Technical Specifications

Alterations to Cedar, Albion, Henshaw, Swartout Improvement Project #06-1

Wenck File #0002-130

Prepared for:

CLEARWATER RIVER WATERSHED DISTRICT
PO Box 481
Annandale, MN 55302

Prepared by:

WENCK ASSOCIATES, INC.
1800 Pioneer Creek Center
P.O. Box 249
Maple Plain, Minnesota 55359-0249
(763) 479-4200

November 2009

Wenck

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineering under the laws of the State of Minnesota.

Norman C. Wenck 11-24-09

Registration No. 8946

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A Technical Memorandum dated November 11, 2009
B Legal Memorandum dated November 9, 2009
C Excerpts from Engineer's Report and Project #06-1 dated August 2006
D Excerpts from TMDL Report dated May 2009 (revised September 2009)

1.0 Purpose

On November 11, 2009, the Board of Managers of the Clearwater River Watershed District (CRWD) at their regular meeting received and reviewed a Technical Memorandum from Wenck Associates, Inc., The District Engineer, evaluating Project #06-1, the Cedar, Albion, Swartout, Henshaw Improvement Project (Appendix A). The Board of Managers also reviewed procedures outlined by CRWD's attorney, Mr. Stanley J. Weinberger, Jr., in a memorandum dated November 9 2009 (Appendix B). At the meeting, the Board ordered the District Engineer to prepare Technical Specifications for the alterations to the project. This document is intended to fulfill the requirements of Minnesota Statutes Section 103D.635, Subdivision 1, for an alterations to a project.

2.0 Introduction

Project #06-1 was ordered and implemented to improve the water quality for the four lakes of Cedar, Albion, Swartout and Henshaw. The Engineer's Report dated August 2006 considered 16 activities to reduce the phosphorus loading to the lakes (see Appendix C). Ultimately, six of the alternatives were chosen to be implemented, plus three years of evaluation to determine if more activities were required to meet the project goals. The November 11, 2009, Technical Memorandum indicates that further activities are required to fully meet project goals.

TMDL studies for Albion, Swartout and Henshaw Lakes were completed as part of the Five Lakes TMDL project started in 2008 and submitted to the EPA in a report dated November 2009, Wenck Associates, Inc. (2009).

Excerpts from the TMDL report dated November 2009 (Appendix D) describes the condition of Albion Lake, Henshaw Lake and Swartout Lake, presents the existing loadings to the lakes, presents the load allocation for each lake to reach it's in-lake water quality goal and presents a conceptual implementation plan to reach the water quality goals for these lakes. Fourteen of these activities apply to these lakes and need to be considered for implementation.

3.0 Technical Specifications

In order to fully meet the goals of Project #06-1, further activities are required as listed in Appendix A, C and D. The following activities and others to be identified through further evaluation may be required:

- Eliminate ISTS discharges;
- Aggressive curly leaf pondweed control;
- Removal of cormorants on Swartout Lake;
- Carp population reduction;
- Fish migration barriers between Albion and Swartout, and Henshaw and Swartout Lakes;
- Install fish barriers between Highway 55 and Cedar Lake, and Swartout Lake outlet at CR 6 to prevent upstream migration;
- Treat Swartout wetland outlet to remove phosphorus;
- Increase residence time on wetland between Swartout and Highway 55;
- Watershed best management practices;
- Buffer tile lines, ditches and streams;
- Lake shore management in Cedar, Swartout, Albion and Henshaw Lakes
- Ecological management of Henshaw, Albion and Swartout Lakes;
- Isolate Swartout Lake;
- Isolate wetland treatment system in the Highway 55 wetland;
- Install sedimentation basins;
- Promote Ag BMPS (P Testing and fertilizer application);
- Replace tile intakes with filters;
- Tile intake buffers;
- Buffer tributaries;
- Buffer stream banks

- Tile discharge management;
- Riparian pasture/grazing management;
- Lakeshore septic upgrade;
- Lakeshore restoration (shore land erosion);
- Shallow Lakes Management Plans;
- Public outreach; and
- Other activities as indicated by future project monitoring and evaluation.

4.0 Recommendations

It is recommended that Project #06-1 be altered, as described in Appendix A, C and D, and Section 3.0 Technical Specifications. The alterations will be specifically identified by future project monitoring and evaluation.

5.0 Certification

Additional activities as described in Appendices A, C and D (as summarized in Section 3.0) and others, are required to be implemented to fully achieve the purposes of Project #06-1. The exact nature of additional activities will be determined from the on-going monitoring and evaluation of the project.

6.0 References

Wenck Associates, Inc., Final Draft Five Lakes TMDL Report dated November 2009 (for submittal to EPA).

Appendix A

Technical Memorandum
Dated November 11, 2009

Wenck Associates, Inc.
1800 Pioneer Creek Ctr.
P.O. Box 249
Maple Plain, MN 55359-0249

(763) 479-4200
Fax (763) 479-4242
E-mail: wenckmp@wenck.com

TECHNICAL MEMORANDUM

TO: Marvin Brunsell, Chairperson, Clearwater River Watershed District

FROM: Norman Wenck, District Engineer

DATE: November 11, 2009

SUBJECT: Evaluation of Cedar Lake Project #06-1

INTRODUCTION

This memorandum is prepared to assess Cedar Lake Project #06-1. Project #06-1 was initiated in 2007 in response to a petition by lake shore residents to address the declining water quality and severe algae blooms in Cedar Lake.

The anticipated goals of the project were to reduce phosphorus concentrations in Cedar Lake and the accompanying nuisance algae blooms. More specifically, the goal of the project was to reduce the phosphorus load to Cedar Lake to 1,000 lbs and the in-lake summer average phosphorus concentration in Cedar Lake to 20 µg/l. An additional goal of the project was to further reduce phosphorus loading from upstream lakes through a reduction in the carp population of the lakes.

The recommended solution for reducing the phosphorus loading and carp population in Cedar, Albion, Henshaw, and Swartout Lakes consisted of carp barriers, sedimentation basins, watershed best management practices (BMPs), and a phosphorus removal treatment system. However, the phosphorus removal treatment system was deleted and a three year evaluation task was added. This memorandum presents our evaluation of Project 06-1 as of this date.

Several measures were implemented to reduce in lake phosphorus concentrations in Swartout, Albion, and Henshaw Lakes, thereby reducing the phosphorus load to Cedar Lake and improving lake water quality in Cedar, Swartout, Albion, and Henshaw Lakes. The projects that were implemented are described below and their locations are shown on Figure 1.

Ultimately, the plan that was implemented was a portion of the original plan. When addressing impairments in shallow lakes it is also necessary to address the health of biological communities. To improve the quality of shallow lakes, it is beneficial to restore the health of biological communities in the lake, including fish, plants, and zooplankton. Ideally, shallow lake management plans incorporating water level management to promote vegetation growth, and fish community management strategies, such as lake drawdowns or the application of Rotenone to promote rough fish kills, would be implemented. However, efforts to implement these strategies have been met with limited success with landowners so the implementation strategies were limited to rough fish barriers and harvesting, and watershed BMPs.

Best Management Practices (BMPs)

The Project recommended the implementation of watershed BMPs, including drain tile inlet replacement, buffering of tile inlets, and ditch and stream buffer strips.

Watershed BMPs that were implemented in 2007 included the buffering of five tile intakes for a three year period, 14 acres of alfalfa buffer for one year, and 132 acres of soybean stubble buffer for one year. The one year cropland buffers were not renewed and were planted into corn in 2008. There were no additional buffers implemented in 2008 or 2009.

Rough Fish Management

Rough fish management activities including the construction of carp barriers and rough fish harvesting were recommended and implemented as part of the Project to help control rough fish populations in the upstream lakes.

The Project recommended the construction of four carp barriers on Cedar Lake tributary streams. The fish barriers are intended to impede upstream migration of carp, which prevents adult carp from reaching their preferred spawning grounds in the wetlands adjacent to the lakes. This can help keep carp populations in check and also reduces carp damage to shallow upstream lakes. Carp can cause problems in shallow lakes by stirring up bottom sediments through their feeding activities. This makes the waters turbid which typically does not allow submerged aquatic vegetation to grow in the lake. The disturbance of the nutrient rich bottom sediments can also lead to an increase in internal cycling of nutrients from the bottom sediments, exacerbating the impairment of upstream lakes and therefore adding higher phosphorus loads to Cedar Lake.

Three fish barriers were installed during early spring 2007 on the Cedar Lake inlet upstream of Highway 55, and at the Swartout Lake and Henshaw Lake outlets. In 2008, carp barriers were installed at two inlets to Swartout Lake and in the diversion channel upstream of Segner Pond. Based on observations made during 2008 and 2009, the barriers appear to be effectively restricting the upstream migration of carp from Cedar Lake to the upstream lakes.

In addition to the installation of fish barriers, rough fish harvesting was conducted in the upstream lakes in 2008. Approximately 57,000 lbs of carp were removed from Swartout Lake by two nettings performed by a commercial fishing operation in February 2008. An additional 4,760 lbs of rough fish were removed from Swartout Lake in December 2008. Netting was also performed on Henshaw Lake in 2008, removing 220 lbs of bullheads from the lake.

While it is difficult to completely eradicate carp from lakes, effective rough fish population management would likely result in a significant reduction in the internal loading in upstream watershed lakes, and a decrease in nutrient loading to waters downstream. A reduction in the carp population in the lakes together with improved water clarity may allow aquatic vegetation to grow in the lake, which would provide more suitable habitat for waterfowl and other wildlife.

It is difficult to determine with certainty the impact that the rough fish management practices that have been implemented have had on carp populations. However, observations made in 2008 and 2009, coupled with the significant decrease in the amount of carp harvested from the lake in

December 2008, indicate that the implemented practices have been effective in reducing carp populations.

Sedimentation Basins
The Project recommended the construction of three sedimentation basins. However, one larger basin was constructed.

Construction of the Segner Pond treatment wetland on the Cedar Lake inlet just upstream of Cedar Lake was completed in 2008. Construction of the treatment wetland began in December 2007, and the grading and placement of the limestone treatment filter was completed in January 2008. Flow from the inlet to Cedar Lake was not diverted into Segner Pond until September 2008 to allow vegetation to become established on the slopes of the pond and in the mitigation wetland.

The treatment wetland consists of a 2.9 acre sedimentation basin with a limestone treatment filter. A diversion constructed in the stream channel upstream of the treatment wetland routes stream flow into the sedimentation basin to remove particulate phosphorus from the inflow to Cedar Lake. The limestone treatment filter further reduces the phosphorus load to Cedar Lake by removing dissolved phosphorus from the inflow. The limestone filter targets the soluble portion of the phosphorus load to Cedar Lake.

RESULTS

Water quality monitoring was conducted for the past three years to track the progress of the Project. The results of the monitoring are described in the following section. Samples were collected from four lakes, including Albion Lake, Cedar Lake, Henshaw Lake, and Swartout Lake. Samples were also collected from eight locations in tributary streams in the subwatershed during the time period that the tributary streams were flowing.

Stream Loads

The tributary streams that were monitored typically started flowing in early spring after snow melt and flowed until early summer, depending on precipitation conditions. Since precipitation was near or below normal in 2007-2009 (See Table 1), most of the streams were not flowing after early summer during each year in which they were monitored.

Table 1: Annandale Precipitation, 2007-2009

	2007 Annandale/ Corinna (Wright)	2008 Annandale/ Corinna (Wright)	2009 Annandale/ Corinna (Wright)	1971-2000 Normal (Cokato)
January	0.39	0.34	0.66	0.93
February	0.69	0.40	0.76	0.70
March	2.29	0.83	2.93	1.69
April	1.78	3.31	0.97	2.33
May	2.37	5.21	0.88	3.30
June	2.29	4.12	5.49	4.62
July	1.84	1.61	1.45	4.04
August	4.97	1.95	5.90	4.00
September	5.20	2.46	1.06	2.78
October	4.79	2.39	6.32	2.23
November	0.02	1.31	--	1.73
December	1.19	1.07	--	0.71
Total	27.82	25.00	26.42*	29.06

*Total through October (Normal through October is 26.62 inches)

The calculated phosphorus loads at each stream location monitored from 2007-2009 are shown below in Table 2 and on Figure 2. Runoff and phosphorus loads were highest in 2008 due to increased precipitation during the early summer period when the streams were flowing. Overall, the external phosphorus load to Cedar Lake, as measured at monitoring site SSW04 ranged from approximately 500 lbs to 1000 lbs with an average of 797 lbs compared to the project goal of 1000 lbs.

The phosphorus load calculated for monitoring site SSW02 indicates that a large load of phosphorus enters Swartout Lake from the watershed east of the lake.

Table 2: Tributary Stream 2007-2009 Data

	Mean TP Concentration (ug/L)			TP Load (lbs)			Runoff (in)		
Site	2007	2008	2009	2007	2008	2009	2007	2008	2009
SCE01	38	28	34	121	199	136	1.6	3.6	2
SCE03	186	49	*	136	8	*	*	*	*
SDD01	352	165	178	163	120	10	3.1	4.8	0.4
SHE01	283	222	195	81	247	61	1.2	4.5	1.3
SSW01	232	159	276	98	698	602	0.7	7	3.5
SSW02	96	301	345	292	858	739	0.5	4.7	3.5
SSW03	257	71	*	102	39	*	1.6	2.2	*
SSW04	58	201	265	870	1011	512	1.2	4	1.5

*Site not monitored

In-Lake Water Quality

Summer average phosphorus and chlorophyll-a concentrations and Secchi depth from the four lakes monitored from 2007-2009 is shown below in Table 3. Data from the closest year in which each lake was monitored prior to the start of the Project is also included in Table 3 for comparison. These summer average values are compared to past concentrations from all monitoring conducted prior to 2007 in Appendix A.

Table 3: Summer Average Monitoring Data

Lake	Year	Summer Average (June-Sept) Phosphorus (ug/L)	Chlor-a (ug/L)	Secchi Depth (m)
	2006	296	203	1.2
	2007	186	79	1.1
	2008	188	97	1.1
Albion	2009	173	38	1.4
	2006	58	20	2.6
	2007	29	11	1.7
	2008	19	9	1.8
Cedar	2009	32	12	1.9
	2005	281	144	0.5
	2007	390	278	0.2
	2008	266	121	0.7
Henshaw	2009	90	25	0.7
	2006	372	207	0.9
	2007	262	168	0.2
	2008	401	832	0.6
Swartout	2009	299	152	0.2

Overall, summer average phosphorus and chlorophyll-a concentrations in Albion and Henshaw Lakes have decreased since the start of the Project. Similarly, water clarity in the two lakes has improved. Abundance of submerged aquatic vegetation was noted to be improved in Albion and Henshaw Lakes in 2009. The suspected cause of the improvement in water quality in these two lakes is the improved ecological health of the two lakes resulting from natural fish kills due to freeze out and lower water levels due to below normal precipitation allowing for an increase in aquatic vegetation growth.

Summer average total phosphorus and chlorophyll-a concentrations in Swartout Lake have remained high but relatively stable since 2006. Water clarity remains low in the lake due primarily to severe algae blooms throughout the summer.

Monitoring data from events conducted from 2007 to 2009 in Cedar Lake is found in Appendix B. Overall, summer average in-lake phosphorus concentrations ranged from 19 to 32 µg/l during that time period. From 2007 to 2009, Cedar Lake was also sampled by a lake resident as part of a volunteer lake monitoring program. As demonstrated in Appendix B, data from the two monitoring programs was found to be similar.

While in-lake summer average phosphorus concentrations have decreased in Cedar Lake since 2006, they remain above the Project goal of 20 µg/l.

Although internal loading of phosphorus is not suspected to make up a significant portion of the phosphorus load in Cedar Lake, it is likely that there is some internal loading of phosphorus in the lake. This is evidenced by increased concentrations of phosphorus in the lake in 2009, even though the external load to the lake was relatively low. Samples were collected near the bottom of the lake in 2007 and 2009 (See Table 4). Elevated concentrations of phosphorus near the lake bottom indicates potential internal loading. Temperature and dissolved oxygen profile data indicates that the lake is stratified during most of the time period from June to September.

Table 4: Cedar Lake Near Bottom Monitoring Data

Site ID	Date	TP (µg/L)	OrthoPhos (µg/L)	Total Fe (mg/L)
LCE01B	5/25/2007	56	39	0.14
LCE 01B	6/29/2007	158	121	0.08
LCE01B	7/27/2007	150	129	0.12
LCE01B	8/24/2007	159	139	0.04
LCE01B	6/11/2009	212	166	< 0.015
LCE01B	7/13/2009	279	179	0.015
LCE01B	8/6/2009	272	254	0.036
LCE01B	9/14/2009	365	263	0.135

It is suspected that curly leaf pondweed, which is present in small areas of the lake, may contribute to internal loading in the lake by making phosphorus from buried lake sediment available in the water column during the growing season.

Although the summer average Secchi depth has not shown an improvement since 2006, at times, water clarity in Cedar Lake has been very good. In 2007, although the average Secchi depth was 1.7 meters, the observed range of Secchi depth was 0.9 to 5.2 meters. In 2008, Secchi depth ranged from 1.4 to 5.5 meters with an average of 1.8 meters, and in 2009 Secchi depth ranged from 1.1 to 9.4 meters with an average of 1.9 meters.

CONCLUSIONS

1. The external phosphorus load to Cedar Lake from the upstream watershed for 2007 to 2009 was between approximately 500 lbs and 1000 lbs with an average of 798 lbs/year compared to the project goal of 1000 lbs.

2. Precipitation during 2007 to 2009 was below average overall, and thus lower than average annual runoff.

3. The in-lake phosphorus concentration in Cedar Lake was between 19 and 32 μg/l compared to a goal of 20 μg/l.

4. Three years of reduced external phosphorus loading has not resulted in meeting the Cedar Lake in-lake phosphorus concentration goal.

5. Fewer BMPs were implemented than planned.

6. Rough fish harvesting in conjunction with the installation of carp barriers was effective in reducing carp populations in Swartout Lake.

7. Curly leaf pondweed appears to be contributing to the internal phosphorus loading of Cedar Lake.

RECOMMENDATIONS

1. Continue funding additional BMPs (especially in the watershed tributary to Swartout Lake to the southeast) and maintain existing BMPs.

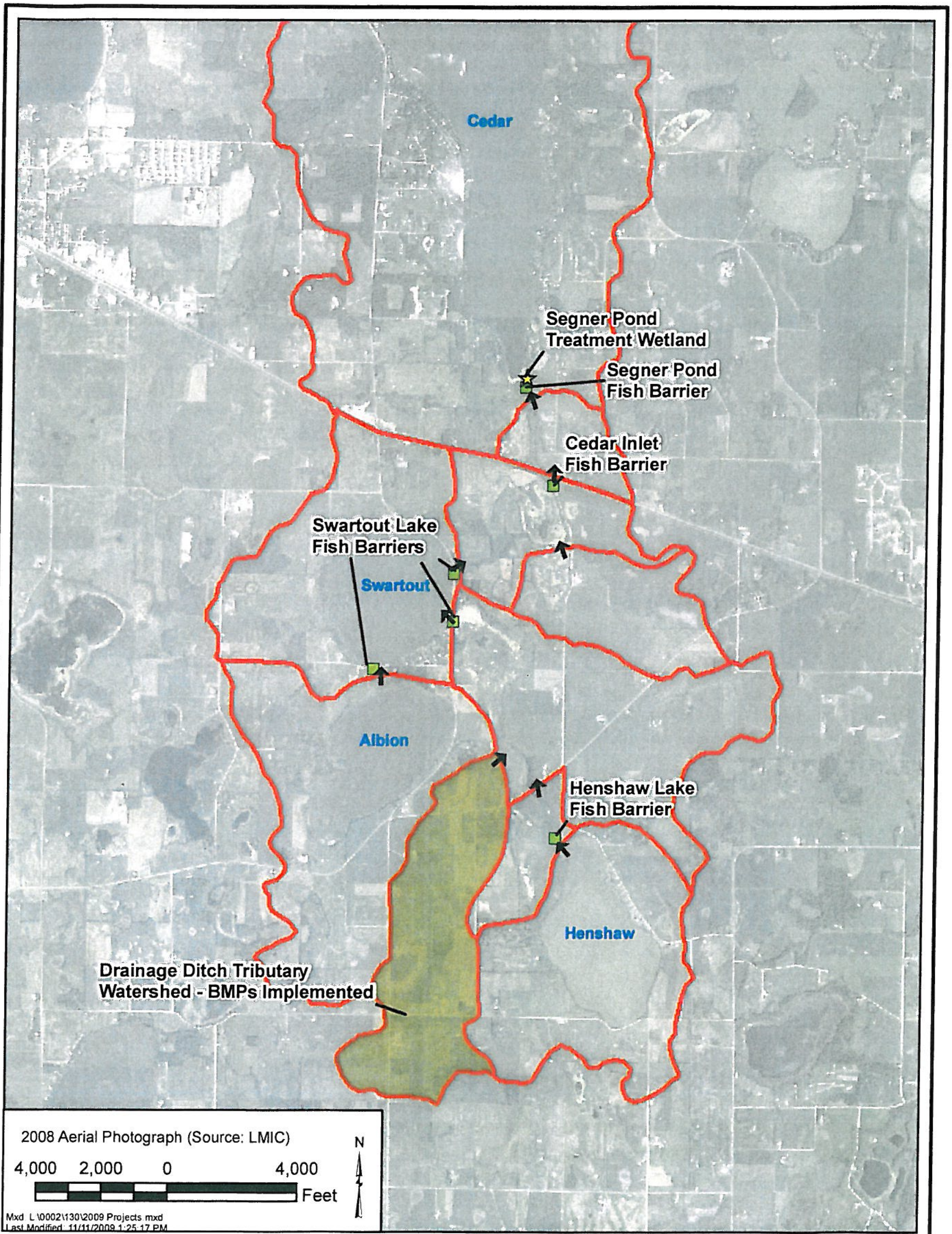
2. Continue maintaining carp barriers and continue with rough fish harvesting from Swartout Lake.

3. Continue the project evaluation monitoring program.

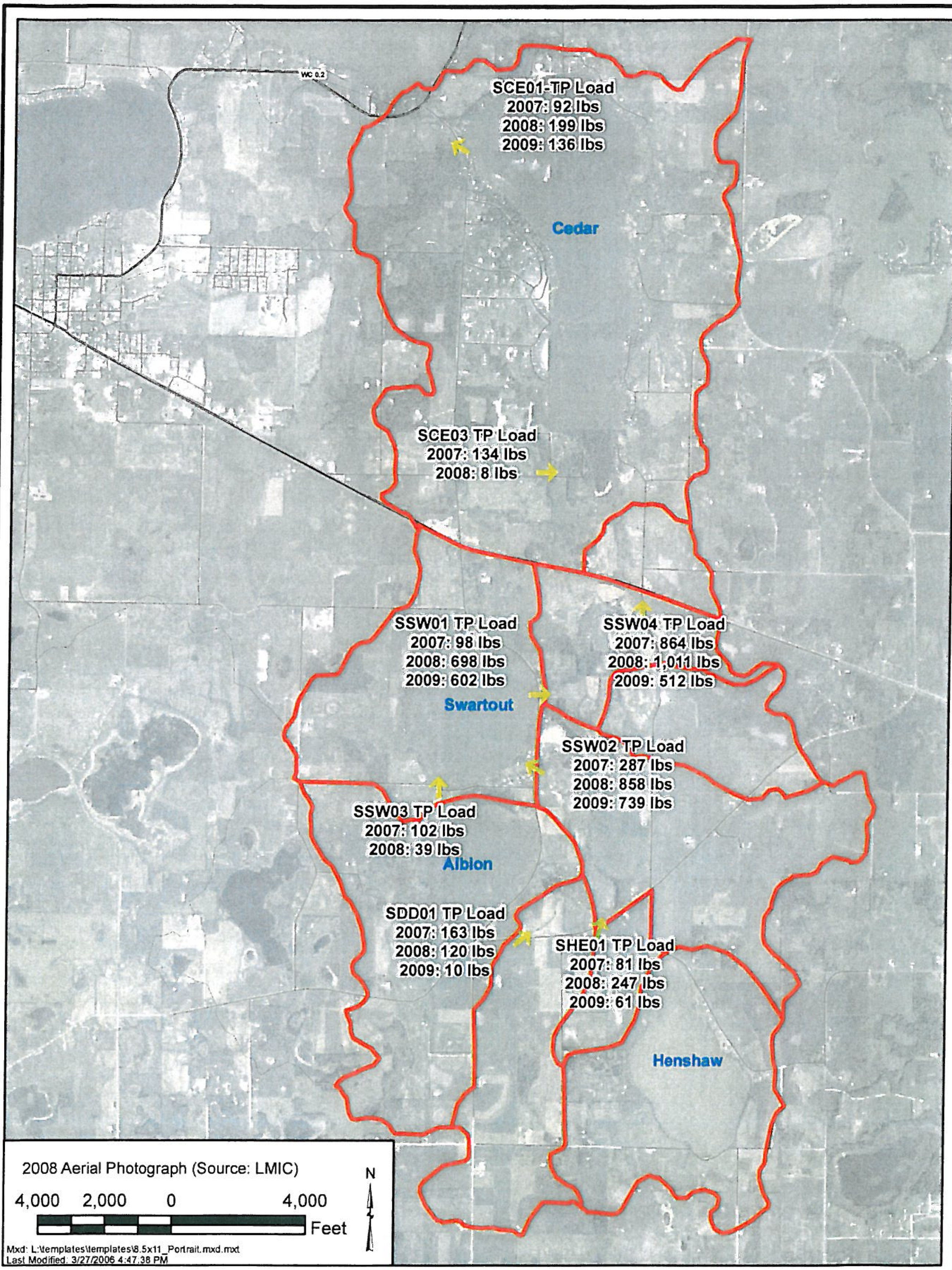
4. Consider curly leaf pondweed management in Cedar Lake, which may include vegetation inventories and chemical treatment.

5. Continue maintenance of Segner Pond.

Figures



CRWD	Wenck	NOV 2009
Implementation Location Map	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359-0429	Figure 1



CRWD

Tributary Stream Phosphorus Loads

Wenck

Wenck Associates, Inc.
Environmental Engineers

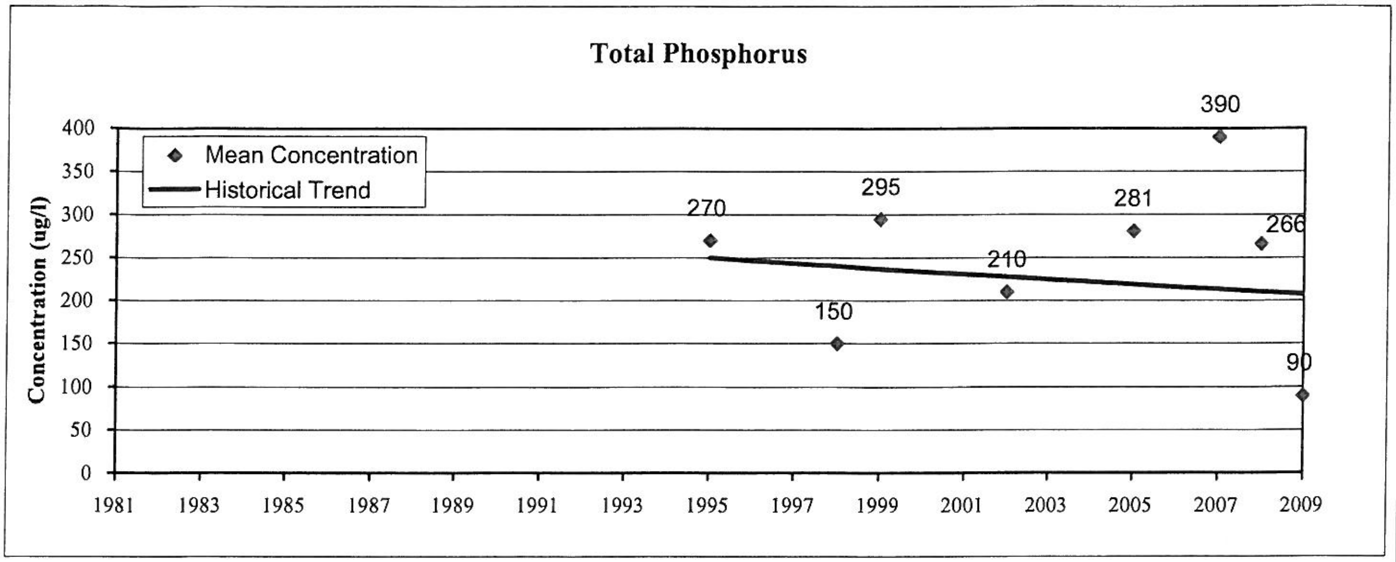
1800 Pioneer Creek Center
Maple Plain, MN 55359-0429

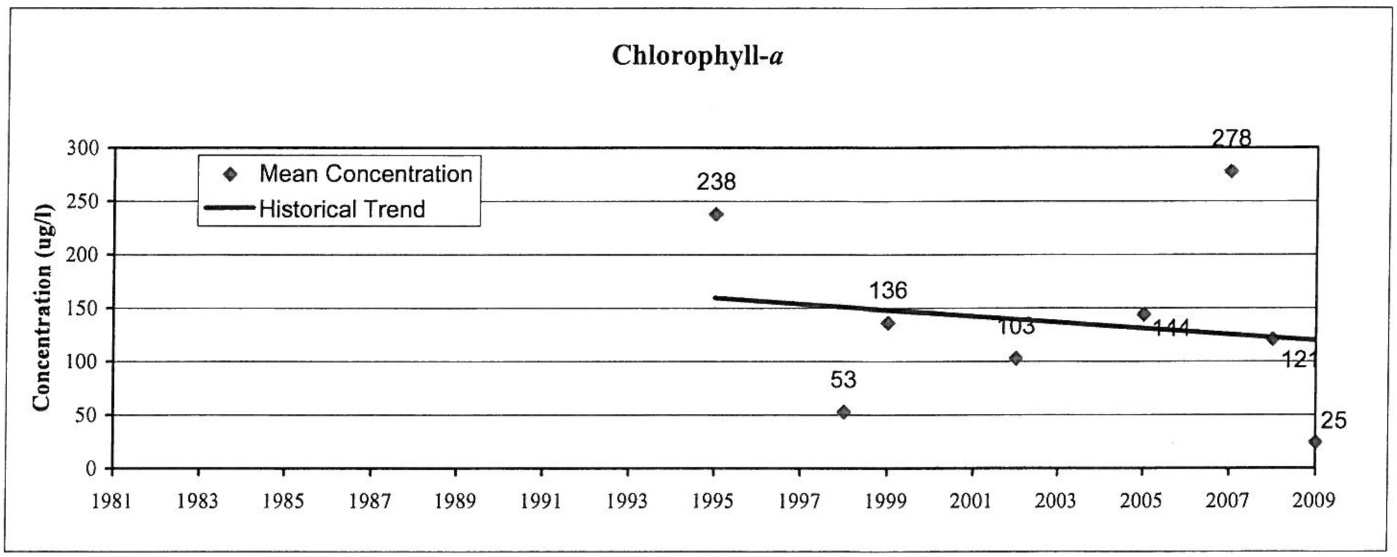
NOV 2009

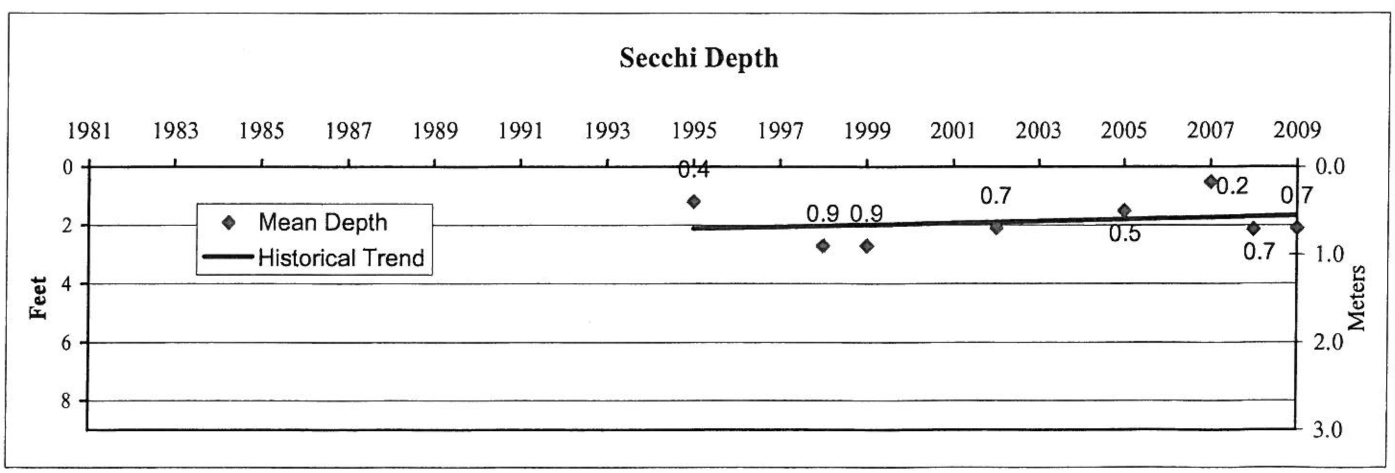
Figure 2

Appendix A

Historical In-Lake Water Quality

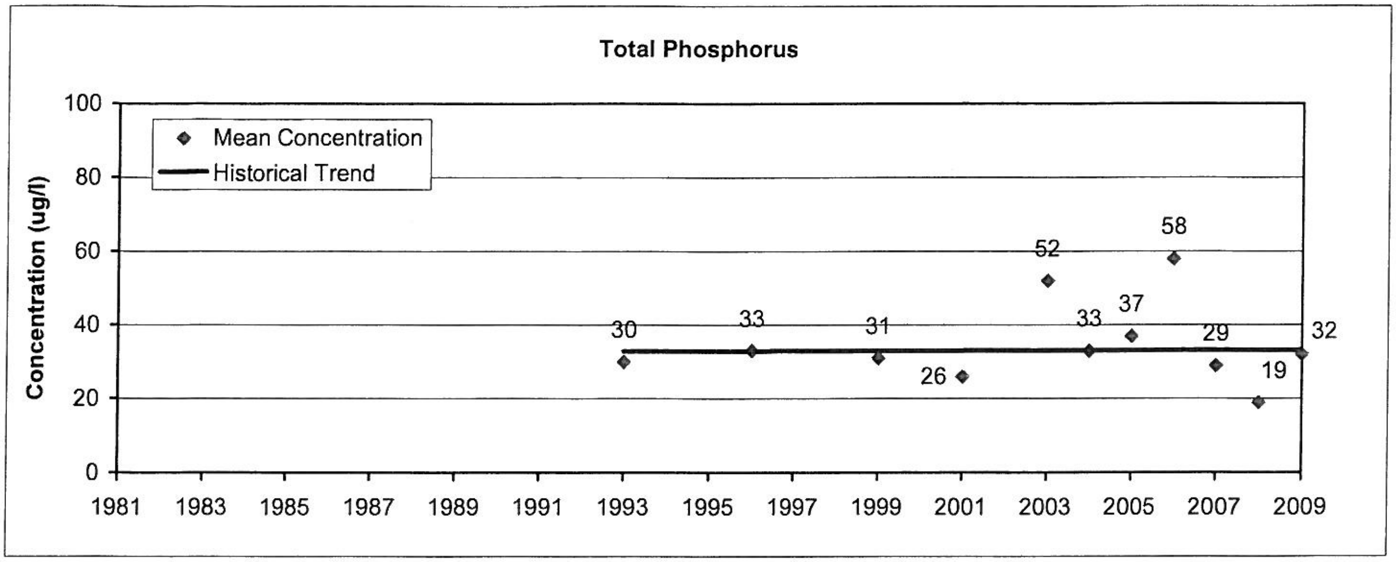


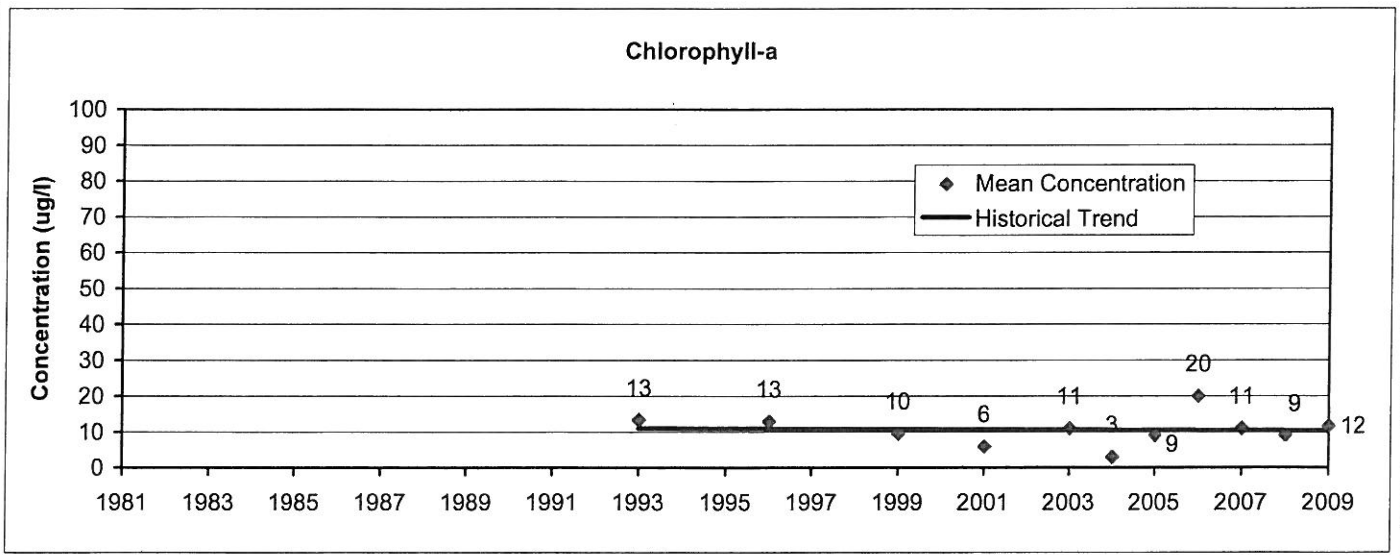


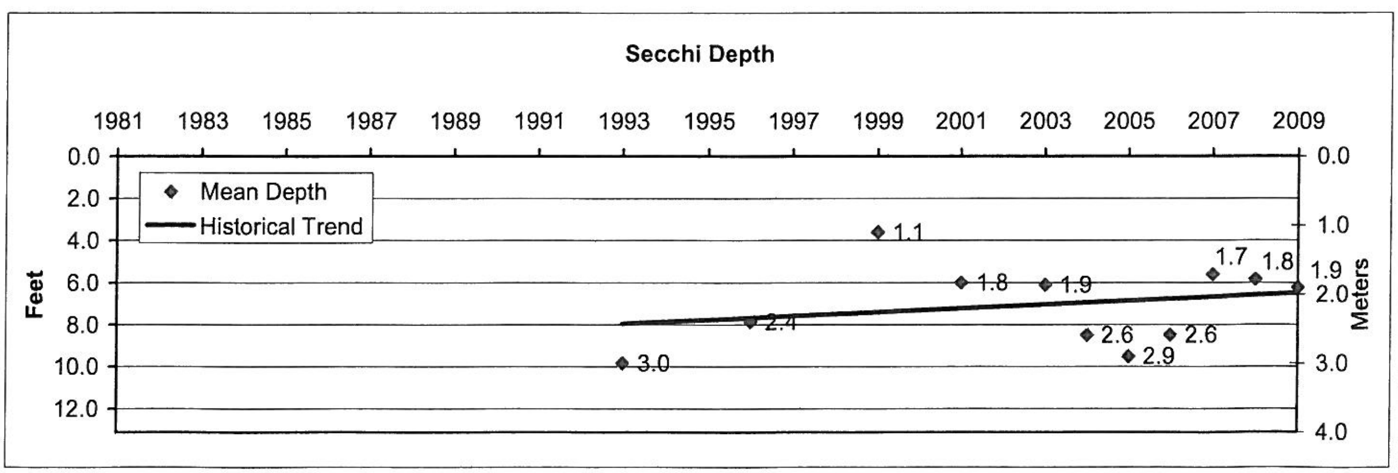


Clearwater River Watershed District	Wenck	Jan 2009
Henshaw Lake Historical Data	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	Appendix A-1

T:\0002\130\Cedar Chain_WQ_ 2009Henshaw Lake

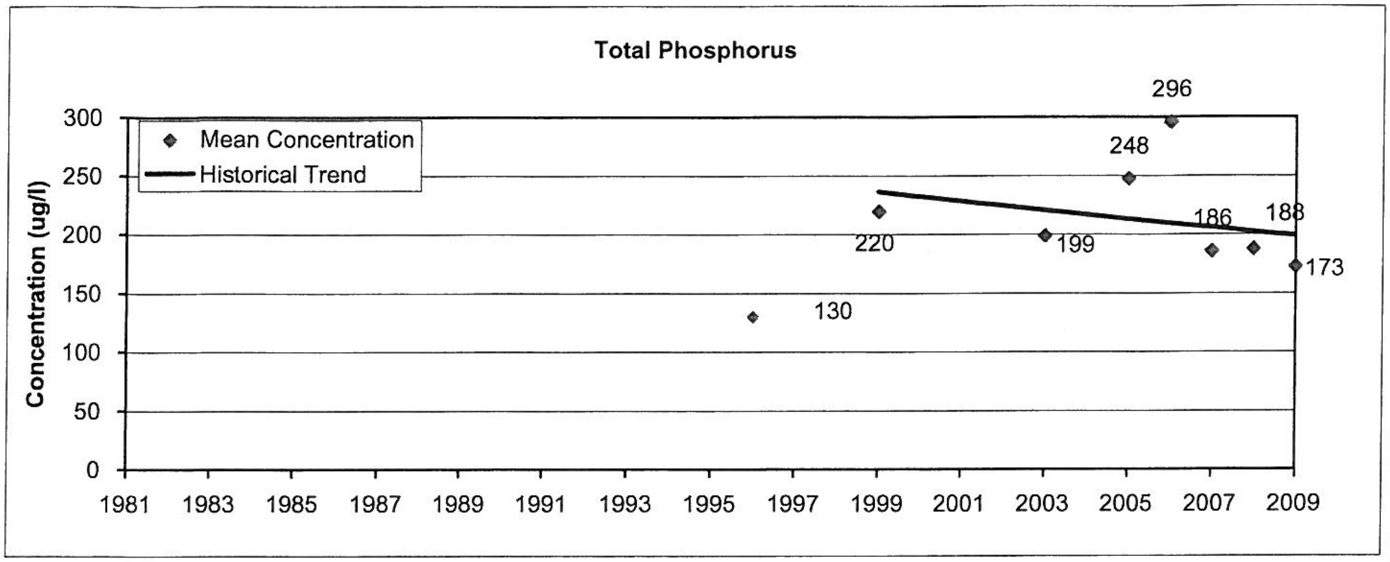


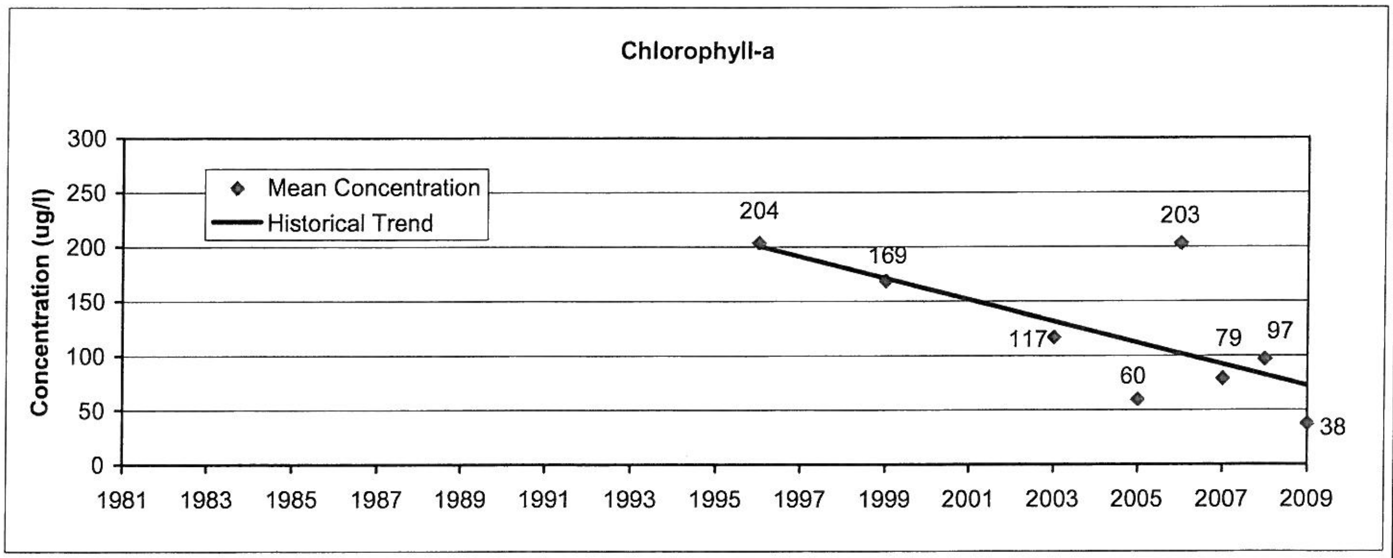


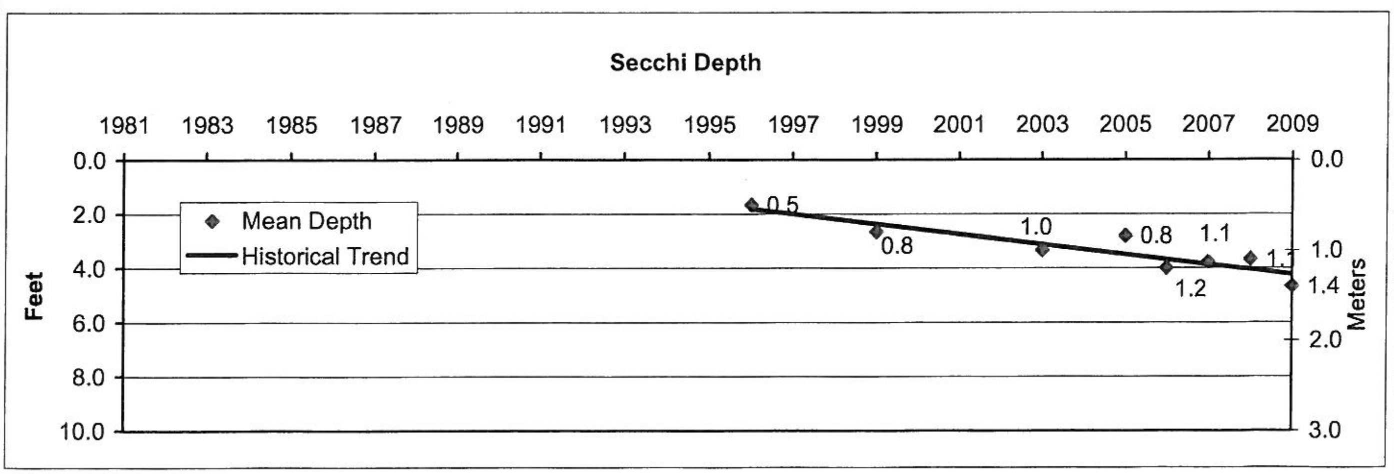


Clearwater River Watershed District	Wenck	Jan 2009
Cedar Lake Historical Data	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	Appendix A-2

T:\0002\130\Cedar Chain_WQ_ 2009Cedar Lake

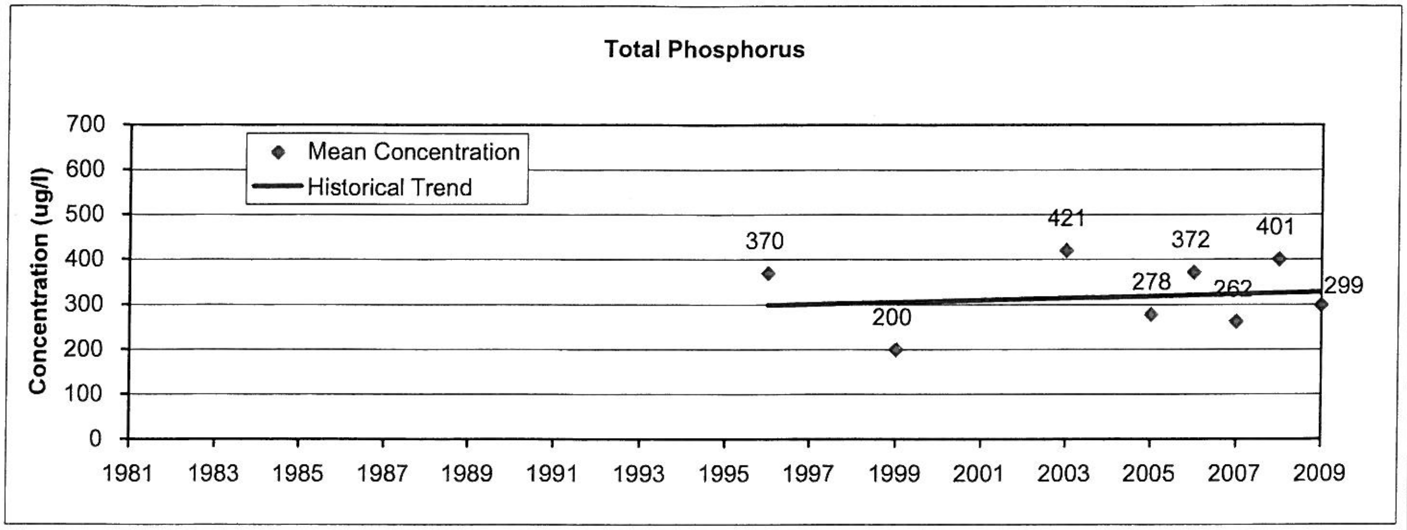




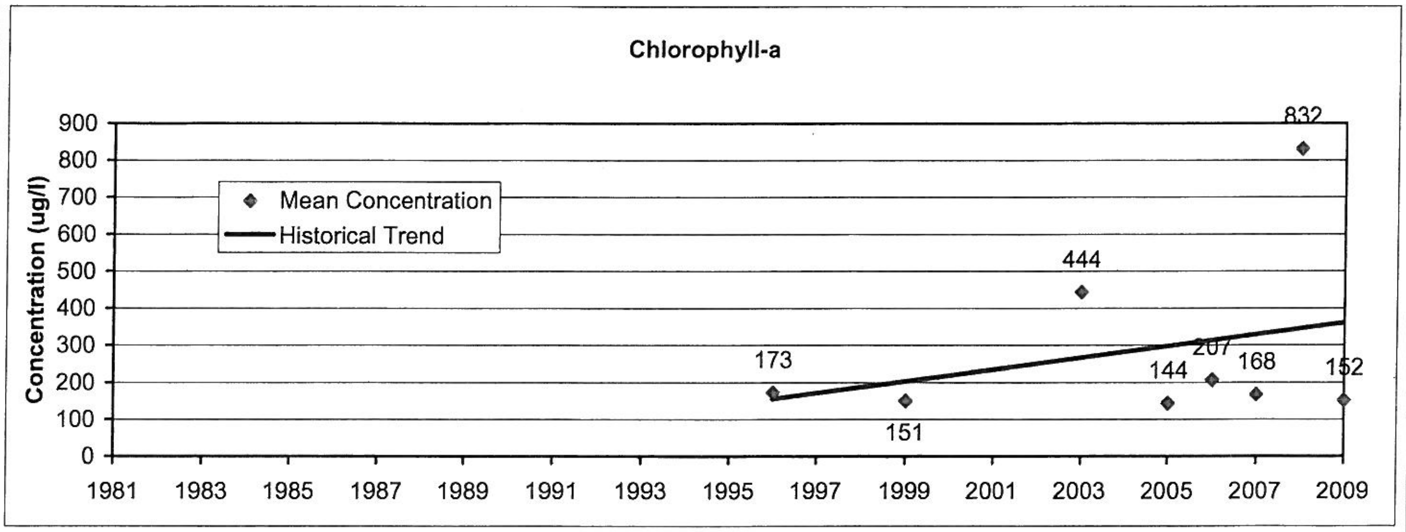


Clearwater River Watershed District	Wenck	Jan 2009
Lake Albion Historical Data	Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	Appendix A-3

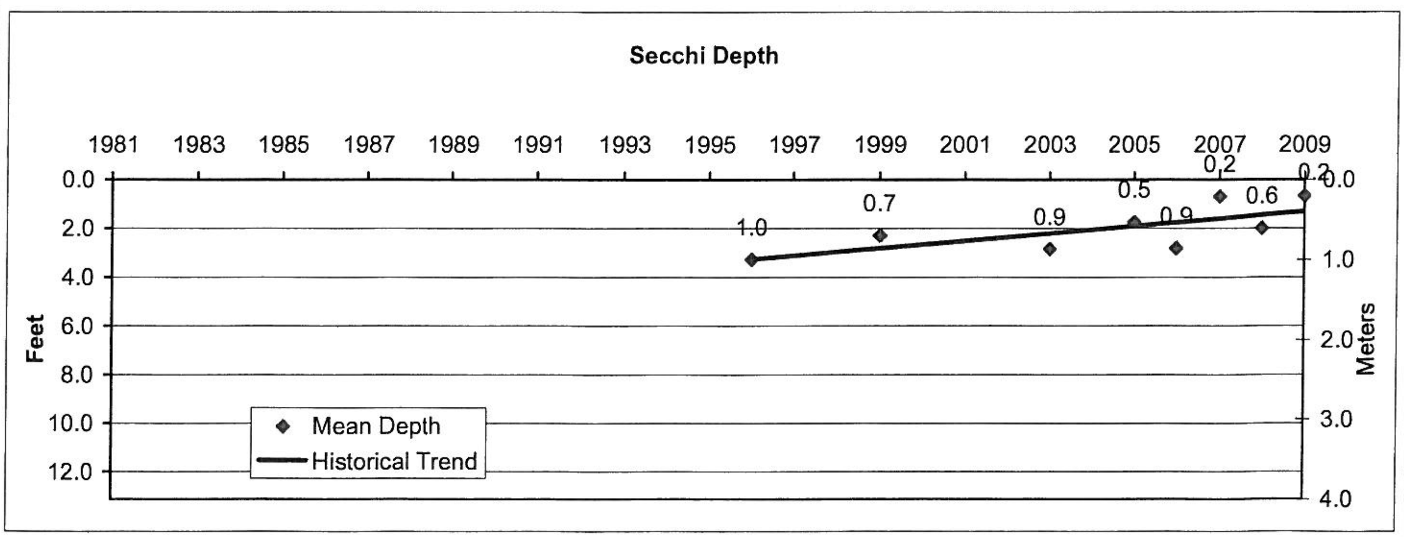
T:\0002\130\Cedar Chain_WQ_ 2009Lake Albion



Total Phosphorus
Concentration (ug/l)
700
600
500
400
300
200
100
0
Mean Concentration
Historical Trend
370
200
421
278
372
262
401
299
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009



Chlorophyll-a
Concentration (ug/l)
900
800
700
600
500
400
300
200
100
0
Mean Concentration
Historical Trend
173
151
444
144
207
168
832
152
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009



Secchi Depth
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Feet
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Meters
0.0
1.0
2.0
3.0
4.0
1.0
0.7
0.9
0.5
0.9
0.2
0.6
0.2
Mean Depth
Historical Trend

Appendix B

Cedar Lake Monitoring Data

Appendix B: Cedar Lake 2007-2009 Water Quality Data

	Date	Total Phosphorus (ug/L)	Chlorophyll-a (ug/L)	Secchi Depth (m)
	5/25/2007	18		3.5
	6/29/2007	45	11	0.9
	7/27/2007	20	9	0.9
	8/24/2007	31	14	1.5
CRWD Sampling Results	**2007 Summer (June-Sept) Average**	**32**	**11**	**1.1**
	5/19/2007	26	6	5.2
	6/3/2007	37	21	2.1
	6/17/2007	28	16	1.4
	7/1/2007	34	9	1.1
	7/15/2007	20	4	1.7
	8/19/2007	20	14	1.4
	9/4/2007	19	8	1.4
	9/16/2007	21	8	2.0
Volunteer Lake Sampling Results	**2007 Summer (June-Sept) Average**	**26**	**11**	**1.6**
	5/8/2008	38	17	3.1
	7/7/2008	18	9.2	1.8
	8/6/2008	20		1.8
	9/30/2008			1.7
	10/21/2008	70	17	1.7
CRWD Sampling Results	**2008 Summer (June-Sept) Average**	**19**	**9**	**1.8**
	5/18/2008	37	4	4.7
	6/16/2008	24	3	5.5
	7/20/2008	39	14	2.0
	8/17/2008	24	8	1.4
	9/14/2008	20	9	2.4
Volunteer Lake Sampling Results	**2008 Summer (June-Sept) Average**	**27**	**9**	**2.8**
	6/11/2009	26	13.8	3.5
	7/13/2009	42	16.3	1.1
	8/6/2009	32	9.2	1.4
	9/14/2009	26	7.4	1.8
CRWD Sampling Results	**2009 Summer (June-Sept) Average**	**32**	**12**	**1.9**
	5/17/2009	44	1	9.4
	6/14/2009	34	23	2.1
	7/19/2009	42	22	1.4
	8/23/2009	27	9	1.5
	9/20/2009	36	5	1.7
Volunteer Lake Sampling Results	**2009 Summer (June-Sept) Average**	**35**	**15**	**1.7**

Appendix B

Legal Memorandum
Dated November 9, 2009

MEMORANDUM

TO: Clearwater River Watershed District Board of Managers

FROM: Stan Weinberger

RE: Use of Cedar Lake Maintenance Fund for Curly Leaf Pond Weed Removal

DATE: November 9, 2009

In 2006, the Clearwater River Watershed District ("CRWD") approved the Cedar Lake Project 06-1 ("Project") to improve the nutrient balance in Cedar, Albion, Swartout and Henshaw Lakes by reducing the phosphorous loading and carp populations in those lakes. At the time the Project was approved, the element of the Project providing for the removal of invasive aquatic vegetation was not included in the Project but a water monitoring program was included to determine the overall effectiveness of the Project. The results of the water monitoring has shown that in order to meet water quality goals, additional measures must be taken to control and reduce the contribution to internal phosphorus loading due to curly leaf pond weed in Cedar Lake. These findings are set out in a Technical Memorandum prepared for the CRWD by Norman Wenck, Project Engineer, dated August 14, 2008 ("Memorandum"). The conclusion of this Memorandum is that if the CRWD does not address the problems created by curly leaf pond weed growth, the Project will not be attain the level of operating efficiency contemplated at the time the Project was originally constructed and implemented.

Minn. Stat. Section 103D.631 provides that the managers of the CRWD are responsible for maintaining the Project in a condition so that it will accomplish the purpose for which it was constructed. If this cannot be done through normal repair and maintenance, Minn. Stat. Section 103D.635 provides the managers with the authority to alter or improve the Project to attain the level of operating efficiency contemplated at the time of the original construction and implementation. The monitoring results cited in the Memorandum show that the Project will not accomplish the necessary reduction of phosphorus loading in the lakes without the control of curly leaf pond weed at an estimated annual cost of $35,000.

It appears from my review of the original Engineers Report for the Project and the Memorandum that efforts to control and reduce curly leaf pond weed growth in Cedar Lake is essential to the future operation and success of the Project. It also appears that because the efforts to control and reduce curly leaf pond weed must be ongoing to be effective, this activity amounts to an alteration and improvement to the Project which will be permanent. For this reason, I believe that the CRWD may use its operating and maintenance funds in the short term to protect the Project but, to establish curly leaf pond weed control and reduction in the long term, it must proceed under Minn. Stat. Section 103D.635 to alter the Project to include the annual control and removal of curly leaf pond weed in Cedar lake. This will require having the District Engineer update the Memorandum and holding a public hearing on the Memorandum, with notice to the property owners initially assessed for the Project.

I recommend that the CRWD consider an assessment to include the cost of proceeding with the aquatic weed control and reduction program in next year's maintenance plan. I recommend that the managers request that the District Engineer provide an updated Memorandum to include a long term plan for the control and reduction of curly leaf pond weed in Cedar Lake and provide an estimate of the annual cost of such a modification of the Project. Once the updated Memorandum is received, the CRWD should hold a public hearing on the proposed alteration to the Project and, following the hearing, if the managers believe it is in the best interests of the CRWD to alter the Project to include the curly leaf pond weed control and reduction measures in the future, it should order the Project altered to include the measures recommended. This hearing should be held early in 2010 to allow the work to proceed during the spring of 2010 in the event it is approved.

I hope this is helpful. If you have any questions or need additional information, please please feel free to contact me at your convenience.

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Appendix C

Excerpts from
Engineer's Report on Project #06-1
Dated August 2006

3.0 Alternative Solutions Considered

3.1 GENERAL

The CRWD conducted a special monitoring project from 2004 to 2005 to study the potential causes for increasing nutrient levels in Cedar Lake observed starting in Fall 2003, and persisting high nutrient levels in Swartout, Albion and Henshaw Lakes. Available data was analyzed, including data collected during the scope of the study, historical lake data, and data available from other sources such as the MPCA, the Minnesota DNR and the University of Minnesota.

The District identified the specific cause and identified feasible methods to reduce nutrient loading to Cedar Lake and reduce phosphorus concentrations in upper watershed lakes through the data collection, data analysis, and a nutrient balance.

In-lake water quality was used to predict the total annual phosphorus load to Cedar Lake. Based on characteristics of the lake and surrounding watershed, a total phosphorus load of 1,000 pounds per year is predicted to yield in-lake phosphorus concentrations observed prior to 2003 and thus maintain water quality in Cedar Lake. This information, coupled with supplemental monitoring data collected in 2004 and 2005, indicated that presently 2,000 to 3,000 pounds of phosphorus per year were entering Cedar Lake through the southeast inlet alone, about 96 % of the total phosphorus load to Cedar Lake under current conditions.

The primary phosphorus source to Cedar Lake is caused by high phosphorus concentrations in upper watershed lakes. To reduce the phosphorus concentrations in Cedar Lake it will be necessary to reduce the nutrient load from upper watershed lakes. This finding also rules out other causes for the increasing nutrient levels in Cedar Lake such as individual septic systems for lakeshore homes, internal loading in Cedar Lake exacerbated by carp or curly leaf pondweed within the lake, or other point sources.

The nutrient balance in Swartout Lake showed a small amount of phosphorus and sediment coming into the lake from the outside watershed relative to the internal loading in Swartout Lake. Internal loading to Swartout Lake is about 76% of the load to the lake. Internal loading for Albion and Henshaw Lakes represent about 91% and 95% respectively of the phosphorus loads to each lake. A reduction of in-lake phosphorus concentrations in Swartout Lake will require addressing both internal and external phosphorus loading.

3.2 ALTERNATIVES CONSIDERED

Sixteen alternatives were evaluated to reduce phosphorus loading to Cedar Lake, and reduce phosphorus concentrations in the upper watershed lakes:

1. Eliminate ISTS discharges to Cedar Lake through grants to homeowners or installation of a regional treatment facility.

   Data showed that potential point source loading to Cedar Lake from ISTS was low, while the cost of implementing this option was high.

2. Aggressive curly leaf pondweed control in the southern portion of Cedar Lake.

   Data showed that internal loading to Cedar Lake though exacerbated by curly leaf pond weed, was not a significant portion of the nutrient load to Cedar Lake. Further, a 2005 macrophyte study by the Minnesota DNR showed that the extent of curly leaf pond weed in Cedar Lake is small. (Figure 3)

3. Removal of Cormorants on Swartout Lake

   Based on a water foul survey conducted by the University of Minnesota in 2004, removing the cormorants from Swarout Lake would result in only a maximum of 1% phosphorus load reduction to Swartout Lake.

4. Carp population reduction through Rotenone, physical harvesting

   Carp population reduction in the upper watershed lakes would reduce the internal loading in Swartout Lake between 15 and 40 %, which in turn would likely reduce the phosphorus loading to Cedar Lake as well.

   Management of the carp population would be an ongoing task with annual activities necessary to maintain reduced loads and would require installation of migration barriers to prevent repopulation of upstream lakes by the carp that over winter in Cedar Lake.

   However, there was no interest by residents in actively managing the carp populations in any of the upstream lakes through chemical means, or through lake draw downs.

5. Fish migration barriers between Albion and Swartout, and Henshaw and Swartout Lakes

   Fish migration barriers used in conjunction with fish population management techniques such as lake drawdown to induce winter kill, harvesting, or chemical treatment, will likely result in a significant reduction in the internal loading in upstream watershed lakes, and a decrease in nutrient loading to watershed lakes.

   Short of active management of carp populations, the shallow upstream lakes will likely experience a winter fish kill at some point in the future given their depth. The installation of fish migration barriers coupled with a natural winter fish kill would likely have a lakes. Temporary lake drawdowns would be used to induce winter fish kills and stimulate submergent and emergent plant communities in the lakes.

13. Isolate Swartout Lake and redirect outflow downstream of Cedar Lake

    This option was rejected due to potential impacts to downstream water bodies.

14. Isolate wetland between Highway 55 and Swartout Lake and re-direct outflow downstream

    This option was rejected due to potential impacts to downstream water bodies.

15. Install wetland treatment system in the Highway 55 Wetland.

    This option might have allowed for more residence time and greater settling for suspended nutrients, and perhaps greater uptake of nutrients in the wetland. However, the size of the wetland and the high dissolved component to the phosphorus load showed this option to be less effective with a high cost.

16. Install sedimentation basins to reduce external nutrient and sediment load to Swartout Lake.

    Installing sediment basins in the watershed that is a direct tributary to Swartout Lake is an important component of addressing nutrient concentrations in Swartout Lake. This option has the potential to reduce the loading to Swartout Lake by 1 to 10%.

Appendix D

Excerpts from Five Lakes TMDL Report Dated May 2009 (Revised September 2009)

Clearwater River Watershed District

Five Lakes Nutrient TMDL

for:

Lake Caroline
Lake Augusta
Albion Lake
Henshaw Lake
Swartout Lake

DRAFT

Wenck File #. 0002-127

Prepared by:

WENCK ASSOCIATES, INC.
1800 Pioneer Creek Center
P.O. Box 249
Maple Plain, Minnesota 55359-0249
(763) 479-4200

May 2009
(Revised September 2009)

Wenck

Township in Wright County, Minnesota. There are no municipalities located within the Henshaw Lake watershed. Henshaw Lake is a 270-acre basin with an average depth of four feet and a maximum depth of eight feet (Table 3.1). The littoral zone covers the entire 270-acres of the basin due to the maximum depth being less than 15 feet. As a result of Henshaw Lake having a littoral area greater than 80 percent of the basin, the lake meets the MPCA definition of a shallow lake. There are no defined inflow or outlet tributaries for Henshaw Lake. A wetland complex at the northwest corner of the basin serves as the lake outlet as it flows north toward Swartout Lake.

3.1.5 Swartout Lake

Swartout Lake is not located along the main stem of the Clearwater River, but instead is part of a chain of three lakes that is tributary to Cedar Lake in the southeast-most corner of the Clearwater River watershed. Swartout Lake is located downstream of Albion and Henshaw Lakes and upstream of Cedar Lake. The Swartout Lake watershed covers 4,768 acres including approximately 2,771 acres of direct sub-watershed and the upstream watersheds of Albion and Henshaw Lakes. The Swartout Lake watershed is located within Albion Township in Wright County, Minnesota. There are no municipalities located within the Swartout Lake watershed. Swartout Lake is a 296-acre basin with an average depth of seven feet and a maximum depth of 12 feet (Table 3.1). The littoral zone covers the entire 296-acres of the basin due to the maximum depth being less than 15 feet. As a result of Swartout Lake having a littoral area greater than 80 percent of the basin, the lake meets the MPCA definition of a shallow lake. There are two unnamed tributaries that flow into Swartout Lake. One tributary flows from Albion Lake and enters the southwest corner of the basin and the second flows from a wetland complex that is part of the Swartout State Wildlife Management area and enters at the southeast corner of the basin. The outlet of Swartout Lake is a perennial stream that exits the northeast corner of the lake and flows north to Cedar Lake.

Table 3.1 Morphometric characteristics for the five lakes in the Clearwater River Chain of Lakes

Parameter	Lake Caroline	Lake Augusta	Albion Lake	Henshaw Lake	Swartout Lake
Surface Area (ac)	125	169	251	271	296
Average Depth (ft)	15	25	6	4	7
Maximum Depth (ft)	44.5	82	9	8	12
Volume (ac-ft)	1,923	4,269	1,508	1,904	2,105
Average Residence Time (days)	0.07	0.15	4.80	4.65	1.26
Littoral Area (ac)	59	55	251	270	293
Watershed (ac)	61,975	64,779	1,094	903	4,768

3.2 LAND USE

The Clearwater River watershed is composed mainly of agricultural land uses. The National Agriculture Statistics Services (NASS) 2007 cropland data layer was used to determine land use

Figure 5.2 Average In-lake TP Concentrations for Deep Impaired Lakes

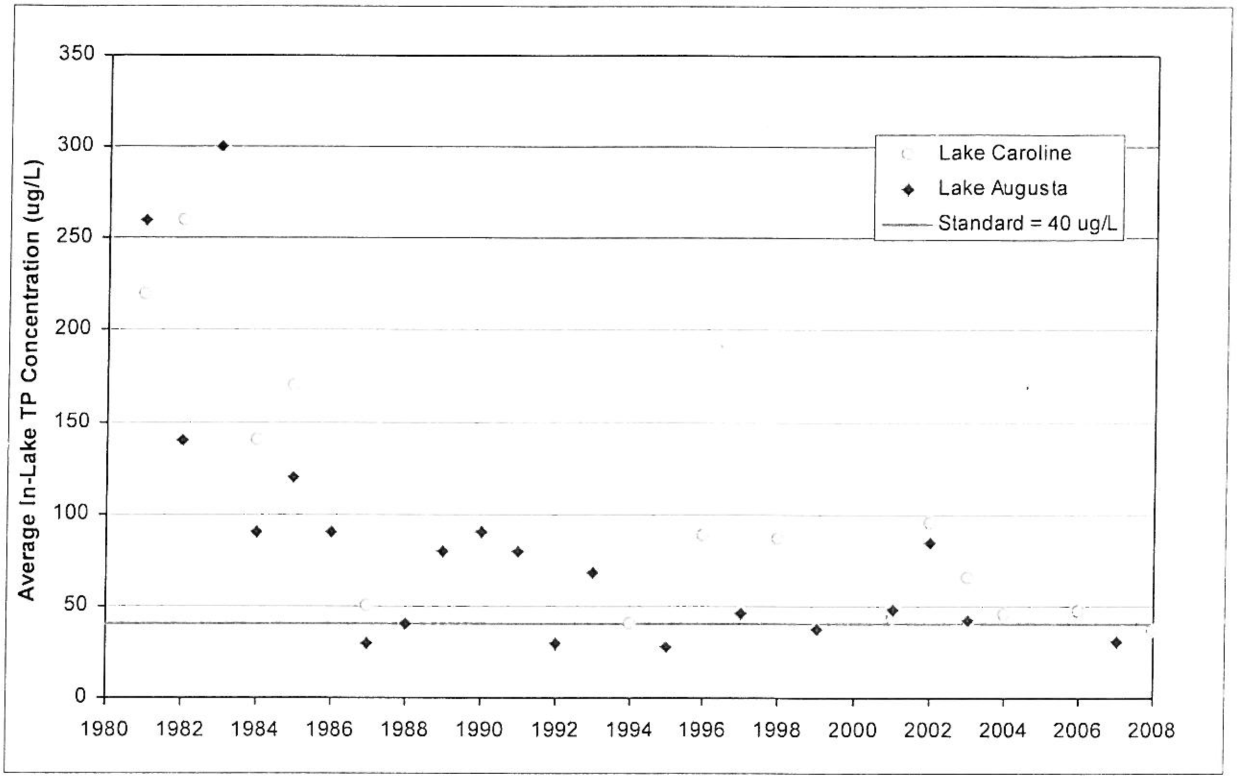

Table 5.1 Recent Typical Annual Average TP Concentrations Compared to Numeric Standard

	TP (µg/L)		Chlorophyll-a (µg/L)		Secchi Depth (ft)	
Lake	**Standard**	**Recent**	**Standard**	**Recent**	**Standard**	**Recent**
Lake Caroline	40	36 – 95	14	12 - 55	4.6	4.2 - 7.2
Lake Augusta	40	31 - 84	14	6 – 29	4.6	5.7 - 7.2
Albion Lake	60	130 - 296	20	60 - 204	3.3	1.6 - 5.2
Henshaw Lake	60	150 - 390	20	53 - 278	3.3	0.7 - 2.9
Swartout Lake	60	200 - 421	20	144 - 832	3.3	0.7 - 3.3

5.1 LAKE CAROLINE

District monitoring for Lake Caroline began in 1981 with the Clearwater Chain of Lakes Restoration Project. Summer average total phosphorus concentrations in Lake Caroline ranged from 36 in 2008 to 300 µg/L in 1983. With the exception of 2008, average in-lake concentrations exceed the state standard of 40 µg/L during all monitoring years. Since 1998, recent typical in-lake average summer surface TP concentrations have averaged about 60 µg/L.

Summer average chlorophyll-a concentrations ranged from 3 µg/L in 1983 to 55 µg/L in 1998. Since 1998, typical recent chlorophyll-a concentrations have averaged about 32 µg/L. Observed Secchi-depth readings have ranged from just over 2.5 feet in 1994 to greater than 6 feet in 2006. Since 1998 the recent average Secchi depth is approximately 5 feet. In-lake water quality in Lake Caroline has improved significantly relative to monitoring conducted in the early 1980s.

5.2 LAKE AUGUSTA

District water quality monitoring in Lake Augusta began in 1981. Summer average total phosphorus concentrations in Lake Augusta have exhibited a wide range of variation, ranging from 28 µg/L in 1995 to 300 µg/L in 1983. Average in-lake concentrations exceed the state standard of 40 µg/L during 14 of 20 monitoring years. Since 1997, recent typical in-lake average summer surface TP concentrations have averaged about 50 µg/L.

Observed in lake chlorophyll-a concentrations have varied widely in Lake Augusta with some years below the State standard of 14 µg/L and other years greatly exceeding the standard. Summer average chlorophyll-a concentrations ranged from 4 µg/L in 1983 to 73 µg/L in 1990. Since 1997, typical recent chlorophyll-a concentrations have averaged about 16 µg/L. Secchi depth has varied from 3.5 feet in 1991 to a high of 6.2 feet in 2002. Since 1997, recent typical Secchi depth values have averaged about 5.5 feet. In-lake water quality in Lake Augusta has improved significantly relative to monitoring conducted in the early 1980s; however, the lake remains impaired.

5.3 ALBION LAKE

District monitoring in Albion Lake began in 1996. Summer average total phosphorus concentrations in Albion Lake have ranged from 130 to 296 µg/L during that time. Average in-lake concentrations have exceeded the State standard for shallow lakes of 60 µg/L during all monitoring years. Recent typical in-lake P concentrations have average about 230 µg/L. Albion Lake is located in the southeast-most corner of the Clearwater River watershed. It has no contributing upstream lakes and a relatively small contributing watershed. The outlet to Albion Lake is a tributary stream that flows north into Swartout Lake.

Chlorophyll-a values observed in Albion Lake have ranged from 60 µg/L in 2005 to 203 µg/L in 2006, with recent values averaging approximately 120 µg/L. The Secchi depth readings have ranged from 1.6 to 5.2 feet, averaging 3.6 feet. Secchi values have been equal to or better than the State standard during each of the past three monitoring years.

5.4 HENSHAW LAKE

District monitoring for Henshaw Lake began in 1995. Summer average total phosphorus concentrations in Henshaw Lake ranged from 150 µg/L in 1998 to 390 µg/L in 2007. Average in-lake concentrations have exceeded the state standard for shallow lakes of 60 µg/L during all monitoring years. Recent typical in-lake P concentrations have averaged about 270 µg/L.

Henshaw Lake is located in the southeastern corner of the Clearwater River watershed. It has a very small drainage area with a 2.3:1 ratio and no upstream lakes. An outlet structure for Henshaw Lake installed at an unknown time artificially maintains lake elevations compared to native conditions. The native condition of Henshaw Lake was likely waterfowl habitat instead of its current state as fish habitat. The combination of artificially maintained hydrology in Henshaw Lake and the introduction of carp likely led to the current level of degradation in vegetative habitat and the resulting water quality.

Chlorophyll-a concentrations in Henshaw Lake have varied from a low of 53 µg/L in 1998 to a high of 278 µg/L in 2007. Recent chlorophyll-a concentrations have averaged approximately 150 µg/L. Water clarity is very poor in Henshaw Lake. The Secchi depth readings have ranged from 0.7 to 2.95 feet due primarily to high non-algal turbidity, though algal turbidity is also an issue. Non-algal turbidity is driven by wind suspension and the lack of aquatic macrophytes. The water clarity values have been less than the State standard for shallow lakes (>3.2 ft) during all monitoring years. Recent Secchi values have averaged slightly less than 2 feet.

The CRWD has worked unsuccessfully with Ducks Unlimited and land owners to implement a shallow lakes management plan that includes drawdown of the lake and rough fish management. The lake shore residents have been unreceptive to such plans citing an unwillingness to manipulate lake levels or to treat the lake with pesticide to eradicate rough fish.

5.5 SWARTOUT LAKE

District monitoring for Swartout Lake began in 1996. Water quality is very poor in Swartout Lake with observed total phosphorus and chlorophyll-a concentrations exceeding State standards during all monitoring years. Summer average total phosphorus concentrations in Swartout Lake ranged from 200 µg/L in 1999 to 421 µg/L in 2003. Recent typical in-lake P concentrations have averaged about 300 µg/L.

Observed chlorophyll-a concentrations have ranged from 144 µg/L in 2005 to 444 µg/L in 2003. Recent typical chlorophyll-a concentrations have averaged about 220 µg/L. Water clarity is very low in Swartout Lake, with Secchi depth values ranging from 0.7 to 3.2 feet. Recent Secchi values have averaged approximately 2 feet.

Rough fish migration control and removal is an important element of past and current lake management. The District has worked in recent years with the Swartout Lake residents in an attempt to control populations and movements of rough fish, specifically carp, in Swartout Lake. Fish barriers to prevent carp from migrating into wetlands adjacent to Swartout Lake have been installed. Additionally, commercial fishermen were hired during the winter of 2007/2008 and again during the winter to 2008/2009 to net and remove rough fish from Swartout Lake. Table 5.2 shows the pounds of fish removed during recent commercial fishing efforts.

Table 5.2 Rough Fish Removal from Swartout Lake

Year	Rough Fish Removed (lbs)
February 2008	57,000
December 2008	5,000

Lake Augusta:

- Water quality in Lake Augusta is dominated by loads from the Clearwater River and Lake Caroline. The short residence time of this lake means that water quality in the lake during the early spring and summer months is essentially the same as in the river.
- Based on the model results, it appears that water quality goals can be met through a combination of watershed and internal load reductions and management.

Albion Lake:

- Lake Albion is much closer to a clear state shallow lake than are either Swartout or Henshaw. Management strategies for this lake should be taken very carefully given the lake's current state of ecological integrity.
- Albion Lake has a small tributary watershed. As a result, while a reduction of watershed loads will be important, reducing watershed loads alone will not be sufficient to achieve water quality targets for the lake.
- Internal loads in Albion Lake are the major nutrient source to the lake. A significant reduction in this internal nutrient source will be required to meet water quality targets; however, care must be taken to maintain high ecological integrity.

Henshaw Lake:

- Henshaw Lake has a small tributary watershed. As a result, while a reduction of watershed loads will be important, reducing watershed loads alone will not be sufficient to achieve water quality targets for the lake.
- The tributary watershed alone is unlikely to have caused the impairment of the lake itself. Artificial maintenance of lake level through installation of an outlet, coupled with the introduction of rough fish, has likely resulted in the turbid water conditions observed on Henshaw Lake. As phosphorus loading alone did not impair the lake, hydrologic and ecological restorations will also be required to return the lake to a more clear state. To date, however, residents have been unwilling to implement recommended strategies outside of watershed load reduction.
- Internal loads in Henshaw Lake are the major nutrient source to the lake. A significant reduction in this internal nutrient source will be required to meet water quality targets

Swartout Lake:

- Internal loads in Swartout Lake are the major nutrient source to the lake. A significant reduction in this internal nutrient source will be required to meet water quality targets
- Swartout Lake receives significant nutrient loads from both the lake direct subwatershed and the upstream lakes, Albion and Henshaw.
- Management of both internal and external loads to Swartout Lake will be critical in achieving water quality goals.

Table 7.1 WWTPs in the Clearwater River Watershed District Tributary to Listed Waters Addressed in this Report.

Permit Holder/ System	Waste Water Treatment Method
City of Fairhaven	SSTS (Potential future)
City of Kimball	Land Application (SDS Permit)
City of Watkins	Land Application (SDS Permit)
City of South Haven	Land Application (SDS Permit)
CRWD- Regional	Master System (Potential)
CRWD- Rest-a-While Shores	Cluster System
CRWD- Wandering Ponds	Cluster System
CRWD- Lake Louisa Hills	Pending Cluster System

The load allocation must be divided among existing sources, save those that are not permitted under state law. Discharge from septic systems, for example, is not allowed by law and therefore the load allocation for septic systems is zero. Relative proportions allocated to each source are based on reductions that can reasonably be achieved through best management practices as discussed in the implementation section of the report.

7.1.2 Critical Conditions

The critical period for lakes is the summer growing season. Minnesota lakes typically demonstrate the impacts of excessive nutrients during the summer recreation season (June 1 to September 30) including excessive algal blooms and fish kills. Lake goals have focused on summer-mean total phosphorus, Secchi transparency and chlorophyll-a concentrations. These parameters have been linked to user perception of water quality (Heiskary and Wilson 2005). Consequently, the lake response models have focused on the summer growing season as the critical condition.

7.1.3 Allocations

The loading capacity is the total maximum daily load. The daily load and wasteload allocations for the average conditions for each lake are shown in Table 7.2

Table 7.2 Total Phosphorus TMDL Allocations Expressed as Daily Loads

Lake	Total Phosphorus TMDL (lbs/day)	Waste Load Allocation (lbs/day)	Load Allocation (lbs/day)	Margin of Safety
Lake Caroline	10.14	0.10	10.04	Implicit
Lake Augusta	11.36	0.11	11.25	Implicit
Albion Lake	0.98	0.01	0.97	Implicit
Henshaw Lake	0.73	0.01	0.72	Implicit
Swartout Lake	2.22	0.02	2.20	Implicit

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Load allocations by source for each lake are provided in Table 7.3. No reduction in atmospheric loading is targeted because this source is impossible to control on a local basis. The remaining load reductions were applied based on our understanding of the lakes and efficacy of proposed implementation strategies, as well as the model fit.

Table 7.3 Total Phosphorus Partitioned Load Allocation Expressed as Daily Load

Lake	Load Allocation (lbs/day)	Direct Watershed	Upstream Lakes	Septic Systems	Atmospheric + Groundwater	Internal
Lake Caroline	10.04	0.59	6.41	0.00	2.23	0.82
Lake Augusta	11.25	0.76	6.65	0.00	1.93	1.91
Albion Lake	0.97	0.34	0.00	0.00	0.16	0.47
Henshaw Lake	0.72	0.08	0.00	0.00	0.18	0.46
Swartout Lake	2.20	0.82	0.33	0.00	0.19	0.86

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Annual total maximum loads are provided in Tables 7.4 and 7.5. The values in Tables 7.2 and 7.3 are calculated from annual loads dividing by 365.25 days per year (to account for leap year). The loading capacity provided in Tables 7.4 and 7.5 are based on average model predicted results for the years in which lake water quality data was available during the recent seven-year period, which represents both wet and dry conditions.

Table 7.4 Total Phosphorus TMDL Allocations Expressed as Annual Loads

Lake	Total Phosphorus TMDL (lbs/yr)	Waste Load Allocation (lbs/yr)	Load Allocation (lbs/yr)	Margin of Safety
Lake Caroline	3,705	37.05	3,668	Implicit
Lake Augusta	4,150	41.5	4,109	Implicit
Albion Lake	359	3.59	355	Implicit
Henshaw Lake	265	2.65	262	Implicit
Swartout Lake	812	8.12	804	Implicit

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Table 7.5 Total Phosphorus Partitioned Load Allocation Expressed as Annual Load

Lake	Load Allocation (lbs/yr)	Direct Watershed	Upstream Lakes	Septic Systems	Atmospheric + Groundwater	Internal
Lake Caroline	3,668	214	2,342	0	814	298
Lake Augusta	4,109	279	2,429	0	704	697
Albion Lake	355	125	0	0	59	171
Henshaw Lake	262	30.1	0	0	64.8	167.5
Swartout Lake	804	300	120	0	70.5	314

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9.0 Implementation

9.1 IMPLEMENTATION FRAMEWORK

Implementing TMDLs within the CRWD will be a collaborative effort between state and local government, and individuals led by the CRWD. To meet water quality standards, CRWD will leverage existing regulatory framework, and relationships to generate support for TMDL implementation efforts. CRWD will provide technical support, funding, coordination and facilitation to other cooperating LGUs when needed. For example, the CRWD has funded stormwater studies for the cities of Kimball, Annandale and Watkins though which several opportunities to retrofit BMPs to existing development were identified as well as opportunities for BMPs for future development. Efficiency and cost savings are realized by using existing governmental programs and services for TMDL implementation to the maximum extent possible.

Second, the CRWD is committed to identifying new technologies and new methods for reducing nutrient loads to lakes. For example, the CRWD achieved their in lake water quality goal in Clearwater Lake by identifying watershed sources and designing cutting edge projects that reduced watershed P through the Chain of Lakes Restoration in the 1980s.

9.1.1 Clearwater River Watershed District

The mission of the Clearwater River Watershed District is to promote, preserve and protect water resources within the boundaries of the District in order to maintain property values and quality of life as authorized by MS103D. To this end, the District's Comprehensive Plan approved July 23, 2003, documents the District's goals, existing policies and proposed actions. One of the District's stated goals is to bring all of CRWD surface water into compliance with state water quality standards through the TMDL process.

Because the primary goal and mission of the CRWD is in line with the goal of TMDL implementation, many of the implementation strategies are extensions of existing CRWD programs and projects and can be funded using existing CRWD budgets. However, additional implementation funding will be necessary. The recommended implementation plan to meet lake water quality goals and associated cost is described in the following section.

9.1.2 Counties, Cities, Townships, Lake Associations

Partnerships with counties, cities, townships and lake associations are one mechanism through which the CRWD protects and improves water quality. The CRWD will continue its strong tradition of partnering with state and local government to protect and improve water resources and to bring waters within the CRWD into compliance with State standards.

9.1.3 Board of Water and Soil Resources

The CRWD recognizes that public funding to set and implement TMDLs is limited, and therefore understands that leveraging matching funds as well as utilizing existing programs will be the most cost efficient and effective way to implement TMDLs within the CRWD. The CRWD does project a potential need for about 50% cost-share support from the Board of Water and Soil Resources, MPCA or other sources in the implementation phase of the TMDL process.

9.2 REDUCTION STRATEGIES

9.2.1 Annual Load Reductions

The focus in implementation will be on reducing the annual phosphorus loads to the lakes through structural and non-structural Best Management Practices. The TMDL established for each lake is shown in Section 7 of this report (Table 7.2 and allocated among sources in Table 7.3). Table 9.1 shows load reductions by source for each lake.

Table 9.1 Load Reductions by Source

Lake	Total	Direct Watershed	Upstream Lakes	Septic Systems	Atmospheric + Groundwater	Internal
Lake Caroline	35%	31%	43%	100%	0%	26%
Lake Augusta	27%	31%	33%	100%	0%	21%
Albion Lake	91%	63%	NA	100%	0%	95%
Henshaw Lake	93%	88%	NA	100%	0%	95%
Swartout Lake	90%	70%	77%	100%	0%	95%

No reductions in atmospheric or groundwater loading are targeted because these sources are not readily controllable. The remaining load reductions were applied based on our understanding of the lakes and surrounding watersheds as well as output from the model.

9.2.2 Actions

A conceptual implementation plan for reducing phosphorus loads to the six impaired lakes is presented below (Table 9.2). Strategies are recommended based on their relative cost and effectiveness given the current level of understanding of the sources and in-lake processes. Recommendations take into account findings from stakeholder participation. Cost share breakdown is expected to be 50% from the state and federal funds, 25% from the individual, and 25% from watershed budgets.

The implementation plan pulls from existing CRWD studies and project proposals to reduce watershed phosphorus loads.

Table 9.2 Conceptual Implementation Plan and Costs

Practice	TMDL	Unit Cost	Units	Note	Qty	Cost
Promote Ag BMPs (P Testing and fertilizer application)	Nutrient, DO	$75,000	ls		1	$75,000
Replace Tile Intakes w/ Filters	Nutrient, DO, Bacteria	$500	per intake	*evaluate limestone/steel wool filter intakes to increase P removal	400	$200,000
Tile Intake Buffers	Nutrient, DO, Bacteria	$100	per intake		300	$30,000
Buffer Tributaries	Nutrient, DO, Bacteria	$350	ac		300	$105,000
Buffer Stream Banks	Nutrient, DO, Bacteria	$350	ac		200	$70,000
DO Augmentation for Clearwater River	DO		lf	*design and construct, operation		$500,000
Tile Discharge Management	Nutrient, DO, Bacteria	$130,000	ls	* Inventory, FS, design construct	1	$130,000
Riparian Pasture/ Grazing Management Grants	Nutrient, DO, Bacteria	$10,000	ea		10	$100,000
Street Sweeping: Kimball, Southaven, Fairhaven & Watkins	Nutrient, DO, Bacteria	$40	per curb mile	* high efficiency, 55 curb miles for 15 years		1,125,000
Lakeshore Septic Upgrade Grants	Nutrient	$7,500	ea	All Impaired Lakes	130	$975,000
Lake shore restoration grants (Shore land Erosion)	Nutrient	$300	ea	*grants	300	$90,000
Shallow Lakes Management Plans for Marie, Clear, Swartout, Albion & Henshaw Lakes	Nutrient	$15,000	ea		5	$75,000
Carp Control	Nutrient	$25,000	average per year per lake	*Fish trap already installed at Louisa, harvesting under way in several impaired lakes (5 lakes, 6 yrs)	30	$750,000
Curly Leaf Pondweed Control	Nutrient			*Lake association cost, some cost share		$100,000
Lake Aeration	Nutrient			2 Existing aerators re-installed		$600,000
Alum dosing of Cleawater River upstream of Kingston	Nutrient, DO					$600,000
Hypolimnetic withdrawl (Betsy)	Nutrient					$350,000
Kingston Wetland Maintenance / Enhancement	Nutrient, DO					$250,000
South Haven Stormwater Enhancement	Nutrient, DO, Bacteria					$75,000
City of Kimball Stormwater Enhancement Per 2004 Kimball Area Stormwater Management Study	Nutrient, DO, Bacteria					$500,000
City of Watkins Stormwater Enhancement per 2006 Watkins Area Stormwater Management Study	Nutrient, DO, Bacteria					$800,000
Public Outreach	Nutrient, DO, Bacteria	$10,000	per year		10	$100,000
Implementation Project Management and Administration	Nutrient, DO, Bacteria	$30,000	per year		10	$300,000
Implementation Performance Monitoring, Recommendations for Adaptive Management	Nutrient, DO, Bacteria	$25,000	per year		10	$250,000
Implementation Engineering	Nutrient, DO, Bacteria	$15,000	per year		10	$150,000
T:\0002\127\[TMDL Implementation_FINAL.xls]August 08					TOTAL:	$8,300,000