll-a. In August 2014 the lake was thermally stratified with an epilimnion (upper layer) from 0 to 21 feet, a metalimnion (transitional layer) from 21 to 100 feet, and a hypolimnion from approximately 100 feet to the lake bottom. By November 2014, the lake was still slightly thermally stratified and the epilimnion had extended to approximately 60 feet below the lake surface.

4.4 Long Term Trends

Results from 2004 to 2014 are shown for all sample locations in **Figure 4,** and **Figure 5** shows minimum, maximum, and average results from 2004-2014. Nutrient concentrations have generally shown a decreasing trend since consistent yearly monitoring began in 2004. In 2014, Little Bitterroot Lake had the 4th lowest average total nitrogen concentration for the entire sampling period, and the lowest average total phosphorus concentration. These trends are encouraging from the standpoint of improving water quality, but should be interpreted with caution because of the limited temporal data available for Little Bitterroot Lake. Nutrient concentrations can vary between seasons or change rapidly due to episodic events such as runoff or lake turnover, so sample events may not coincide with periods of peak nutrient concentration. Data and trends will become more robust as future measurements are added to the dataset, and continuity and consistency are maintained within the monitoring program.

Data from the entire sampling period (1999 to 2014) were analyzed spatially by combining all data for each sample location shown in **Figure 6**. These charts show the minimum, maximum, and average nutrient concentrations for each sample site for the period of record. Sample locations are organized from left to right in the general direction of flow through the lake, from the inlet (Herrig Creek) to the outlet (Little Bitterroot River). Average concentrations of total nitrogen are lowest at the lake center and highest at the lake outlet. Concentrations of total phosphorus are lowest at the inlet and at Slaughter House Bay, and are highest at the center of the lake. However, results for total nitrogen and phosphorus are quite variable at each location and differences between sample locations may not be statistically significant.

4.5 Trophic Status

Trophic status refers to a lake's ability to produce and sustain populations of algae in response to available nutrients, also referred to as biological productivity. High biological productivity is an indicator of high nutrients and poor water quality, whereas low biological productivity is an indicator of low nutrient concentrations and good water quality. The trophic status of Little Bitterroot Lake was determined by calculating the Carlson's Trophic State Index (TSI) from measurements of total nitrogen, total phosphorus and chlorophyll-a (Carlson, 1977). The TSI for Little Bitterroot Lake is shown in **Figure 7** for data from 2004 to 2014.

TSI data suggest that Little Bitterroot Lake is classified as eutrophic based on concentrations of total nitrogen; however, measurements of total phosphorus and chlorophyll-a indicate that the lake is oligotrophic with low biological productivity. Total phosphorus concentrations in 2014 were the lowest measured during the sampling period, indicating oligotrophic conditions.

Despite having relatively high concentrations of total nitrogen, Little Bitterroot Lake typically does not experience large blooms of nuisance algae and has shown low concentrations of chlorophyll-a during sample events conducted from 2010 to 2014. The low biological productivity is likely because the lake's morphology is favorable to oligotrophic conditions and limited by low phosphorus concentrations. Little Bitterroot Lake has steep sides, limited littoral (shallow shoreline) habitat, and a low watershed/lake ratio of 4.8 (Ellis et al, 1998). The lake appears to be phosphorus-limited, meaning that it has an adequate amount of nitrogen compared to the amount of phosphorus needed to support algae growth.

Lakes that are phosphorus-limited often show increased algae growth when phosphorus concentrations increase, but not necessarily when nitrogen concentrations increase. Total phosphorus is commonly associated with sediment, so high concentrations often occur in years following land disturbance (such as road building or logging) or increased precipitation and runoff.

5.0 Discussion and Conclusions

Water quality in Little Bitterroot Lake was very good in 2014, with low concentrations of nutrients and chlorophyll-a. Total nutrient concentrations (nitrogen and phosphorus) have generally been decreasing since the inception of the monitoring program in 1999. The highest concentrations of total nitrogen have typically occurred at Herrig Creek Bay and the lake outlet, while the highest concentrations of total phosphorus have occurred at the lake center. The highest concentrations of both nutrients were exhibited in 2011, which was a high precipitation year during which excess nutrients may have been flushed in Little Bitterroot Lake from the surrounding watershed. Past sampling events indicate that lake water quality is strongly influenced by ground water with less input from Herrig Creek and other intermittent streams.

The trophic state index for Little Bitterroot Lake suggests eutrophic conditions exist due to high concentrations of total nitrogen, but measurements of total phosphorus and chlorophyll-a indicate oligotrophic conditions with low biological productivity and good water quality. Little Bitterroot Lake has typically been phosphorus-limited, meaning it has an inadequate amount of phosphorus compared to the amount of nitrogen needed to support algae growth. Based on this observation, Little Bitterroot Lake is more likely to experience algae blooms with the addition of phosphorus since concentrations of nitrogen are already relatively elevated. However, nutrient concentrations can vary significantly, and efforts to reduce inputs of both phosphorus and nitrogen should be encouraged to help maintain the water quality of Little Bitterroot Lake and limit algae growth.

Overall, Little Bitterroot Lake has shown excellent water quality throughout its monitoring history. Nutrient and chlorophyll-a concentrations are low, algae blooms are rare, and field data indicate suitable ranges of temperature, dissolved oxygen and pH to support a viable fishery.

Water quality monitoring will continue in 2015 with support from Water & Environmental Technologies, Whitefish Lake Institute, and a grant from the Volunteer Monitoring Support Program at Montana DEQ. Water quality sampling is planned for early August 2015 for nutrients, chlorophyll-a, and depth profile sampling. Depth profile sampling will also be conducted in late fall by Whitefish Lake Institute. The 2015 sampling program will include more sampling for attached algae than previous years in an effort to provide baseline information. If possible, benthic algae sampling will take place in July when peak conditions are more likely to occur.

A presentation of the water quality program was provided by WET personnel during the 2014 annual meeting in July, including a question-and-answer session with members of LBLA. Below is a summary of questions and concerns raised by members of LBLA.

> *Question: Water quality sampling has traditionally been limited to the upper portion of Little Bitterroot Lake, with water samples collected above 80 feet and field parameters to 140 feet. Is it possible to collect data from deeper depths, and would it be beneficial?*
>
> Response: Water samples at depth have been collected with either an electric pump or Van Dorn type sampler which has limited sampling to approximately 80 feet in most years. Depth profile sampling has been conducted with a Hydrolab instrument which has a cord length of 140 feet.

Results from previous sampling efforts have shown that the lake is typically stratified in mid-summer, and conditions become very uniform below depths of approximately 100 feet where the hypolimnion occurs. Furthermore, laboratory results have been quite consistent when collected within the hypolimnion. The biggest changes in water quality occur above the hypolimnion in the upper 100 feet of the water column, so sampling below this depth does not provide much additional information about the water quality status of the lake. Furthermore, available light becomes limited at depth, and most biological activity occurs within the upper 100 feet above the hypolimnion. Sampling from deeper depths would also require different or additional equipment which could be expensive or difficult to procure.

Question: Water quality appears to be improving throughout the monitoring period, especially in more recent years. Can you explain why?

Response: In theory, water quality in a lake should remain relatively stable unless it is affected by changes in land use or climate. The watershed surrounding Little Bitterroot Lake has historically experienced periods of logging, road construction, and home development, as well as natural variability in weather patterns. Since the inception of the monitoring program in 1999, relatively minor disturbances have occurred in the watershed such as logging or construction, which has helped stabilize soil erosion and the input of nutrients from the surrounding watershed. Climatic conditions can also affect water quality in the lake. 2011 was an exceptionally wet year, which may have contributed to a greater influx of sediment and nutrients from the surrounding watershed. As a result, nutrient concentrations showed a higher average in 2011 when compared to recent years, but overall water quality appears to be improving throughout the monitoring period.

Question: With a limited monitoring program that includes just one yearly sampling event, are we likely to detect significant changes in water quality?

Response: Water quality in lakes is often a reflection of conditions within the contributing watershed. Significant changes in water quality are generally a result of changes within the watershed, such as forest fire, logging, road building, or development. Water quality changes may also occur due to climatic effects, such as a high water year, a cold summer, or persistent drought. Short-term changes can occur due to episodic events such as a high precipitation and runoff event, or lake turnover. Understanding human and natural induced activities within the watershed can help us anticipate changes in water quality.

Even within the limited time frame of our sampling program we have been able to detect some changes and trends. For example, 2011 was an exceptionally high precipitation year with high snowpack and persistent rain through the summer months. As a result, more sediment and nutrients were flushed into Little Bitterroot Lake from the surrounding watershed compared to other sampling years, which was evident in results for nitrogen and phosphorus. A limited sampling program may not capture episodic events or peak periods; however, annual monitoring with consistent methods provides reliable baseline data that can help detect long-term changes within the watershed and ensure continued health of Little Bitterroot Lake.

Question: How does ash from forest fires affect water quality?

Response: Experimental studies (Tulonen et al, 2002) have shown that high application rates of wood ash will raise pH, alkalinity, calcium, phosphorus, and potassium in a water body; however, smaller applications of wood ash to a forested watershed will not necessarily cause significant changes in water quality. Stream and lakes may be affected by direct application of fire retardants which often contain phosphate-based chemicals. This was experienced in the Rock Creek drainage west of Missoula during the 2001 fire season and was evident in the water quality data. Furthermore, water quality in lakes and streams is at a greater risk of nutrient inputs following a forest fire due to the loss of vegetative cover, increased soil erosion, and increased runoff, although the input from fire ash itself is likely very small and insignificant.

Question: A "water combine" machine was used to cut floating aquatic vegetation in the northwest bay of Little Bitterroot Lake in summer of 2014, resulting in increased sediment and vegetation debris in this portion of the lake. How does mechanical harvesting of vegetation affect water quality in the lake?

Response: Nutrients, especially phosphorus, are commonly bound in lake sediments. Any disturbance to lake sediments will introduce nutrients into the water column, which increases the potential for algae blooms. Furthermore, the harvesting of aquatic vegetation may release nutrients from the plant material during harvesting and as the vegetation decays. The party responsible for vegetation removal allegedly went through a permitting process with the appropriate state agency, yet this type of activity may not be readily known to the public. An increased presence with state agencies, especially the local fisheries biologist at Fish, Wildlife & Parks, may help citizens become aware of these activities prior to implementation and allow public input.

Question: Several homeowners noted increased algae on rocks near their residences, commonly referred to as "slime". Is there a reason for more algae on rocks this year, and what can be done about it?

Response: Attached algae on rocks (known as benthic algae) may be an indicator of increase nutrients, although water quality sampling still shows relatively minor amount of nutrients in Little Bitterroot Lake. The proliferation of benthic algae in 2014 may be due to higher summer temperatures than previous years. The August 2014 sampling event had the highest average lake temperature since sampling began in 1999. Additionally, several homeowners commented that lake levels were quite high during spring 2014. High lake levels can introduce lake water to more nutrient sources, including fertilizer from lawns, shoreline sediment, or septic drainfields. Future sampling efforts will include collection of algae samples from shoreline rocks to provide baseline information and allow us to monitor yearly changes. Homeowners can also photograph algae conditions as a way of documenting growth and monitoring yearly changes.

Question: How do high or fluctuating water levels affect water quality?

Response: High water levels may introduce lake water to nutrient sources in shoreline areas, such as fertilized lawns, shoreline sediment, or septic systems and drainfields. Fluctuating water levels can also increase soil erosion, which introduces sediment and nutrients into the lake and can affect water quality and algae growth. Proper management and maintenance of shoreline areas is encouraged to reduce nutrient inputs during high water, such as limiting the amount of fertilizer applied to lawns, keeping a buffer around the lake, reducing soil erosion with proper landscaping, maintaining septic systems, or using septic systems with secondary treatment that provide a more complete reduction of nutrients.

6.0 References

Carlson RE. 1977. A trophic state index for lakes. Limnology and Oceanography. Vol 22, Pgs 361-9.

Cole GA. 1983. Textbook of Limnology, 3rd Edition. Waveland Press.

Ellis B K and Craft JA. 2008. Trophic status and trends in water quality for Volunteer Monitoring Program lakes in northwestern Montana, 1993–2007. Flathead Lake Biological Station Report 200-08. Prepared for Flathead Basin Commission.

Ellis BK, Craft JA, Stanford JA. 1998. Baseline Water Quality Study of Little Bitterroot, Mary, Ronan, Ashley and Lindbergh Lakes, Montana. Flathead Lake Biological Station Report 148-98.

Little Bitterroot Lake Zoning District. 1996. Little Bitterroot Lake Neighborhood Plan and Development Code: An Amendment to the Flathead County Master Plan. Adopted February 27, 1996.

Suplee MW, et al. 2009. How Green is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. Journal of American Water Resources Association. Vol 45, No 1.

Suplee MW and Sada de Suplee R. 2011. Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels. Montana Dept of Environmental Quality. Helena, MT.

Tulonen T, Arvola L, Ollila S. 2002. Limnological Effects of Wood Ash Application to the Subcatchments of Boreal, Humic Lakes. Journal of Environmental Quality. Vol 31, No 3.

Water & Environmental Technologies (WET). 2014. Little Bitterroot Lake Eutrophication Study Sampling and Analysis Plan. Prepared for Montana DEQ.

Whitefish Lake Institute (WLI). 2013. Montana Lake Book – Second Edition. Whitefish, MT. Available online at: http://www.nwmtlvmn.org/docs/Montana%20Lake%20Book%202nd.pdf.

Whitefish Lake Institute (WLI). 2015. Northwest Montana Lakes Volunteer Monitoring Network 2014 Summary Report. Prepared for Montana Fish, Wildlife & Parks. March 2015.

Attachment A – Tables and Figures

Table 1. August 2014 Water Quality Data.

Sample Info		Field Water Quality						
Site ID	Site Description	Temp (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	pH	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Chla (mg/L)
						0.04	**0.003**	**0.1**
SP-7	Inlet - Herrig Cr.	11.89	9.7	47	5.44	**0.11**	**0.009**	NS
SP-2	North - Herrig Cr. Bay	22.06	7.7	116	7.86	**0.17**	0.003	0.10
SP-10	Northwest - Northwest Bay	21.49	7.9	117	7.76	**0.09**	0.003	0.10
SP-1	East - Slaughter House Bay	22.19	7.6	117	7.77	**0.15**	**0.004**	0.10
SP-5	Center - 0' Depth	22.22	7.4	116	7.85	**0.11**	0.003	0.10
SP-5	Center - 10' Depth	Field parameters at depth are shown with depth profile data.				**0.11**	**0.004**	**1.20**
SP-5	Center - 20' Depth					**0.20**	**0.005**	**10.0**
SP-11	Southwest - Near Point	22.33	7.6	117	7.76	**0.15**	0.003	0.10
SP-6	Southeast - Baileys	22.58	7.5	117	7.18	**0.15**	0.003	0.10
SP-9	Outlet - Ltl. Bitterroot R.	22.65	7.3	120	7.58	**0.13**	0.003	NS

The analytical detection limit for nutrient parameters are provided below the nutrient name.
Values in **BOLD** are above the analytical detection limit.
NS = not sampled

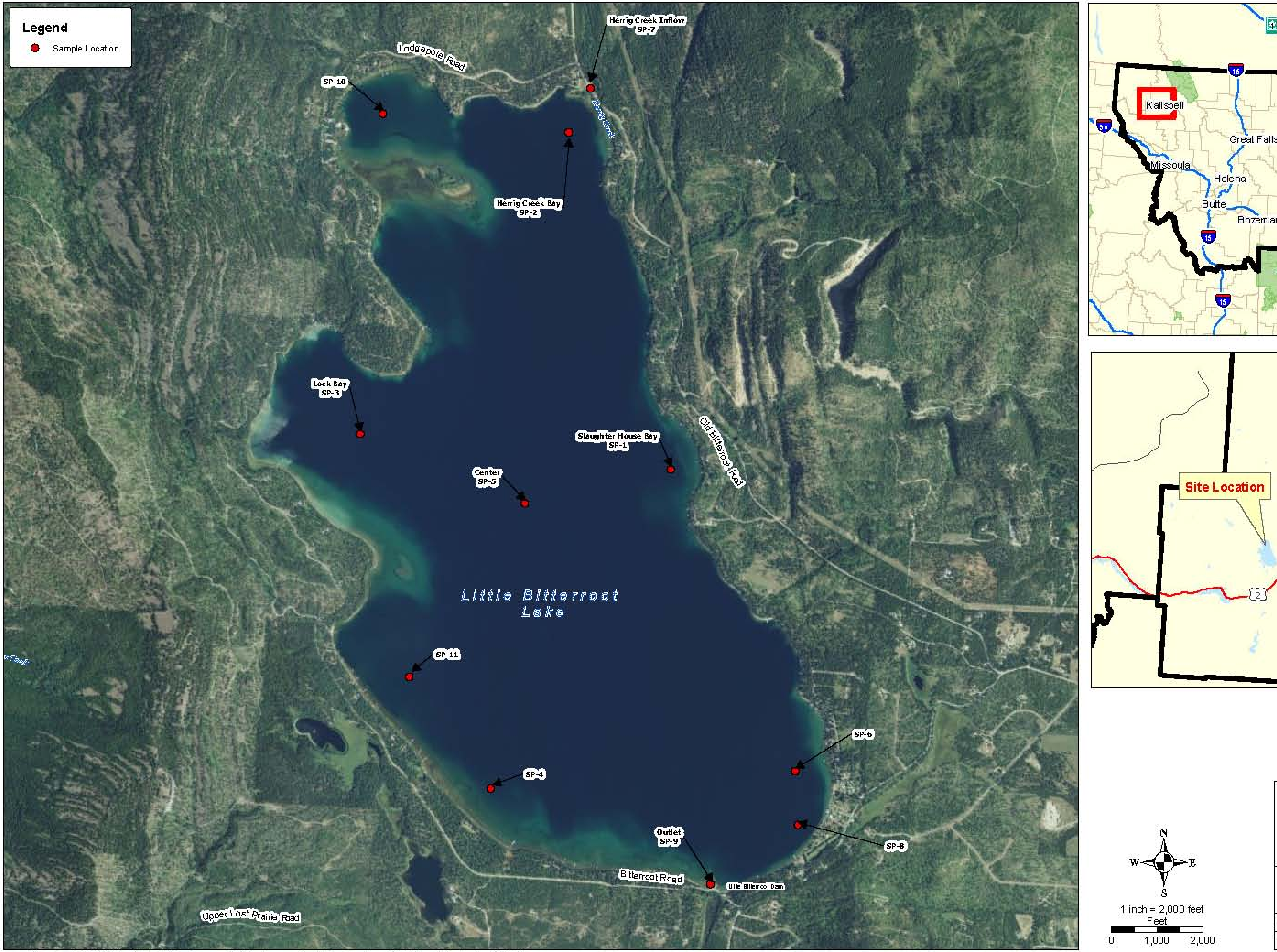

Image Source: 2009 NAIP 1m Natural Color Imagery for Montana acquired between June 23, 2009 and September 2, 2009.

WATER & ENVIRONMENTAL TECHNOLOGIES, PC

Little Bitterroot Lake
Site Location

LBHHM01
10/30/09

FIGURE 1

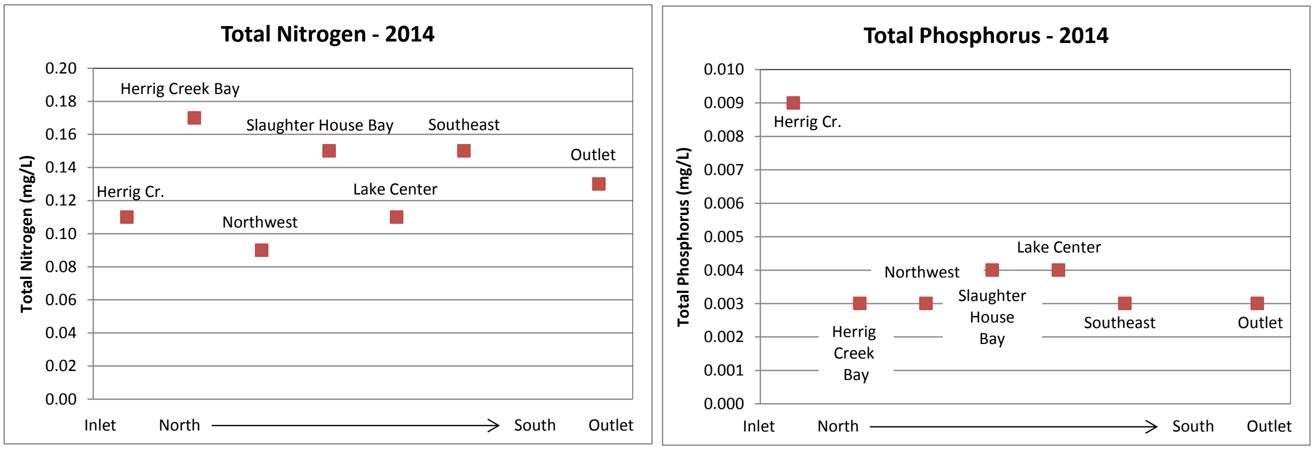

Figure 2. Total Nitrogen and Total Phosphorus Results for 2014.

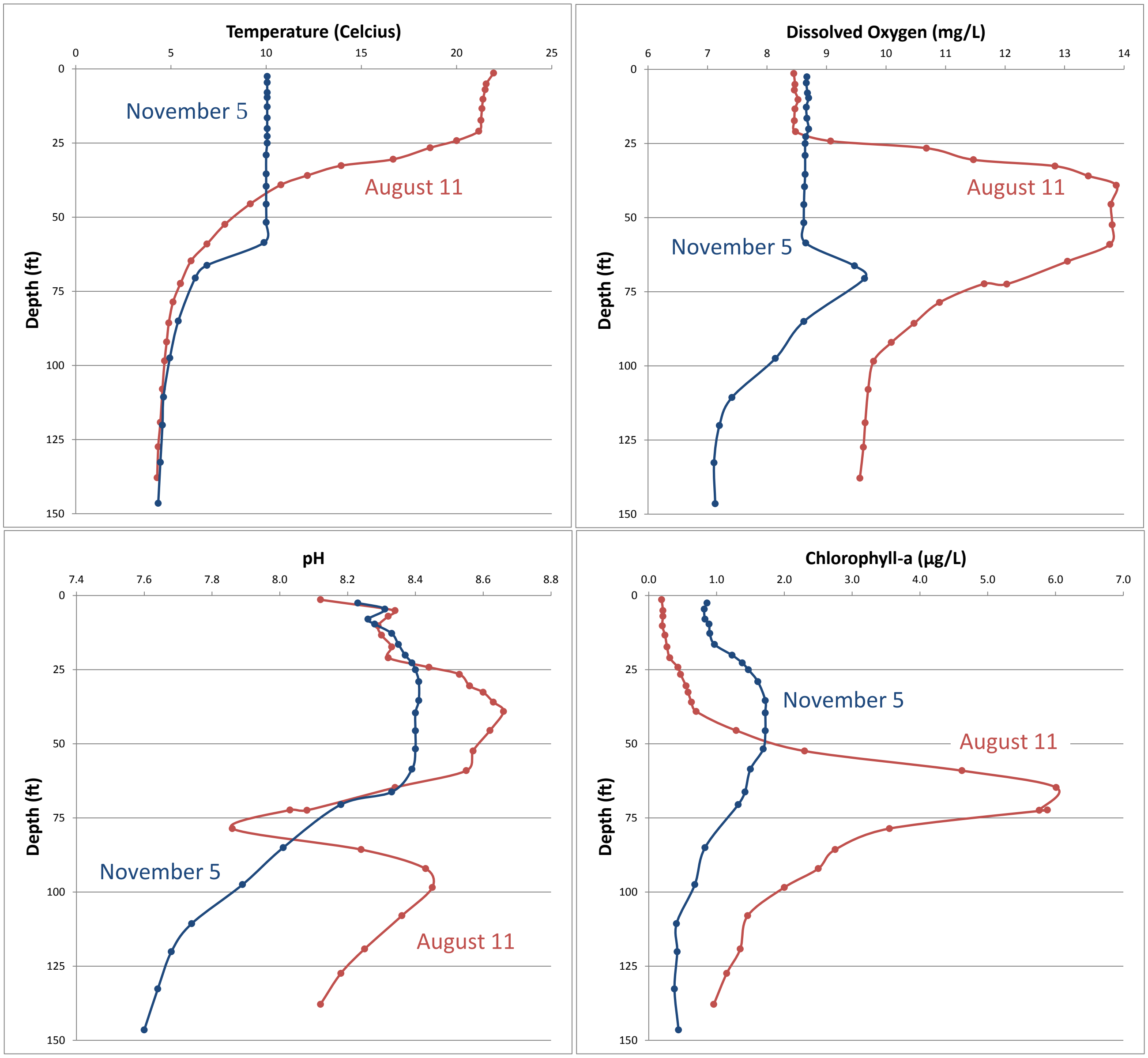

Figure 3. Depth Profile Results for 2014.

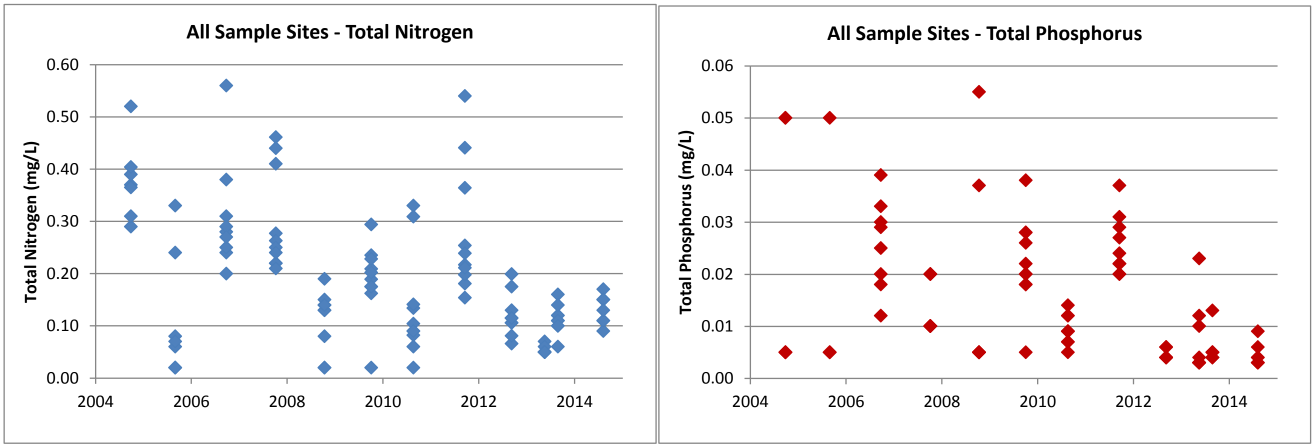

Figure 4. Total Nitrogen and Total Phosphorus Results for 2004-2014.

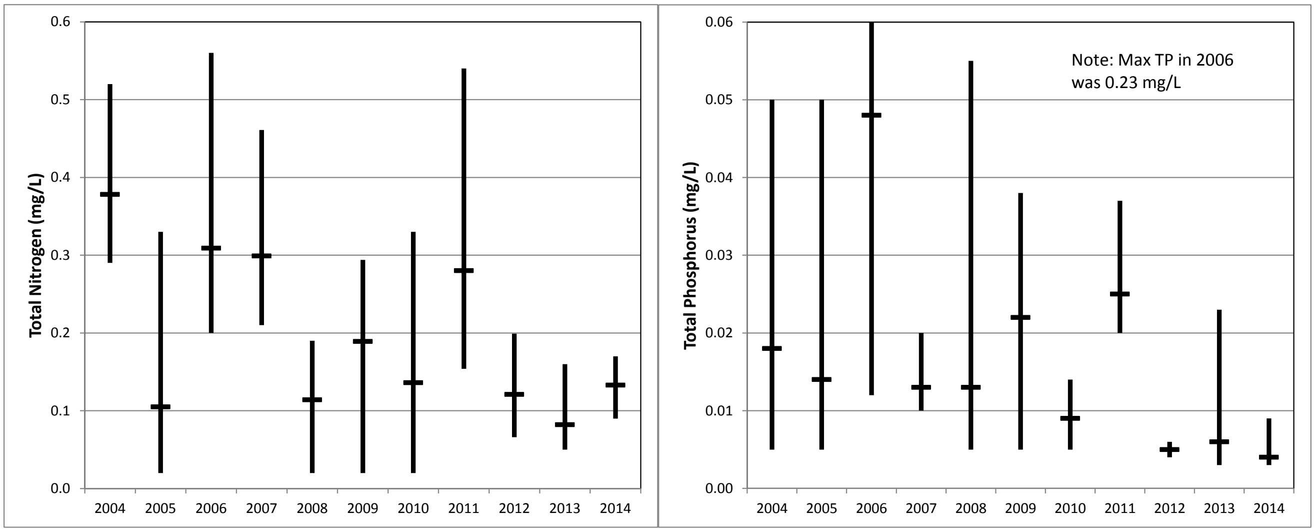

Figure 5. . Yearly Nutrient Statistics (Minimum, Maximum, Average) from 2004-2014.

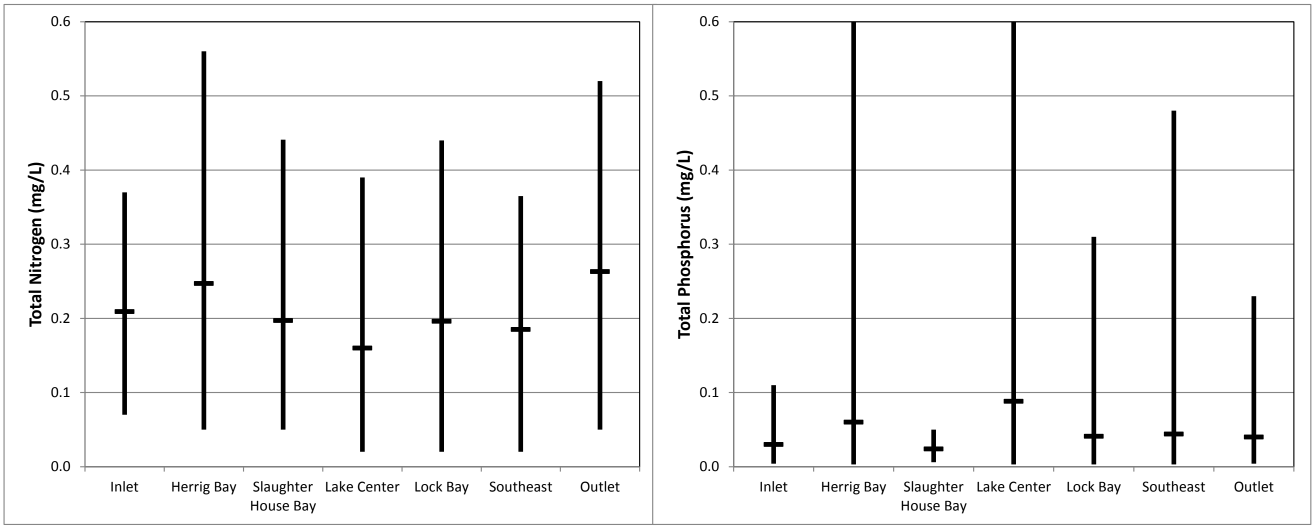

Figure 6. Spatial Nutrient Statistics (Minimum, Maximum, Average) from 1999-2014.

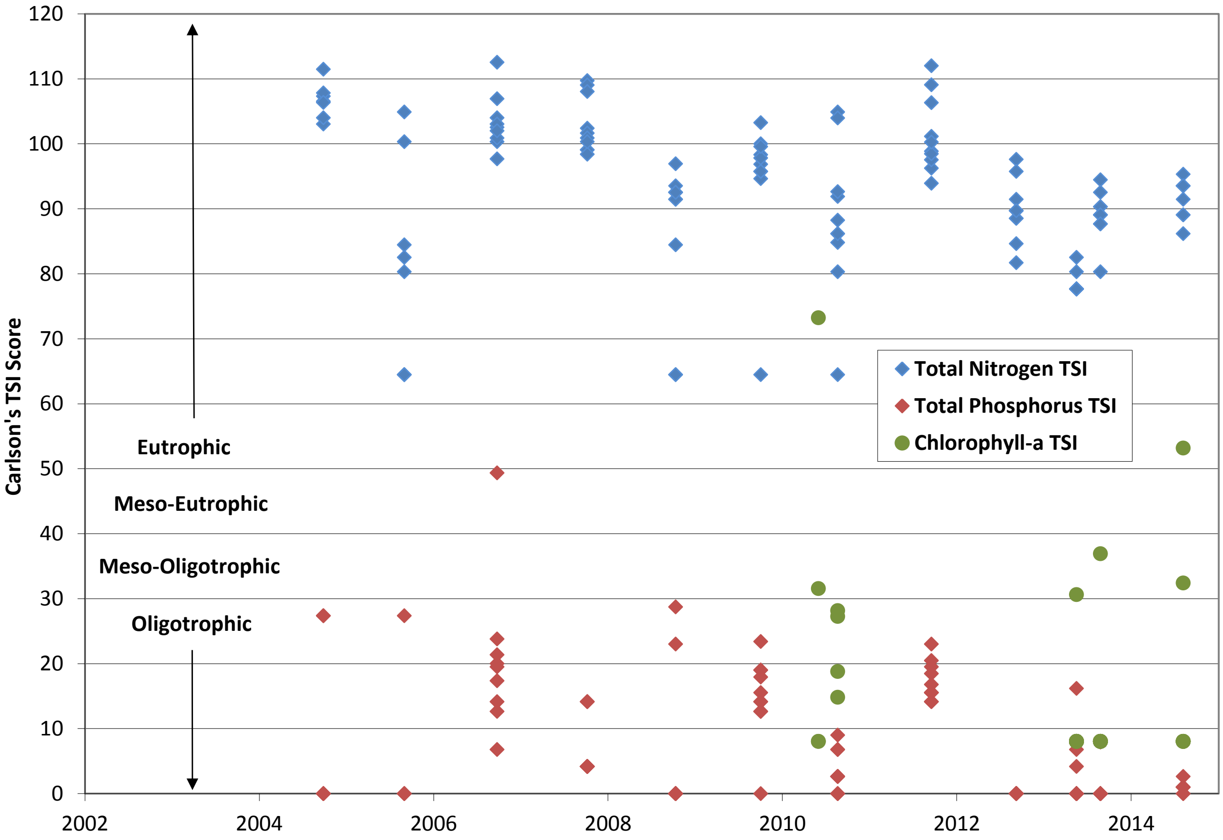

Figure 7. Trophic Status of Little Bitterroot Lake from 2004-2014.