



Volney Ditch in 2008

Influence of Barley Straw on Lake Volney Ditched Wetland Water Quality in 2008

Submitted to:
Le Sueur County and
BWSR

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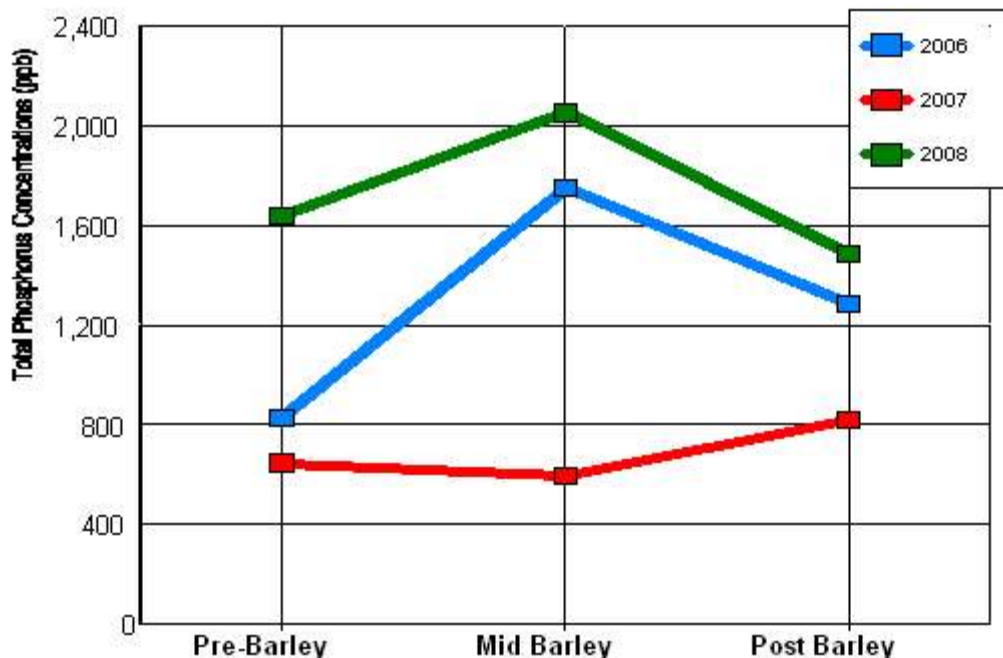
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SUMMARY

It is not conclusive if barley reduced phosphorus in the Volney Ditch in 2006 or 2008. It turns out the ditch is not a free-flowing system all summer. Over the course of the three summers (2006, 2007, and 2008) water in the ditch would form a series of pools. A heavy rain would generate some flow for a period of several days, but then ditch water levels would drop and the pools would redevelop.

The ditch was rarely dry because it received seepage (or interflow) from the surrounding wetlands. This wetland groundwater had remarkably high iron and phosphorus concentrations with levels over several parts per million for both phosphorus and iron. This was an unexpected finding in the course of this project.

For the two years with barley (2006 and 2008) summer averages for phosphorus concentrations were moderately high at the pre-barley site, then increased at the barley site, and then decreased at the post barley site. The increase at the mid-barley site was attributed to high phosphorus from wetland groundwater seeping into the ditch. The decrease in phosphorus at the post barley site compared to the mid barley site may be attributed to the action of the barley straw. In 2007, the year without barley straw, average phosphorus concentrations were lower at the pre-barley site, stayed about the same at the mid-barley site, and increased slightly at the post barley site.



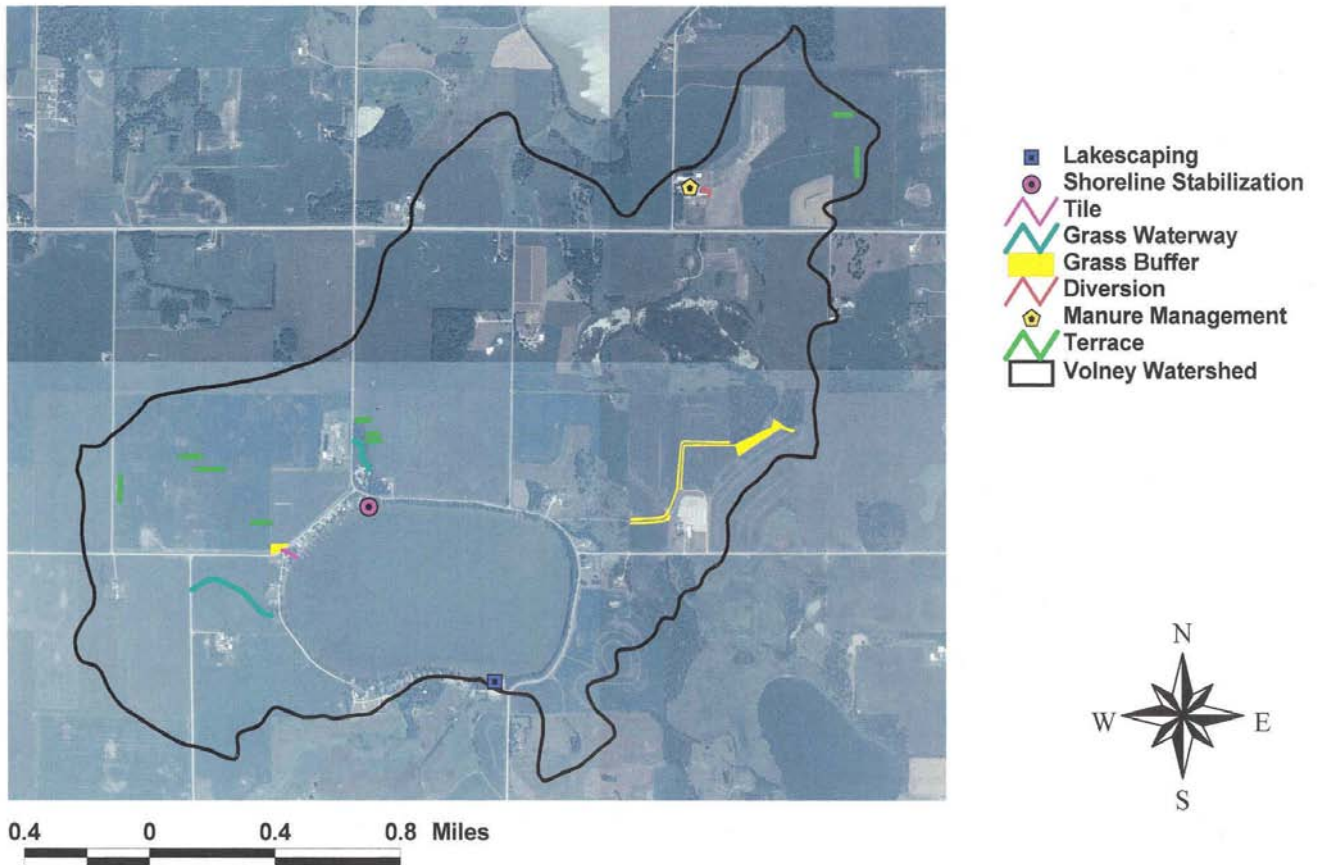
Summer averages (May - September) for total phosphorus for three sample sites for 2006, 2007, and 2008.

Potential Factors Influencing Lake Volney Water Quality: Water clarity in Lake Volney in 2006 and 2008 (years with barley in the ditched wetland) was better than 2007 (year without barley). It's not apparent why the clarity was better in 2006 and 2008 compared to 2007. The other lakes in the area had typical algae blooms in July and August (Appendix B). Lake Volney did not experience July and August nuisance algae blooms in 2006 and in 2008.

Possible factors responsible for the good clarity in Lake Volney in 2006 and 2008 include the following:

- In Lake Volney maybe the carp or the freshwater drum population is at a lower density or was not as active as it has been in the past and did not contribute as large of a phosphorus load to the water column.
- Lack of runoff at key times of the year may have influenced the algae community structure.
- It may be that if the ditched wetland doesn't flow into the lake all summer, that the lake receives a reduced nutrient load resulting in reduced algae concentrations.
- It may be that zooplankton in Lake Volney are grazing on algae and keep the upper water column relatively clear of algae, which in turn would produce good clarity.
- However, it's also possible barley straw removed enough phosphorus in the early summer, while the ditch was still flowing to Lake Volney, to dampen algae blooms in July and August.

Lake Volney Watershed - BMP's Installed (through 2005)



Introduction

Lake Volney is a 283 acre lake located in the Le Sueur County, Minnesota. The maximum depth of Lake Volney is 20 m (67 feet). The total watershed area is about 1,802 acres. The land use in the direct drainage area to Lake Volney consists of primarily of rural development including farms, forests, and wetlands. One of the largest sources of watershed phosphorus comes from a subwatershed that is drained through a ditched wetland (documented in a Phase I Diagnostic/Feasibility Report in 1996).

The objective of installing barley straw in a ditched wetland flowing into Lake Volney was to reduce the phosphorus concentration in the ditch which would reduce the external nutrient loading to Lake Volney to improve summertime water clarity in Lake Volney and reduce the intensity of summer algae blooms.

Barley straw was installed in the Volney Ditch in 2006 and 2008. This report summarizes Volney Ditch water quality results from 2006, 2007, and 2008 and compares ditch water quality in a strawless 2007 to water quality in 2006 and 2008 when straw had been added to the ditch..



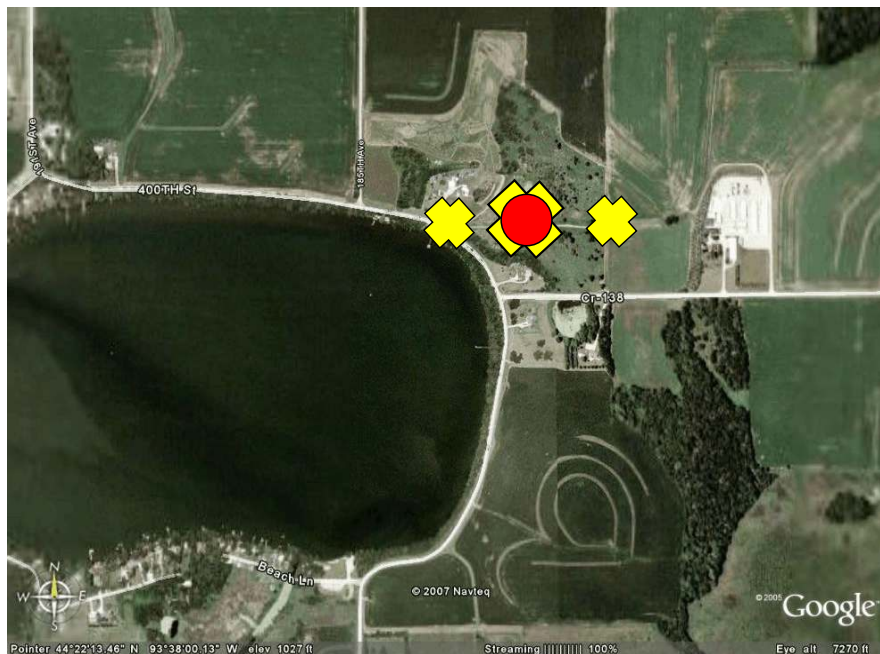
Figure 1. On May 14, 2008, barley straw was added to the stream that outflows a ditched wetland that flows into Lake Volney.

Methods

Barley straw was added in 2008 at a dose of 2,000 pounds of barley. 1,000 pounds of barley straw was added on May 14 and another 1,000 pounds was added on May 20, 2008.

The ditched wetland was sampled at three locations and two times per month from May through September in 2008 (Figure 2). The sampling sites in 2008 were the same as they were in 2007 and 2006. The first sample site in the ditch was located before any of the barley straw installation (pre-barley). The second sample location was in the middle of the area where the barley was deployed (mid barley). The third location was an area downstream of the installed barley (post barley). The experimental ditch length is approximately 1,400 feet long.

At each sample location, the following analyses were conducted: total phosphorus, soluble reactive phosphorus, total iron, dissolved oxygen and temperature. Lab analyses were performed by MVTL Labs in New Ulm. Dissolved oxygen and temperature were measured in the field by Blue Water Science.



- barley straw location in 2006 and 2008
- X Sample sites

Figure 2. Barley location for 2006 and 2008 is shown in red and sample sites are shown in yellow. The same three sample sites were used in 2007 when no barley was added.

Barley Straw Installation in 2008

Barley straw was installed for the second time in three years in 2008. A total of 2,000 pounds of barley was installed in 2008 (Figure 3). In 2006 a total of 2,000 pounds was also installed (1,000 pounds on May 16 and another 1,000 pounds on May 31).



Figure 3. [top] Barley straw was contained in mesh bags. Each bag weighed about 20 pounds. [bottom] A total of 100 bags were placed in the Volney ditch in May of 2008. Bags were tied together and staked along the side of the ditch.

Results

Phosphorus and Iron: Total phosphorus, dissolved phosphorus, and total iron concentrations found at three sample locations in the ditch for 2008 are shown in Table 1. The pre-barley sample was collected in front of the barley straw installation site of 2006 and 2008 (upstream of the barley) and represents ditch nutrient concentrations without any barley straw influence. Samples collected within the barley installation area (mid barley) had higher phosphorus concentrations than the pre-barley and post barley sample sites (post barley site was downstream of the barley).

Starting in July, both phosphorus and iron concentrations were elevated at all three sample sites.

In August and September, ditch samples were collected upstream of pre-barley site. Phosphorus and iron concentrations were high. The ditch was not flowing and the water level was low and this contributed to the high TP and iron in the sample.

Table 1. Volney Ditch total phosphorus (TP), dissolved phosphorus (diss P), and iron for 2008 results.

	5.14	5.20	5.29	6.11	6.20	7.8	7.30	8.8	8.26	9.9	9.30	AVE (May-Sept)
Pre-Barley Site												
TP	106	--	202	258	353	945	847	1,080	2,320	9,320	966	1,640
SRP	74	--	137	188	299	416	267	660	142	84	364	263
Total iron	60	--	1,330	641	198	787	1,530	804	6,660	44,400	2,120	5,853
pH	--	--	--	--	6.4	7.5	--	7.32	7.13	6.14	--	
Mid Barley Site												
TP	132	--	148	461	318	582	1,680	1,280	2,930	4,560	8,460	2,055
SRP	91	--	96	187	241	375	1,360	549	216	104	2,170	539
Total iron	120	--	188	294	243	2,260	4,460	1,790	8,600	22,200	23,200	6,336
pH	--	--	--	--	6.7	--	--	7.1	6.89	6.15	--	
Post Barley Site												
TP	179	--	72	296	389	1,370	dry	460	2,480	3,610	4,510	1,485
SRP	95	--	32	215	277	470	--	196	678	1,970	3,270	800
Total iron	358	--	96	212	420	2,530	--	1,750	6,610	2,540	1,220	1,748
pH	--	--	--	--	6.7	--	--	7.53	7.34	6.33	--	
Gibbs Tile Site												
TP	71	174	242	--	--	--	--	--	--	--	--	
SRP	79	--	--	--	--	--	--	--	--	--	--	
Total iron	108	157	--	--	--	--	--	--	--	--	--	
Post Flume before Pre-Barley Site												
TP	--	--	--	--	--	--	--	--	15,600	4,960	--	
SRP	--	--	--	--	--	--	--	--	--	--	--	
Total iron	--	--	--	--	--	--	--	--	218,000	29,300	--	
pH	--	--	--	--	--	--	--	--	7.06	--	--	

Key: TP = Total phosphorus (ppb)
 SRP = Soluble ortho phosphorus (ppb)
 Total iron = (ppb)

The iron and phosphorus concentrations increased over the summer (Figure 4-top) and were somewhat correlated for all three sites in 2008 (Figure 4-bottom). As iron increases, total phosphorus increases. This is a signature for a wetland phosphorus source.

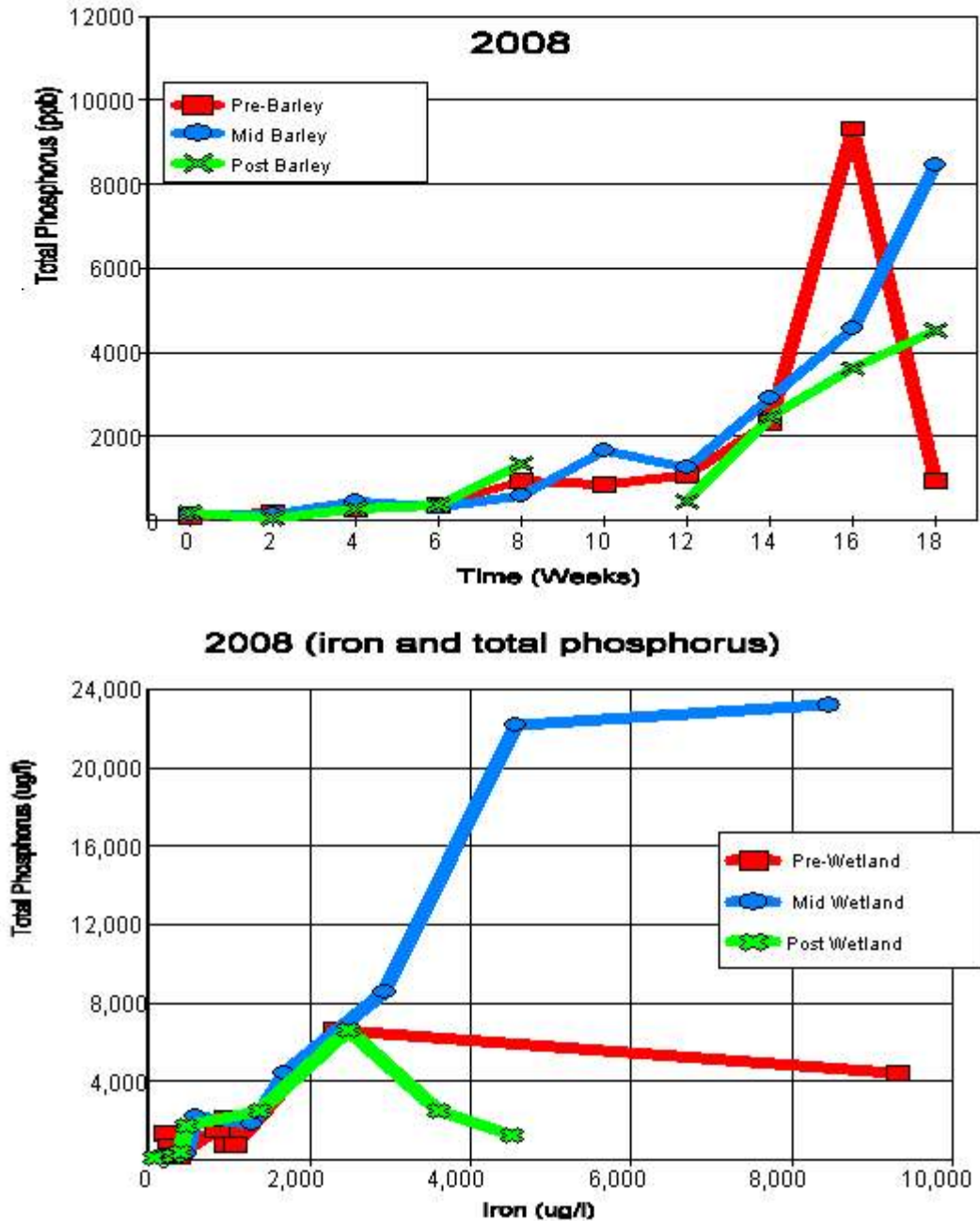


Figure 4. [top] Total phosphorus concentration over the 2008 summer for three sample dates. [bottom] The concentrations of iron and phosphorus were somewhat correlated for the sample sites over the summer (all data are shown). Total phosphorus is on the vertical axis (y-axis) and total iron is on the horizontal axis (x-axis).

Dissolved Oxygen and Temperature: After the May 14 sample date, dissolved oxygen (DO) levels are low at all three sample sites (Table 2). Because dissolved oxygen is low at the pre-barley site, it does not appear that barley is the cause of low DO in the mid and post barley sites, rather, it may be that groundwater seeping into the ditch is low in DO.

Table 2. Dissolved oxygen (mg/l) and temperature (C) for the three sample sites in the Volney Ditch for 2008.

2008	Pre-Barley			Mid Barley			Post Barley		
	DO (mg/l)	Temp (C)	pH	DO (mg/l)	Temp (C)	pH	DO (mg/l)	Temp (C)	pH
May 14	11.2	9.7		8.0	9.8		6.4	9.8	
May 29	2.3	14.6	7.0	3.2	14.8	7.4	7.9	15.6	7.3
Jun 11	3.1	17.1		3.1	17.1		2.4	17.1	
Jun 20	2.8	17.3	6.4	1.7	19.2	6.7	1.7	18.6	6.7
Jul 8	4.5	21.8	7.5	1.45	21.9		0.9	21.9	
Jul 30	0.6	19.9	6.9	0.55	19.2	6.8	0.7	19.7	6.9
Aug 8	1.2	18.0	7.3	0.81	17.4	7.1	0.8	20.0	7.5
Aug 26	0.6	15.6	6.9	0.6	16.6	7.1	0.6	16.8	7.1
Sept 9	0.3	15.7	6.1	1.43	16.0	6.2	0.5	12.7	6.3
Sept 30	8.5	14.2					1.3	15.0	

Special Tile Sampling in 2008

Early in the summer, there was a tile repair occurring in a corn field in an area that was adjacent to the pre-barley sample site (Figure 5 and 6). The tile was repaired by mid-June. Water samples were collected on the excavated area and results are shown in Table 3.



Figure 5. Area of the broken tile. Soil was removed to reach the tile.



Figure 6. Water in the pit was clear, with no turbidity. Three water samples were collected from this pool and results are shown in Table 3.



Figure 7. Possible source of water to the tile was this wetland across the road from the tile.

Phosphorus concentrations in the tile water were less than ditch water phosphorus on May 14 but was slightly higher on the May 29 sample date (ditch sample results are shown in Table 1). The source of subsurface water and its outlet were not clear. The tile was repaired by mid-June.

Table 3. Tile sampling in 2008.

	Dates			
	May 14	May 20	May 29	June
TP (ppb)	71	174	242	tile fixed and soil replaced
SRP (ppb)	79			
Total iron (ppb)	108	157		

Summary of 2006, 2007, and 2008 Volney Ditch Data

Phosphorus and iron concentrations varied widely within a growing season as well as from year to year. Summer averages for the three sites over the three years is shown in Table 4. It appears in 2006 and 2008 there may have been hydrological conditions that were different from 2007. There was less annual precipitation in 2006 and 2008 compared to 2007 (Table 5). With lower runoff due to less precipitation in 2006 and 2008, phosphorus and iron were more concentrated (less diluted). This could account for the higher concentrations, including at the pre-barley site. Lower TP and iron concentrations in 2007 may be the result of more precipitation and a combination of dilution, more runoff, and less phosphorus and iron from the wetland complex.

It's clear that the nutrient dynamics in a ditched wetland are influenced by many factors, with hydrology being a significant driver.

Table 4. Summer averages (May - Sept) for Volney Ditch total phosphorus (TP), dissolved phosphorus (diss P), and iron results.

	Pre-Wetland				Mid Wetland				Post Wetland			
	Fe:TP Ratio	TP (ppb)	Diss P (ppb)	Iron (ppb)	Fe:TP Ratio	TP (ppb)	Diss P (ppb)	Iron (ppb)	Fe:TP Ratio	TP (ppb)	Diss P (ppb)	Iron (ppb)
2006	8.7	827	430	7,163	17.5	1,750	729	30,550	1.5	1,285	1,476	1,916
2007	1	647	370	626	1.3	593	383	771	1.7	821	565	1,397
2008	2.4	1,640	263*	5,853	2.2	2,055	539*	6,336	1.6	1,485	800*	1,748

* analysis was for SRP rather than dissolved P.

Table 5. Monthly precipitation for LeSueur County (inches) and Lake Volney phosphorus and Secchi disc results for 2005-2008.

	2005	2006	2007	2008
January	1	1.2	1.27	0.24
February	1.46	0.34	1.18	0.23
March	1.37	1.47	3.21	1.4
April	3.23	3.45	1.82	3.42
May	4.78	1.64	2.29	3.26
June	4.31	3.72	2.56	3.65
July	1.58	1.68	2.56	3.36
August	4.2	4.19	8.57	2.7
September	7.02	4.31	3.23	1.81
October	3.14	0.57	4.4	2.15
November	1.96	1.29	0.2	1.86
December	1.29	2.11	1.45	1.33
Total	35.40	26.67	33.74	26.26
Lake TP (Jun-Sept)(ppb)	87	65	55	57
Lake SD (Jun-Sept)(ft)	6.9	9.9	7.6	8.1

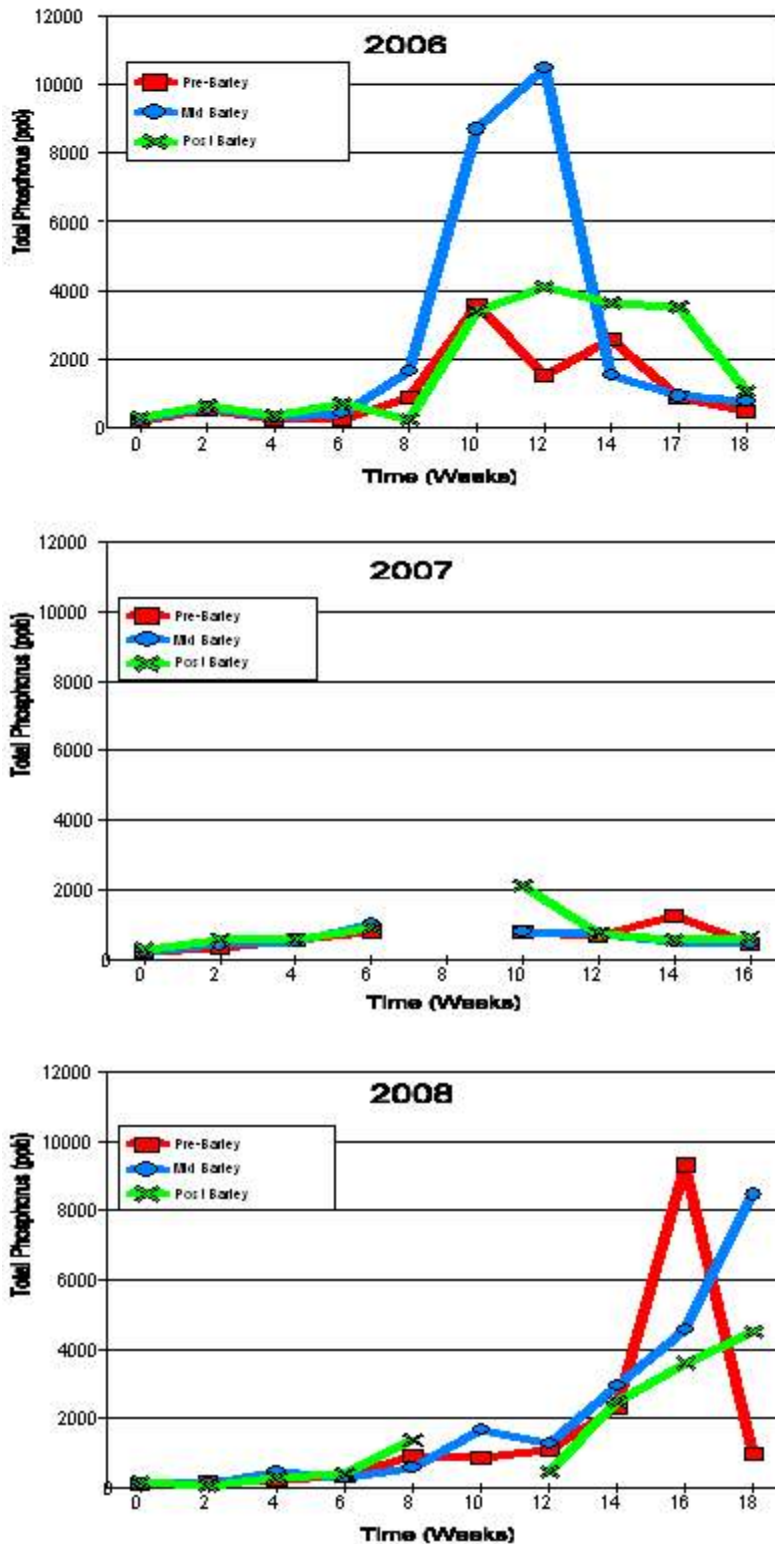


Figure 8. Total phosphorus concentrations in the Volney Ditch for three sites for 2006, 2007, and 2008. No barley was applied in 2007, and although phosphorus was lower, there was more precipitation and more dilution in the ditch than in 2006 and 2008. What is of interest is that in 2006 and 2008, years with barley, phosphorus levels decreased from the mid-barley site to the post-barley site. The mid-barley phosphorus peak in 2006 is attributed to wetland phosphorus contributions.

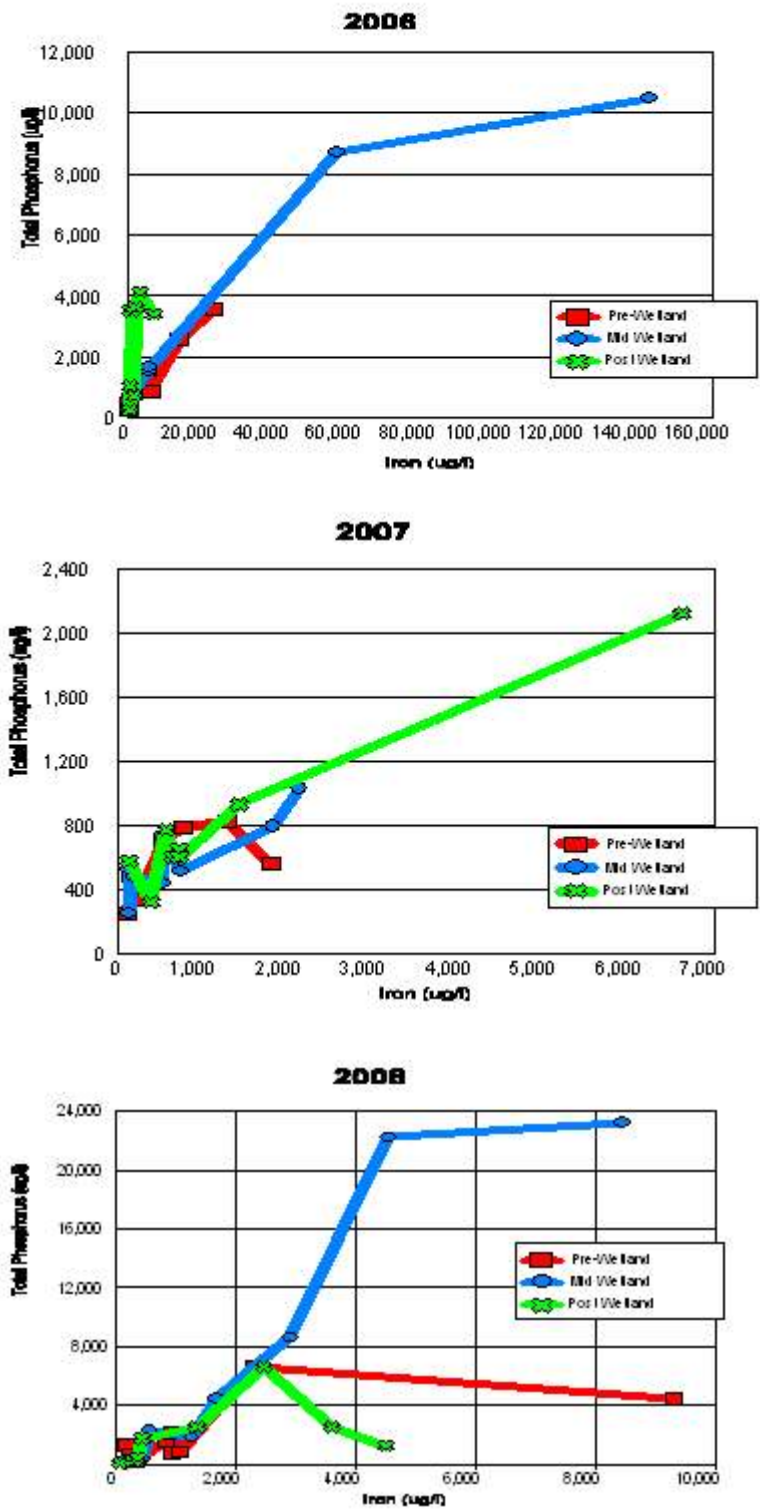


Figure 9. The concentrations of iron and phosphorus were somewhat correlated for the pre-barley and mid-barley sites over the summers of 2006, 2007, and 2008.

Ditch sample results show as phosphorus concentrations increase so do iron concentrations. This may indicate that in the wetland sediments, phosphorus and iron are coupled and if iron dissolves under anoxic conditions, phosphorus is released into the pore water of the wetland sediments. The surface flow is toward the ditch.

Because phosphorus and iron increase from the pre-barley to mid barley site, the source of phosphorus and iron is suspected to be from groundwater flowing into the ditch. The ratio of iron to phosphorus concentrations ranged from 0.1 to 13.6 over the three summers for the three sites (Table 6). It would appear that wetland subsurface flows probably account for the elevated iron and phosphorus concentrations found in the ditch. It would appear that wetland dynamics are influencing iron and phosphorus concentrations in the ditch.

Table 6. Iron to phosphorus ratios for barley sample sites and for two barley straw samples analyzed for total iron and total phosphorus. Barley straw Fe/TP = 0.1 (n=2).

	Sample Locations - 2006			Outlet Status
	Pre-Barley Fe/TP	Mid Barley Fe/TP	Post Barley Fe/TP	
June	0.7	1.7	2.2	Flowing
July	6.9	3.4	1.3	Not determined
July	6.6	6.6	2	Not determined
Aug	3.3	13.6	0.8	No flow
Aug	5.4	3.5	0.5	No flow
Sept	1.1	1.6	0.2	No flow
Sept	0.3	0.7	0.5	No flow

	Sample Locations - 2007			Outlet Status
	Pre-Barley Fe/TP	Mid Barley Fe/TP	Post Barley Fe/TP	
May 9	0.4	0.5	1.2	Flowing
May 21	0.7	1.2	1.1	No flow
Jun 6	3.2	1.4	1.2	No flow
Jun 20	1	2.1	1.5	No flow
Jul 10	no sample	no sample	no sample	Dry
Aug 15	1.5	2.3	3.1	No flow
Aug 28	0.7	0.7	0.7	Flowing
Sept 12	0.1	0.2	0.2	No flow
Sept 28	0.3	0.4	1.1	No flow

	Sample Locations - 2008			Outlet Status
	Pre-Barley Fe/TP	Mid Barley Fe/TP	Post Barley Fe/TP	
May 14	0.6	0.9	2	Flowing
May 29	6.6	1.3	1.3	Flow from lake
Jun 11	2.5	0.6	0.7	Not determined
Jun 20	0.6	0.8	1.1	No flow
Jul 8	0.8	3.9	1.8	No flow
Jul 30	1.8	2.7	dry	No flow
Aug 8	0.7	1.4	3.8	No flow
Aug 26	2.9	2.9	2.7	No flow
Sept 9	4.8	4.9	0.7	No flow
Sept 30	2.2	2.7	0.3	No flow

Ditch Conditions in 2006, 2007, and 2008

2006



May 16, 2006



September 20, 2006

2007



May 21, 2007



July 10, 2007

2008



May 14, 2008



May 20, 2008

Figure 10. Ditch water depth is about 2 to 2.5 feet in early summer. By late summer, water levels vary from 0.5 to 1.0 feet deep and the water surface is covered with duckweed.

Conclusions on the Effect of Barley Straw Additions to the Volney Ditch Water Quality

It is not conclusive if barley reduced phosphorus in the Volney Ditch in 2006 or 2008. It turns out the ditch is not a free-flowing system all summer. Over the course of the three summers (2006, 2007, and 2008) water in the ditch would form a series of pools. A heavy rain would generate some flow for a period of several days, but then ditch water levels would drop and the pools would redevelop.

The ditch was rarely dry because it received seepage (or interflow) from the surrounding wetlands. This wetland groundwater had remarkably high iron and phosphorus concentrations with levels over several parts per million for both phosphorus and iron. This was an unexpected finding in the course of this project.

For the two years with barley (2006 and 2008) summer averages for phosphorus concentrations were moderately high at the pre-barley site, then increased at the barley site, and then decreased at the post barley site (Figure 11). The increase at the mid-barley site was attributed to high phosphorus from wetland groundwater seeping into the ditch. The decrease in phosphorus at the post barley site compared to the mid barley site may be attributed to the action of the barley straw. In 2007, the year without barley straw, average phosphorus concentrations were lower at the pre-barley site, stayed about the same at the mid-barley site, and increased slightly at the post barley site.

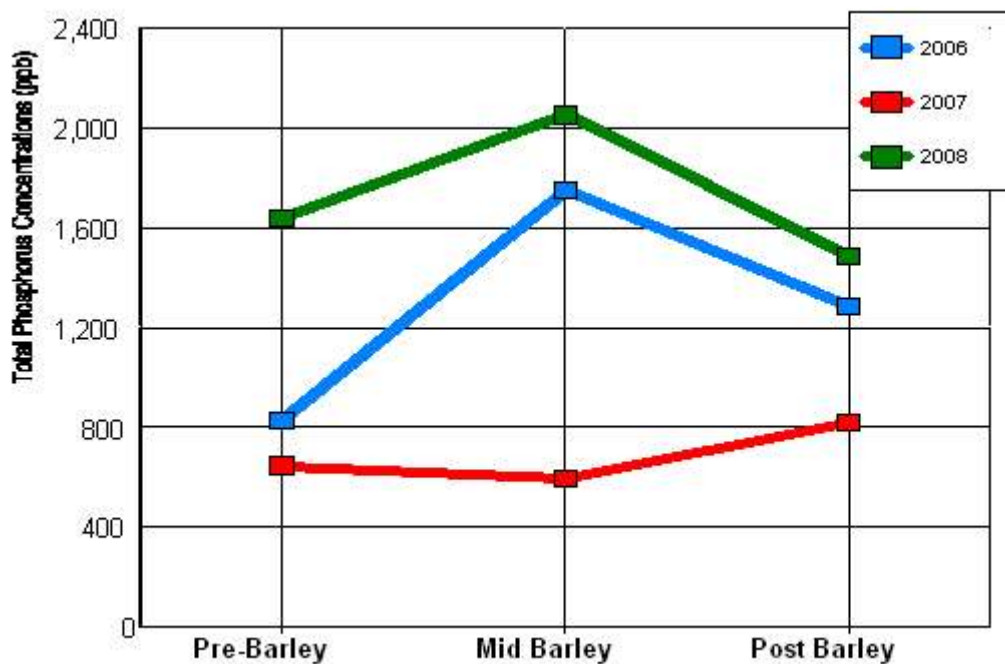


Figure 11. Summer averages (May - September) for total phosphorus for three sample sites for 2006, 2007, and 2008.

Lake Volney Long Term Clarity Data

Lake Volney water clarity data from 1986 through 2008 is shown in Table 7 and Figure 12. Summer seasonal water clarity was good in 2008, slightly less 2007, with a slight improvement in 2008. Although water clarity was better in the two years with barley straw compared to 2007, the year without barley straw, that doesn't mean barley straw was the reason. Maybe it was a contributing factor.

Table 7. Volney Lake Secchi disc measurement summary for the June through September average and the seasonal minimum and maximum readings as well.

	Secchi Disc (ft)			Annual Precipitation
	Minimum	Average (Jun-Sept)	Maximum	
1986	1.5	5.3	12	39.1
1987	2.5	4.6	6.5	18.3
1988				18.1
1989				22
1990	8.5	10.9	14.5	38.2
1991	4.5	6.7	8.5	39.5
1992	0.5	4.9	13	32.9
1993	3.5	8.1	20	42.8
1994	0.5	5.1	9.5	32.1
1995	1	8.7	20	30.8
1996	2.5	6.7	12	32.6
1997	3.5	6.2	13.5	29.9
1998	2.5	5.4	8.5	32.8
1999	2.5	4.8	8	35.3
2000				31.5
2001	1.8	6.5	14	29.9
2002	2	6.4	10.5	32.1
2003	1.9	8.3	14.5	22
2004				37.4
2005	3.3	6.9	17.1	35.4
2006	6.6	9.9	12.1	26.7
2007	3.6	7.6	11.2	33.9
2008	2.9	8.1	16.9	26.3

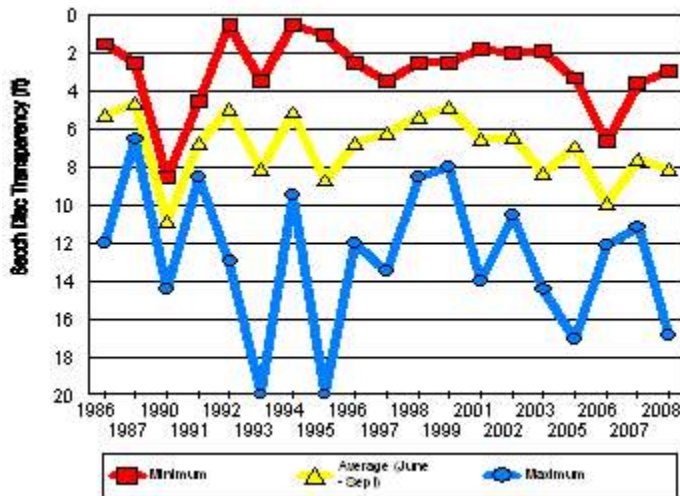


Figure 12. Available Secchi disc transparency for Lake Volney from 1986 through 2008. Water clarity in 2006 was the second highest recorded over the last 20 years.

Impact of Watershed Loading on Lake Volney

Lake Volney is surrounded by agricultural acreage with some urban land use as well. Although, the watershed loading is a significant factor impacting lake water quality, it does not appear that watershed loading alone accounts for observed lake water quality.

For example when annual precipitation is plotted against lake water clarity, there is a poor correlation (Figure 12). Annual precipitation should reflect watershed loading rates. The greater the precipitation, the greater the runoff, which should produce a higher nutrient loading. The expected result would be more algae growth and poorer Secchi disc readings.

Because watershed nutrient loading is not correlated with water clarity, there is a strong indication that lake processes contribute to lake water clarity as well.

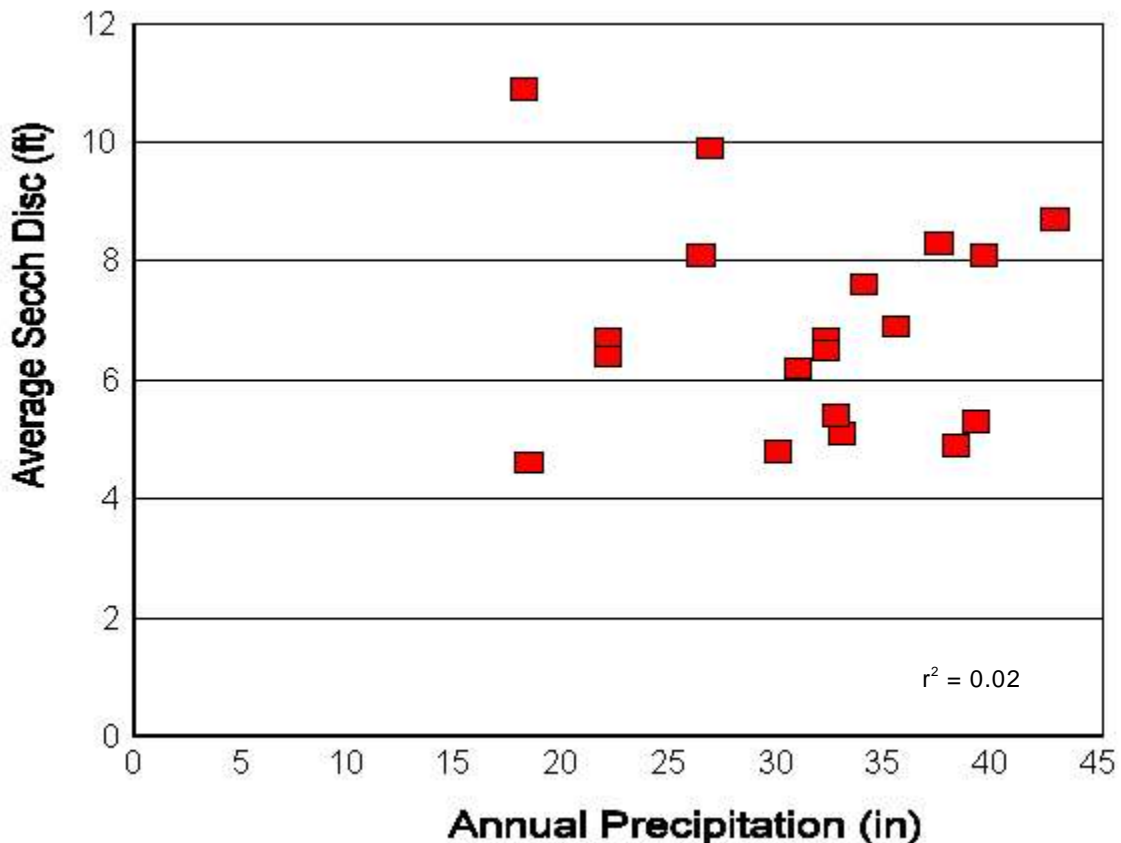


Figure 13. Annual precipitation and Lake Volney summer average clarity for 1986 through 2008.

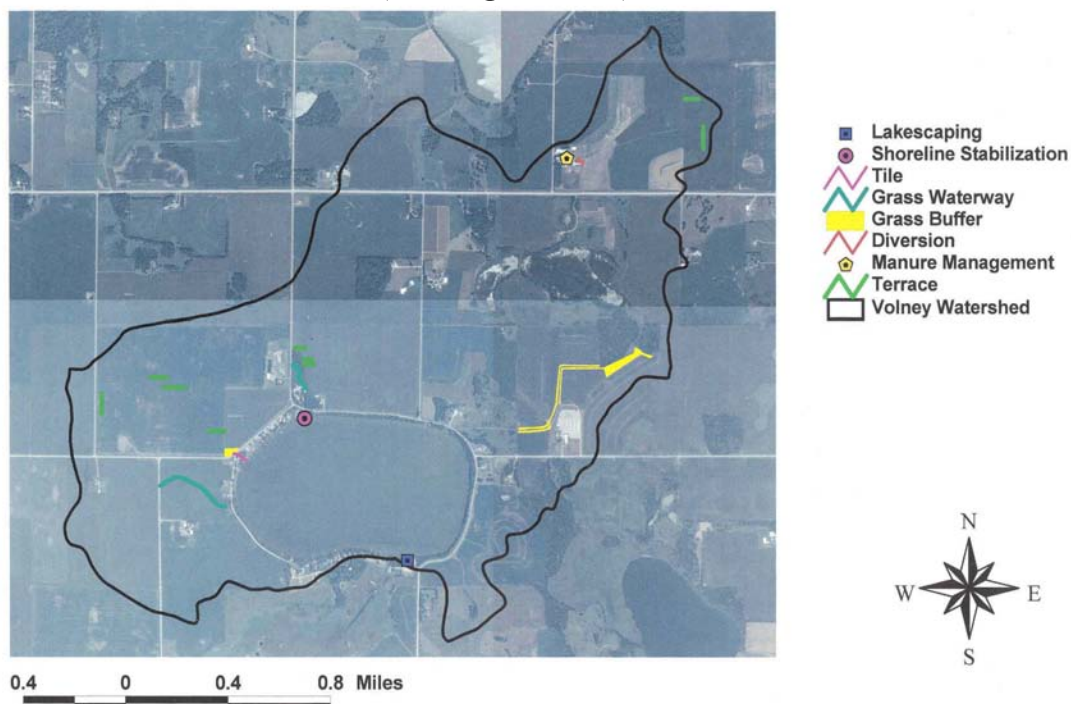
Potential Factors Influencing Lake Volney Water Quality

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Possible factors responsible for the good clarity in Lake Volney in 2006 and 2008 include the following:

- In Lake Volney maybe the carp or the freshwater drum population is at a lower density or was not as active as it has been in the past and did not contribute as large of a phosphorus load to the water column.
- Lack of runoff at key times of the year may have influenced the algae community structure.
- It may be that if the ditched wetland doesn't flow into the lake all summer, that the lake receives a reduced nutrient load resulting in reduced algae concentrations.
- It may be that zooplankton in Lake Volney are grazing on algae and keep the upper water column relatively clear of algae, which in turn would produce good clarity.
- However, it's also possible barley straw removed enough phosphorus in the early summer, while the ditch was still flowing to Lake Volney, to dampen algae blooms in July and August.

Lake Volney Watershed - BMP's Installed (through 2005)



Appendix A: Volney Ditch Data for 2006

Volney Ditch total phosphorus (TP), dissolved phosphorus (diss P), and iron for 2006 results.

Week	Sample Date	Pre-Barley			Mid Barley			Post Barley			Ditch Flow into Lake
		TP (mg/l)	Diss P (mg/l)	Iron (mg/l)	TP (mg/l)	Diss P (mg/l)	Iron (mg/l)	TP (mg/l)	Diss P (mg/l)	Iron (mg/l)	
0	May 16* (pre installation)	0.188	0.165		0.214	0.148		0.283	0.169		yes
		0.19	--		0.233	--		0.303	--		
		0.189	--		0.2	--		0.308	--		
2	May 31 (two weeks after installation of 1,000 lbs, another 1,000 lbs added)	0.551	0.321		0.564	0.365		0.639	0.377		yes
		0.553	--		0.566	--		0.638	--		
		0.549	--		0.575	--		0.638	--		
4	Jun 13	0.266			0.335			0.362			yes
		0.246			0.305			0.334			
		0.257			0.29			0.392			
6	Jun 29	0.264	0.25	0.196	0.41	0.318	0.679	0.711	0.621	1.57	ND
8	Jul 13	0.875	0.343	6.07	1.68	1.23	5.71	0.258	0.2	0.324	ND
10	Jul 27	3.58	0.406	23.6	8.7	0.61	57	3.39	1.67	6.91	ND
12	Aug 14	1.55	0.408	5.19	10.5	2.02	143	4.12	2.9	3.29	no
14	Aug 30	2.59	0.658	14	1.55	0.216	5.46	3.63	2.95	1.94	no
17	Sep 20	0.863	0.856	0.963	0.922	0.899	1.48	3.51	3.4	0.755	no
18	Sep 28	0.489	0.467	0.125	0.758	0.755	0.521	1.05 (8.32 tile)	1	0.538	no

*Flume: TP: 171 ppb; Diss P: 126 ppb

Dissolved oxygen (mg/l) and temperature (C) in the ditch.

Week		Pre-Barley		Mid Barley		Post Barley	
		DO (mg/l)	Temp (C)	DO (mg/l)	Temp (C)	DO (mg/l)	Temp (C)
0	May 16	--	--	--	--	--	--
2	May 31	2.9	--	1.5	--	1.3	--
4	Jun 13	0.8		0.4		0.5	
6	Jun 29	0.6	16.1	0.6	17.1	0.5	16.5
8	Jul 13	0.2	21.1	0.3	21	1.5	21.1
10	Jul 27	0.3	20	0.3	20.1	0.2	19.5
12	Aug 14	0.8	20.7	2.5	23.8	0.4	20.4
14	Aug 30	0.5	19.6	0.9	18.3	0.7	18
17	Sep 20	1.2	11.3	0.6	10.1	0.7	9.3
18	Sep 28	0.9	10.2	0.8	9.9	1.4	10.3

Volney Ditch Data for 2007

Volney Ditch total phosphorus (TP), dissolved phosphorus (diss P), and iron for 2007 results.

	Pre-Wetland			Mid Wetland			Post Wetland			Ditch Flow
	TP (ppb)	Diss P (ppb)	Iron (ppb)	TP (ppb)	Diss P (ppb)	Iron (ppb)	TP (ppb)	Diss P (ppb)	Iron (ppb)	
May 9	249	228	101	246	198	123	318	246	378	outflow present, about 4" on culvert
May 21	330	262	237	439	294	517	602	378	642	no outflow, water is above culvert
Jun 6	560	411	1790	510	355	731	600	389	717	no outflow, water is above culvert
Jun 20	780	302	768	1030	396	2130	930	505	1420	no outflow, water is 3" above culvert
Jul 10										No water in ditch. No sample.
Aug 15*	823	426	1270	793	493	1820	2120	1410	6620	4 inches of water in ditch.
Aug 28	709	554	531	733	538	522	769	722	560	ditch is flowing
Sept 12	1240	411	157	521	451	126	577	471	123	water level is 2 inches above culvert
Sept 28	482	362	152	474	336	199	650	402	716	no outflow, water is 2 inches over culvert.
Summer Average	647	370	626	593	383	771	821	565	1397	

* August 15: white pipe by culvert sample: total phosphorus = 510 ppb

Dissolved oxygen (mg/l) and temperature (C) in the ditch (T=top and B=bottom).

2007	Pre-Barley		Mid Barley		Post Barley	
	DO (mg/l)	Temp (C)	DO (mg/l)	Temp (C)	DO (mg/l)	Temp (C)
May 21	8.2 T	19.7 T	7.6 T	22.6 T	3.6 T	20.5 T
	7.1 B	19.7 B	5.2 B	21.6 B	3.2 B	19.5 B
Jun 6	6.6 T	17.0 T	7.5 T	17.2 T	2.7 T	16.6 T
	5.6 B	16.9 B	7.1 B	16.9 B	2.2 B	16.5 B
Jun 19	0.7 T	19.1 T	1.5 T	20.2 B	0.6 T	19.9 T
Jul 10	NO WATER IN STREAM					
Aug 15	3.8	23.7	2.9	23.4	2.9	22.3
Aug 28	1.6	21.1	2.2	21.1	2.6	21.3
Sep 27	2.5	14.3	4.8	15.5	2.6	14.7

Appendix B: Lake Water Quality

Volney, German, and Jefferson Lake Sampling Data for 2005

	May 19	May 31	June 16	June 30	July 19	July 28	Aug 17	Aug 31	Sept 16	Sept 30	AVERAGE (May-Sept)
Volney											
SD (ft)	15.3	17.4	17.1	7.5	3.5	4.7	3.3	5.5	4.4	9.0	8.8
Chl a (ppb)	1	1.9	1.1	23.8	57.3	42.2	45.2	8.8	10.5	2.2	19.4
TP -T (ppb)	141	132	114	110	81	56	66	45	39	83	87
TP -B (ppb)	--	162	175	214	527- 35 ft 322 - 50 ft	644	158	267	722	116	331
German											
SD (ft)	8.8	9.5	9.2	5.7	3.2	3.2	3.1	2.5	2.2	2.6	5.0
Chl a (ppb)	11.3	4.7	7.2	11.3	21.2	13.0	41.0	52.7	38.4	31.0	23.2
TP -T (ppb)	27	26	38	43	62	69	62	84	102	79	59
TP -B (ppb)	--	42	83	68	359	118	84	86	83	93	113
East Jefferson											
SD (ft)	6.8	9.1	6.6	2.5	3.2	3.0	2.7	2.2	2.8	2.6	4.2
Chl a (ppb)	13.3	5.1	20.1	36.9	19.2	15.4	43.0	49.1	19.4	17.8	23.9
TP -T (ppb)	44	29	37	80	54	66	80	93	98	91	67
TP -B (ppb)	--	29	70	100	79	321	192	126	107	113	126
Mid Jefferson											
SD (ft)	5+	5+	6+	2.5	1.4	1.1	1.3	1.8	1.8	2.0	2.8
Chl a (ppb)	1	1	1	12.5	86.2	62.2	120	80.7	57.9	43.4	46.6
TP -T (ppb)	22	30	135	238	182	239	200	158	158	109	147
West Jefferson											
SD (ft)	5.5	7.2	4.5	1.9	1.5	1.5	1.7	1.9	2.6	2.2	3.1
Chl a (ppb)	13.1	6.3	23.4	66.1	74.9	63.9	71.3	52.7	30.6	39.7	44.2
TP -T (ppb)	37	29	68	108	82	97	75	69	73	76	71
TP -B (ppb)	--	35	107	121	86	168	83	65	81	78	92
South Jefferson (Swedes Bay)											
SD (ft)	--	--	3.5	1.1	1.2	0.9	1.4	1.1	1.4	1.4	1.5
TP -T (ppb)	--	--	321	388	332	297	196	210	182	162	261

Key: SD = Secchi disc
 Chl a (ppb) = Chlorophyll a in parts per billion
 TP - T = Total phosphorus - top water
 TP - B = Total phosphorus - bottom water

Volney, German, Jefferson, and Washington Lake Sampling for 2006

	May 16	May 31	June 13	June 29	July 13	July 27	August 14	August 30	Sept 20	Sept 28	AVERAGE (May-Sept)
Volney											
SD (ft)	17.8	10.2	11.9	8	6.6	9.3	7.5	12.5	11	12.1	10.7
Chl a (ppb)	2.5	11.5	13.1	14.1	10.7	8.9	8.2	3.3	10.5	6.6	8.9
TP -T (ppb)	130	95	83	30	27	30	[179]*	17	83	87	65
TP -B (ppb)	334	141	122	403	411	410	[713]	229	91	170	257
German											
SD (ft)	8.7	6.4	5.1	3.9	2.8	1.9	1.8	2.1	2.5	2.2	3.7
Chl a (ppb)	9.7	6.6	19.7	17.6	23.8	43.8	52.1	67.1	35.4	51.7	32.7
TP -T (ppb)	37	22	36	39	43	38	[189]	52	79	71	46
TP -B (ppb)	24	31	45	98	51	56	[658]	50	73	77	56
East Jefferson											
SD (ft)	8	6.5	3.9	2.8	1.9	1.9	2.7	2	1.9	2	3.4
Chl a (ppb)	16.5	20.9	34.9	32.6	40.6	29.3	41.4	48.1	26.2	28.9	31.9
TP -T (ppb)	27	33	64	47	54	45	[192]	74	104	105	61
TP -B (ppb)	36	42	58	46	66	58	[543]	123	93	109	70
Mid Jefferson											
SD (ft)	6.0-bot	6.0-bot	4.5	2.8	1.5	1.3	1.2	2	2	1.7	2.9
Chl a (ppb)	1.7	6.2	19.9	39.3	57.1	86.9	124	64	48.6	57.1	51
TP -T (ppb)	23	71	76	69	166	133	[276]	55	69	127	88
West Jefferson											
SD (ft)	4.1	8	3.4	2.1	1.5	1.4	1.9	1.9	2.6	2.2	2.9
Chl a (ppb)	20.3	<1	43.5	31.9	58.9	67.9	88.4	74.5	45.9	47.9	48
TP -T (ppb)	40	36	70	45	64	41	[213]	38	65	71	52
TP -B (ppb)	51	38	81	71	71	52	[196]	52	55	82	61
South Jefferson (Swedes Bay)											
SD (ft)	4.5-bot	4.0-bot	1.8	1.4	1.3	1.3	1.4	1.1	1.1	1	1.9
TP -T (ppb)	29	182	403	193	173	189	[285]	112	102	174	173
East Washington											
SD (ft)	6.9	8.6	3.7	2.5	2.1	1.9	2.1	2.1	1.9	2.1	3.4
Chl a (ppb)	24	11.2	39.6	24.7	46.4	48.5	54.9	153	63.6	52.8	51.9
TP -T (ppb)	27	32	55	45	63	52	[205]	74	121	92	62
TP -B (ppb)	32	200	164	347	39	682	[208]	1250	67	94	319
West Washington											
SD (ft)	7.8	5.3	3	2.2	1.8	1.5	1.5	1.5	1.6	1.8	2.8
Chl a (ppb)	11.2	15.6	31.8	19.9	39.7	52.7	75.7	60.8	40	42.1	39
TP -T (ppb)	20	29	43	54	46	49	[208]	51	56	87	48
TP -B (ppb)	23	50	39	52	38	80	[209]	68	70	88	56

Key: SD = Secchi disc
 Chl a (ppb) = Chlorophyll a in parts per billion
 TP - T = Total phosphorus - top water
 TP - B = Total phosphorus - bottom water

* phosphorus values in brackets appear to be systematically too high for August 14. Values are shown but were not used for determining the May - September seasonal average.

Volney, German, Jefferson, and Washington Lake Sampling for 2007

	5.9.07	5.21-22.07	6.6.07	6.20.07	7.10.07	7.20.07	8.15.07	8.28.07	9.12.07	9.27.07	AVERAGE (May-Sept)
Volney											
SD (m)	6.7	4.7	2.54	1.7	1.62	1.1	1.95	3.4	3.15	3.1	3
Chl a (ppb)	1.2	2.3	18.2	35.5	12.3	12.7	6.2	9.2	9.9	1	10.85
TP -T (ppb)	111	83	71	64	39	36	19	37	38	54	55.2
TP -B (ppb)	157	253	193	418	367	480	552	471	55	54	300
German											
SD (m)	4.35	1.9	1.5	1.6	1.2	0.8	0.85	0.7	0.55	0.7	1.4
Chl a (ppb)	2.5	29	<1	9.9	27.6	36	51.4	76.7	63.3	58.4	35.58
TP -T (ppb)	28	19	22	30	48	56	59	82	84	75	50.3
TP -B (ppb)	37	26	25	78	183	68	68	85	83	75	72.8
East Jefferson											
SD (m)	2.1	1.85	2.7	2.2	0.89	0.7	0.63	0.6	0.75	1.1	1.4
Chl a (ppb)	8.5	16.3	3.4	10	40.9	34.8	57.7	39.7	54.6	24.2	29.01
TP -T (ppb)	14	34	18	37	53	61	59	120	102	80	57.8
TP -B (ppb)	27	35	22	114	223	55	112	157	117	87	94.9
Mid Jefferson											
SD (m)	1.4	0.8	1.2	1.75b	0.35	0.6	0.45	0.5	0.55	0.4	0.6
Chl a (ppb)	6.7	13.2	3.3	15.9	72.9	61.6	72.8	57.1	45.4	43.9	39.28
TP -T (ppb)	23	74	75	81	223	151	138	108	92	115	108
West Jefferson											
SD (m)	1.95	0.75	0.81	0.47	0.41	0.4	0.4	0.6	0.75	0.6	0.7
Chl a (ppb)	6.1	34.4	19.9	77.7	94.2	72.8	79.9	49	53.8	45.1	53.29
TP -T (ppb)	32	59	83	111	88	96	78	70	65	75	75.7
TP -B (ppb)	44	69	81	109	108	74	88	70	84	63	79
South Jefferson (Swedes Bay)											
SD (m)	1.1	1.4	1.8	0.54	0.55	0.5	0.85	0.5	0.3	0.3	0.8
Chl a (ppb)		8.4	5	44.7	39.5	109	36.4				40.5
TP -T (ppb)	51	56	40	436	123	499	102	195	363	285	215
East Washington											
SD (m)	1.9	0.83	0.9	0.65	0.62	0.6	0.7	0.6	0.55	0.5	0.8
Chl a (ppb)	20.5	38.9	37.2	47	46.6	45.7	38.5	54.5	69.5	75.3	47.37
TP -T (ppb)	40	56	37	57	76	77	48	68	118	105	68.2
TP -B (ppb)	90	61	53	66	222	122	155	87	112	104	107.2
West Washington											
SD (m)	1.6	0.68	0.52	0.53	0.35	0.4	0.5	0.5	0.5	0.6	0.6
Chl a (ppb)	19	46.3	39	39.7	52.2	53.4	58.4	48.9	44.2	45.7	44.68
TP -T (ppb)	37	65	54	73	87	81	67	71	84	69	68.8
TP -B (ppb)	66	59	44	81	93	105	69	83	79	64	74.3

Key: SD = Secchi disc
 Chl a (ppb) = Chlorophyll a in parts per billion
 TP - T = Total phosphorus - top water
 TP - B = Total phosphorus - bottom water

Summary of water quality data 2008 for Lakes Volney, Gorman, Sabre, East Washington, West Washington (SD = Secchi disc, total phos = total phosphorus and chl a = chlorophyll a).

Date (2008)	Volney			Gorman			Sabre			East Washington			West Washington		
	SD (ft)	Total Phos (µg/l)	Chl a (µg/l)	SD (ft)	Total Phos (µg/l)	Chl a (µg/l)	SD (ft)	Total Phos (µg/l)	Chl a (µg/l)	SD (ft)	Total Phos (µg/l)	Chl a (µg/l)	SD (ft)	Total Phos (µg/l)	Chl a (µg/l)
5.14	14.0	51	<1	6.7	118	<1	7.1	125	<1	6.1	45	25.4	5.3	39	47.2
5.29	23.0	61	1.6	8.6	191	1.6	9.4	175	1.2	7.9	60	5.9	7.6	33	5.0
6.10	16.9	63	1.2	4.5	341	<1	5.0	307	<1	6.0	36	24.9	5.2	29	15.5
6.20	15.0	49	3.3	5.8	333	5.4	6.9	339	1.9	6.4	14	2.8	5.1	22	10.0
7.8	7.1	39	25.7	2.3	693	52.1	9.1	576	3.7	6.0	69	53.1	3.5	47	26.4
7.30	3.9	70	52	3.5	1,050	13.7	3.7	1,180	79.1	2.4	62	49.9	2.4	57	22.3
8.8	2.9	70	57.7	1.4	1,420	27.3	4.8	1,270	7.4	2.7	105	44.4	2.3	64	42.2
8.26	8.2	37	11.2	4.1	1,500	41.9	1.5	1,500	43.1	2.3	80	35.5	2.1	75	35.2
9.9	5.0	71	31.0	2.9	1,380	16.3	4.3	1,300	62.1	1.9	97	41.4	1.7	56	30.8
9.30	5.9	59	12.4	3.6	1,210	48.1	2.6	1,540	8.6	2.0	98	51	2.0	68	37.2
Avg	10.2	57	18.7	4.3	824	20.8	5.5	831	20.9	4.4	67	33.4	3.7	49	27.2
Avg (Jun - Sept)	8.1	57	23.1	3.5	991	25.7	4.8	1,001	25.9	3.7	70	37.9	3.0	52	27.5