Phosphorus Mass Balance for the Briggs Lake Chain and Big Elk Lake Sherburne County, Minnesota

Data Collected in 2006 and 2007

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1. Introduction

The Minnesota Pollution Control Agency monitored the Briggs Chain and Big Elk Lake in 1998. From the nitrogen to phosphorus ratio, they determined that phosphorus is most likely the limiting nutrient for algae growth for Briggs, Julia and Rush lakes (Reference Lake and Trend Monitoring Summary for Sherburne County, Minnesota, 1998, Minnesota Pollution Control Agency). The data for Big Elk Lake indicated that periodically nitrogen may be limiting although some forms of algae take nitrogen from the atmosphere thus nitrogen may not limit their growth.

Because phosphorus limits algae growth for the Briggs Chain and is also a key nutrient for Big Elk Lake, efforts to reduce algae blooms should emphasize reducing in-lake phosphorus. To determine relative sources, a phosphorus mass balance study was conducted in 2006 and 2007.

Stream and in-lake monitoring was conducted from April through October in 2006 and 2007. Sampling was performed by Sherburne Soil and Water Conservation District staff and Briggs Lake Chain Association volunteers. Streams were sampled for stage, discharge and total phosphorus. Lakes were sampled for Secchi disc transparency, total phosphorus and chlorophyll-a. Dissolved oxygen and temperature profiles were also done for the four lakes. Data management and analysis were performed by the Sherburne Soil and Water Conservation District.

The 2006/2007 mass balance monitoring follows up on work conducted in 1992 by Water Resources Management. Data from the 2 studies is compared in this report. For the 2006/2007 study, an effort was made to include sources not measured in 1992. In addition, because 1992 was a dry year it is desirable to add to the phosphorus mass balance data.

Special thanks to BLCA volunteers:

Chuck Heinemann for scheduling, daily stream level monitoring, stream flow monitoring, lake level monitoring and lake sampling; Walt Munsterman for coordinating lake sampling; Paul Fors, Dennis Koste, Randy Peterson, Doug Brown, George LaMotte, Bill and Sandy Stai, Harry Ernzer, Tom Koontz, Jim Wicklund and Gordy Schumann for their work on stream and lake monitoring; George Kydd for stream transparency and lake level monitoring; Dave Jones for stream transparency monitoring; and Terry Polsfuss for precipitation and lake level monitoring.

Project funding:

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2. Project Description

Methods

Stream stage was monitored daily from April through October in 2006 and 2007 using staff gages set at 4 stream sites and using the tape down method at culverts for smaller streams. Staff gages were fastened to 1½ inch pipes driven at least 3 feet into the stream bottom. The staff gage elevations were tied to bench marks for future reference.

Stream flow was monitored 9 times during the monitoring period at varying water levels. Only 3 measurements were possible for the Briggs Lake Bayou because it only flows during high water levels. Multiple measurements were done across each cross section. When wading was possible, stream flow was measured using a Swoffer model 2100 current velocity meter. This instrument automatically sets the monitoring depth at 0.6 of the stream depth. Where wading was not possible during high flows, a General Oceanics Model 2030 mechanical flow meter (G.O. meter) was suspended from a bridge. The G.O. meter was used for 1 sampling date at the 2 Elk River sites and for the 3 flow monitoring dates at the Briggs Lake Bayou. Stream flow measurements made at high flows using the G.O. meter have a greater degree of error associated with them due to the difficulty of accurately setting the sampling depth. A relatively high error is associated with the in-flow calculations for the Briggs Lake Bayou due to the occurrence of back flows and the limited number of flow measurements.

Phosphorus samples were taken at stream sites weekly from April through July and biweekly from August through October using a 16 oz. bottle attached to a telescoping rod.

Lake water chemistry samples were taken bi-weekly from mid-May through mid-October using a 2 meter integrated sampler.

Dissolved oxygen and temperature profiles were done by Sherburne SWCD for the four lakes using a YSI model 55 meter. In 2007, shallow and deep total phosphorus samples were taken in conjunction with the dissolved oxygen and temperature profiles. A Van Dorn horizontal sampler was used for these phosphorus samples.

Monitoring for this project followed guidelines from the Elk River Watershed 319 Project Quality Assurance Project Plan, approved by the Minnesota Pollution Control Agency. Training sessions were conducted for volunteers.

Rating curves were constructed for each stream site. The rating curves were used to calculate discharge for each day of the monitoring period. Daily loading was calculated for each site using the stream phosphorus data and discharge calculations.

During 2006 and 2007, volunteers monitored lake levels on Big Elk Lake and Rush Lake using staff gages installed by the Minnesota DNR. Lake elevations were also surveyed by Sherburne SWCD at the start and end of the monitoring period in both 2006 and 2007. Precipitation data was recorded daily by a volunteer on Rush Lake working with Sherburne SWCD's rain gage network. Daily evapotranspiration (ET) was calculated daily using the Penman method. ET input data was available from the Crescent Lake climate station located in Clear Lake Township approximately 3.2 miles south of Big Elk Lake. This climate station is operated by USDA-NRCS. Sherburne SWCD downloads climate data weekly and the daily ET is calculated using software provided by USDA-NRCS.

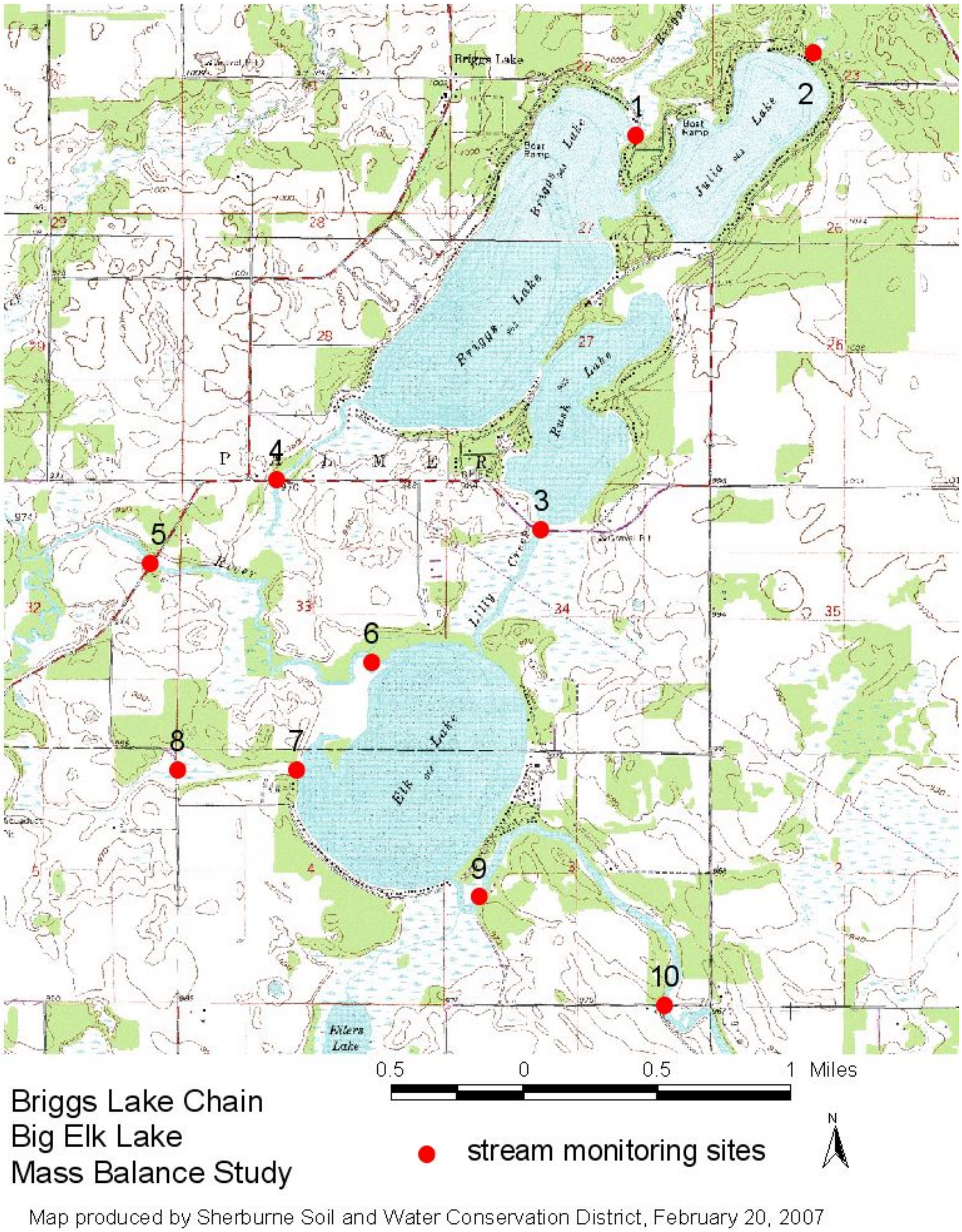
Atmospheric phosphorus loading was estimated using data from Appendix E of Detailed Assessment of Phosphorus Sources to Minnesota Watersheds, Vol. 1, Barr Engineering Co., February, 2004. Phosphorus loading from shoreland runoff was estimated using the method from Appendix L of the 2005 Minnesota Stormwater Manual, Version 1.0, Minnesota Pollution Control Agency. For determining ground water phosphorus loading, the net groundwater flow was determined by constructing a water balance and solving for ground water flow. The ground water phosphorus concentration was based on samples taken from 2 shallow wells located near Big Elk Lake and Rush Lake.

Table 1. Precipitation, Lake Level, Evapotranspiration and Well Sample Sites

Station Type	**Description**	**Location**
Precipitation	4 inch cylinder	Polsfuss residence, Rush Lake, 5314 114th Ave.
Lake level, Briggs Lake Chain	staff gage	Polsfuss residence, Rush Lake, 5314 114th Ave.
Lake level, Big Elk Lake	staff gage	Heinemann residence, Big Elk Lake, 7215 100th Ave.
Evapotranspiration	Climate station	SNOTEL Climate monitoring station at Crescent Lake, USDA-NRCS. Clear Lake Township, T34, R29, SW¼ of SE¼ of Sect. 21
Groundwater total phosphorus	Drive point well.	Heinemann residence, Big Elk Lake, 7215 100th Ave.
Groundwater total phosphorus	Drive point well.	Langowski residence, Rush Lake, 5060 114th Ave.

Surface water monitoring sites are shown in Figures 1a and 1b.

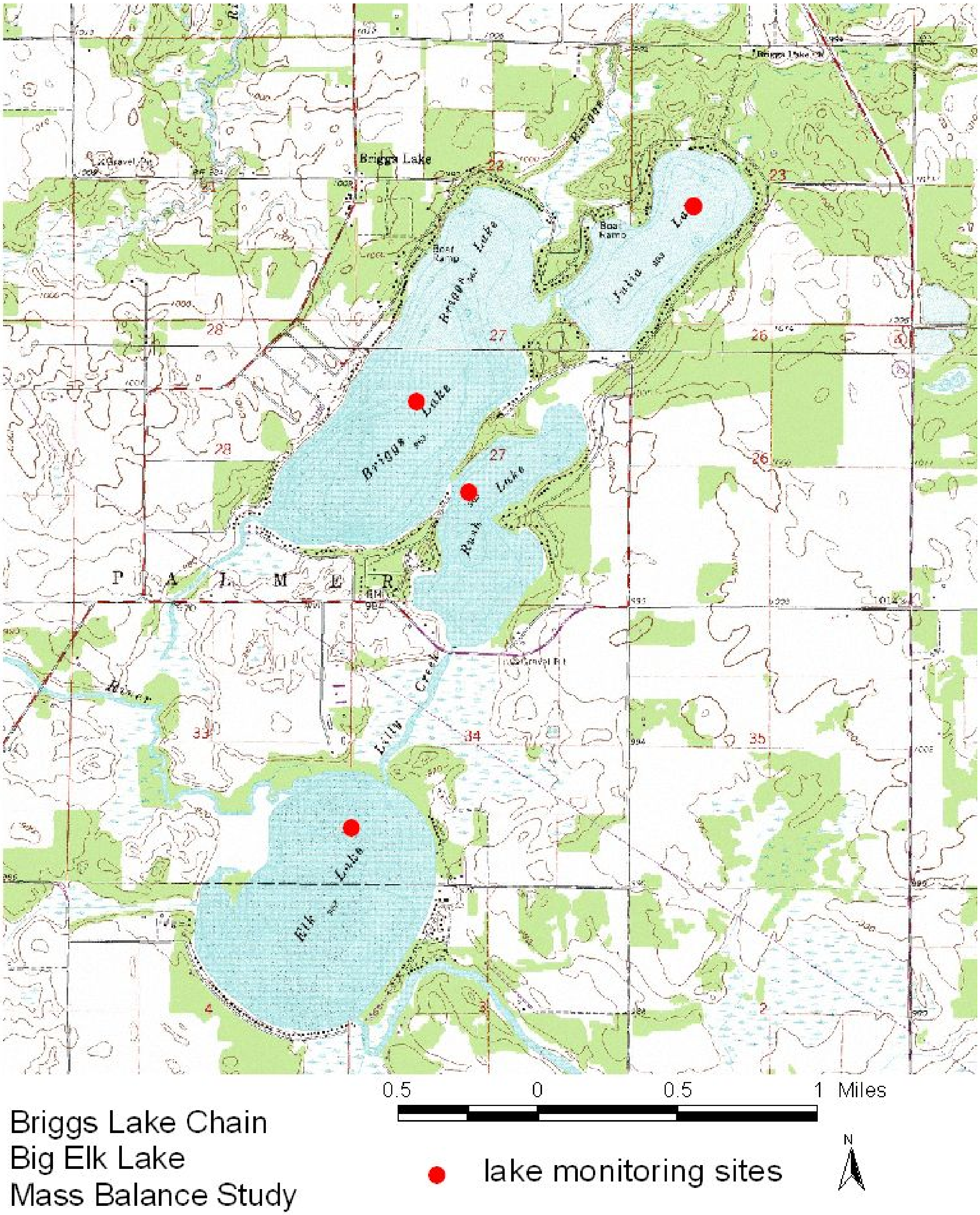
Figure 1a. Stream Monitoring Sites



Site Key:

1	Briggs Creek	6	Elk River at Big Elk Lake inlet
2	Julia Creek	7	Ditch 13 at Big Elk Lake
3	Lily Creek	8	Ditch 13 at CR 55
4	Briggs Lake Bayou	9	Elk River at Big Elk Lake outlet
5	Elk River at CSAH 6	10	Elk River at CR 53/54

Figure 1b. Lake Monitoring Sites

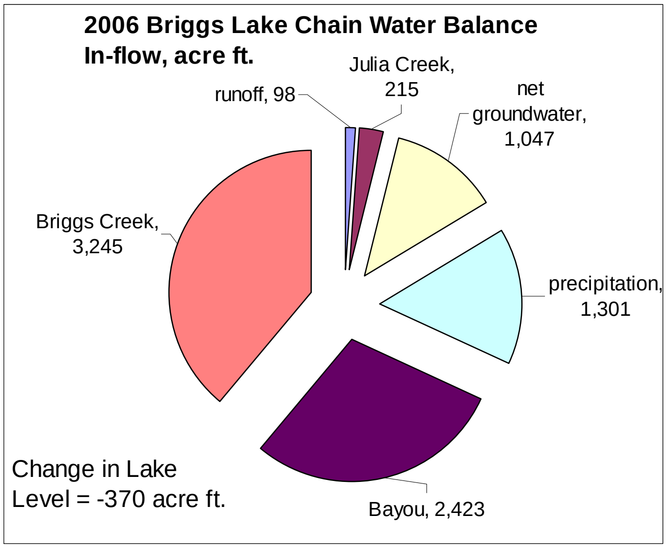


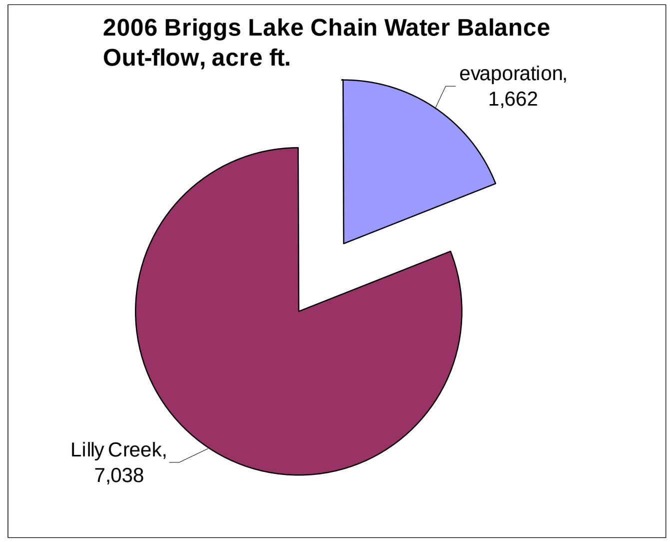
Map produced by Sherburne Soil and Water Conservation District, February 20, 2007

3. Stream Monitoring Results

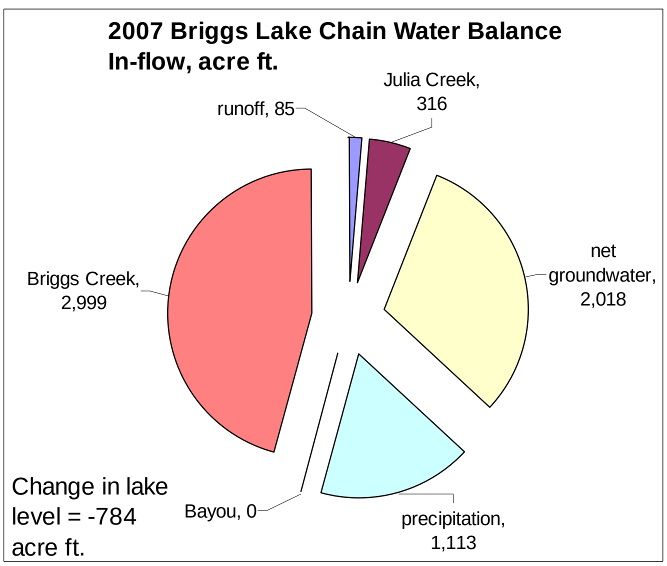
Figure 2. Briggs Lake Chain Water Balance

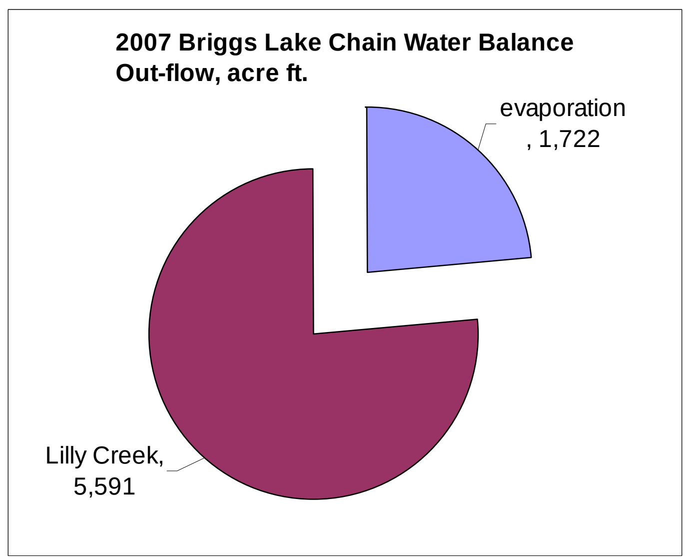
2006:





2007:





Precipitation for the 2006 monitoring period was close to average. The total precipitation for the Hydrological year (October 1, 2005 to September 30, 2006) was 31.28 inches and for April through October it was 21.51 inches. 2007 was a dry year with 23.09 inches of precipitation for the hydrological year and 18.40 inches for April through October. Stream flow and runoff were considerably less in 2007 as compared to 2006. The channel at the south end of Briggs Lake known as the Briggs Lake Bayou flows into the Briggs Lake Chain intermittently when the Elk River overflows its banks at a point to the South of Briggs Lake. There was flow through the Bayou into Briggs Lake in May of 2006 but due to the relatively low spring runoff in 2007 no inflow from the Bayou occurred in that year.

In 2006 the level of the Briggs Lake chain dropped 0.51 feet during the monitoring period. In 2007 the lake level dropped 1.08 feet.

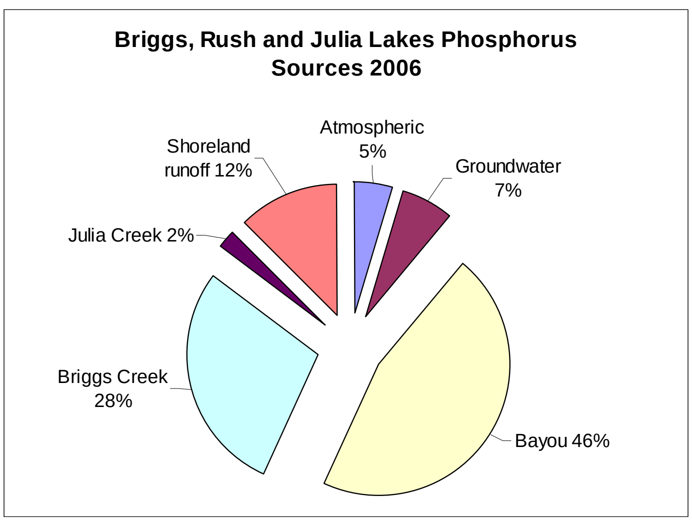
Table 2a. 2006 Phosphorus Mass Balance – Briggs Lake Chain

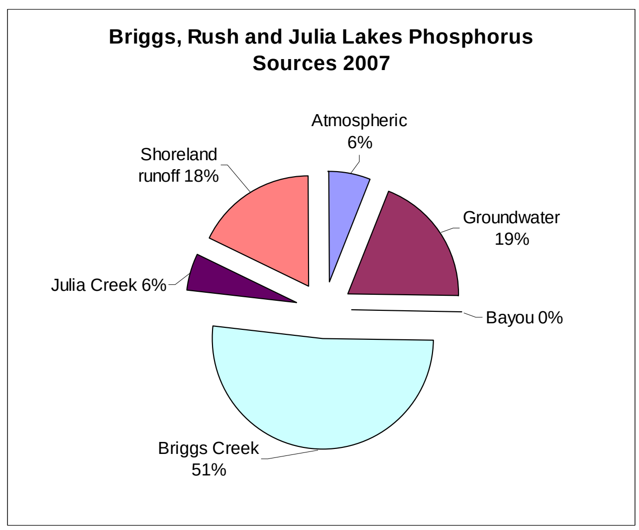
	Lbs. Phosphorus	Percent of input:
Atmospheric Deposition	65	5%
Net groundwater inflow	91	7%
Bayou inflow	634	46%
Briggs Creek inflow	396	28%
Julia Creek inflow	34	2%
Shoreland runoff	173	12%
Total inflow	1,393	
Lilly Creek outflow	1,179	

Table 2b. 2007 Phosphorus Mass Balance – Briggs Lake Chain

	Lbs. Phosphorus	Percent of input:
Atmospheric Deposition	57	6%
Net groundwater inflow	176	19%
Bayou inflow	0	0
Briggs Creek inflow	474	51%
Julia Creek inflow	53	6%
Shoreland runoff	164	18%
Total inflow	924	
Lilly Creek outflow	1,044	

Figure 3. Briggs Lake Chain Phosphorus Sources

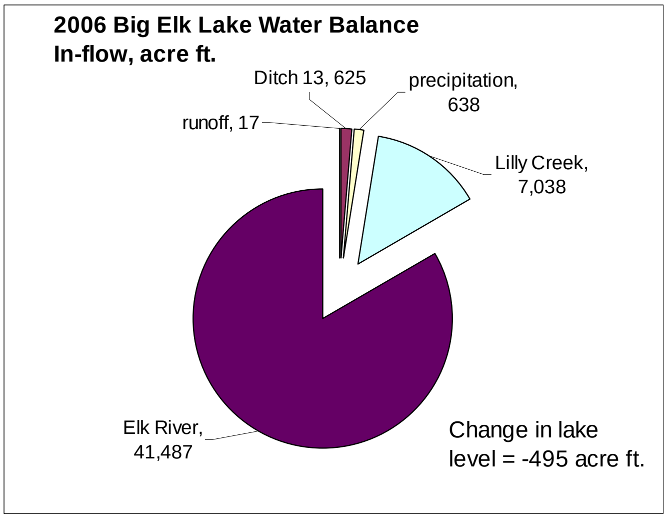


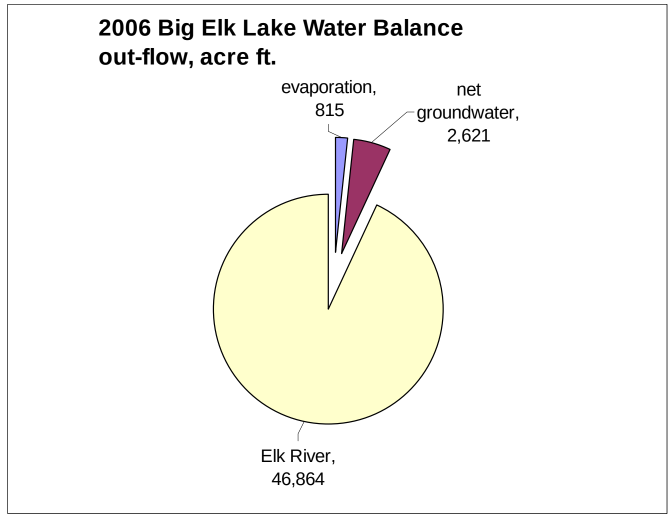


The inflow from the Briggs Lake Bayou in 2006 contributed 46% of the total phosphorus to the Briggs Lake Chain in that year. In contrast, for 2007 the input from the Briggs Lake Bayou was zero due to the fact that there was no measurable inflow through that channel. Briggs Creek was the most significant phosphorus source in 2007. In 2006, more phosphorus flowed into the Briggs Lake Chain than flowed out of the basin. In 2007, the total outflow of phosphorus was greater than the inflow. Estimates remain to be calculated for septic system sources and internal phosphorus loading. Direct runoff from the shoreland area is significant for the Briggs Chain contributing between 12% and 18% of the phosphorus budget. BMPs that reduce runoff should have a significant impact on water quality.

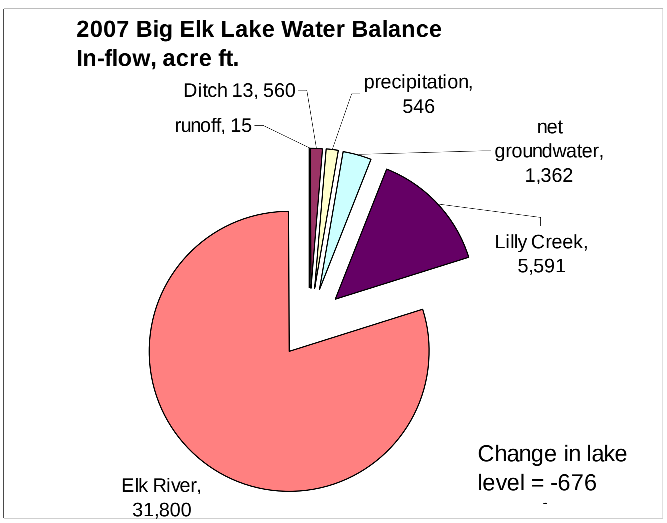
Figure 4. Big Elk Lake Water Balance

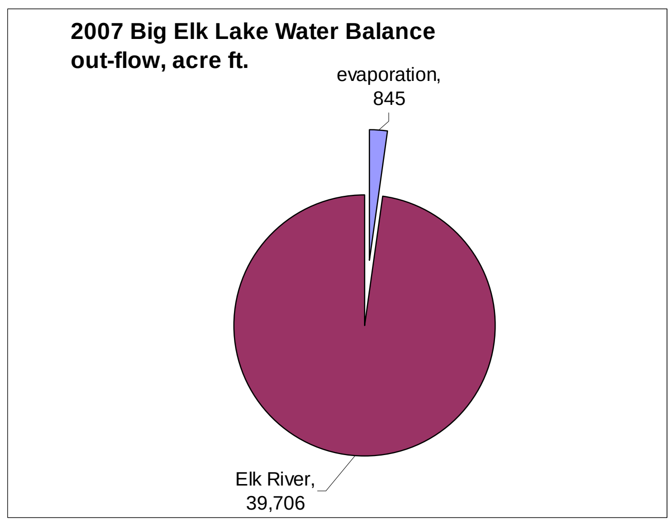
2006:





2007:





Stream flow was greater in 2006 reflecting the dryer conditions in 2007 as compared to average conditions prevailing in 2006. The water balances show a net groundwater outflow from the basin in 2006 and a net groundwater inflow in 2007.

In 2006 the level of Big Elk Lake dropped 1.39 feet during the monitoring period. In 2007 the lake level dropped 1.90 feet.

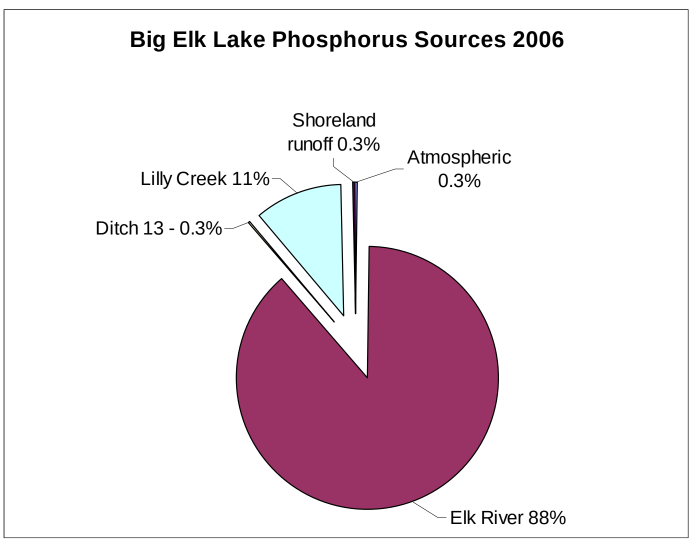
Table 3a. 2006 Phosphorus Mass Balance – Big Elk Lake

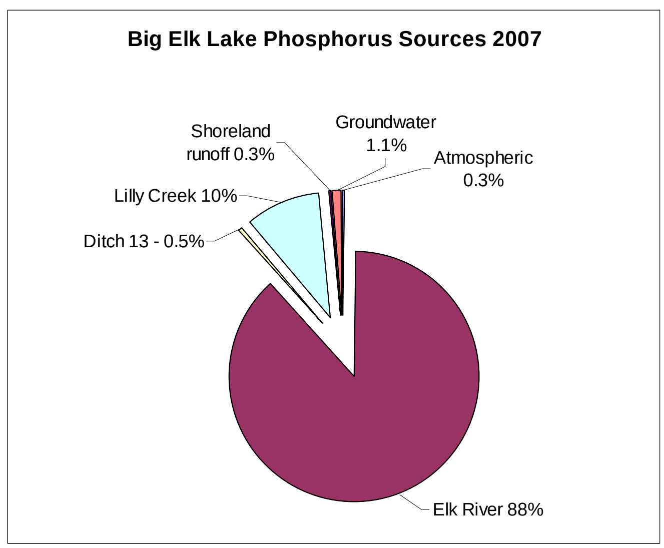
	Lbs. Phosphorus	Percent of input:
Atmospheric Deposition	32	0.3
Elk River inflow	9,633	88
Ditch 13 inflow	34	0.3
Lilly Creek inflow	1,179	11
Shoreland runoff	31	0.3
Total inflow	10,909	
Elk River outflow	9,973	
Net groundwater outflow	228	
Total outflow	10,201	

Table 3b. 2007 Phosphorus Mass Balance – Big Elk Lake

Phosphorus Inflow	Total Phos Lbs.	Percent of input:
Atmospheric Deposition	28	0.3
Elk River inflow	9,461	88
Ditch 13 inflow	50	0.5
Lilly Creek inflow	1,044	10
Shoreland runoff	29	0.3
Net groundwater inflow	119	1.1
Total inflow	10,731	
Elk River outflow	12,290	

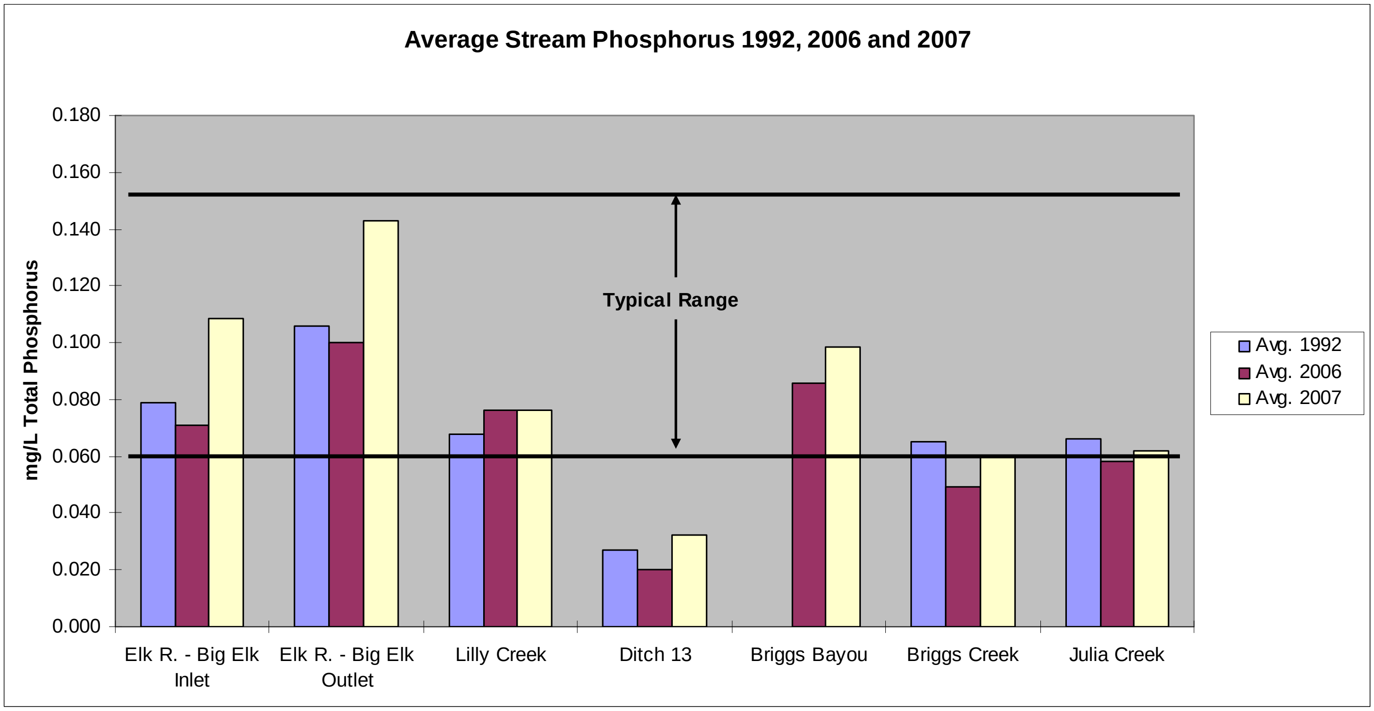
Figure 5. Big Elk Lake Phosphorus Sources





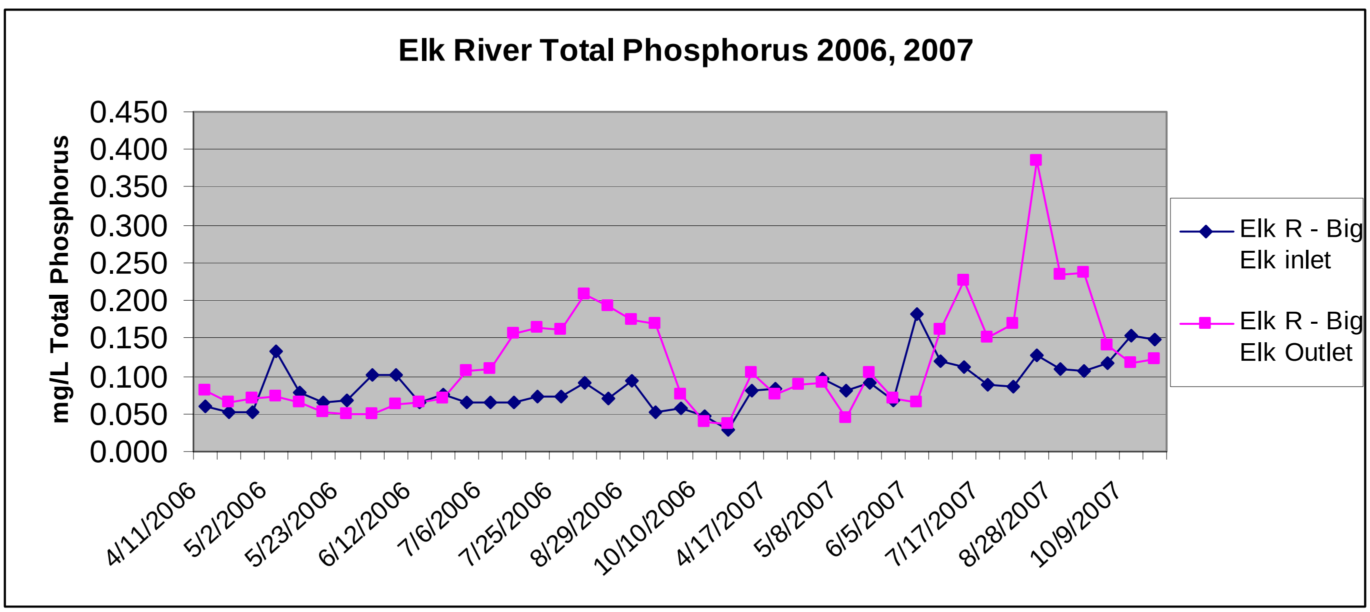
The Elk River is the major phosphorus source for Big Elk Lake. Lilly Creek is a significant source. Other sources are relatively small in comparison. In 2006, more phosphorus flowed into Big Elk Lake than flowed out of the basin. In 2007, the total outflow of phosphorus was greater than the inflow. Estimates remain to be calculated for septic system sources and internal phosphorus loading.

Figure 6a. Average Stream Phosphorus



Typical range: The 25 to 75 percentile range for the north central hardwoods forest eco-region (0.060 mg/L to 0.150 mg/L total phosphorus).

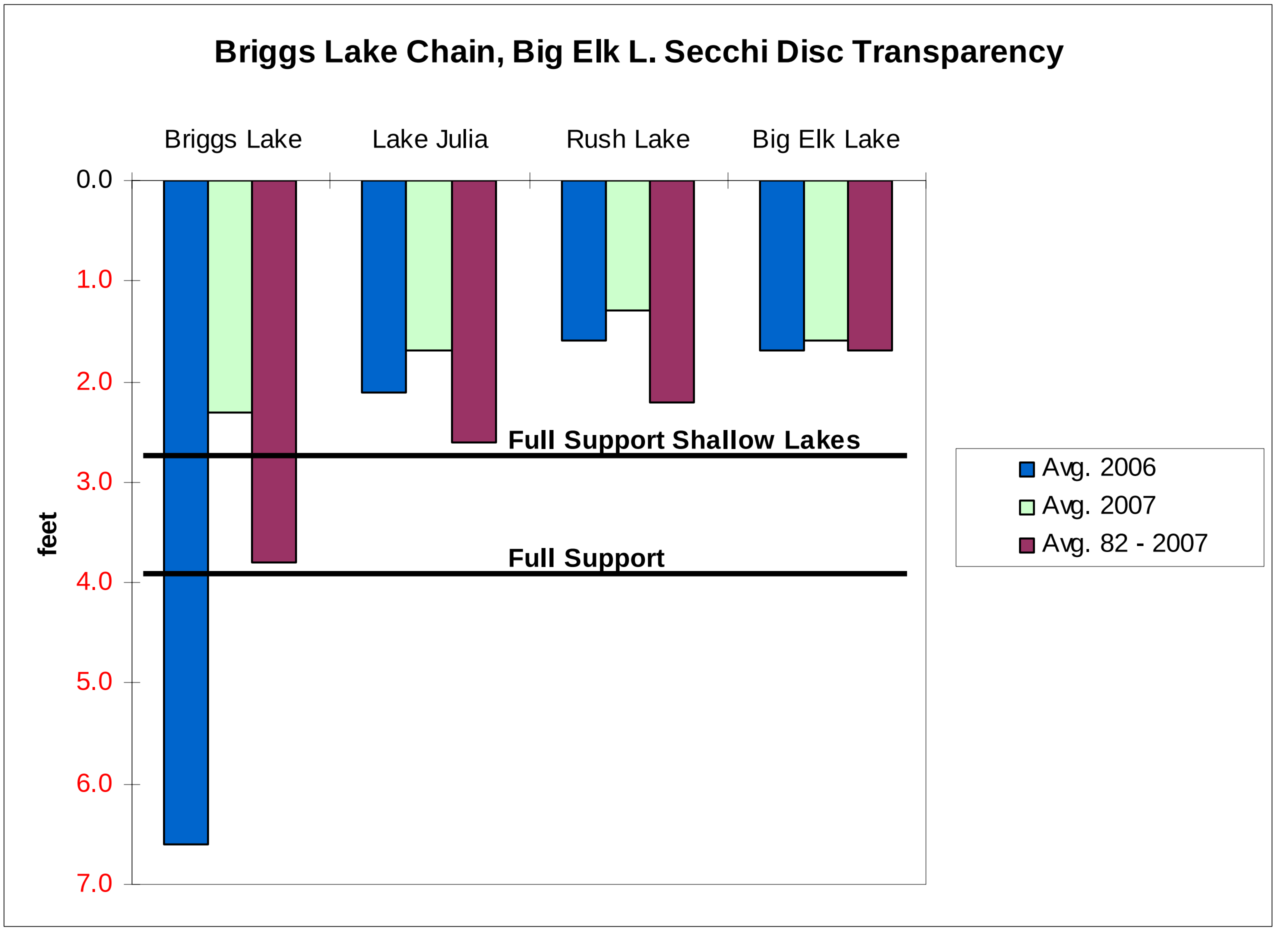
Figure 6b. Elk River Total Phosphorus.



Average stream total phosphorus concentration has been within the typical range for "minimally impacted" streams in the eco-region. For 2007, the average total phosphorus was significantly greater for the Elk River sites. For all the dates shown above, the average total phosphorus concentration for the Elk River outflow from Big Elk Lake was greater than the inflow concentration. This can be attributed to the phosphorus contribution from the Briggs Lake Chain via Lilly Creek and possibly due to internal loading within the basins.

4. Lake Water Quality

Figure 7. Secchi Disc Transparency



Full support criteria are based on water quality standards determined by the Minnesota Pollution Control Agency (Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria 3rd Edition, September 2005). Full support for deeper lakes is based on the desirability for recreation including swimming. Full support for shallow lakes is based on supporting a balance between algae and macrophytes (rooted plants). The threshold is set to minimize the chance of a shift toward algae dominance and frequent algae blooms. Lakes are considered shallow if the maximum depth is 15 feet or less or the littoral area is 80% or more. The littoral area is the portion of the lake that can support macrophytes (usually a depth of 15 feet or less).

Figure 8. Chlorophyll-a

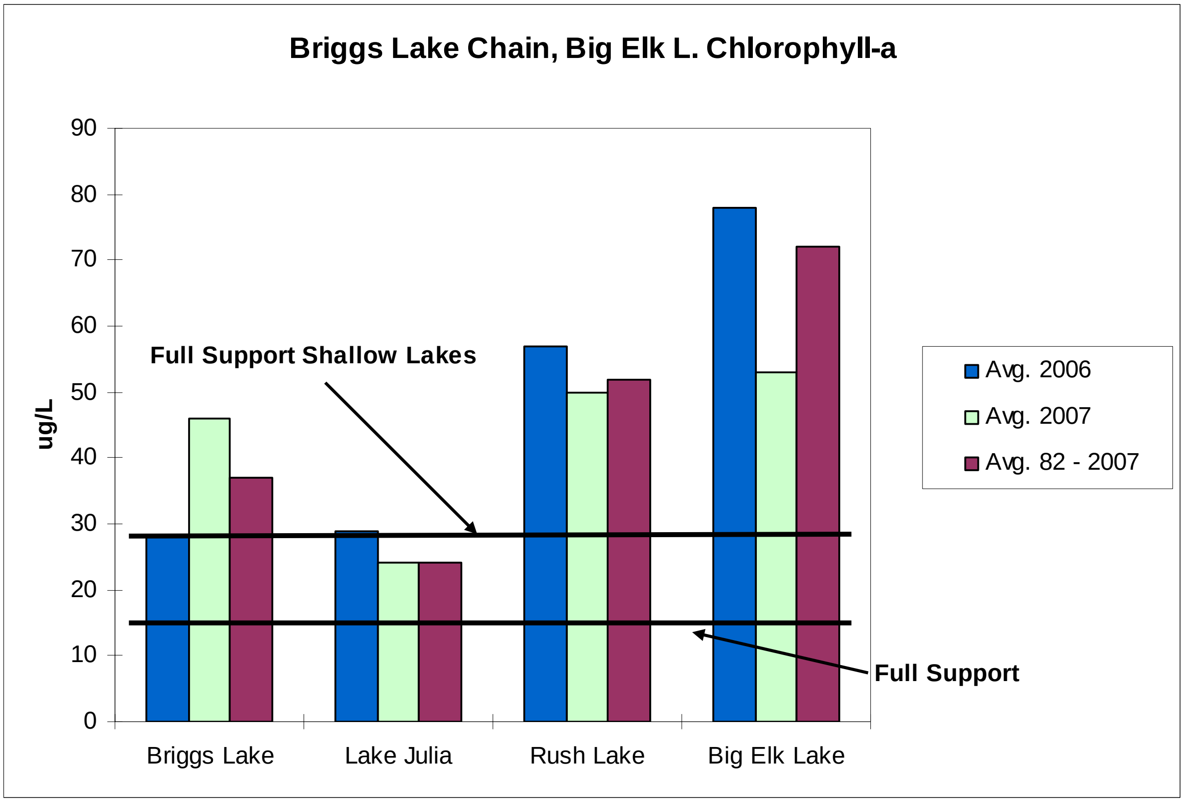
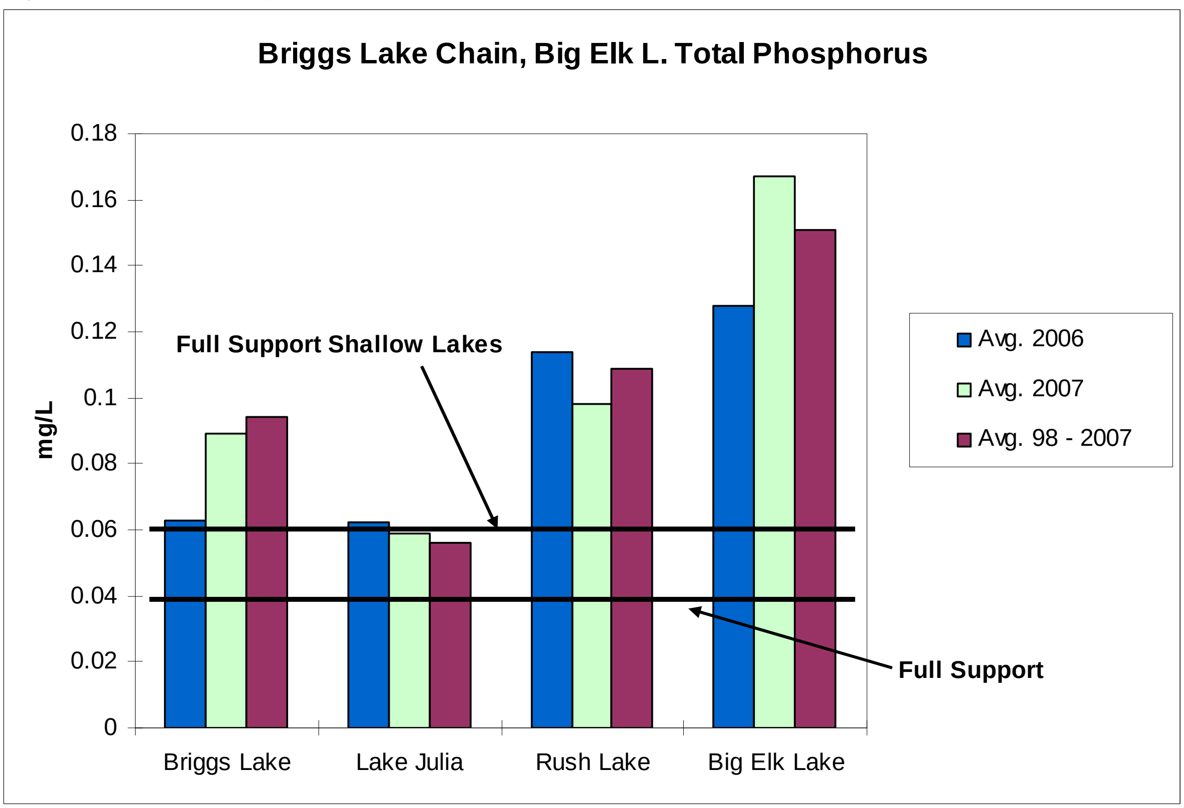
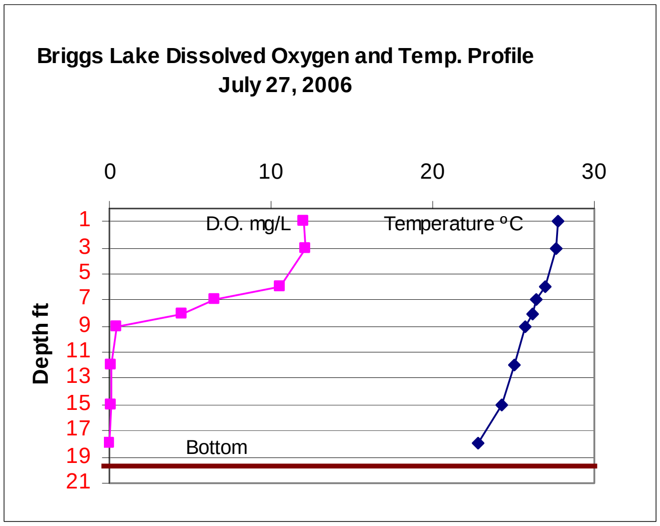


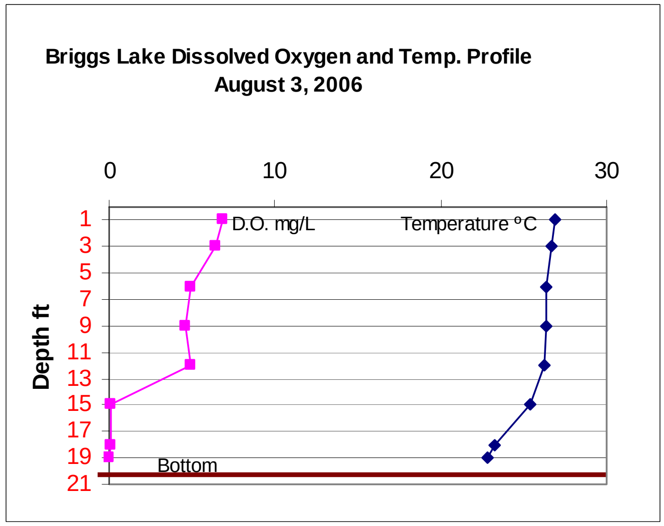
Figure 9. Total Phosphorus

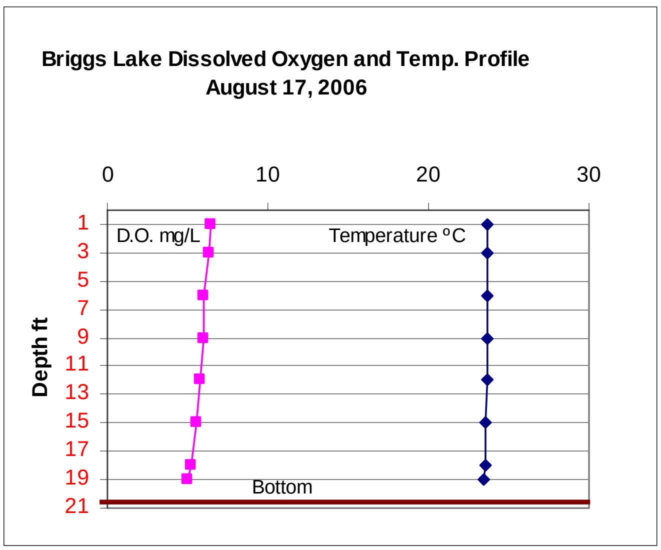


5. Lake Dissolved Oxygen and Temperature

Figure 10a. Briggs Lake 2006 D.O. and Temperature Profiles

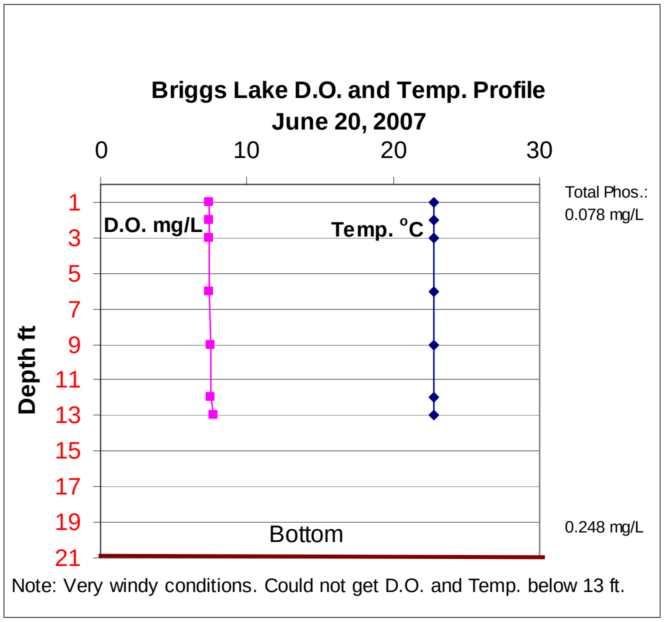


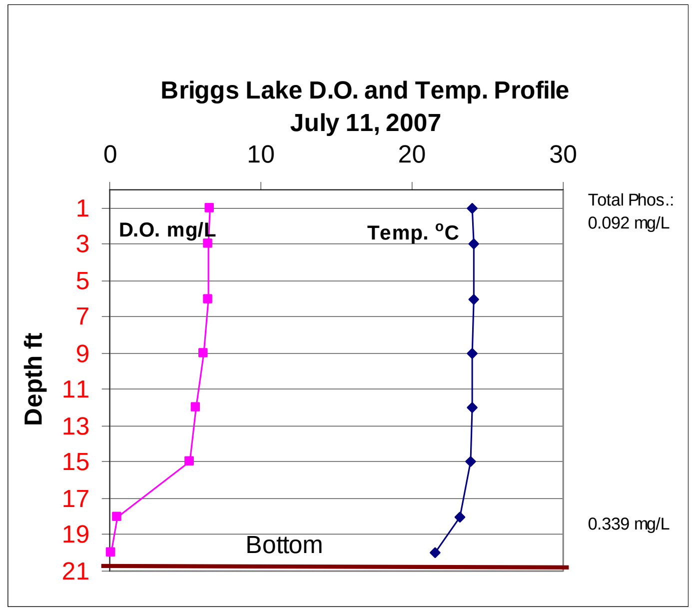


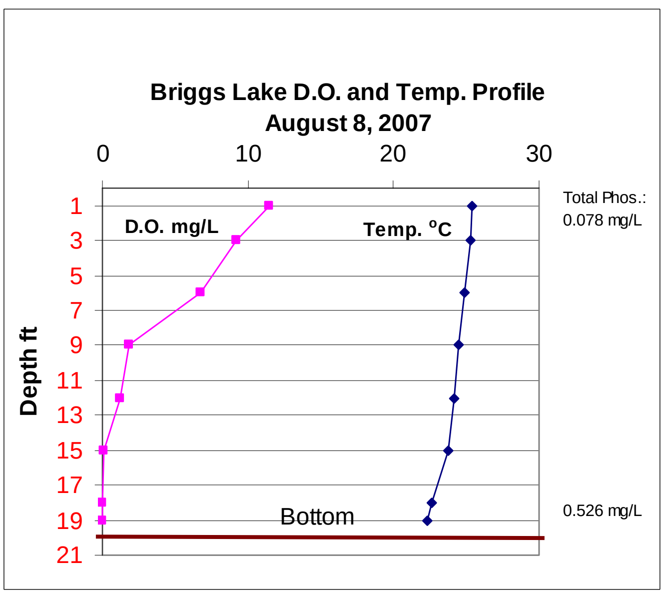


In 2006, Briggs Lake was stratified on July 27th and August 3rd. Stratification occurs in lakes during the summer months when colder, denser water near the bottom does not mix with the upper warmer layer of water. Deeper lakes tend to remain stratified all summer until the upper layer of water cools in the fall allowing mixing to occur. The upper strata of water is called the epilimnion and the deep strata is called the hypolimnion. Dissolved oxygen depletion in the hypolimnion is evident on July 27th and August 3rd. This occurs due to oxygen consumption by organic sediments at the bottom and the lack of mixing with well oxygenated water in the epilimnion. On August 17th there was very little change in D.O. and temperature with depth indicating mixing of the upper and deep water layers, probably due to wind. In 2006 Briggs Lake was intermittently stratified at the monitoring site.

Figure 10b. Briggs Lake 2007 D.O. and Temperature Profiles

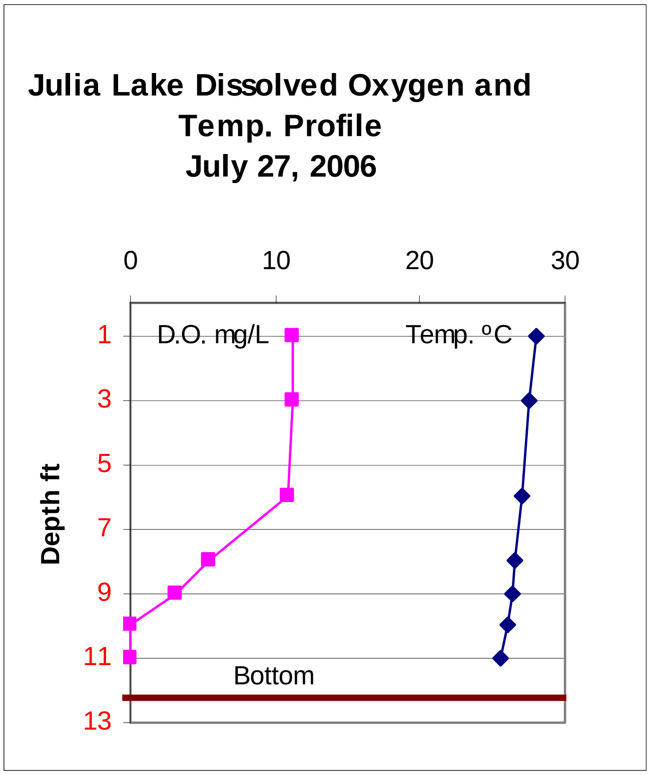


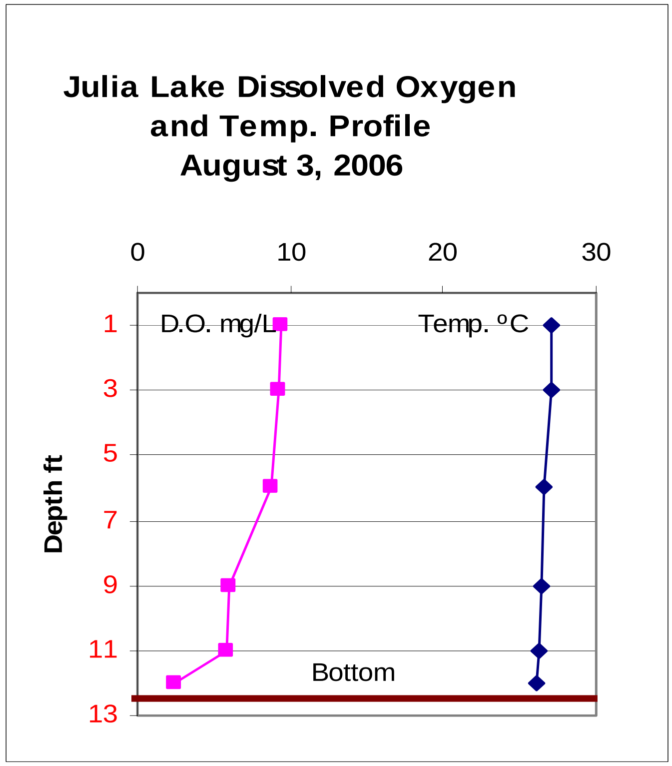


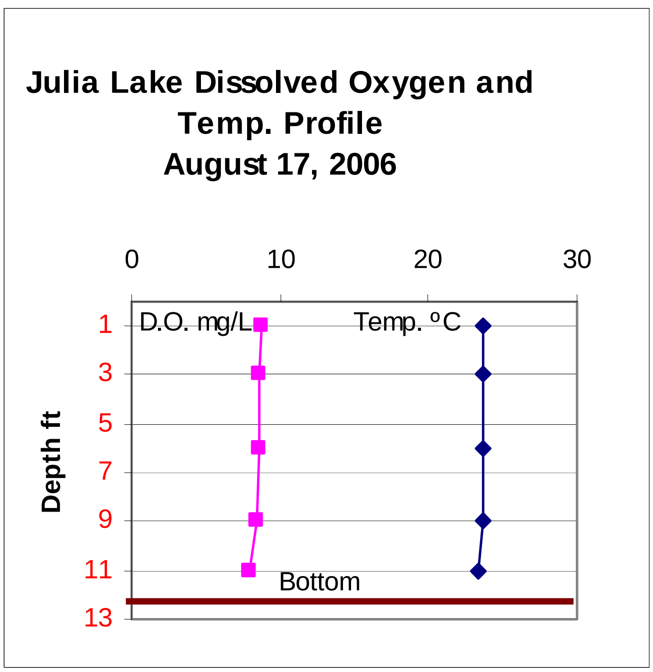


In 2007, stratification is evident on July 11th and August 8th. The profile for June 20th is incomplete because windy conditions made it difficult to anchor. In 2007, shallow (epilimnion) and deep (hypolimnion) total phosphorus samples were taken in conjunction with the profiles. The results are shown to the right of each graph at the approximate depth the sample was taken. On all dates, the hypolimnion total phosphorus level was significantly greater than in the epilimnion. This is an indicator of internal phosphorus loading from the bottom sediments. This type of internal loading occurs when dissolved oxygen is depleted in the bottom layer of water. The profiles show that the D.O. was close to zero in the hypolimnion on July 11th and August 8th. Phosphorus that is released from the sediments is not available for algae growth until the stratification breaks down and mixing of the upper and deep layers occurs.

Figure 11a. Lake Julia 2006 D.O. and Temperature Profiles

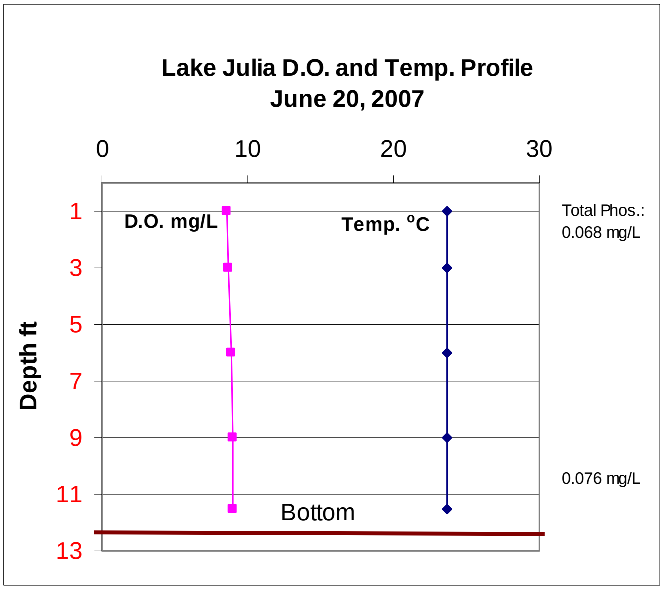


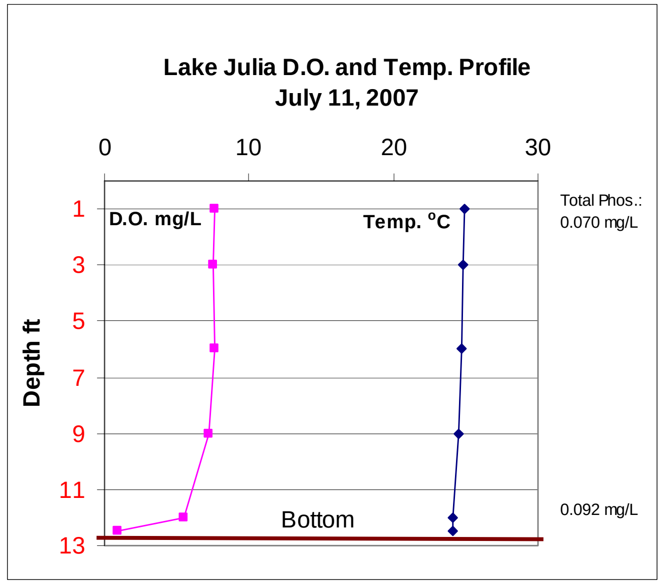


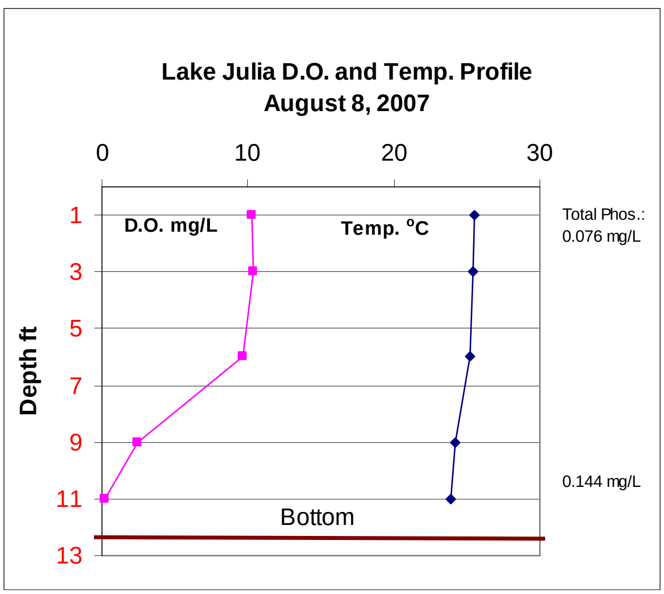


In 2006, profiles for Lake Julia showed dissolved oxygen depletion in the bottom layer on July 27th and August 3rd. Lake Julia appears to be stratified on July 27th. The profile for August 17th shows Lake Julia was well mixed from top to bottom on that date. In 2006, Lake Julia was intermittently stratified at the monitoring site.

Figure 11b. Lake Julia 2007 D.O. and Temperature Profiles

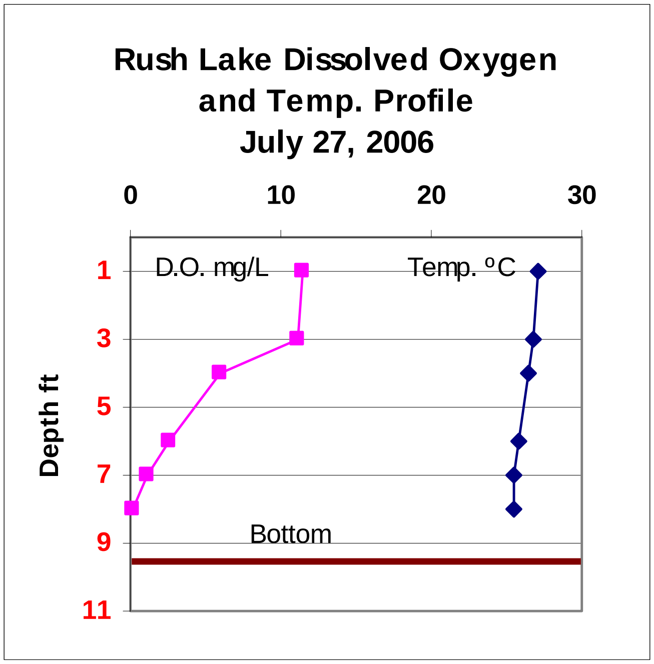


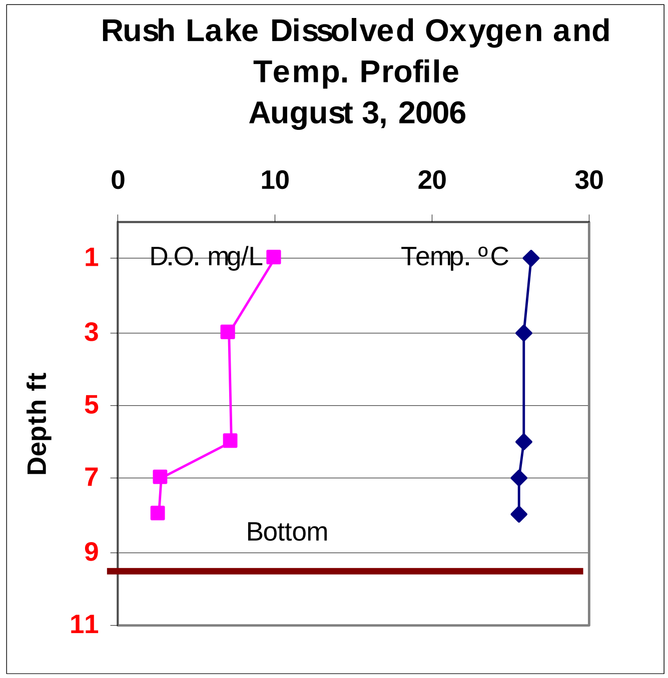


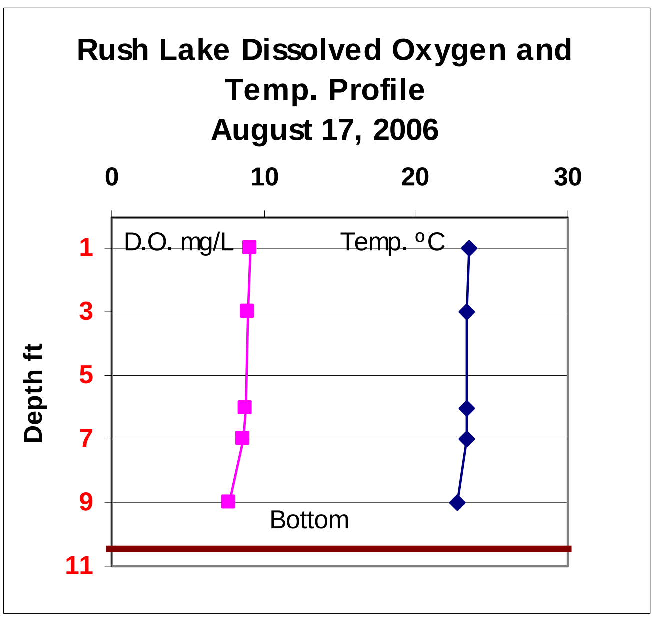


The 2007 profiles show that Lake Julia was well mixed from top to bottom on June 20th. Dissolved oxygen depletion near the bottom is evident on July 11th and August 8th. On July 11th, total phosphorus concentration was somewhat higher near the bottom than near the surface. Total phosphorus was significantly higher near the bottom on August 8th. This is an indication of internal loading of phosphorus from the bottom sediments. On August 8th, the decrease in temperature with depth and the large increase in total phosphorus concentration near the bottom indicate Lake Julia was stratified on that date. The 2006 and 2007 profiles indicate that Lake Julia is intermittently stratified during the summer at the monitoring site.

Figure 12a. Rush Lake 2006 D.O. and Temperature Profiles

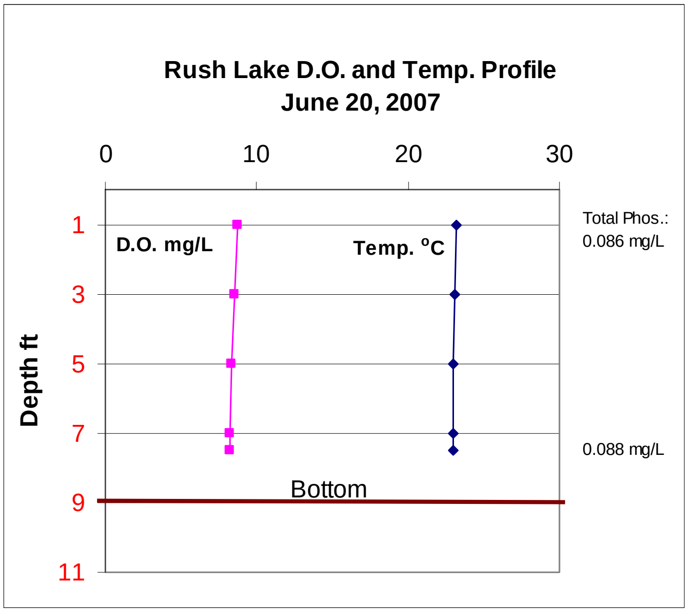


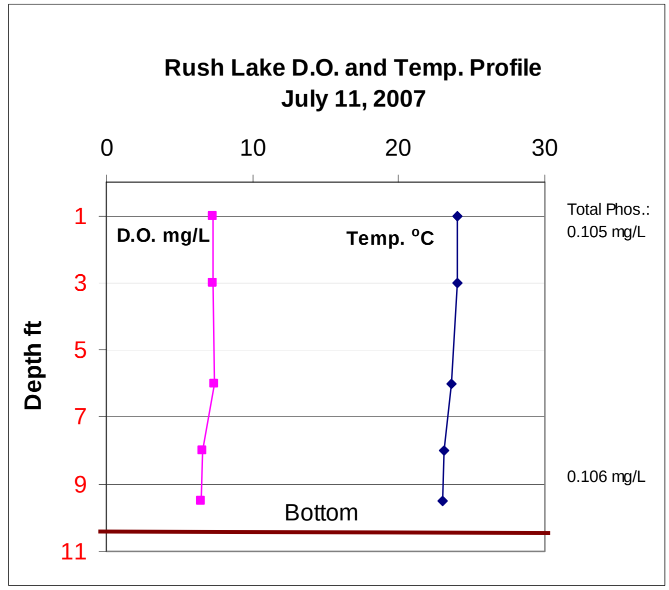


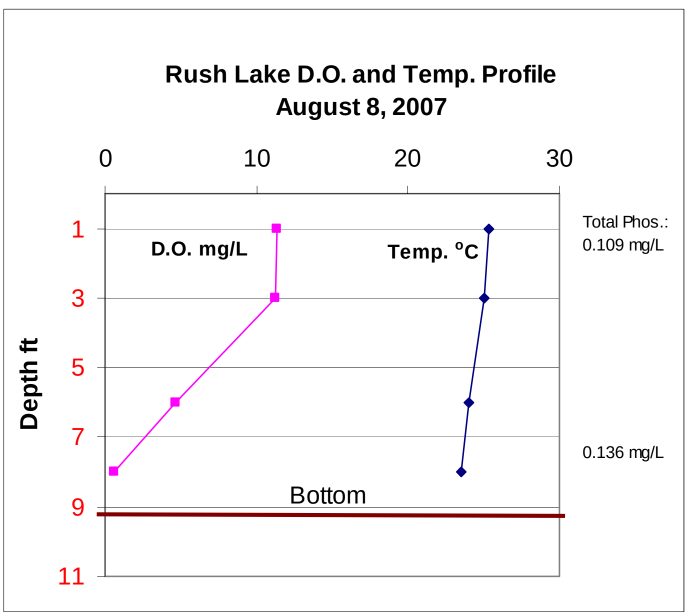


The 2006 profiles for Rush Lake show dissolved oxygen depletion in the bottom layer on July 27th and August 3rd. The decrease in temperature and dissolved oxygen with depth on July 27th indicates that Rush Lake was stratified on that date. On August 17th, Rush Lake was well mixed from top to bottom. Rush Lake was intermittently stratified in 2006 at the monitoring site.

Figure 12b. Rush Lake 2007 D.O. and Temperature Profiles

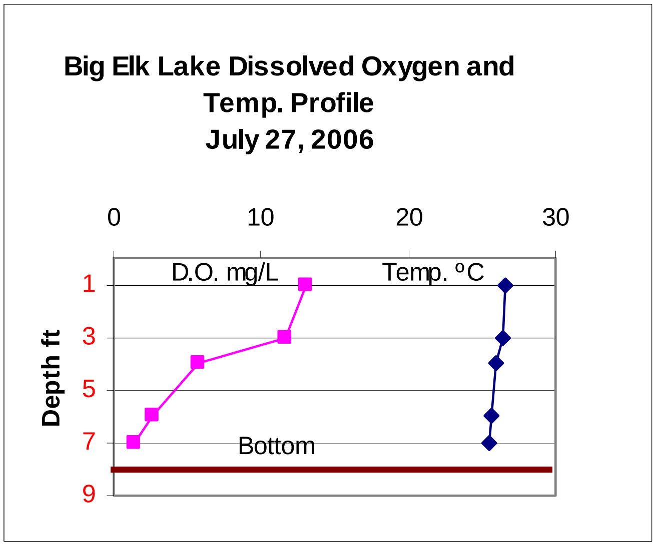


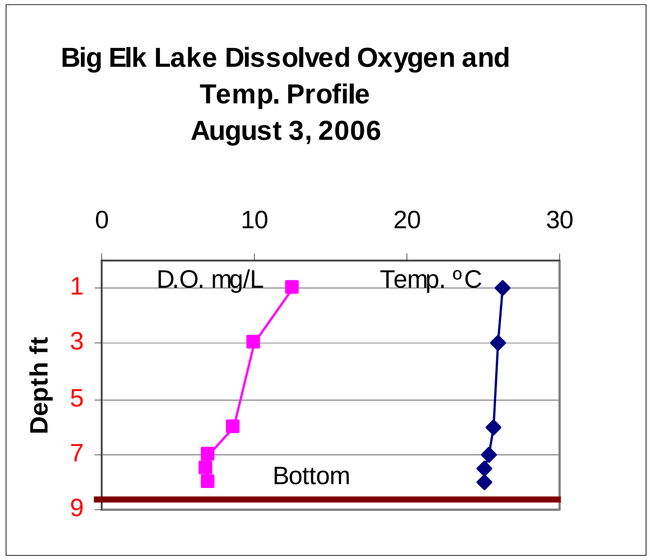


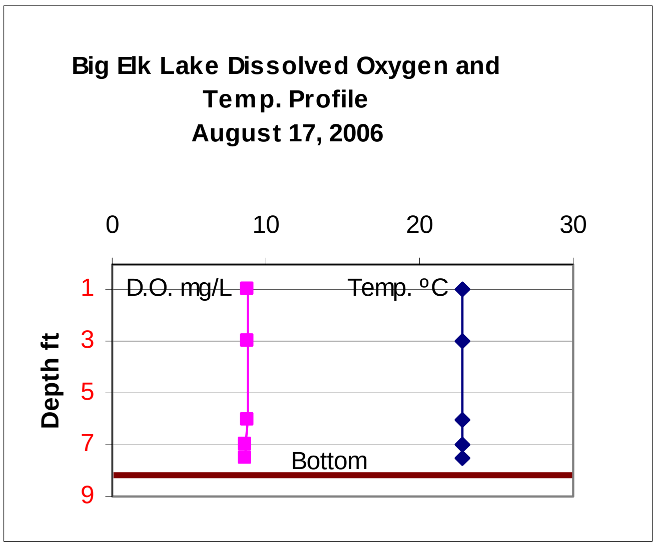


The 2007 profiles show that Rush Lake was well mixed from top to bottom on June 20th and July 11th. On August 8th, the decrease in temperature with depth and the depletion of dissolved oxygen and increase in total phosphorus near the bottom indicate stratification was occurring. The 2006 and 2007 profiles indicate that Rush Lake stratifies intermittently in the summer at the monitoring site.

Figure 13a. Big Elk Lake 2006 D.O. and Temperature Profiles

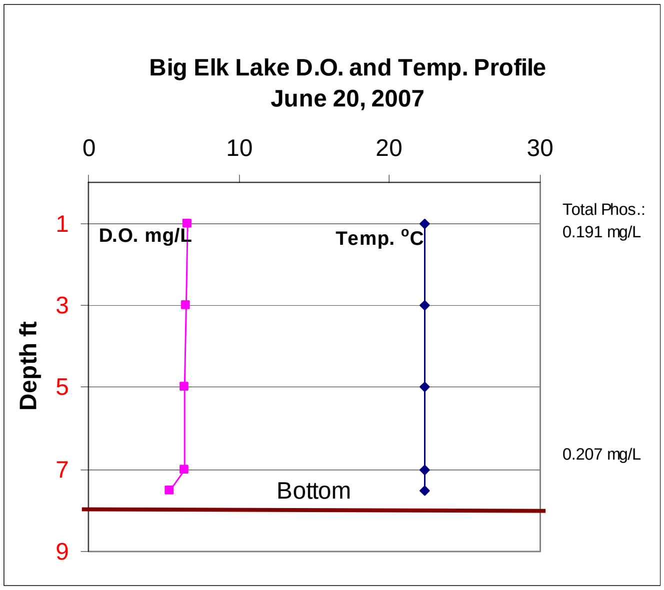


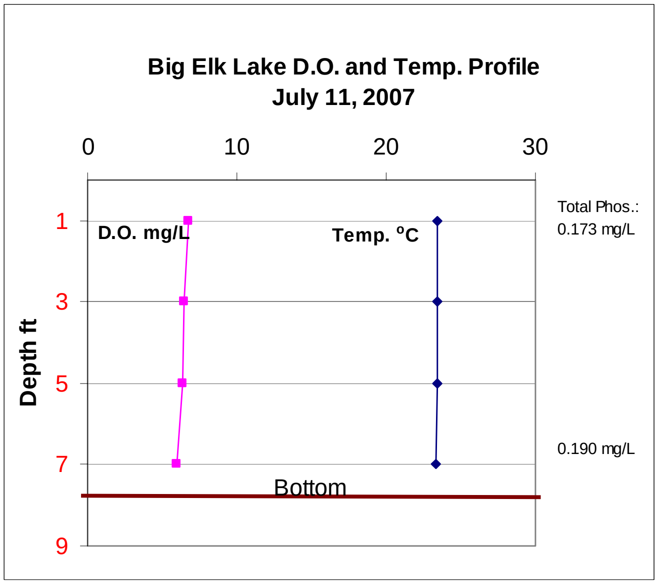


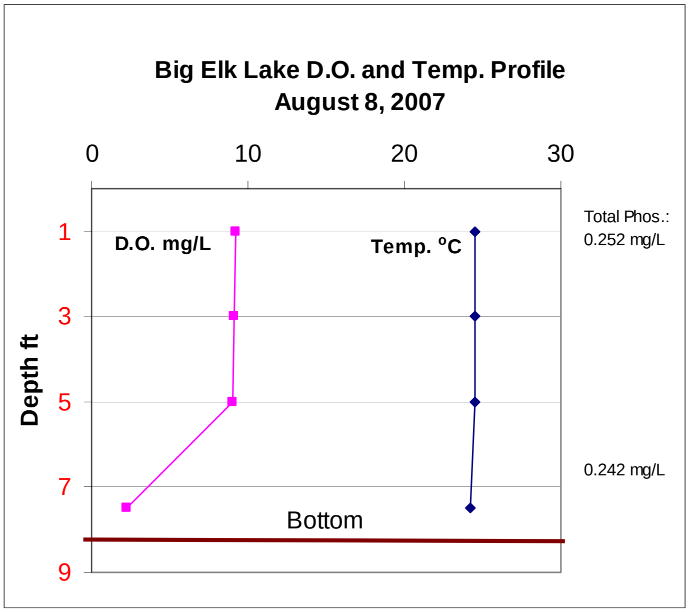


The 2006 profiles for Big Elk Lake show a small decrease in temperature with depth on July 27th and August 3rd. Significant oxygen depletion in the bottom layer is evident on July 27th indicating that the lake was stratified at that site on that date. The D.O. and temperature profile indicates Big Elk Lake was well mixed from top to bottom on August 17th.

Figure 13b. Big Elk Lake 2007 D.O. and Temperature Profiles







The 2007 temperature profiles show that Big Elk Lake was well mixed from top to bottom on all dates. Dissolved oxygen depletion was evident in the bottom layer on August 8th but the concentration of shallow and deep total phosphorus was similar. The shallow and deep phosphorus samples for all dates show very little tendency for phosphorus to accumulate near the bottom. The 2006 and 2007 profiles and shallow and deep total phosphorus samples indicate that generally the upper and deep water layers in Big Elk Lake were well mixed during the summer at the monitoring site. However, stratification can occur near the bottom on some dates.

5. Comparison of the 2006/2007 and the 1992 mass balance study of the Briggs Lake Chain and Big Elk Lake.

5.1 Precipitation, Streamflow and Phosphorus Levels

Precipitation differed for the 3 monitoring years. Precipitation for the 1992 hydrological year (October 1, 1991 to September 30, 1992) was 21.72 inches as compared to 31.28 inches for the 2006 and 23.09 for the 2007 hydrological years.

The large difference in precipitation between 1992 and 2006 is reflected in the total stream flow. For example, the total Elk River inflow to Big Elk Lake was 19,034 acre feet in 1992 and 41,487 acre feet in 2006. Fluctuations in precipitation appear to have less affect on Briggs Creek. The Briggs Creek inflow to Briggs Lake was 2,895 acre feet in 1992 and 3,245 acre feet in 2006.

The average total phosphorus levels were somewhat lower in 2006 as compared to 1992 (Figure 6a). However, because stream flow was much greater in 2006 the total phosphorus load for the Elk River inflow was 2.6 times greater in 2006 as compared to 1992. On the other hand, the annual phosphorus load for Briggs Creek was lower in 2006 as compared to 1992. Generally stream phosphorus concentrations were higher in 2007 as compared to 2006. Comparing 2006 and 2007 data, the average total phosphorus level at the Elk River inlet to Big Elk Lake increased from 0.071 mg/L to 0.108 mg/L and the outlet increased from 1.00 mg/L to 1.43 mg/L.

5.2 Differences Between the 1992 and 2006/2007 Mass Balance Calculations

Some differences in the phosphorus budget between the 2 studies can be attributed to differences in the estimates used for groundwater concentrations of phosphorus. There are also differences in the estimates for atmospheric deposition and the sources included in the phosphorus budgets.

In 1992, WRM used 0.060 mg/L for ground water phosphorus concentration based on their 1991 septic system leachate study. A ground water phosphorus concentration of 0.032 mg/L was used for 2006/2007 based on samples take from shallow wells.

The 1992 study used 0.5 lb/acre/yr as an estimated atmospheric deposition of phosphorus. Based on more recent data on atmospheric phosphorus deposition, 0.15 lb/acre/yr was used for the 2006 mass balance and 0.14 lb/acre/yr was used for 2007 (Detailed Assessment of Phosphorus Sources to Minnesota Watersheds, Vol. 1, Barr Engineering Co., February, 2004)

For the 2006/2007 study, an estimate of phosphorus loading from direct runoff from the lake shore area was included. This data was calculated using the method described in Appendix L of The Minnesota Stormwater Manual, Minnesota Pollution Control Agency, 2005. Contribution for runoff from the shoreland area was not estimated in 1992.

The 2006/2007 study included phosphorus loading for the Briggs Lake Bayou inflow. Data for the Bayou were not included in the 1992 study. The Bayou typically flows into the Briggs Lake Chain when the Elk River over flows its banks. It is possible this did not occur in 1992 given the below average precipitation for that year. Significant inflow from the Bayou to Briggs Lake occurred in 2006 but not in 2007.

The 1992 study included an estimate of septic system phosphorus loading based on the 1991 septic leachate study. The 1991 data probably does not reflect the current status of septic systems on the lakes. An updated estimate for septic system sources of phosphorus remains to be added to the 2006/2007 mass balance study. Methods to estimate septic system contributions should be investigated.

5.3 The following tables and graphs are taken from 1992 Water Quality Monitoring Report Briggs Chain of Lakes Sherburne Co., MN by Water Research and Management Inc.

Table 4

1992 Water Quality Monitoring Report
Briggs Chain of Lakes

Briggs, Rush and Julia Hydrologic Budget
1992

	Water		
INCOME	acft/yr	hm³/yr	Percent
Briggs Creek (BC-1)	2,895	3.57	47
Julia Creek (J1)	154	.19	3
Groundwater	2,114	2.61	34
Precipitation	997	1.23	16
TOTAL IN	6,160	7.60	100
OUTGO			
Lilly Creek (LC)	5,320	6.56	78
Evaporation	1,523	1.88	22
TOTAL OUT	6,843	8.44	100
CHANGE IN STORAGE	-683	-0.85	

Source: FLUX Computer Modeling
* Groundwater by difference
Minus 683 acft is equal to a 13-inch drop in lake level.

Table 5

1992 Water Quality Monitoring Report
Briggs Chain of Lakes

Briggs, Rush and Julia Phosphorus Budget
1992

INCOME	lb/yr	kg/yr	Percent
Briggs Creek (BC-1)	561	255	42
Julia Creek (J1)	29	13	2
Groundwater	343	156	26
Atmospheric	315	143	24
Septic Leachate	80	36	6
TOTAL IN	1,328	603	100
OUTGO			
Lilly Creek (LC)	862	391	100
TOTAL OUT	862	391	100
CHANGE IN STORAGE	+466	+212	(+16)

Figure 14

BRIGGS, RUSH AND JULIA

1992 ANNUAL PHOSPHORUS BUDGET

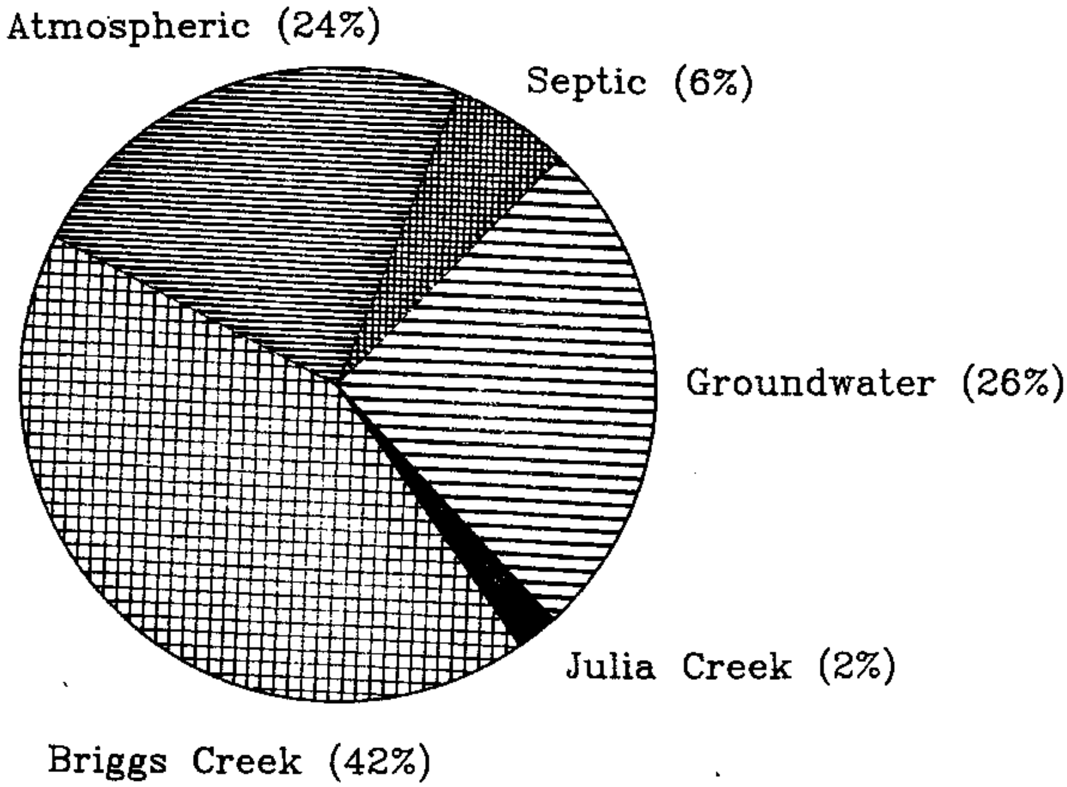


Table 6

1992 Water Quality Monitoring Report
Briggs Chain of Lakes

Elk Lake Hydrologic Budget
1992

		Water	
INCOME	acft/yr	hm^3/yr	Percent
Lilly Creek (LC)	5,320	6.56	21
Elk River (EL1)	19,034	23.47	75
Elk Creek (EL2)	316	.39	1
Groundwater	300	.37	1
Precipitation	570	.70	2
TOTAL IN	25,541	31.49	100
OUTGO			
Elk Lake Outlet (ELO)	26,220	32.33	97
Evaporation	870	1.07	3
TOTAL OUT	27,090	33.40	100
CHANGE IN STORAGE	-1,549	-1.91	

Source: FLUX Computer Modeling
* Groundwater by difference
Minus 1,549 acft is equal to a 18.8 inch drop in lake level.

Table 7

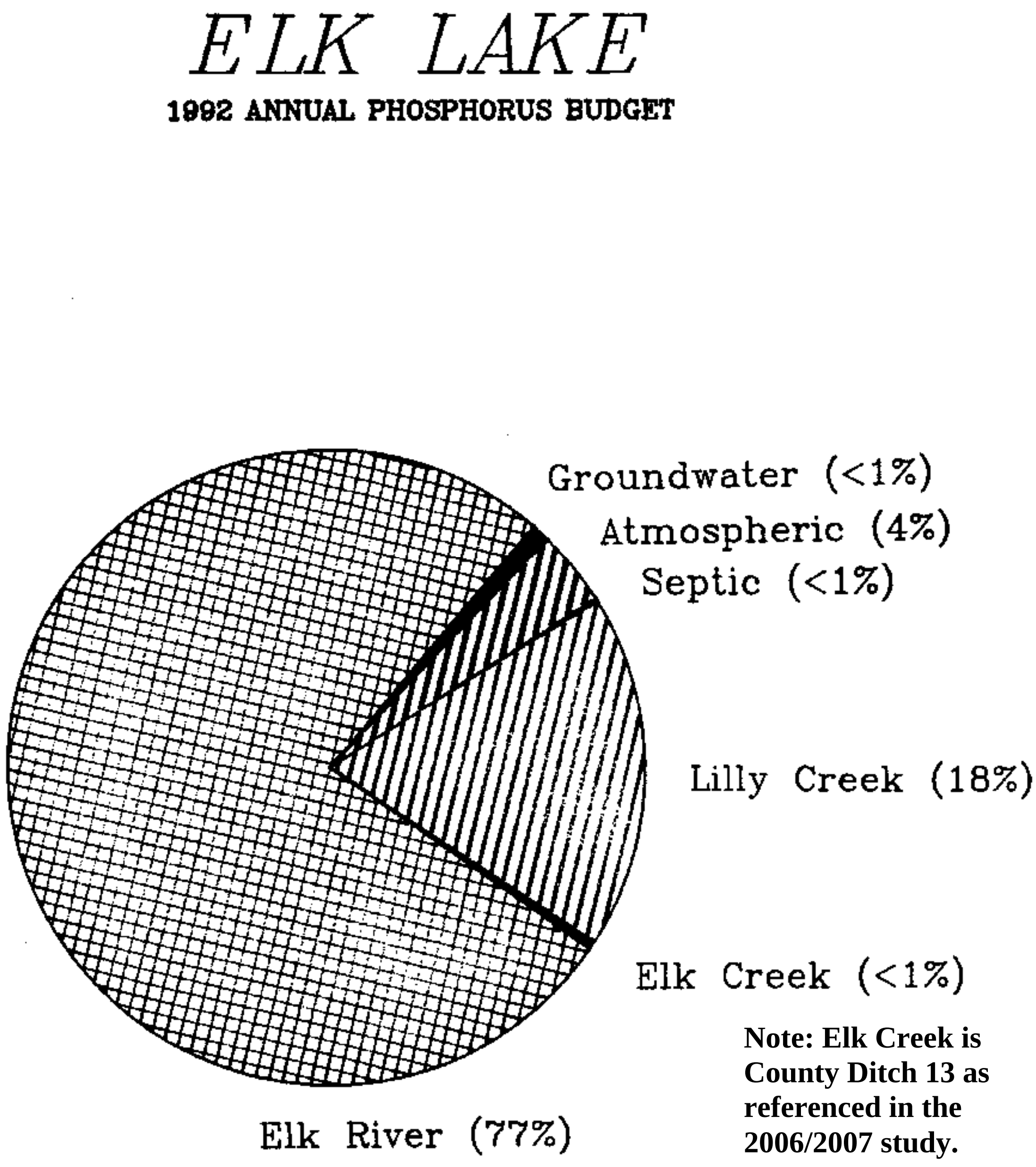
1992 Water Quality Monitoring Report
Briggs Chain of Lakes

Elk Lake Phosphorus Budget
1992

INCOME	lb/yr	kg/yr	Percent
Lilly Creek (LC)	862	391	18
Elk River (ELI)	3,687	1,674	77
Elk Creek (EL2)	24	11	<1
Groundwater	49	22	<1
Atmospheric	180	82	4
Septic Leachate	12	6	<1
TOTAL IN	4,814	2,186	100
OUTGO			
Elk Lake Outlet (ELO)	6,930	3,146	100
TOTAL OUT	6,930	3,146	100
CHANGE IN STORAGE	-2,116*	-961	

* More phosphorus left the lake than came into the lake

Figure 15



Note: Elk Creek is County Ditch 13 as referenced in the 2006/2007 study.