Lake Poinsett Water Quality Investigative Report
January 2009
South Dakota Department of Environment and Natural Resources
Water Resources Assistance Program (WRAP)-Watershed Protection
Water Rights Program

Introduction

Lake Poinsett is a windswept prairie lake located in the glaciated region of eastern South Dakota. The lake is one of the largest natural waterbodies in South Dakota with a surface area of 7,868 acres and an average depth of 9.5 feet at outlet elevation (1650.5 feet above mean sea level). Moderate shoreline development exists around the lake with numerous homes, businesses and public access points. Lake Poinsett is a popular recreational lake located in close proximity to the following communities: Lake Norden, Estelline, Arlington, Watertown and Brookings.

The immediate watershed encompasses approximately 250,000 acres with surface water contributions from Dry Lake to the north and Lake Albert to the west. Lake Albert receives outflow from Marsh Lake, Lake Norden, Lake Mary and Lake St. John commonly referred to as the western chain of lakes. Lake Poinsett has a long history of considerable lake fluctuation. In 2006, the lake fell 4.1 feet below the outlet elevation. (DENR Water Rights Program).

Lake Poinsett is directly and indirectly connected to the Big Sioux River. In 1929, the Boswell diversion was constructed to assist in stabilizing water levels in Lake Poinsett. The Boswell diversion consisted of a mechanical gate (dam) constructed on the Big Sioux River mainstem which could be used to divert upstream flow through a gated diversion ditch into Dry Lake and eventually into Lake Poinsett. Flooding and water quality issues later sparked a series of management plans regarding operation of the diversion. For instance, one management plan prohibits opening the diversion gates when Big Sioux River water quality is poorer than that in Lake Poinsett. A summarization of the purpose and history of the Boswell diversion is presented in Appendix A. Copies of the various water rights associated with the Boswell diversion can be obtained by contacting the DENR Water Rights Program.

The natural outlet of Lake Poinsett is a linear wetland channel that adjoins to the Big Sioux River approximately 2 miles downstream of the lake (Appendix B). Historically, flood waters from the Big Sioux River back-flowed to the lake. Lake Poinsett's connectivity to the Big Sioux River increased the total watershed drainage area an additional 470,000 acres to approximately 720,000 acres. Following a major flood event that caused extensive damage to lake property in 1986, a control (gated) structure was constructed at the natural outlet to prevent backflow from the Big Sioux River. The structure was completed in 1989 and first operated in June 1991. The outlet elevation was established at 1650.5 feet above mean sea level.

The gated structure on the natural outlet is authorized and regulated by Flood Control Permit FC-5 issued by the state Water Management Board and held by the Lake Poinsett Water Project District. The operation plan does not allow the gates to be used in a manner to raise the water level of Lake Poinsett by diverting Big Sioux River water into the lake. The purpose of the gated structure and flood control permit is to reduce flood damage, bank erosion, and nutrient loading into Lake Poinsett.

Water levels in Lake Poinsett have receded steadily since 2002 due to the onset of a dry cycle in eastern South Dakota. Local concerns surrounding the decreasing water levels have sparked the Lake Poinsett Water Project District and several local patrons to question the use of the Big Sioux River, in particular the Lake Poinsett outlet channel as a method to resolve low water issues. Growing interest to use the Big Sioux River as a supplemental water source prompted DENR to conduct a water quality and hydrologic investigation. Personnel from the Water Resources Assistance Program and the Water Rights Program collaborated. Results of this effort were compiled into this comprehensive report.

Goal and Objectives

The primary goal of the water quality portion of this investigation was to compare phosphorus concentrations and loading from the immediate watershed to potential inputs from the Big Sioux River and describe the in-lake phosphorus response of Lake Poinsett to each load source.

Objective 1: Attain phosphorus concentrations from all main sources of water to Lake Poinsett including the Big Sioux River.

Objective 2: Estimate potential water volumes and phosphorus loading the Big Sioux River may have contributed over the period of record.

Data Collection and Methods

Phosphorus samples were collected during the spring and early summer of 2007 and 2008 from a suite of monitoring sites within the immediate watershed of Lake Poinsett and the Big Sioux River (Appendix B). All sample collection and equipment operations were conducted according to methods described in the SD DENR Standard Operating Procedures for Field Samplers manual (2005). Water samples were analyzed by the State Health Laboratory in Pierre, SD. Water level and periodic flow measurements were monitored from Dry Lake and sources above Lake Poinsett. In 2008, continuous stage recorders were installed at the Lake Albert outlet channel off Highway 81 and the Lake Poinsett outlet channel 1 mile downstream of Lake Poinsett between the outlet structure (T39A) and the Big Sioux River confluence. In addition, staff gages were installed in Dry Lake, Lake Albert and Lake Poinsett to periodically monitor lake levels. All recorded stage information was converted to feet mean sea level (fmsl) using 1929 datum (DENR Water Rights Program).

Long-term Big Sioux River phosphorus data was acquired from DENR's Surface Water Quality Program. The long-term (1977-2008) phosphorus dataset constituted monthly samples collected during the ice-free periods (March-October) from two ambient water quality monitoring stations (water quality monitoring station-WQM 1 South of Watertown and Big Sioux-BS08 near Estelline) in closest proximity to Lake Poinsett (Appendix A). Long-term Lake Poinsett trophic state (i.e., total phosphorus, Secchi and chlorophyll-*a*) data was acquired from Water Resources Assistance Program's Statewide Lakes Assessment Project (1989-2008) and the 1994 assessment project (SD DENR, 1996). The water quality data from all monitoring efforts are included in Appendix D.

Estimates of average daily flow volumes from the Big Sioux River into Lake Poinsett were based on 31 years (1977-2008) of flow record obtained from the U.S. Geological Survey's gage station near Castlewood, SD. Several sequential steps were required to convert the U.S. Geological Survey flow data to feet mean sea level and apply it back to Lake Poinsett inflow.

1). Developed equation to convert average daily flow from U.S. Geological Survey gage to daily stage.
2). Developed equation to relate Big Sioux River stage to Lake Poinsett outlet channel stage.
3). Establish long-term daily stage for Lake Poinsett outlet channel
4). Converted long-term modeled Lake Poinsett outlet channel stages to elevation (feet mean sea level).
5). Related long-term daily elevations at Lake Poinsett outlet channel to the outlet elevation on Lake Poinsett.
6). Converted estimated elevations at Lake Poinsett outlet channel to inflow at Lake Poinsett.

The hydrologic software program <u>Aquarius</u> was used to develop rating curves and best fit models to relate stage on the Big Sioux River to stage at Lake Poinsett outlet channel. The elevation data was related to the outlet structure at Lake Poinsett to estimate water height over head of the outlet weir (1650.5 feet mean sea level.). Daily discharge based on corresponding modeled long-term daily stages at the Lake Poinsett outlet channel was estimated based on the following weir equation.

$$CFS = 3.33\ (20-0.2H)\ H^{1.5}$$

Where 3.33 and 0.2 are constants, H represents head or water height and 20 is the distance in feet between a single section on the outlet structure.

The outlet structure contains three equally spaced gated sections (Appendix B). Discharge at a given elevation was calculated for a 20 foot section and then multiplied by three to estimate total discharge across the structure. Flow estimates were likely liberal due to limitations associated with the weir equations ability to compensate for obstructions and restriction caused by the lake-side shape of the wing walls.

Results and Discussion

In 2007, all primary water sources to Lake Albert including the chain of lakes upstream began to contribute water to the Lake Albert basin. In addition, Dry Lake reached outlet elevation and began to contribute minimal inflow to Lake Poinsett. In 2008, water levels continued to increase and both Lake Albert and Dry Lake contributed inflow to Lake Poinsett. The final inputs were relatively minor as Lake Poinsett remained 2.9 feet below outlet elevation in the fall of 2008.

Phosphorus concentrations varied significantly between the Big Sioux River sites and outflows from Dry Lake and Lake Albert including waterbodies associated with the immediate watershed (Table 1). Average phosphorus concentrations were highest for the Big Sioux River sites in comparison to outflows from Dry Lake and the western chain of lakes. The Big Sioux River concentrations demonstrate a wide range of values which contribute extreme deviation from the mean. This variation is likely due to several environmental factors associated with a riverine system that flows through a relatively large agricultural landscape. The lake outlet concentrations display less variability in comparison, perhaps due to more stable upstream basin effects.

Table 1. Summary statistics for phosphorus concentrations (mg/L) within the immediate watershed and Big Sioux River based on all available data.

Location	Station	Code	# samples	Average	Standard Deviation	Range
Big Sioux River	S. Watertown (WQM)	WQM1	193	0.71	+/- 0.64	4.1 -- 0.095
Big Sioux River	Near Estelline (WQM)	BS08	56	0.36	+/- 0.15	0.81 -- 0.083
Big Sioux River	Near Lake Poinsett	BSR 18.5	17	0.43	+/- 0.25	1.26 -- 0.163
Big Sioux River	Boswell Diversion	T38	3	0.79	+/- 0.37	1.2 -- 0.5
Poinsett Outlet Gate	River-side of Gate	T39	7	0.74	+/- 0.38	1.18 -- 0.28
Dry Lake Outlet	Stone Bridge	DLO	15	0.34	+/- 0.13	0.703 -- 0.197
Lake Albert Outlet	Highway 81 culvert	LAO	9	0.17	+/- 0.07	0.345 -- 0.108
Lake Norden Outlet	Spillway	LNO	13	0.17	+/- 0.06	0.287 -- 0.116
Marsh Lake Outlet	culvert	MLO	2	0.12	+/- 0.02	0.139 -- 0.106
Lake St. John Outlet	Bridge	LSJO	13	0.34	+/- 0.55	2.13 -- 0.115
Lake Poinsett	composite	LP1,2,3	109	0.13	+/- 0.06	0.3—0.03

Lake Poinsett has lower phosphorus concentrations in comparison to Dry Lake and the western chain of lakes. Lake Poinsett's average summer (May-August) phosphorus concentration based on available data from 1989-2008 was calculated at 0.13 mg/L. Lake Poinsett's relatively large volume and downstream position in the watershed likely attribute to lower phosphorus levels than the upstream basins. The upstream basins likely provide nutrient and sediment retention and thus reduce loading to Lake Poinsett. Nonetheless, the average summer phosphorus concentration of Lake Poinsett reflects a level above that required to support significant algae biomass (0.07 mg/L) with an algae community dominated (>80%) by blue-greens or cyanobacteria (Downing et al. 2001).

The water quality goal for Lake Poinsett was a 40% reduction in watershed phosphorus contributions and an in-lake phosphorus concentration target of 0.07 mg/L (SD DENR, 1996). This goal was established to reduce algal biomass and protect the recreational value of Lake Poinsett.

Lake Poinsett has received minimal to no phosphorus loading from the immediate watershed since 2002. Algae production in Lake Poinsett has decreased significantly in recent years compared to wet years observed in the 1990s (Figure 1). As a result, water clarity has also shown similar improvement. The average 2008 summer Secchi depth was recorded at 8.5 feet (Figure 2). The relative improvement of these trophic state indicators demonstrates Lake Poinsett's sensitivity to annual phosphorus loading. This is also supported by the 1994 assessment which found relatively high phosphorus loads associated with increased algal biomass and decreased water clarity. The lack of watershed phosphorus loading since 2002, coupled with low algae biomass and increased water clarity triggered a shift in lake primary production. Aquatic macrophyte (plants) communities began to establish (2004) in the littoral zone or shallower shoreline areas of Lake Poinsett.

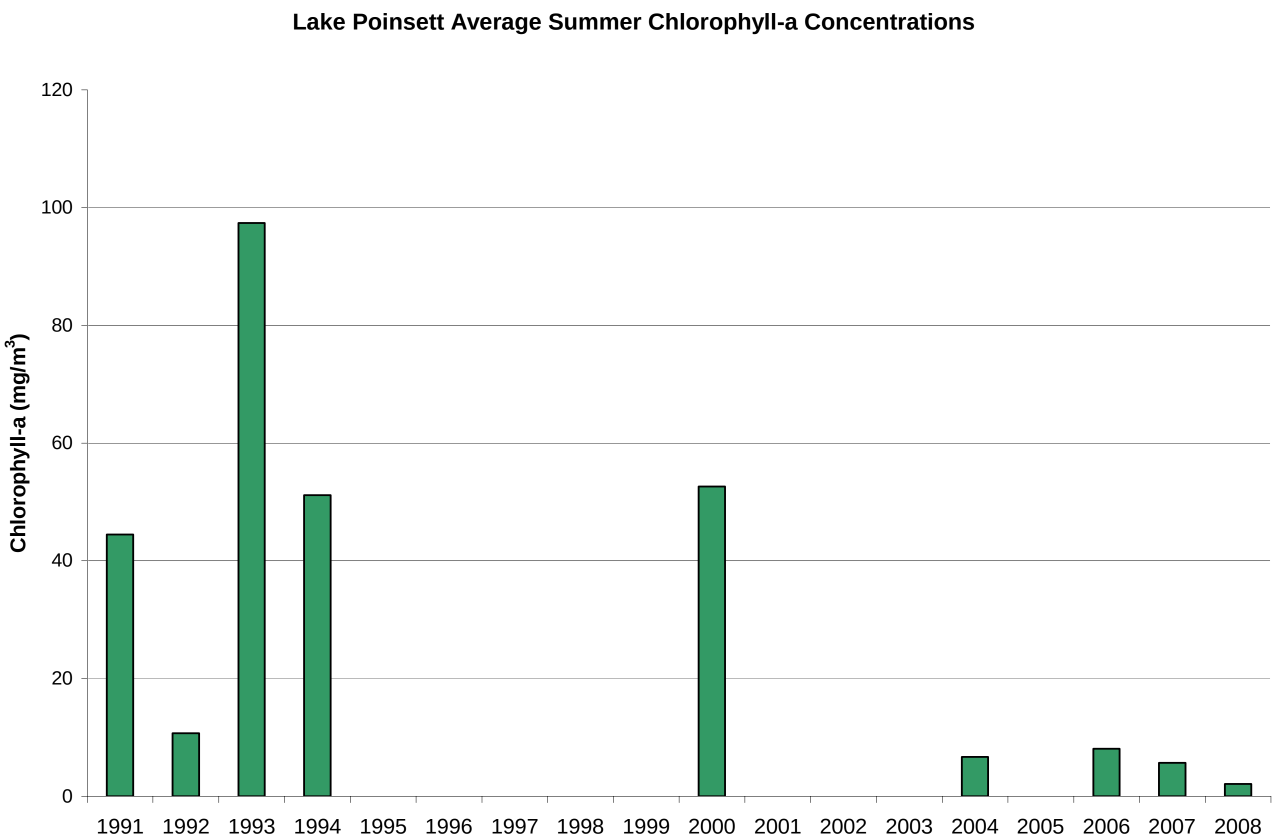


Figure 1. Average chlorophyll-*a* concentrations for Lake Poinsett based on available data.

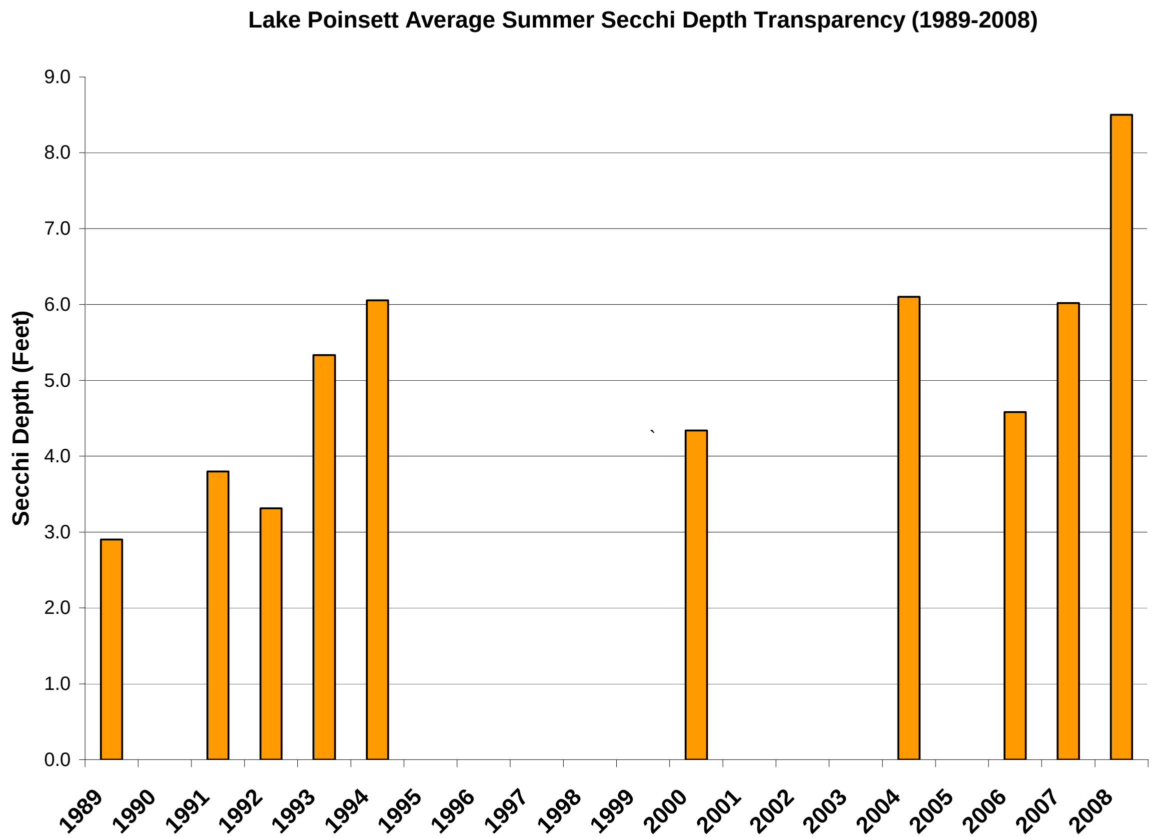


Figure 2. Average growing season Secchi depth Lake Poinsett

Modeled estimates of potential Big Sioux River inflow into Lake Poinsett were calculated for a 31-year (1977-2008) period. Figure 3 shows only those years when the lake level was below outlet level. Model results indicate the Big Sioux River would have contributed minimally to supplement the water level of Lake Poinsett over the past 31 years (Figure 3). In 1978 and 1984, the Big Sioux River did fill Lake Poinsett to outlet elevation from deficits of 2.4 feet and 1.4 feet, respectively. During these years water was also received from Lake Albert and Dry Lake following the Big Sioux River inflows (DENR Water Rights Program). The Big Sioux River was also estimated to have potentially filled Lake Poinsett in 2007 when the spring lake elevation was approximately 2.4 feet below outlet elevation. Estimates suggest that Big Sioux River inflow could have filled the lake to the outlet elevation by early April. In most years when the lake was below outlet elevation, the Big Sioux River would have contributed less than 4 inches of depth to the lake. The gaps in Figure 3 during the mid 1980s and most of the 1990s were due to lake elevations being equal to or higher than the outlet elevation (1650.5 feet mean sea level.).

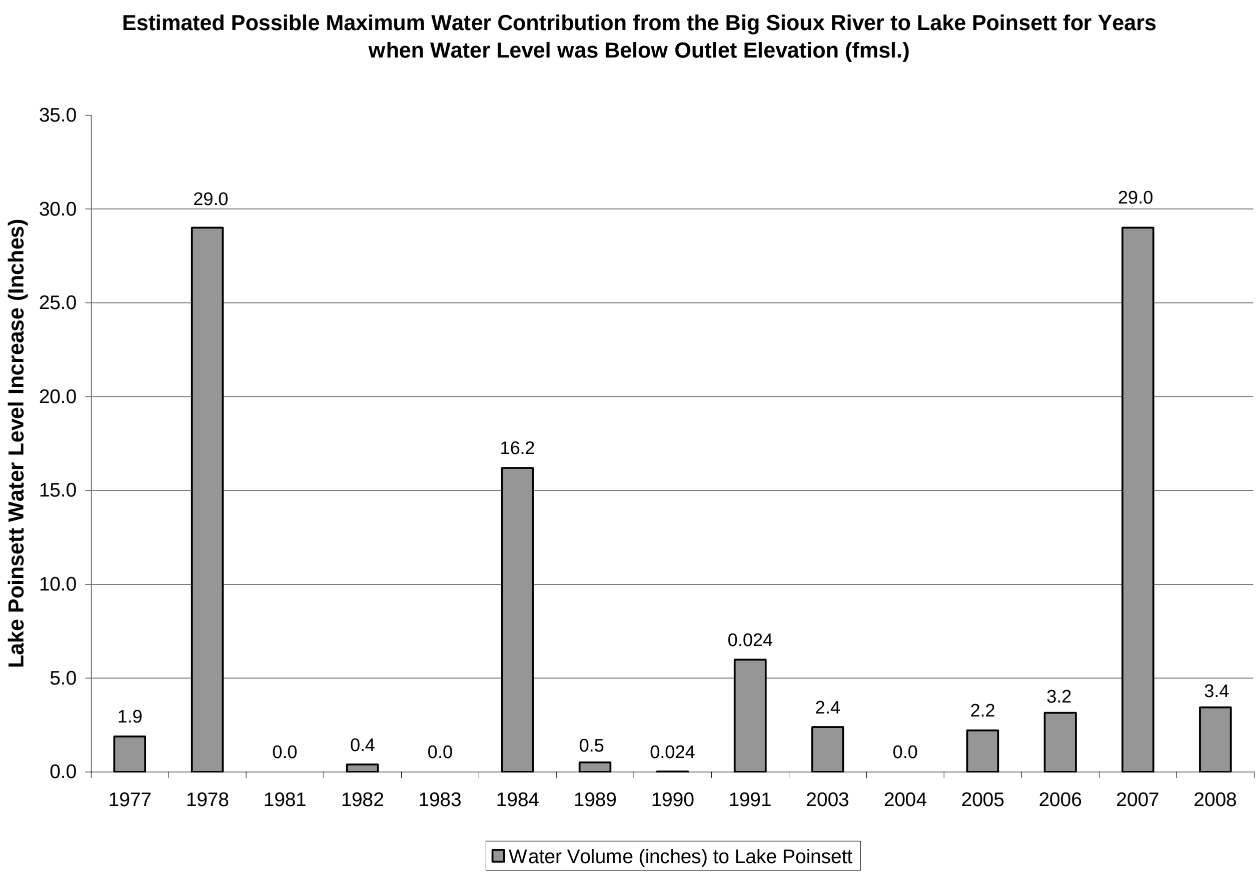


Figure 3. Estimated yearly possible maximum water volume contributions from the Big Sioux River to Lake Poinsett for years when the water level was below outlet elevation (1650.5 fmsl).

Historic Big Sioux River phosphorus concentrations were applied to the estimated Big Sioux River inflow volumes for the purpose of calculating yearly loads. Unfortunately, minimal historic phosphorus data existed on dates when flow was estimated to have been occurring into Lake Poinsett. As a result, average concentrations were not considered representative and therefore yearly phosphorus loads were not calculated. Phosphorus data was collected in 2007 and 2008 during periods of potential inflow and in many cases in closer proximity to Lake Poinsett (BSR 18.5) then the respective water quality monitoring stations. Since 2007 was estimated to have contributed significant inflow, it was deemed appropriate to use the 2007 phosphorus and hydrologic data as a model for estimating the difference in phosphorus load from the Big Sioux River and the immediate watershed.

The average Big Sioux River phosphorus concentration was derived from a combination of samples collected at BSR 18.5 and the water quality monitoring stations during periods when flow was estimated to have been able to reach Lake Poinsett. A total of eleven phosphorus samples were used to calculate the 2007 Big Sioux River average phosphorus concentration (Table 2). Phosphorus data from the water quality monitoring stations was added when available to supplement gaps in the BSR 18.5 dataset (i.e., 4/10/07). Most of the flow was estimated to occur between March 14 and May 19, 2007. The two phosphorus concentrations collected from the water quality monitoring stations on 6/11/07 were included in the average calculation to represent low flow data that occurred later in May. Based on these data the average phosphorus concentration used to develop the 2007 Big Sioux River loading scenario was 0.52 mg/L. This concentration was used to cover a range of flows and was considered conservative since the lake was estimated to have filled by April 3, 2007. Based on the limited dataset during this time period March 14 to April 3) the average concentration would have been 0.73 mg/L.

Table 2. Phosphorus data used to derive the 2007 average phosphorus concentration for estimating the 2007 Big Sioux River phosphorus load.

Sample Date	Sample Site	Total Phosphorus (mg/L)
3/15/2007	BSR 18.5	1.26
3/22/2007	BSR 18.5	0.697
3/28/2007	BSR 18.5	0.394
4/2/2007	BSR 18.5	0.555
04/10/2007	BS08	0.446
4/15/2007	BSR 18.5	0.336
4/23/2007	BSR 18.5	0.514
4/25/2007	BSR 18.5	0.366
5/7/2007	BSR 18.5	0.452
06/11/2007	WQM1	0.384
06/11/2007	BS08	0.274

The aforementioned 2007 spring water level of Lake Poinsett was approximately 2.4 feet below outlet elevation. The water volume (18,270 acre-feet) associated with 2.4 feet of depth across the area of Lake Poinsett was applied to the 2007 average phosphorus concentration (0.52 mg/L). The resultant Big Sioux River phosphorus load was calculated at 25,829 pounds. For comparison, the same water volume was applied to the average concentrations of Dry Lake (0.34 mg/L) and Lake Albert outflow (0.17 mg/L). Based on annual load estimates calculated in 1994, Lake Albert contributed 75% of the water volume and Dry Lake contributed 25% (SD DENR, 1996). This is a function of drainage area as the Lake Albert watershed is much larger than the Dry Lake watershed. Therefore, the total volume (18,270 acre-feet) was divided to allocate 75% of the volume (13,702.5 acre-feet) to Lake Albert and 25% (4,567.5 acre-feet) to Dry Lake to represent the immediate watershed. The load associated with Lake Albert and Dry Lake was 6,333 and 4,222 pounds, respectively. The cumulative phosphorus load from both sources was estimated at 10,555 pounds. Based on these estimates, the Big Sioux River phosphorus load would be nearly 2.5 times higher than that from the immediate watershed. This is also consistent with other studies that estimated phosphorus loads from the Big Sioux River and immediate watershed (SD DENR, 1996 and Skille, 1971).

The 2007 estimated phosphorus loads from the Big Sioux River and the immediate watershed were used to simulate an inlake phosphorus response. To perform this scenario, the appropriate lake volumes, phosphorus loads and base-line in lake phosphorus concentrations were added to a mass balance equation. The average depth of Lake Poinsett at outlet elevation is 9.5 feet. The corresponding volume of Lake Poinsett at outlet elevation was estimated at 74,746 acre-feet. When the lake was 2.4 feet low, the average depth equated to 7.1 feet and the corresponding volume was 56,492 acre-feet. The base-line in lake phosphorus concentration used for this scenario was 0.13 mg/L based on the long-term average phosphorus concentration of Lake Poinsett (Table 1). This exercise was based strictly on a mass balance equation, no account of system chemical, physical and biological processes were considered.

Results of the mass balance equation based on 2007 estimates depict a significant difference in inlake phosphorus concentration with estimated phosphorus loads from the Big Sioux River compared to the immediate watershed (Figure 4). The in lake phosphorus concentration of Lake Poinsett was estimated to increase from 0.13 mg/L to 0.15 mg/L (increase of 0.02 mg/L) when subjected to the estimated phosphorus load from the immediate watershed (i.e., 10,555 pounds). The in lake phosphorus concentration of Lake Poinsett was estimated to increase from 0.13 mg/L to 0.23 mg/L (increase 0.1 mg/L) with the estimated Big Sioux River phosphorus load (25,896 pounds). Thus, this potential Big Sioux River load may have nearly doubled the in lake concentration of Lake Poinsett if inflow would have occurred in 2007. The basis of this result is strictly a function of the higher average phosphorus concentration exhibited by the Big Sioux River. Again the average phosphorus concentration used to derive the loading estimates was considered conservative.

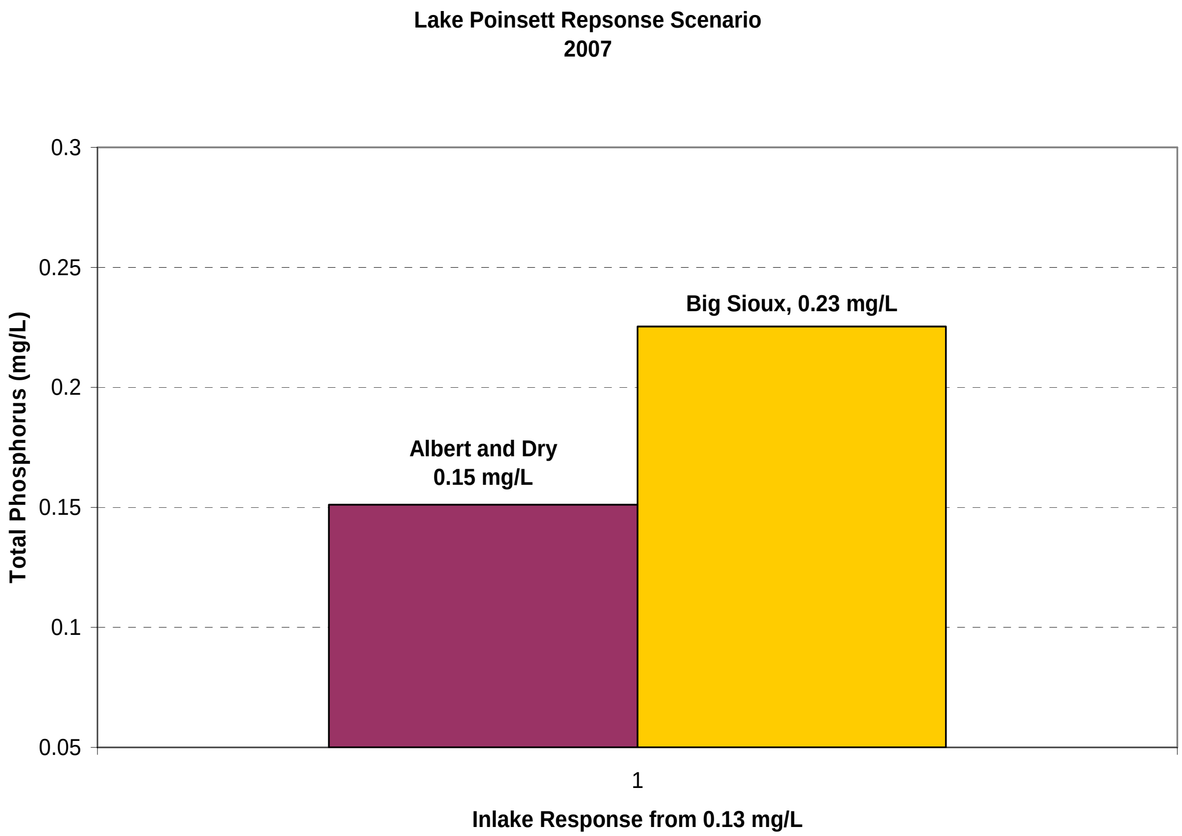


Figure 4. Lake Poinsett's inlake phosphorus response to estimated 2007 phosphorus loads from the immediate watershed and the Big Sioux River.

Aside from 2007, the potential for flow contributions from the Lake Poinsett outlet channel were estimated to be minor, in terms of providing significant water level relief (DENR Water Rights Program). Nonetheless, phosphorus loads would still be associated with these relatively small water volumes. In 2008, the Big Sioux River was estimated to contribute a potential 3.4 inches or 2,226 acre-feet of volume to Lake Poinsett. Applying the 2008 average phosphorus concentration when flow was estimated to occur (0.32 mg/L) to this volume equates to a total phosphorus load of 1,936 pounds. Applying this phosphorus load to the same mass balance equation as constructed for the 2007 scenario the in-lake phosphorus concentration of Lake Poinsett would increase from 0.13 mg/L to 0.14 mg/L. Again, the immediate watershed would be expected to deliver less phosphorus load and resultant in lake response based on lower average phosphorus concentrations.

A significant positive linear relationship was observed in 2007-2008 between Big Sioux River (18.5) flow and phosphorus concentration (Figure 5). This relationship suggests that as flow volume increases total phosphorus concentrations increase. This is an important relationship to consider since Big Sioux River flow is often considerable (175 cubic feet per second at Castlewood gage) before it is capable of making it to the outlet elevation (1650.5 feet mean sea level.) of Lake Poinsett. The first snowmelt event of

2007 was estimated to have provided significant flow (800 cubic feet per second) at a phosphorus concentration well over 1.0 mg/L. As the season progressed, concentrations decreased though still showed a pattern of increase with increasing flow volume following storm events.

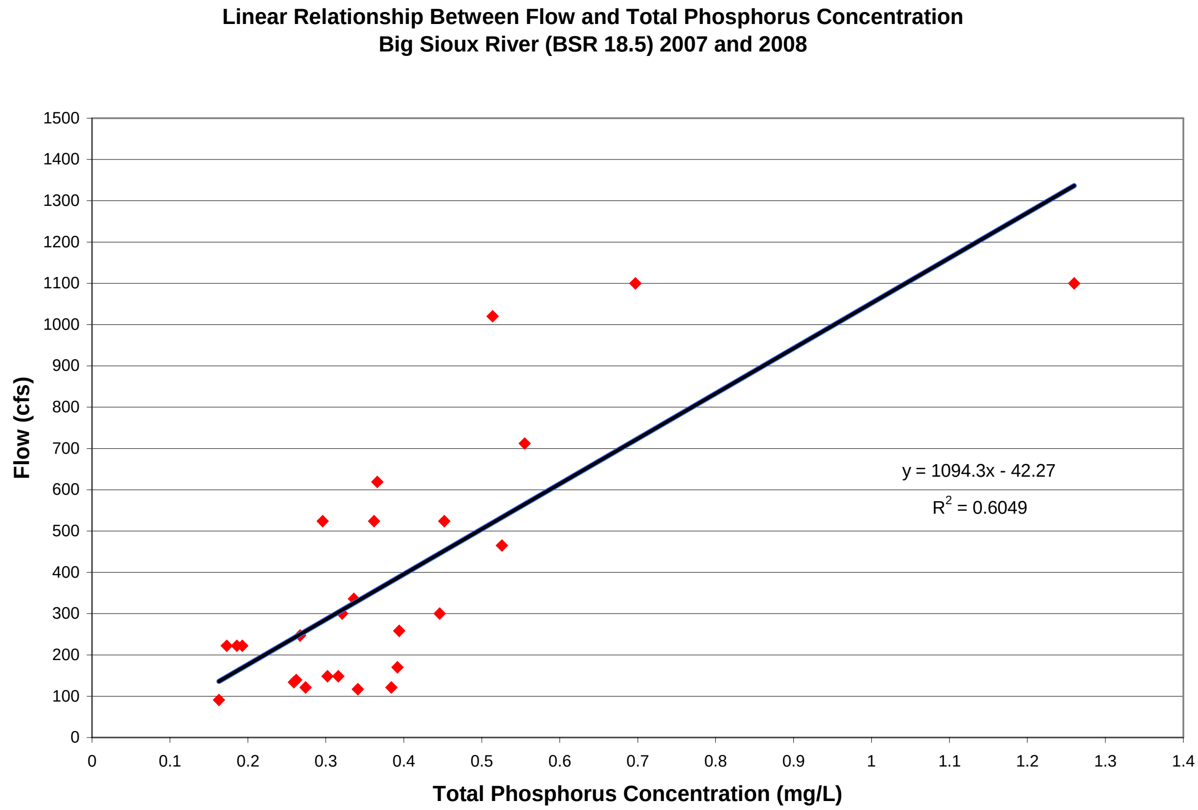


Figure 5. Linear relationship between flow and total phosphorus from samples collected in 2007 and 2008 at BSR 18.5.

Approximately 75% of the total flow volume that the Big Sioux River was estimated to potentially contribute to Lake Poinsett during 2007 would have occurred within a 10-day period in March 2007. The highest phosphorus concentrations (1.26 mg/L and 0.7 mg/L) were also recorded during this flow period. The phosphorus concentrations associated with the remaining 25% of the flow volume were much lower ranging from 0.56 mg/L to 0.27 mg/L with an average of 0.41 mg/L. This implies that significant Big Sioux River inflow to Lake Poinsett depends on relatively large-scale precipitation events associated with spring thaw, which is also associated with a period of critical phosphorus loading.

Boswell diversion and Dry Lake

The Boswell diversion was originally constructed and operated to help stabilize the water level of Lake Poinsett. Operation of the Boswell diversion has required many changes over the years due to the Big Sioux River's influence on flooding, shoreline erosion and nutrient loading to Lake Poinsett (Appendix A). The current operation plan requires the water quality of the river be equal or better to that of Lake Poinsett before Big Sioux River water is allowed down the diversion ditch. Only the secretary of Game, Fish and Parks can authorize gate operation. In 2008, the Boswell dam on the Big Sioux River was removed when the bridge was replaced. The gates on the Boswell ditch were left in place though have remained closed since 1991 due to poorer water quality of the Big Sioux River in comparison to Lake Poinsett.

The Boswell ditch was suggested as a method of resolve for the recent water level deficiencies of Lake Poinsett. Implications were that Dry Lake would provide a settling effect for nutrient loads offered by the Big Sioux River. Dry Lake is a highly productive (hypereutrophic) shallow lake with a surface area of 1,960 acres, an average depth of 6 feet and a volume of 11,760 acre-feet at outlet elevation. DENR does not sample Dry Lake as part of the statewide lakes assessment project, and the basin was not sampled during this investigation. However, phosphorus concentrations were collected from Dry Lake outflow in 2007 and 2008. The average phosphorus concentration was 0.34 mg/L with a standard deviation of +/- 0.13 mg/L and a range of 0.7 mg/L to 0.2 mg/L.

BATHTUB, a lake eutrophication model designed by the Army Corps of Engineers was used to model the Big Sioux River phosphorus load conveyed from the Boswell ditch to Dry Lake and ultimately Lake Poinsett (Walker, 1999). Model inputs were based on the same hydrologic load (i.e., 18,270 acre-feet) and Big Sioux River phosphorus concentration (0.52 mg/L) used to calculate the 2007 phosphorus load scenario for the Lake Poinsett outlet channel. Additional model inputs included Dry Lake surface area, mean depth, mixed layer and average phosphorus concentration (0.34 mg/L). The BATHTUB model uses mathematic equations that can account for basin effects of Dry Lake based on the hydrologic, morphologic and limnologic input characteristics provided.

Model results indicate only a slight decrease in phosphorus load to Lake Poinsett from the Boswell ditch in comparison to that estimated from the Lake Poinsett outlet channel. The modeled phosphorus load from Dry Lake to Lake Poinsett via the Boswell ditch was calculated at 23,761 pounds. This phosphorus load was only 2,135 pounds lower than that estimated from the Lake Poinsett outlet channel (25,896 lbs.). The phosphorus load associated with the Boswell ditch option was just over twice that previously estimated for the immediate watershed without the Big Sioux River (10,555 lbs). The BATHTUB model also indicated the in lake phosphorus concentration of Dry Lake would increase from 0.34 mg/L to 0.48 mg/L with this Boswell ditch phosphorus load.

The phosphorus concentration of Dry Lake can be quite variable depending on the environmental conditions. Due to a north-south orientation and shallow depth, windy conditions could allow sediment re-suspension potentially increasing the water column phosphorus concentration above the average (0.34 mg/L). This was observed in samples collected in 2008 as concentrations were recorded as high as 0.7 mg/L. This potential internal load factor along with future Big Sioux River contributions could decrease assimilative capacity of Dry Lake and increase the phosphorus load above that directly received from the Lake Poinsett outlet channel. Increased sedimentation from the Big Sioux River and Boswell ditch over time could decrease the storage capacity of Dry Lake, which would facilitate nutrient loading, flooding and increase the incidence of shoreline damage in the future.

Conclusions

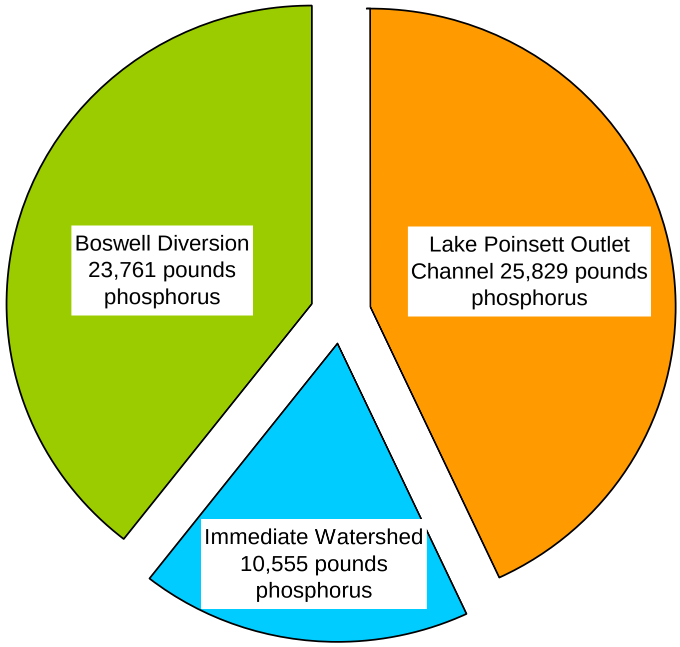
The water quality goal for Lake Poinsett based on the 1996 water quality assessment study conducted by DENR was a 40% reduction in watershed phosphorus (SD DENR 1996). The target in lake phosphorus concentration was 0.07 mg/L. The purpose of the watershed phosphorus reduction and in lake phosphorus target was to decrease the intensity of nuisance blue-green algae blooms. Considerable resources have been spent at the local, state and federal level to try and achieve this goal.

DENR has and continues to support the Lake Poinsett Water Quality Improvement project sponsored by the Hamlin County Conservation District. DENR has awarded the district nearly $1,000,000 in Environmental Protection Agency 319 Nonpoint Source grant funds. Most of this money is used by the district to provide cost share to help landowners reduce the amount of phosphorus entering Lake Poinsett from the immediate watershed. For example, 17 manure management systems for livestock operations around Lake Poinsett have been constructed, 3,500 acres of grazing management have been installed with 4,400 acres of vegetative buffer strips planted, and 20 alternative livestock watering systems have been constructed to keep livestock out of tributaries. Several local producers in the watershed have contributed in-kind labor and monetarily to these restoration efforts.

The trophic state of Lake Poinsett appears to be sensitive to watershed phosphorus loading. During the recent dry cycle (2002-2008) minimal to no phosphorus loading occurred to Lake Poinsett. The lake responded with a decrease in algal biomass and an increase in water clarity which was opposite of that observed during the wet cycle of the1990s. To meet the water quality goal, it is imperative efforts focus on reducing annual phosphorus loads that result in decreased algal biomass and ultimately protect the beneficial uses of Lake Poinsett.

The goal of this investigation was to estimate how Big Sioux River phosphorus loads compare to that from the immediate watershed. Figure 6 depicts the comparative phosphorus load estimates from the immediate watershed, Lake Poinsett outlet channel and the Boswell diversion.

Comparison Between Existing Phosphorus Loadings to Lake Poinsett and Phosphorus Loadings from Potential Diversions of the Big Sioux River



The immediate watershed was estimated to contribute approximately 2.5 times less phosphorus than the Big Sioux River. The Big Sioux River load from the Lake Poinsett outlet channel was estimated to nearly double the average (0.13 mg/L to 0.23 mg/L) in lake phosphorus concentration of Lake Poinsett. The immediate watershed load had less effect (increase 0.02 mg/L) on the average in lake concentration of Lake Poinsett. The basis of this result is a function of the higher average phosphorus concentration exhibited by the Big Sioux River.

The Boswell diversion ditch was also recognized as a potential option for routing Big Sioux River water to help alleviate low water levels in Lake Poinsett. Implications were that Dry Lake may provide a settling effect for phosphorus loads carried by the Big Sioux River, in comparison to the direct inflow from the Lake Poinsett outlet channel. Modeled results, following the 2007 scenario, showed a similar total phosphorus load from the Boswell diversion ditch through Dry Lake in comparison to the direct inflow from the Lake Poinsett outlet channel. Dry Lake is a relatively small, highly productive shallow basin not capable of assimilating relatively large Big Sioux River phosphorus loads that would accompany flows required to fill Lake Poinsett from a deficit of 2.5 feet. The current Boswell diversion operation plan requires the water quality of the Big Sioux River be equal to or better than that of Lake Poinsett before Big Sioux River water is considered to be routed to Lake Poinsett.

A significant relationship was observed between Big Sioux River flow and phosphorus concentration. The pattern suggests that as Big Sioux River flow increases phosphorus concentrations also increase. The highest phosphorus concentrations recorded in 2007 were associated with significant spring flood flows. These potential Big Sioux River events could contribute relatively high phosphorus loads to Lake Poinsett.

The Big Sioux River is expected to contain higher concentrations of chemical and biological pollutants in comparison to the immediate watershed. Such pollutants include total suspended solids, dissolved solids, nutrients and bacteria. While this investigation focused strictly on phosphorus, the aforementioned pollutants are expected to be elevated due to the riverine nature of the Big Sioux River and the increase in drainage area through a predominantly agricultural landscape. The immediate watershed contains several upstream waterbodies and wetlands that, to a certain extent, provide settling effects that ultimately reduce pollutant concentrations downstream to Lake Poinsett.

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Appendix A

Purpose and History of the Boswell Diversion.

PURPOSE:
In 1918 the GFP Commission agreed to undertake improvement of the lakes for the better preservation and propagation of game and fish by construction of a ditch or waterway from the Big Sioux River westerly to Dry Lake

The original and continuous purpose of the Lake Poinsett project was to assist in stabilizing lake water levels in Lake Poinsett by diverting water from the Big Sioux River into the diversion ditch in a westerly direction and eventually into Lake Poinsett at times when the lake water level was low and there was water available in the Big Sioux River. The Boswell dam on the Big Sioux River, the diversion channel and the gates were not intended to be used for flood control and have not been operated as such.

STRUCTURE:

Boswell Dam: Located three miles east of Dry Lake and northeast of Lake Poinsett. Combination bridge and dam over the BSR consisting of 4 – 20 foot wide gates, a small concrete block building housing the electrical controls to raise and lower the gates.

Diversion Channel Gates: Located ¾ mile west of the Boswell gates. Gate structure just upstream of township road bridge consisting of 5 – 20' wide gates and a small concrete block building housing the electrical controls to raise and lower the gates.

Diversion Ditch: A 2 mile ditch constructed from the BSR to a point where the ditch intersects a natural channel to Dry Lake.

WATER RIGHTS:

28-3 April 1941 priority date, authorizes diversion from the Big Sioux River. Held by South Dakota Game Fish and Parks.

119-3 August 1955 priority date, authorizes enlargement of diversion ditch from 500 cfs to 1500 cfs. Held by South Dakota Game Fish and Parks.

1576-3 Vested right for Lake Poinsett with an 1889 priority date. Held by South Dakota Game Fish and Parks.

FC-5 August 1986 priority date, authorizes gates on the inlet/outlet of Lake Poinsett. Held by Lake Poinsett Area Development District.

FC-6 October 1986 priority date, authorizes extension boards of 16.5 inches to the diversion gates in Boswell Ditch. Held by Lake Poinsett Area Development District. Request form LPADA to cancel permit has been received but no action has been taken by the Water Management Board.

HISTORY:

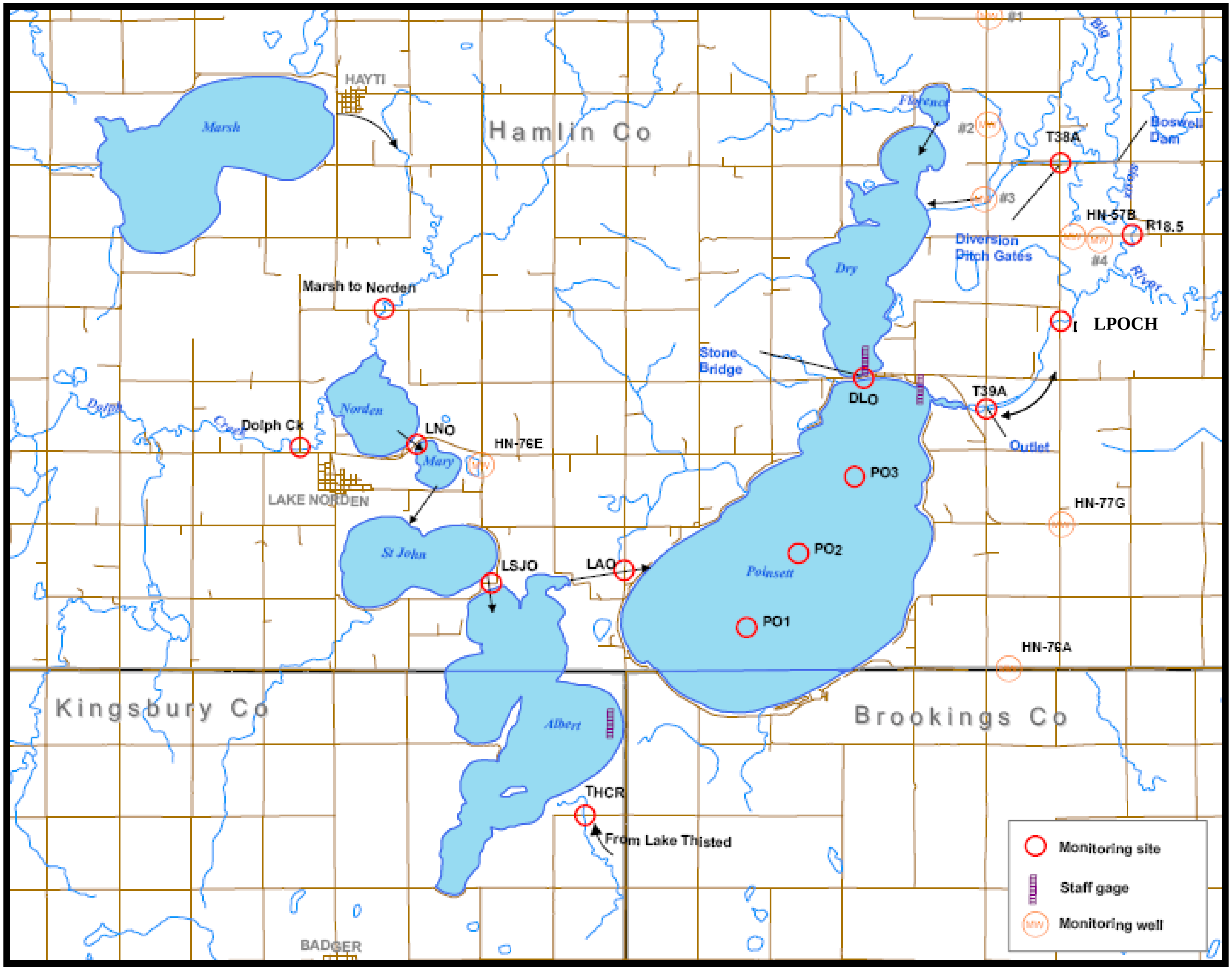
1918	The GFP Commission undertake improvement of Dry Lake and Lake Poinsett for the better preservation and propagation of game and fish through construction of a ditch and head gates to convey water from the BSR to Dry Lake. Resolutions were passed for construction of the diversion project and condemnation of land for the ditch.
1919	The land necessary for the ditch was condemned in Circuit Court and judgments entered.
1920	SD Supreme Court upholds judgments in State vs Sayer.
1924	County adopts resolution acknowledging that GFP had acquired condemnation rights to construct the ditch.
1928	GFP Commission and County determined that the project would not be for flood control and approved $10,000 for the project. Hamlin County Commison meeting passed a resolution that

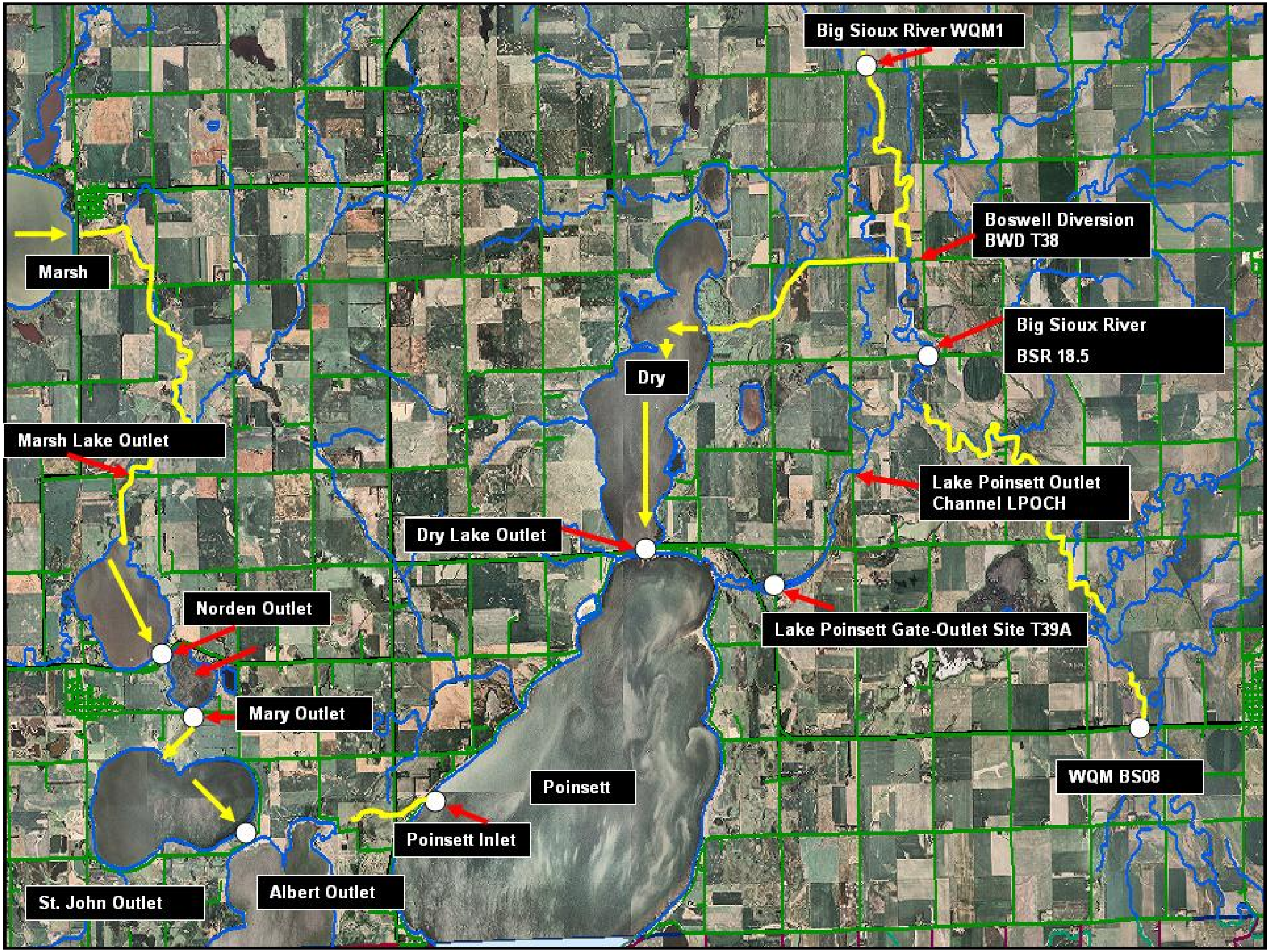
	the bridge/dam over the BSR be constructed.
1929	Hamlin County and GFP accepted the bid of L.J. Dunn for construction of the combination bridge and gate structure over the BSR. April 1941 priority date.
1941	WR 28-3 was granted authorizing GFP to divert 500 cfs of "Flood waters to be used for natural lake restoration and maintenance of Lake Poinsett and Dry Lake."
1946-47	GFP reconstructed the gates and motors.
1955	WR 119A-3 was granted authorizing GFP to enlarge the diversion ditch and for an additional 1000 cfs for a combined diversion of 1500 cfs of the flood water of the BSR for the purpose of stabilizing the water levels of Dry Lake and Lake Poinsett.
1962	Management Plan – "the diversion ditch should be used only under unusual conditions of water requirements". There was concern about flushing poor water quality from Dry Lake into Lake Poinsett.
1966	Management Plan – Stated that water from the diversion ditch is of poor quality. Gates in the diversion ditch are to be raised in fall to prevent freeze and remained raised until June 1. If water from the chain of lakes to the west is feasible or ground water is adequate water diverted from the BSR can eventually be eliminated.
1971	Letter from LPADA states that the gates in the diversion ditch should remain closed at all times due to poor water quality in the BSR, ditch and Dry Lake.
1971	Management Plan – Due to poor water quality concerns the Boswell dam should be left open at all times and the diversion ditch gate closed at all times except during extreme drought or flood conditions. Diversion allowed only if Lake Poinsett is 2.5' or more below the OHWM and continued drought conditions are eminent. Diversion allowed if extreme flood conditions can be alleviated without great harm to Lake Poinsett. Gates shall be opened in the above situations only after chemical tests show equal or better quality to Lake Poinsett.
1974	Discussion of opening the outlet gates to let water into Lake Poinsett. Though the lake level is dropping it is not 2.5' below the OHWM of 1651.5 fmsl. There was concern that letting water in from the BSR would degrade the water quality in Lake Poinsett.
1975	May of 1975 the lake is 1649 fmsl, 2.5' below the OHWM. There was interest and concern about diverting BSR water through the Boswell ditch to Lake Poinsett. Water quality tests were taken weekly and showed that it was worse than water in Lake Poinsett. Water could not be diverted.
1976	April – decision made to open gates, lake was 1648, though there was concern about water quality. BSR water quality close to that of Poinsett.
1976	May – Poinsett at 1647.8. Letter from Gov Kneip stating that water levels in Lake Poinsett generate a tremendous amount of public reaction. Personally the Gov felt that runoff due to more precipitation was the only real solution to low lake levels.
1976	July – Poinsett at 1646.8. Boswell gates opened and ditch gates closed due to little chance of getting significant amounts of water into Poinsett while the chance of what little flow did make it would be of poorer quality than the water in Poinsett.
1977	March – Poinsett at 1647.5. GFP grants authorization to operate Boswell diversion due to low water levels in Poinsett.
1977	May – Poinsett at 1647. Boswell gates opened and ditch gates closed to allow bypass of nutrient rich waters.
1977	June – Poinsett at 1647. GFP repairs Boswell gates.
1978	February – Boswell left open while diversion gates were left open.
1979	Under the direction of the Gov the Poinsett Diversion Committee was formed to make recommendations to the Secretary of GFP on operation of the gates. Plan – Boswell gates shall be open at all times; diversion gates normally closed at all times except to avoid freeze in. Diversion operated if Poinsett is 2.5' below OHWM and BSR water quality is better than or equal to Poinsett.
1980's	Several meeting of the Diversion Committee to discuss the operation of the diversion gates.
1980	Memorandum from the AGO that the Diversion Committee does not have the decision making authority to operate the gates, can act only as an advisory committee. The Secretary of GFP has the authority to make the decision on gate operation.
1983	Bids are let for the diversion ditch to be cleaned out.

1984	April – Poinsett at 1648.5 Oct 1983 and 1650.3 May 1984. Letter authorizing diversion of water into Poinsett. So much water coming into Poinsett through the outlet channel that the Boswell gates were opened to take some head off the BSR. Also to dilute polluted feedlot water that has been taken into Poinsett through the outlet channel. Diversion was open April 2 thru May 1.
1984	September – Poinsett at 1652.5 fmsl.
1985	January – Revised operating plan. Boswell gates shall be open at all times; diversion gates normally closed at all times except to avoid freeze in; diversion operated if Poinsett is 2.5' below OHWM; BSR water quality is better than or equal to Poinsett and tested on a scheduled basis; any diversion will be conducted in accordance with existing water rights; the Secretary of GFP will make final decision.
1985	October – Poinsett at 1652.5. Letters concerning high water levels on Lake Poinsett ruining lake property and putting silt into the lake.
1987	July – FC6-3 was approved by the Water Management Board with an October 1986 priority date, authorizing extension boards of 16.5 inches to the diversion gates in Boswell Ditch. Held by Lake Poinsett Area Development District.
1991	March – discussion to modify operation plan. Plan is still the same as previous plan.
1991	April – GFP makes the decision to close the Boswell gates and open the ditch gates. DENR sent notice to cease diversion until flood flows are available and Poinsett was at least 2.5' below the OHWM. WR and operation plan conditions. This is the last time Boswell gates were operated.
1997	Spring – Landowners concerned about flooding farmland request diversion to be opened. Poinsett already 27" overfull, request denied. Concern that boards on ditch gates adding to flooding, request that they be removed.
1997	May – Poinsett at 1656.2 fmsl. Interest by Poinsett residents in removing gates and blocking the ditch. There was interest in dredging Dry Lake but it would be useless if sediment laden water enters from the Boswell diversion.
1997	June – Flooding caused significant damage to the diversion ditch berm. The berm was repaired and clean out above and below the Boswell gates.
1997	September – LPADA states in letter that they intend to remove the boards from the ditch gates (FC6-3), abandoning the flood control permit.
2001	Spring – Poinsett at 1655.6 fmsl. More flooding causes damage to ditch berm. Most of the damage came from overland flow from the BSR to the north.
2001	Many public meetings are held to discuss removal of the Boswell gates. State Risk Management recommends that GFP remove gates or turn them over to a non-state entity to avoid any liability that the inoperable gates might pose. GFP and Hamlin County agree to remove gates when the bridge is replaced.
2001	November – LPADA goes on record as supporting the decision to remove the Boswell gates.
2002	March – Record of Decision and Declaratory Ruling issued by GFP Commission stating that the Boswell gates, control centers and building, electrical components and concrete piers were to be removed.
	Boswell gate are welded in the open position and other workings have been removed.
	Extension boards and metal slides are removed from the ditch gates.
2006	January – Poinsett at approximately 1647. At an informational meeting Poinsett landowners discuss wanting to divert water into Poinsett via Boswell diversion and Poinsett outlet channel. DENR staff attended the meeting to explain water quality issues and area hydrology.
2006	FC6-3 needs to be cancelled; WR 119-3 needs to be modified or cancelled depending on fate of ditch.
2007	DENR initiates a water quality investigation to monitor water levels and phosphorus concentrations from the immediate watershed and the BSR.
2008	The Boswell Dam was removed August 15th. A transportation bridge was constructed in its place, approximate completion date Nov. 15th. The new bridge structure did not contain gates.
2008	DENR continues water quality investigation. Results of the two year effort were compiled into a comprehensive report.

Appendix B

Maps depicting waterbodies associated with the Lake Poinsett drainage including the Big Sioux River and all associated monitoring stations.


Hamlin Co
Kingsbury Co
Brookings Co
HAYTI
Marsh
Marsh to Norden
Norden
Mary
LNO
HN-76E
Dolph Ck
LAKE NORDEN
St John
LSJO
LAO
Albert
THCR
From Lake Thisted
BADGER
Poinsett
PO1
PO2
PO3
DLO
Dry
Florence
Stone Bridge
T39A
Outlet
LPOCH
T38A
Boswell Dam
HN-57B
R18.5
Diversion Ditch Gates
HN-77G
HN-76A
#1
#2
#3
#4
Monitoring site
Staff gage
Monitoring well


Big Sioux River WQM1
Boswell Diversion
BWD T38
Marsh
Big Sioux River
BSR 18.5
Dry
Marsh Lake Outlet
Lake Poinsett Outlet
Channel LPOCH
Dry Lake Outlet
Norden Outlet
Lake Poinsett Gate-Outlet Site T39A
Mary Outlet
WQM BS08
Poinsett
Poinsett Inlet
Albert Outlet
St. John Outlet

Appendix C

Digital photographs of the gated structure at the outlet of Lake Poinsett (T39A) depicting gated sections across the outlet weir.


05.02.2008


05.02.2008

Appendix D
Water Quality Data

Sample Date	Sample Location	Total Phosphorus (mg/L)
09/16/1975	BS08-Estelline	0.216
09/17/1975	BS08-Estelline	0.242
09/18/1975	BS08-Estelline	0.214
03/16/1976	BS08-Estelline	0.388
03/17/1976	BS08-Estelline	0.351
03/18/1976	BS08-Estelline	0.379
10/14/1997	BS08-Estelline	0.151
04/13/1998	BS08-Estelline	0.297
05/11/1998	BS08-Estelline	0.240
06/08/1998	BS08-Estelline	0.308
07/13/1998	BS08-Estelline	0.336
08/10/1998	BS08-Estelline	0.337
03/14/2000	BS08-Estelline	0.220
04/10/2000	BS08-Estelline	0.225
05/08/2000	BS08-Estelline	0.484
06/13/2000	BS08-Estelline	0.382
07/10/2000	BS08-Estelline	0.542
08/14/2000	BS08-Estelline	0.519
09/11/2000	BS08-Estelline	0.317
10/10/2000	BS08-Estelline	0.159
03/12/2001	BS08-Estelline	0.083
04/11/2001	BS08-Estelline	0.422
05/15/2001	BS08-Estelline	0.140
06/11/2001	BS08-Estelline	0.246
07/09/2001	BS08-Estelline	0.226
08/13/2001	BS08-Estelline	0.290
09/10/2001	BS08-Estelline	0.235
10/09/2001	BS08-Estelline	0.210
03/11/2002	BS08-Estelline	0.251
04/08/2002	BS08-Estelline	0.314
05/15/2002	BS08-Estelline	0.218
06/10/2002	BS08-Estelline	0.380
07/09/2002	BS08-Estelline	0.441
08/12/2002	BS08-Estelline	0.557
09/09/2002	BS08-Estelline	0.417
06/05/2006	BS08-Estelline	0.414
07/10/2006	BS08-Estelline	0.775
08/07/2006	BS08-Estelline	0.812
09/05/2006	BS08-Estelline	0.532
10/19/2006	BS08-Estelline	0.397
03/12/2007	BS08-Estelline	0.482
04/10/2007	BS08-Estelline	0.321
05/07/2007	BS08-Estelline	0.362
06/11/2007	BS08-Estelline	0.274
07/09/2007	BS08-Estelline	0.445
08/06/2007	BS08-Estelline	0.640
09/10/2007	BS08-Estelline	0.380
10/09/2007	BS08-Estelline	0.476
03/12/2008	BS08-Estelline	0.606
04/07/2008	BS08-Estelline	0.360
05/05/2008	BS08-Estelline	0.173
06/09/2008	BS08-Estelline	0.316
07/07/2008	BS08-Estelline	0.291
08/11/2008	BS08-Estelline	0.519
09/09/2008	BS08-Estelline	0.238
10/06/2008	BS08-Estelline	0.349

Sample Date	Sample Location	Total Phosphorus (mg/L)
07/16/1974	WQM1-S. Watertown	0.737
08/04/1974	WQM1-S. Watertown	0.508
09/17/1974	WQM1-S. Watertown	0.562
10/28/1974	WQM1-S. Watertown	1.340
09/16/1975	WQM1-S. Watertown	0.802
09/17/1975	WQM1-S. Watertown	0.888
09/18/1975	WQM1-S. Watertown	0.883
03/16/1976	WQM1-S. Watertown	1.360
03/17/1976	WQM1-S. Watertown	1.100
03/18/1976	WQM1-S. Watertown	1.090
03/14/1977	WQM1-S. Watertown	0.430
04/06/1977	WQM1-S. Watertown	1.320
05/18/1977	WQM1-S. Watertown	4.090
06/15/1977	WQM1-S. Watertown	1.590
07/07/1977	WQM1-S. Watertown	0.755
08/03/1977	WQM1-S. Watertown	0.915
09/21/1977	WQM1-S. Watertown	0.456
10/13/1977	WQM1-S. Watertown	0.585
03/16/1978	WQM1-S. Watertown	3.690
04/13/1978	WQM1-S. Watertown	0.181
05/11/1978	WQM1-S. Watertown	0.113
06/14/1978	WQM1-S. Watertown	0.350
07/12/1978	WQM1-S. Watertown	0.314
08/16/1978	WQM1-S. Watertown	0.737
09/11/1978	WQM1-S. Watertown	0.195
10/12/1978	WQM1-S. Watertown	0.349
03/15/1979	WQM1-S. Watertown	2.340
04/26/1979	WQM1-S. Watertown	0.176
05/17/1979	WQM1-S. Watertown	0.122
06/13/1979	WQM1-S. Watertown	0.302
07/12/1979	WQM1-S. Watertown	0.353
08/16/1979	WQM1-S. Watertown	0.346
09/12/1979	WQM1-S. Watertown	0.349
03/13/1980	WQM1-S. Watertown	1.535
04/17/1980	WQM1-S. Watertown	1.031
05/15/1980	WQM1-S. Watertown	0.839
06/09/1980	WQM1-S. Watertown	0.366
07/14/1980	WQM1-S. Watertown	0.454
08/14/1980	WQM1-S. Watertown	0.358
09/08/1980	WQM1-S. Watertown	0.493
10/16/1980	WQM1-S. Watertown	0.943
04/08/1981	WQM1-S. Watertown	1.040
05/13/1981	WQM1-S. Watertown	0.624
06/10/1981	WQM1-S. Watertown	1.420
05/07/1982	WQM1-S. Watertown	0.883
06/08/1982	WQM1-S. Watertown	0.129
07/14/1982	WQM1-S. Watertown	2.540
08/11/1982	WQM1-S. Watertown	0.634
09/07/1982	WQM1-S. Watertown	0.448
10/06/1982	WQM1-S. Watertown	0.495
03/17/1983	WQM1-S. Watertown	0.881
04/20/1983	WQM1-S. Watertown	0.685
05/11/1983	WQM1-S. Watertown	1.210
06/16/1983	WQM1-S. Watertown	1.120
07/14/1983	WQM1-S. Watertown	2.61

Sample Date	Sample Location	Total Phosphorus (mg/L)
08/11/1983	WQM1-S. Watertown	1.400
09/08/1983	WQM1-S. Watertown	1.310
10/11/1983	WQM1-S. Watertown	0.982
03/14/1984	WQM1-S. Watertown	1.300
07/10/1984	WQM1-S. Watertown	0.444
08/14/1984	WQM1-S. Watertown	0.940
09/04/1984	WQM1-S. Watertown	0.618
10/10/1984	WQM1-S. Watertown	1.340
04/17/1985	WQM1-S. Watertown	0.258
06/13/1985	WQM1-S. Watertown	0.359
07/10/1985	WQM1-S. Watertown	0.450
08/13/1985	WQM1-S. Watertown	0.702
09/05/1985	WQM1-S. Watertown	0.447
10/16/1985	WQM1-S. Watertown	0.336
03/12/1986	WQM1-S. Watertown	0.830
05/14/1986	WQM1-S. Watertown	0.224
06/11/1986	WQM1-S. Watertown	0.349
07/16/1986	WQM1-S. Watertown	0.292
08/13/1986	WQM1-S. Watertown	0.227
09/08/1986	WQM1-S. Watertown	0.139
10/14/1986	WQM1-S. Watertown	0.197
03/05/1987	WQM1-S. Watertown	0.146
06/09/1987	WQM1-S. Watertown	0.425
03/14/1988	WQM1-S. Watertown	0.427
04/11/1988	WQM1-S. Watertown	0.166
05/11/1988	WQM1-S. Watertown	0.359
07/11/1988	WQM1-S. Watertown	0.292
03/13/1989	WQM1-S. Watertown	0.593
04/17/1989	WQM1-S. Watertown	0.630
05/15/1989	WQM1-S. Watertown	0.441
06/12/1989	WQM1-S. Watertown	0.505
07/10/1989	WQM1-S. Watertown	0.620
08/14/1989	WQM1-S. Watertown	0.441
09/11/1989	WQM1-S. Watertown	0.444
03/13/1990	WQM1-S. Watertown	0.780
04/09/1990	WQM1-S. Watertown	0.610
05/14/1990	WQM1-S. Watertown	0.730
06/11/1990	WQM1-S. Watertown	0.880
07/09/1990	WQM1-S. Watertown	0.996
08/13/1990	WQM1-S. Watertown	0.540
09/10/1990	WQM1-S. Watertown	0.644
03/12/1991	WQM1-S. Watertown	0.902
04/08/1991	WQM1-S. Watertown	0.875
05/13/1991	WQM1-S. Watertown	0.529
06/10/1991	WQM1-S. Watertown	0.542
07/15/1991	WQM1-S. Watertown	0.312
08/12/1991	WQM1-S. Watertown	0.278
09/09/1991	WQM1-S. Watertown	0.546
10/15/1991	WQM1-S. Watertown	0.298
03/10/1992	WQM1-S. Watertown	0.292
04/13/1992	WQM1-S. Watertown	0.212
05/11/1992	WQM1-S. Watertown	0.295
06/08/1992	WQM1-S. Watertown	0.760
07/13/1992	WQM1-S. Watertown	0.359
08/10/1992	WQM1-S. Watertown	0.694

Sample Date	Sample Location	Total Phosphorus (mg/L)
09/14/1992	WQM1-S. Watertown	0.345
10/06/1992	WQM1-S. Watertown	1.534
03/08/1993	WQM1-S. Watertown	0.239
04/12/1993	WQM1-S. Watertown	0.196
05/10/1993	WQM1-S. Watertown	0.209
06/15/1993	WQM1-S. Watertown	0.222
07/12/1993	WQM1-S. Watertown	0.282
08/09/1993	WQM1-S. Watertown	0.295
09/13/1993	WQM1-S. Watertown	0.266
10/05/1993	WQM1-S. Watertown	0.262
03/14/1994	WQM1-S. Watertown	0.336
04/19/1994	WQM1-S. Watertown	0.193
05/09/1994	WQM1-S. Watertown	0.173
06/13/1994	WQM1-S. Watertown	0.296
07/11/1994	WQM1-S. Watertown	0.303
08/08/1994	WQM1-S. Watertown	0.420
09/12/1994	WQM1-S. Watertown	0.253
10/11/1994	WQM1-S. Watertown	0.296
03/13/1995	WQM1-S. Watertown	0.610
04/19/1995	WQM1-S. Watertown	0.500
05/16/1995	WQM1-S. Watertown	0.095
06/12/1995	WQM1-S. Watertown	0.223
07/10/1995	WQM1-S. Watertown	0.272
08/14/1995	WQM1-S. Watertown	0.347
10/10/1995	WQM1-S. Watertown	0.345
03/11/1996	WQM1-S. Watertown	0.275
04/15/1996	WQM1-S. Watertown	0.211
07/08/1996	WQM1-S. Watertown	0.328
10/16/1996	WQM1-S. Watertown	0.268
07/14/1997	WQM1-S. Watertown	0.253
04/13/1998	WQM1-S. Watertown	0.211
07/13/1998	WQM1-S. Watertown	0.439
10/13/1998	WQM1-S. Watertown	1.000
03/15/1999	WQM1-S. Watertown	0.255
04/13/1999	WQM1-S. Watertown	0.182
05/10/1999	WQM1-S. Watertown	0.201
06/14/1999	WQM1-S. Watertown	0.392
08/09/1999	WQM1-S. Watertown	0.856
09/13/1999	WQM1-S. Watertown	0.661
10/12/1999	WQM1-S. Watertown	2.580
03/13/2000	WQM1-S. Watertown	0.247
04/10/2000	WQM1-S. Watertown	1.310
05/08/2000	WQM1-S. Watertown	0.682
06/12/2000	WQM1-S. Watertown	1.370
07/10/2000	WQM1-S. Watertown	0.765
08/14/2000	WQM1-S. Watertown	2.750
09/11/2000	WQM1-S. Watertown	1.220
10/10/2000	WQM1-S. Watertown	2.400
03/12/2001	WQM1-S. Watertown	0.704
04/11/2001	WQM1-S. Watertown	0.400
05/15/2001	WQM1-S. Watertown	0.183
06/11/2001	WQM1-S. Watertown	0.264
07/09/2001	WQM1-S. Watertown	0.360
08/13/2001	WQM1-S. Watertown	0.641
09/10/2001	WQM1-S. Watertown	2.1

Sample Date	Sample Location	Total Phosphorus (mg/L)
10/09/2001	WQM1-S. Watertown	1.690
03/11/2002	WQM1-S. Watertown	0.742
04/08/2002	WQM1-S. Watertown	0.373
05/13/2002	WQM1-S. Watertown	0.278
06/10/2002	WQM1-S. Watertown	0.425
07/08/2002	WQM1-S. Watertown	1.280
08/12/2002	WQM1-S. Watertown	1.930
09/09/2002	WQM1-S. Watertown	1.540
06/05/2006	WQM1-S. Watertown	0.605
07/10/2006	WQM1-S. Watertown	1.410
08/07/2006	WQM1-S. Watertown	2.740
09/05/2006	WQM1-S. Watertown	0.816
10/19/2006	WQM1-S. Watertown	1.810
03/12/2007	WQM1-S. Watertown	0.927
05/07/2007	WQM1-S. Watertown	0.296
06/11/2007	WQM1-S. Watertown	0.384
07/09/2007	WQM1-S. Watertown	0.676
08/06/2007	WQM1-S. Watertown	0.804
09/10/2007	WQM1-S. Watertown	0.685
10/09/2007	WQM1-S. Watertown	0.542
03/12/2008	WQM1-S. Watertown	1.370
04/07/2008	WQM1-S. Watertown	0.334
05/05/2008	WQM1-S. Watertown	0.186
06/09/2008	WQM1-S. Watertown	0.302
07/07/2008	WQM1-S. Watertown	0.373
08/11/2008	WQM1-S. Watertown	0.404
09/09/2008	WQM1-S. Watertown	0.516
10/06/2008	WQM1-S. Watertown	0.528

Sample Location	Code	Date	Total Phosphorus (mg/L)
Big Sioux River	R 18.5	04/12/2008	0.399
Big Sioux River	R18.5	04/27/2008	0.262
Big Sioux River	R 18.5	04/29/2008	0.259
Big Sioux River	R 18.5	05/05/2008	0.193
Big Sioux River	R 18.5	05/12/2008	0.267
Big Sioux River	R 18.5	05/20/2008	0.341
Big Sioux River	R 18.5	05/27/2008	0.163
Big Sioux River	R 18.5	06/08/2008	0.392
Big Sioux River	R 18.5	06/13/2008	0.526
Big Sioux River	R 18.5	03/15/2007	1.26
Big Sioux River	R 18.5	03/22/2007	0.697
Big Sioux River	R 18.5	03/28/2007	0.394
Big Sioux River	R 18.5	04/02/2007	0.555
Big Sioux River	R 18.5	04/15/2007	0.336
Big Sioux River	R 18.5	04/23/2007	0.514
Big Sioux River	R 18.5	04/25/2007	0.366
Big Sioux River	R 18.5	05/07/2007	0.452
Boswell Diversion Site	T38	03/15/2007	1.20
Boswell Diversion Site	T38	03/22/2007	0.666
Boswell Diversion Site	T38	04/23/2007	0.497
Dry Lake Outlet	DLO	04/12/2008	0.309
Dry Lake Outlet	DLO	04/27/2008	0.424
Dry Lake Outlet	DLO	04/29/2008	0.241
Dry Lake Outlet	DLO	05/05/2008	0.229
Dry Lake Outlet	DLO	05/12/2008	0.358
Dry Lake Outlet	DLO	05/20/2008	0.197
Dry Lake Outlet	DLO	05/27/2008	0.703
Dry Lake Outlet	DLO	06/08/2008	0.288
Dry Lake Outlet	DLO	06/13/2008	0.5
Dry Lake Outlet	DLO	03/28/2007	0.294
Dry Lake Outlet	DLO	04/02/2007	0.385
Dry Lake Outlet	DLO	04/15/2007	0.25
Dry Lake Outlet	DLO	04/23/2007	0.38
Dry Lake Outlet	DLO	04/25/2007	0.231
Dry Lake Outlet	DLO	05/07/2007	0.276

Sample Location	Code	Date	Total Phosphorus (mg/L)
Lake Albert Outlet	LAO	04/15/2008	0.345
Lake Albert Outlet	LAO	04/27/2008	0.139
Lake Albert Outlet	LAO	04/29/2008	0.114
Lake Albert Outlet	LAO	05/05/2008	0.108
Lake Albert Outlet	LAO	05/12/2008	0.118
Lake Albert Outlet	LAO	05/20/2008	0.175
Lake Albert Outlet	LAO	05/27/2008	0.187
Lake Albert Outlet	LAO	06/08/2008	0.196
Lake Albert Outlet	LAO	06/13/2008	0.151
Lake Norden Outlet	LNO	04/12/2008	0.128
Lake Norden Outlet	LNO	04/15/2008	0.141
Lake Norden Outlet	LNO	04/27/2008	0.13
Lake Norden Outlet	LNO	04/29/2008	0.116
Lake Norden Outlet	LNO	05/05/2008	0.119
Lake Norden Outlet	LNO	05/12/2008	0.177
Lake Norden Outlet	LNO	05/20/2008	0.133
Lake Norden Outlet	LNO	05/27/2008	0.152
Lake Norden Outlet	LNO	06/08/2008	0.138
Lake Norden Outlet	LNO	04/15/2007	0.287
Lake Norden Outlet	LNO	04/23/2007	0.224
Lake Norden Outlet	LNO	04/25/2007	0.27
Lake Norden Outlet	LNO	05/07/2007	0.225
Lake Poinsett Gate-Outlet Site	T39A	03/15/2007	1.18
Lake Poinsett Gate-Outlet Site	T39A	03/22/2007	1.07
Lake Poinsett Gate-Outlet Site	T39A	03/28/2007	1.02
Lake Poinsett Gate-Outlet Site	T39A	04/02/2007	0.856
Lake Poinsett Gate-Outlet Site	T39A	04/15/2007	0.445
Lake Poinsett Gate-Outlet Site	T39A	04/23/2007	0.312
Lake Poinsett Gate-Outlet Site	T39A	05/07/2007	0.282
Marsh Lake Outlet	MLO	05/27/2008	0.106
Marsh Lake Outlet	MLO	04/28/2007	0.139
St. John Outlet	LSJO	04/12/2008	0.14
St. John Outlet	LSJO	04/27/2008	0.131
St. John Outlet	LSJO	04/29/2008	0.126
St. John Outlet	LSJO	05/05/2008	0.115
St. John Outlet	LSJO	05/12/2008	0.127
St. John Outlet	LSJO	05/20/2008	0.126
St. John Outlet	LSJO	05/27/2008	0.116
St. John Outlet	LSJO	06/08/2008	0.158
St. John Outlet	LSJO	03/22/2007	2.13
St. John Outlet	LSJO	04/15/2007	0.417
St. John Outlet	LSJO	04/23/2007	0.327
St. John Outlet	LSJO	04/25/2007	0.302
St. John Outlet	LSJO	05/07/2007	0.232

Waterbody	SampleDate	Total Phosphorus (mg/L)
Lake Poinsett	06/21/1989	0.112
Lake Poinsett	06/21/1989	0.132
Lake Poinsett	07/25/1989	0.298
Lake Poinsett	07/25/1989	0.254
Lake Poinsett	07/09/1991	0.129
Lake Poinsett	07/09/1991	0.21
Lake Poinsett	08/21/1991	0.122
Lake Poinsett	08/21/1991	0.163
Lake Poinsett	08/05/1992	0.07
Lake Poinsett	08/05/1992	0.06
Lake Poinsett	06/15/1993	0.066
Lake Poinsett	06/15/1993	0.063
Lake Poinsett	06/15/1993	0.056
Lake Poinsett	06/15/1993	0.046
Lake Poinsett	06/15/1993	0.043
Lake Poinsett	06/15/1993	0.06
Lake Poinsett	06/30/1993	0.093
Lake Poinsett	06/30/1993	0.053
Lake Poinsett	06/30/1993	0.093
Lake Poinsett	06/30/1993	0.063
Lake Poinsett	06/30/1993	0.056
Lake Poinsett	06/30/1993	0.1
Lake Poinsett	07/20/1993	0.056
Lake Poinsett	07/20/1993	0.06
Lake Poinsett	07/20/1993	0.08
Lake Poinsett	07/20/1993	0.143
Lake Poinsett	07/20/1993	0.11
Lake Poinsett	07/20/1993	0.143
Lake Poinsett	08/04/1993	0.203
Lake Poinsett	08/04/1993	0.143
Lake Poinsett	08/04/1993	0.113
Lake Poinsett	08/04/1993	0.086

Waterbody	SampleDate	Total Phosphorus (mg/L)
Lake Poinsett	08/04/1993	0.083
Lake Poinsett	08/04/1993	0.093
Lake Poinsett	08/16/1993	0.066
Lake Poinsett	08/16/1993	0.056
Lake Poinsett	08/16/1993	0.09
Lake Poinsett	08/16/1993	0.06
Lake Poinsett	08/16/1993	0.066
Lake Poinsett	08/16/1993	0.1
Lake Poinsett	08/31/1993	0.166
Lake Poinsett	08/31/1993	0.123
Lake Poinsett	08/31/1993	0.206
Lake Poinsett	08/31/1993	0.129
Lake Poinsett	08/31/1993	0.126
Lake Poinsett	08/31/1993	0.129
Lake Poinsett	05/04/1994	0.033
Lake Poinsett	05/04/1994	0.03
Lake Poinsett	05/04/1994	0.063
Lake Poinsett	05/04/1994	0.043
Lake Poinsett	05/04/1994	0.04
Lake Poinsett	05/04/1994	0.04
Lake Poinsett	05/23/1994	0.087
Lake Poinsett	05/23/1994	0.03
Lake Poinsett	05/23/1994	0.037
Lake Poinsett	05/23/1994	0.03
Lake Poinsett	05/23/1994	0.027
Lake Poinsett	05/23/1994	0.033
Lake Poinsett	06/13/1994	0.093
Lake Poinsett	06/13/1994	0.106
Lake Poinsett	06/13/1994	0.09
Lake Poinsett	06/13/1994	0.093
Lake Poinsett	06/13/1994	0.086
Lake Poinsett	06/13/1994	0.086
Lake Poinsett	06/29/1994	0.113
Lake Poinsett	06/29/1994	0.11

Waterbody	SampleDate	Total Phosphorus (mg/L)
Lake Poinsett	06/29/1994	0.09
Lake Poinsett	06/29/1994	0.093
Lake Poinsett	06/29/1994	0.133
Lake Poinsett	06/29/1994	0.136
Lake Poinsett	07/13/1994	0.146
Lake Poinsett	07/13/1994	0.2
Lake Poinsett	07/13/1994	0.116
Lake Poinsett	07/13/1994	0.17
Lake Poinsett	07/13/1994	0.07
Lake Poinsett	07/13/1994	0.067
Lake Poinsett	07/25/1994	0.1
Lake Poinsett	07/25/1994	0.083
Lake Poinsett	07/25/1994	0.09
Lake Poinsett	07/25/1994	0.1
Lake Poinsett	07/25/1994	0.096
Lake Poinsett	07/25/1994	0.106
Lake Poinsett	08/15/1994	0.213
Lake Poinsett	08/15/1994	0.19
Lake Poinsett	08/15/1994	0.183
Lake Poinsett	08/15/1994	0.19
Lake Poinsett	08/15/1994	0.22
Lake Poinsett	08/15/1994	0.193
Lake Poinsett	06/20/2000	0.042
Lake Poinsett	06/20/2000	0.1
Lake Poinsett	08/09/2000	0.212
Lake Poinsett	08/09/2000	0.285
Lake Poinsett	06/16/2003	0.056
Lake Poinsett	06/14/2004	0.056
Lake Poinsett	06/14/2004	0.036
Lake Poinsett	06/19/2004	0.089
Lake Poinsett	07/19/2004	0.102
Lake Poinsett	06/27/2006	0.116
Lake Poinsett	06/27/2006	0.103
Lake Poinsett	08/01/2006	0.169
Lake Poinsett	08/01/2006	0.169
Lake Poinsett	06/20/2007	0.173
Lake Poinsett	07/23/2007	0.232
Lake Poinsett	05/20/2008	0.072
Lake Poinsett	05/20/2008	0.071
Lake Poinsett	05/20/2008	0.061
Lake Poinsett	06/10/2008	0.102
Lake Poinsett	06/10/2008	0.106
Lake Poinsett	08/05/2008	0.224

Waterbody	Sample Date	Chlorophyll-*a* (mg/m^3)
Lake Poinsett	07/09/1991	63.4
Lake Poinsett	08/21/1991	25.5
Lake Poinsett	08/05/1992	10.7
Lake Poinsett	05/04/1993	5.4
Lake Poinsett	05/04/1993	5.4
Lake Poinsett	06/15/1993	9.4
Lake Poinsett	06/30/1993	18.8
Lake Poinsett	07/20/1993	284.8
Lake Poinsett	08/04/1993	151.4
Lake Poinsett	08/04/1993	213.1
Lake Poinsett	08/04/1993	136.7
Lake Poinsett	08/16/1993	77.7
Lake Poinsett	08/16/1993	83.8
Lake Poinsett	08/16/1993	40.2
Lake Poinsett	08/31/1993	104.5
Lake Poinsett	08/31/1993	91.1
Lake Poinsett	08/31/1993	77.7
Lake Poinsett	09/22/1993	126.0
Lake Poinsett	09/22/1993	69.7
Lake Poinsett	09/22/1993	160.1
Lake Poinsett	05/04/1994	2.7
Lake Poinsett	05/23/1994	1.3
Lake Poinsett	05/23/1994	2.7
Lake Poinsett	05/23/1994	4.0
Lake Poinsett	06/13/1994	25.5
Lake Poinsett	06/13/1994	36.2
Lake Poinsett	06/13/1994	12.1
Lake Poinsett	06/29/1994	37.5
Lake Poinsett	06/29/1994	93.8
Lake Poinsett	06/29/1994	136.7
Lake Poinsett	07/13/1994	202.3
Lake Poinsett	07/13/1994	325.6
Lake Poinsett	07/13/1994	18.8
Lake Poinsett	07/25/1994	25.5
Lake Poinsett	07/25/1994	37.5
Lake Poinsett	07/25/1994	36.2
Lake Poinsett	08/15/1994	29.5
Lake Poinsett	08/15/1994	6.7
Lake Poinsett	08/15/1994	33.5
Lake Poinsett	09/20/1994	41.5
Lake Poinsett	09/20/1994	9.4
Lake Poinsett	09/20/1994	6.7
Lake Poinsett	06/20/2000	17.4
Lake Poinsett	08/09/2000	87.9
Lake Poinsett	06/14/2004	3.6
Lake Poinsett	07/19/2004	9.8
Lake Poinsett	06/27/2006	6.8
Lake Poinsett	08/01/2006	9.3
Lake Poinsett	06/20/2007	4.3
Lake Poinsett	06/20/2007	2.1
Lake Poinsett	07/23/2007	10.7
Lake Poinsett	05/20/2008	1.7
Lake Poinsett	05/20/2008	2.7
Lake Poinsett	05/20/2008	0.9
Lake Poinsett	06/10/2008	3.1

Waterbody	SampleDate	Secchi Depth (meters)
Lake Poinsett	06/15/1993	1.13
Lake Poinsett	06/30/1993	2.16
Lake Poinsett	07/20/1993	1.46
Lake Poinsett	08/04/1993	0.70
Lake Poinsett	08/16/1993	2.04
Lake Poinsett	08/31/1993	1.16
Lake Poinsett	05/04/1994	2.74
Lake Poinsett	05/23/1994	3.05
Lake Poinsett	06/13/1994	1.62
Lake Poinsett	06/29/1994	1.19
Lake Poinsett	07/13/1994	0.70
Lake Poinsett	07/25/1994	1.71
Lake Poinsett	08/15/1994	1.40
Lake Poinsett	09/20/1994	0.85
Lake Poinsett	06/15/1993	2.50
Lake Poinsett	06/30/1993	2.41
Lake Poinsett	07/20/1993	1.22
Lake Poinsett	08/04/1993	0.98
Lake Poinsett	08/16/1993	1.62
Lake Poinsett	08/31/1993	1.19
Lake Poinsett	05/04/1994	2.74
Lake Poinsett	05/23/1994	3.35
Lake Poinsett	06/13/1994	1.95
Lake Poinsett	06/29/1994	1.16
Lake Poinsett	07/13/1994	0.82
Lake Poinsett	07/25/1994	1.62
Lake Poinsett	08/15/1994	1.55
Lake Poinsett	09/20/1994	0.85
Lake Poinsett	06/15/1993	2.16
Lake Poinsett	06/30/1993	2.59
Lake Poinsett	07/20/1993	2.16
Lake Poinsett	08/04/1993	0.98
Lake Poinsett	08/16/1993	1.62
Lake Poinsett	08/31/1993	1.19
Lake Poinsett	05/04/1994	3.05
Lake Poinsett	05/23/1994	3.51
Lake Poinsett	06/13/1994	1.92
Lake Poinsett	06/29/1994	0.85
Lake Poinsett	07/13/1994	2.90
Lake Poinsett	07/25/1994	1.31
Lake Poinsett	08/15/1994	1.62
Lake Poinsett	06/21/1989	0.91
Lake Poinsett	07/25/1989	0.85
Lake Poinsett	07/09/1991	0.64
Lake Poinsett	08/21/1991	1.68
Lake Poinsett	08/05/1992	1.01
Lake Poinsett	06/20/2000	0.94
Lake Poinsett	08/09/2000	1.70
Lake Poinsett	06/14/2004	1.97
Lake Poinsett	06/19/2004	1.75
Lake Poinsett	06/27/2006	1.62
Lake Poinsett	06/27/2006	1.62
Lake Poinsett	08/01/2006	0.95
Lake Poinsett	06/20/2007	0.97
Lake Poinsett	07/23/2007	2.70
Lake Poinsett	06/10/2008	2.86
Lake Poinsett	06/10/2008	2.56
Lake Poinsett	08/05/2008	2.49
Lake Poinsett	08/05/2008	2.49