Total Maximum Daily Load
For Nitrate
Cedar Lake
Madison County, Iowa

2005

Iowa Department of Natural Resources
TMDL & Water Quality Assessment Section

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1. Executive Summary

Table 1. Cedar Lake Summary

Waterbody Name:	Cedar Lake
County:	Madison
Use Designation Class:	B(LW) (aquatic life) C (potable water source)
Major River Basin:	Des Moines River Basin
Pollutant:	Nitrate
Pollutant Sources:	Nonpoint
Impaired Use(s):	C (potable water source)
2002 303d Priority:	High
Watershed Area:	10,380 acres
Lake Area:	88 acres
Lake Volume:	792 acre-ft
Detention Time:	0.11 years
Target In-Lake Concentration:	less than 10.0 mg NO_3-N/l.
TMDL:	81 tons per year
Existing Nitrate Load:	103 tons per year
Wasteload Allocation:	0
Load Allocation:	62 tons per year
Margin of Safety	19 tons per year

The Federal Clean Water Act requires the Iowa Department of Natural Resources (IDNR) to develop a total maximum daily load (TMDL) for waters that have been identified on the state's 303(d) list as impaired by a pollutant. Cedar Lake has been identified as impaired by excess nitrate. The purpose of the TMDL for Cedar Lake is to calculate the maximum allowable nitrate loading for the lake associated with levels that will meet the drinking water standard of 10 mg/L NO_3-N.

Phasing TMDLs is an iterative approach to managing water quality that becomes necessary when the origin, nature and sources of water quality impairments are not well understood. In Phase 1, the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations are estimated based on the limited information available. A monitoring plan will be used to determine if prescribed load reductions result in attainment of water quality standards and whether or not the target values are sufficient to meet designated uses. Monitoring activities may include routine sampling and analysis, biological assessment, fisheries studies, and watershed and/or waterbody modeling.

Section 5.0 of this TMDL includes a description of planned monitoring. The TMDL will have two phases. Phase 1 will consist of setting specific and quantifiable targets for nitrate in Cedar Lake. Phase 2 will consist of implementing the monitoring plan, evaluating collected data, and readjusting target values if needed.

Monitoring is essential to all TMDLs in order to:

- Assess the future beneficial use status;
- Determine if the water quality is improving, degrading or remaining status quo;

- Evaluate the effectiveness of implemented best management practices.

The additional data collected will be used to determine if the implemented TMDL and watershed management plan have been or are effective in addressing the identified water quality impairment. The data and information can also be used to determine if the TMDL has accurately identified the required components (i.e. loading/assimilative capacity, load allocations, in-lake response to pollutant loads, etc.) and if revisions are appropriate.

This TMDL has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7. These regulations and consequent TMDL development are summarized below:

1. **Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:** Cedar Lake, S19, T76N, R27W, north of Winterset, Madison County.

2. **Identification of the pollutant and applicable water quality standards:** The pollutant causing the water quality impairment is nitrate. Designated uses for Cedar Lake are Aquatic Life (Class B(LW)) and Potable Water Source (Class C). Excess nitrate loading has impaired the potable water source water quality criteria (567 IAC 61.3(3)) and hindered the designated uses.

3. **Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:** The target of this TMDL is an in-lake nitrate concentration of less than 10.0 mg/L NO_3-N.

4. **Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:** The existing nitrate load based on modeling is 103 tons per year. The estimated nitrate loading capacity for the lake is 81 tons per year. This does not include the margin of safety, which is significant. Including the margin of safety, the targeted reduction in nonpoint source nitrate loading to the lake is 41 tons per year or a 40% reduction in the existing load.

5. **Identification of pollution source categories:** Nonpoint sources of nitrate are identified as the cause of impairments to Cedar Lake.

6. **Wasteload allocations for pollutants from point sources:** No point sources have been identified in the Cedar Lake watershed. Therefore, the wasteload allocation will be set at zero.

7. **Load allocations for pollutants from nonpoint sources:** The nitrate load allocation for nonpoint sources is 62 tons per year.

8. **A margin of safety:** An explicit numerical margin of safety of 19 tons per year has been included to ensure that the required load reduction will result in attainment of the water quality target.

9. **Consideration of seasonal variation:** This TMDL was developed based on the annual nitrate loading that will result in attainment of the nitrate target throughout the year.

10. **Allowance for reasonably foreseeable increases in pollutant loads:** An allowance for increased nitrate loading was not included in this TMDL. Significant changes in the Cedar Lake watershed landuses that would increase nitrate loading are unlikely. Also, efforts in the watershed to reduce nitrate loading to the lake are currently underway. Therefore, future increases in nitrate loading to the lake are not anticipated.

11. **Implementation plan:** Although not required by the current regulations, an implementation plan is outlined in the body of the report.

2. Cedar Lake, Description and History

2.1 The Lake

Cedar Lake was constructed in 1939 and is located northeast of Winterset, Iowa. Cedar Lake has been used as a source of drinking water for the Winterset community since 1940. Today it provides water for almost 4,800 people in Madison County.

Public uses of Cedar Lake include fishing, picnicking, hiking, bicycling, bird watching, canoeing, sail boating, ice skating, cross country skiing, and waterfowl hunting. The Winterset Municipal Water Utility has recently enlarged two parking areas and regraded the boat ramp to better accommodate visitors. The shoreline park and the lake average 2,400 user days per year.

Table 2. Cedar Lake Features

Waterbody Name:	Cedar Lake
Hydrologic Unit Code:	HUC10 0710000804
IDNR Waterbody ID:	IA 04-LDM-03085-L
Location:	Section 19 T76N R27W
Latitude:	41° 22' N
Longitude:	94° 0' W
Water Quality Standards Designated Uses:	1. Aquatic Life Support (B(LW)) 2. Potable Water Source (C)
Tributaries:	Cedar Creek
Receiving Waterbody:	Cedar Creek to North River
Lake Surface Area:	88 acres
Maximum Depth:	18 feet
Mean Depth:	9.0 feet
Volume:	792 acre-feet
Watershed Area:	10,380 acres
Watershed/Lake Area Ratio:	118:1
Estimated Detention Time:	0.11 years

Morphometry

Cedar Lake has a surface area of 88 acres, although much of this is very shallow due to high sediment loads. A more accurate measure of the usable surface area would be around 65 acres. The storage volume is approximately 792 acre-feet. The original volume of Cedar Lake has decreased by approximately 310 acre-feet despite raising the spillway in 1979 to increase the lake's volume. Cedar Lake has a mean depth of 9.0 feet and a maximum depth of 18 feet.

Hydrology

Cedar Lake is fed by and discharges to Cedar Creek, a tributary of the North River. Total inflow to the lake was determined using the BasinSim 1.0 Watershed Simulation Program (1). The estimated annual average detention time for Cedar Lake is 0.11 years based on inflow.

2.2 The Watershed

Land Use

The Cedar Lake watershed has an area of approximately 10,380 acres excluding the lake and has a watershed to lake ratio of 118:1. Landuse data was collected in 2003 by the Madison County SWCD in cooperation with the Nonpoint Source Program of the DNR. The landuses and associated areas for the watershed are shown in Table 3.

Table 3. 2003 Landuse in Cedar Lake watershed.

Landuse	Area in Acres	Percent of Total Area
Rowcrop	8,430	81.2
Timber	590	5.7
Pasture	350	3.4
Farmstead	260	2.5
Grassland	220	2.1
Hay	160	1.5
Roads	150	1.5
Industrial / Commercial	130	1.2
Residential	50	0.5
Grazed Timber	30	0.3
Water	10	0.1
Total	10,380	100

Soils and Topography

The watershed is predominately gently sloping, highly productive soils. The topography of the watershed ranges from very flat A and B slope groups to moderately sloping C and D soils. Two-thirds of the cropland is designated as non-highly erodible. These soils erode at less than “T”. The remaining acres potentially have soils that exceed “T” soil loss. Soils in the watershed are of the Macksburg-Winterset association and the Sharpsburg-Lamoni association. A small portion of the watershed in close proximity to the lake is of the steeper Clinton-Lindley-Steep rock land-Clanton association.

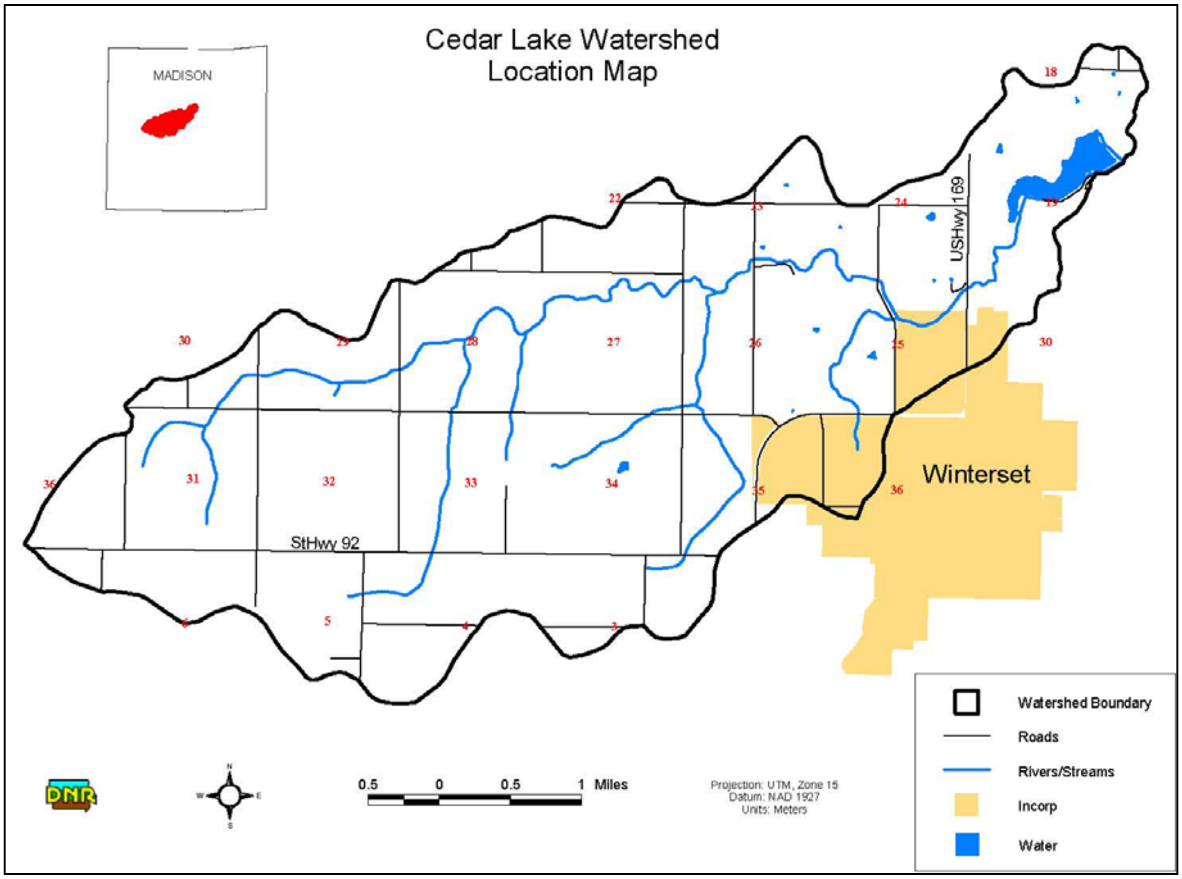
Average rainfall in the area is 33 inches/year, with the greatest monthly amount falling in May.

Current Watershed Conditions

Prior to 2002, many best management practices were present in the Cedar Lake watershed. This includes over 700 acres of cropland being terraced. While terraces are beneficial for erosion reduction, tile drainage from terraces carries nitrate directly to waterways and on to Cedar Lake.

A watershed protection project is underway in the Cedar Lake watershed. The goals of the project include the implementation of soil and water conservation plans for 70% of the watershed area, the installation of six grade stabilization structures with downstream wetlands, and the establishment of 100 acres of conservation buffers. The project and its various components are funded by EPA 319, EQIP, REAP, IFIP, WPF, CRP, and DSC with additional support from the Winterset Municipal Utilities.

Figure 1. Map showing the location of Cedar Creek, Cedar Lake, and the Cedar Lake watershed.



3. TMDL for Nitrate

3.1 Problem Identification

Impaired Beneficial Uses and Applicable Water Quality Standards

The *Iowa Water Quality Standards* (2) list the designated uses for Cedar Lake as aquatic life (Class B(LW)) and potable water source (Class C). In 1998, Cedar Lake was included on the impaired waters 303(d) list due to elevated levels of Atrazine. This assessment was based on the voluntary monitoring program administered by the agribusiness Syngenta. For the 2002 assessment period, data from the sampling program indicated that Atrazine levels in Cedar Lake had decreased to levels below the drinking water standard. Information from the IDNR Water Supply Section, however, shows the issuance of notices of MCL violations for nitrate during April, May, and June of 2001. According to EPA and DNR methods for assessing support of Class C (drinking water) uses, one or more drinking water advisory lasting 30 days or less per year suggests that the Class C use is only "partially supported". Thus, the Class C (drinking water) uses for this lake are assessed as "partially supported" due to elevated nitrate levels.

The *Iowa Water Quality Standards* (2) set water quality criteria for nitrate at 10 mg/L for Class C (potable water source) waters. Cedar Lake has violated this standard.

Data Sources

Raw water quality data has been collected by the Winterset Municipal Utilities for ongoing operations at the drinking water treatment facility. The City of Winterset also collected nitrate data at seven locations in the Cedar Lake watershed several times each spring and summer beginning in 1998.

For this TMDL, watershed sampling for 1998 through 2003 and lake sampling data from May 1995 through March 2004 provided by the City of Winterset and Winterset Municipal Utilities were used to calibrate watershed and water quality models. In addition, raw water temperature data from March 1996 to March 2004 provided by the Winterset Municipal Utilities was used in the water quality modeling. The raw data and watershed sampling locations are shown in Appendix A.

Potential Pollution Sources

Water quality in Cedar Lake is currently influenced only by nonpoint sources. Previously, the Summerset Haven Sewage Treatment Plant near Winterset discharged from a two-cell waste stabilization lagoon designed for a population equivalent of 50 people into a drainage ditch which flows into Cedar Creek and on into Cedar Lake. However, the facility that this treatment system served closed in the summer of 2001 and the lagoon system has since been abandoned. In addition, while the system was still in operation, no effluent discharges from the lagoons directly to Cedar Creek had occurred since 1994. Lagoon effluent was land applied for the 1994 - 2001 operational period (8).

The watershed of Cedar Lake is composed primarily of rowcrop landuses. One concentrated animal feeding operation with a manure storage lagoon and an estimated 360 swine animal units is located in the watershed. In addition, Rose Acre Farms, Inc., a 1,500,000-bird egg-production/processing facility is located within the watershed. Egg wash water and domestic sewage from this facility is treated in a single-cell lagoon prior to land application in the watershed via a 15-acre irrigation system. The facility is authorized to land apply the treated egg wash water and domestic sewage under Iowa Operation Permit Number 61-00-8-01. Since this is a non-discharging lagoon facility, a wasteload allocation is not required for the operation permit. The operation permit prohibits discharge of wastewater from the facility to waters of the State of Iowa. Less than 5% of the manure from the egg-production facility is reported to be land applied in the watershed (7).

Other potential pollution sources include private septic tank systems and atmospheric deposition of nitrogen directly on the lake surface. These sources are believed to be minor relative to total nitrate load to the lake.

3.2 TMDL Target

Criteria for Assessing Water Quality Standards Attainment

The *Iowa Water Quality Standards* (2) set a water quality criteria for nitrate of 10 mg/L for Class C (potable water source) waters. Levels of nitrate above 10 mg/L result in the issuance of a drinking water advisory. According to EPA and DNR methods for assessing support of Class C (drinking water) uses, one or more drinking water advisory lasting 30 days or less per year suggests that the Class C use is only "partially supported". In order to fully support Class C use, nitrate levels must remain at or below 10 mg/L.

Selection of Environmental Conditions

Nitrate loadings are flow dependent and seasonal, with the highest observed concentrations typically occurring in the spring and early summer. In a reservoir (as opposed to a stream), however, peak concentrations can be highly dependent upon antecedent monthly loading conditions. Also, the water quality modeling performed for Cedar Lake indicated little change in the total allowable loading for seasonal reductions versus annual average reductions. Therefore, the nitrate loads in this TMDL are expressed as annual averages.

Modeling Approach

To determine nitrate loading to Cedar Lake the BasinSim 1.0 (1) program, which incorporates the Generalized Watershed Loading Function (GWLF) Model (3) was used. The hydrological portion of the model was developed with precipitation and temperature data from the Iowa Environmental Mesonet (IEM), Iowa State University Department of Agronomy. All other parameters were either model defaults or averages from model default tables (e.g., day length for month).

Since there is no gage on Cedar Creek, the hydrologic parameters for the model were calibrated for a similar sized gauged watershed (Squaw Creek near Colfax, IA - USGS 05471040) in the same landform region for monitored flow data from April 1996 through March 2004. The hydrologic calibration results for the Squaw Creek watershed are shown in Figure 2.

For nutrient loadings, typical dissolved nitrogen concentrations (4) for various agricultural landuses were set as the base values and adjusted during calibration of the water quality model by using the variable nutrient control coefficients option in BasinSim. Nitrogen accumulation rates for urban landuses were calculated from the quality of precipitation report from McNay Research Station near Chariton, Iowa. A tile drain and base flow nitrate concentration of 13 mg/L was used based on the Ohio State University Agricultural Drainage Bulletin 871-98 (5) and water quality model calibration results. A plot of the predicted watershed loads versus the observed loads at Sampling Site No. 1 (see Figure A-1 of Appendix A for sampling site locations) using the modeled flows for the Cedar Lake watershed is shown in Figure 3. BasinSim output is shown in Appendix C.

Figure 2. Hydrologic Calibration Time Series

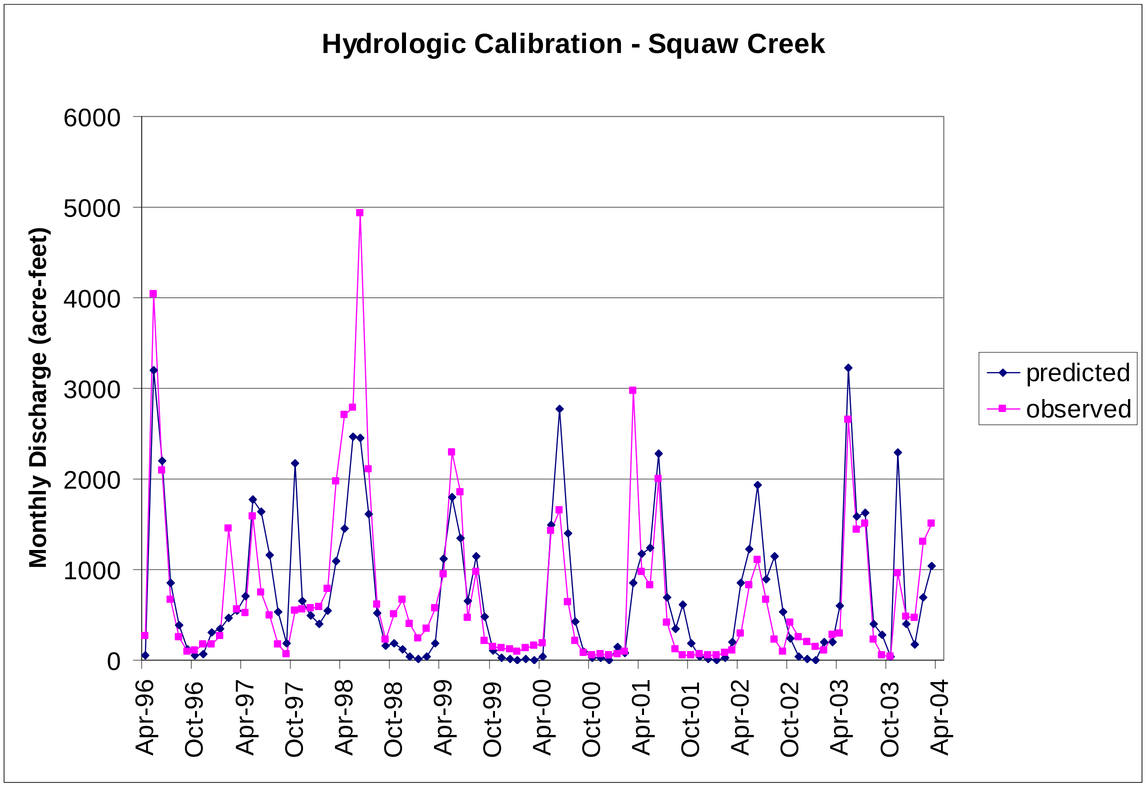
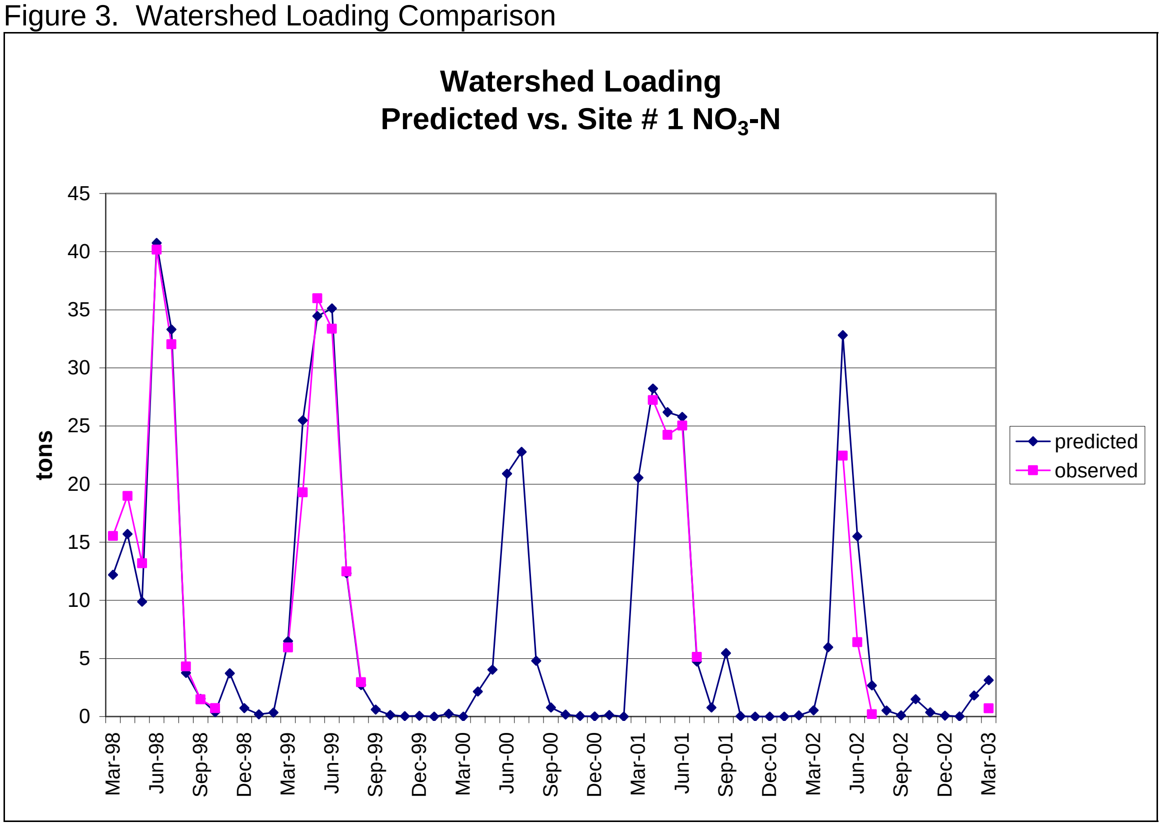


Figure 3. Watershed Loading Comparison



To validate the BasinSim model and to determine the allowable nitrate load, output discharge and dissolved nitrogen data were entered into a well-mixed lake spreadsheet model (Simple Lake Model developed by Steve Chapra 2001 (6)). The lake model uses a Runge-Kutta fourth-order numerical integration method to simulate a completely mixed lake under variable loading conditions for a user-defined time step and first order reaction rate. For application to Cedar Lake, the model was modified to incorporate a temperature-dependent reaction rate.

Water quality model calibration was accomplished by adjusting nutrient concentrations in the watershed model, the lake model reaction coefficient and the temperature activity coefficient to obtain the best statistical fit to observed nitrate concentrations provided by Winterset Municipal Utilities. The calibrated model results for the existing load are shown in Figure 4. The least-squares regression fit of the calibrated model predicted versus observed nitrate concentrations are shown in Figure 5.

Only dissolved nitrogen sources were used in this TMDL. Calibration results using dissolved loadings produced a better statistical fit than combined dissolved and sediment-attached loadings. This result is not surprising given the relatively short detention time of the lake.

Figure 4. Lake Model Results

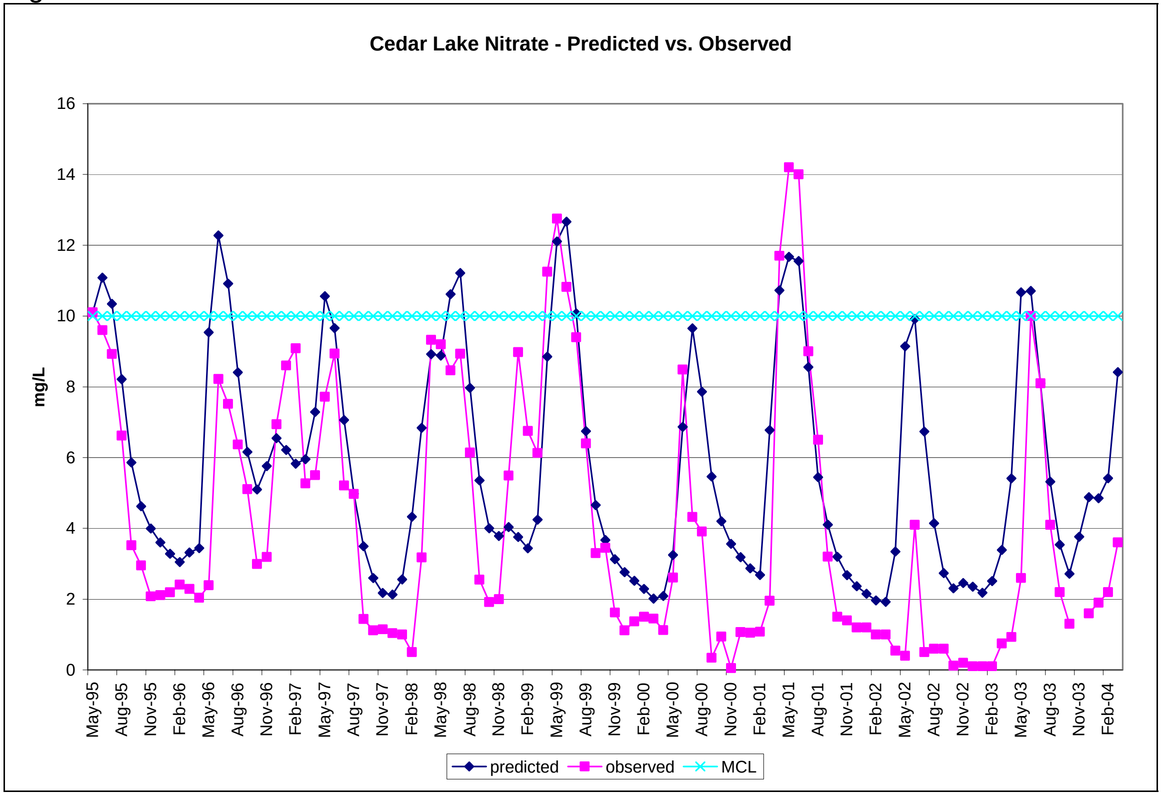
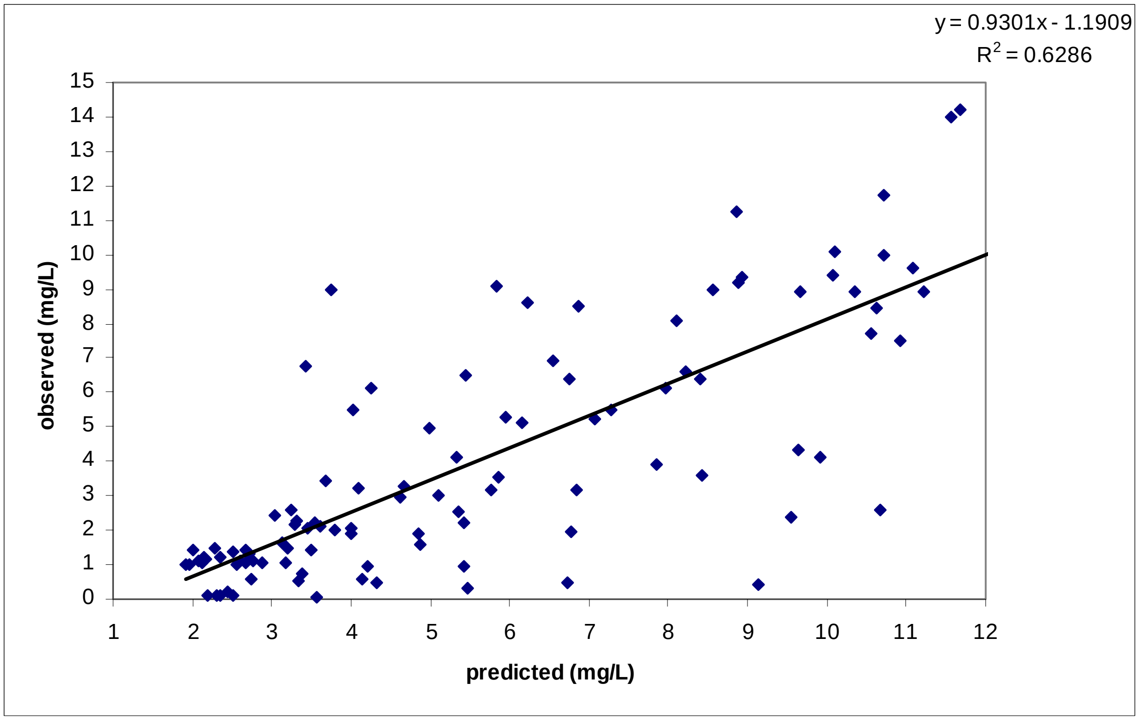


Figure 5. Lake Model Statistical Fit



Waterbody Pollutant Loading Capacity

Load reduction scenarios for the existing monthly loads predicted by the BasinSim model were applied and entered into the calibrated lake model to determine the allowable nitrate loading capacity. A constant reduction of 21% of existing loads resulted in zero predicted violations of the 10 mg/L standard. Figure 6 shows the predicted in-lake concentrations for the 21% load reduction. The corresponding annual average loading capacity for this TMDL is 81 tons per year, excluding the margin of safety.

3.3 Pollution Source Assessment

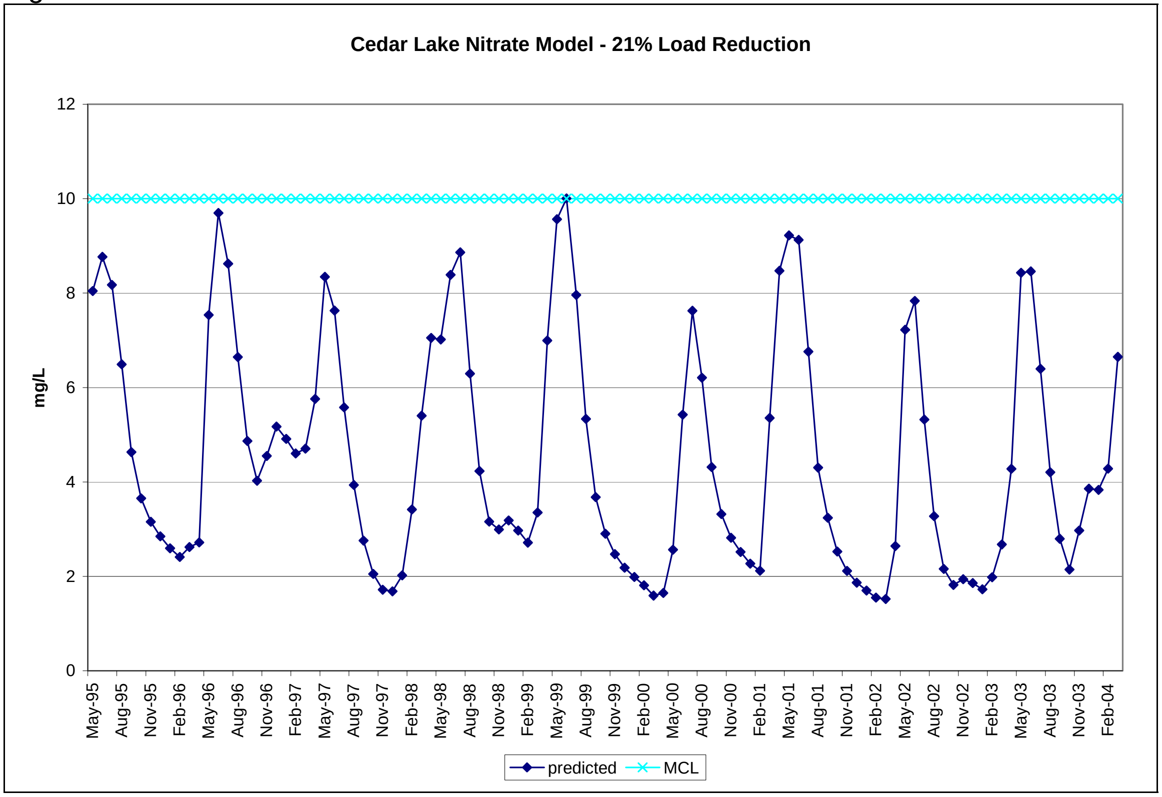
Existing Load

The existing annual average nitrate load to Cedar Lake is estimated to be 103 tons per year based on the watershed and water quality modeling.

Departure from Load Capacity

The modeled load capacity for Cedar Lake is 81 tons per year, excluding the margin of safety. This represents a 21% reduction in the existing load.

Figure 6. Predicted In-Lake Concentrations for 21% Load Reduction



Identification of Pollutant Sources

Figure 7 shows the estimated loads by source from the BasinSim modeling. The tile drain and base flow contribution is by far the largest source indicated, accounting for approximately 86 percent of the total existing load. Surface runoff from rowcrop landuses are estimated to make up 13 percent while all other sources account for less than 1 percent of the total load. Since the water quality model was in part calibrated by adjusting the estimated tile drain/baseflow nitrate concentration in the watershed model, septic tank loads are not separated from tile drain/baseflow component shown in Figure 7. However, assuming an approximate population of 200 permanent residents served by septic tanks within the watershed and the BasinSim default daily per capita contribution of 12 grams of nitrogen per day (1) the contribution from septic tanks is estimated to be less than one ton per year.

Atmospheric deposition on the lake surface using an aerial load of 1,000 mg/m^2 results in a contribution of 0.4 tons per year from this source.

Watershed sampling provided by the City of Winterset may provide the best measure of relative contributions from sub-watersheds within the drainage area of Cedar Lake. To analyze this data, the Cedar Lake watershed was divided into eight sub-watersheds based on the location of the seven sampling sites. The total BasinSim predicted flows for each month were divided among the sub-watersheds by drainage area and applied to measured concentrations to determine sub-watershed and cumulative loads at each sampling site. Figure 8 shows the sub-watershed locations. Figure 9 shows the average load per acre for sub-watersheds 1 through 7 for sampled periods. It should be noted that these loads represent only the average from time periods where sampling data was available and not average annual loads.

Figure 7. BasinSim Predicted Annual Average Dissolved Loads by Source

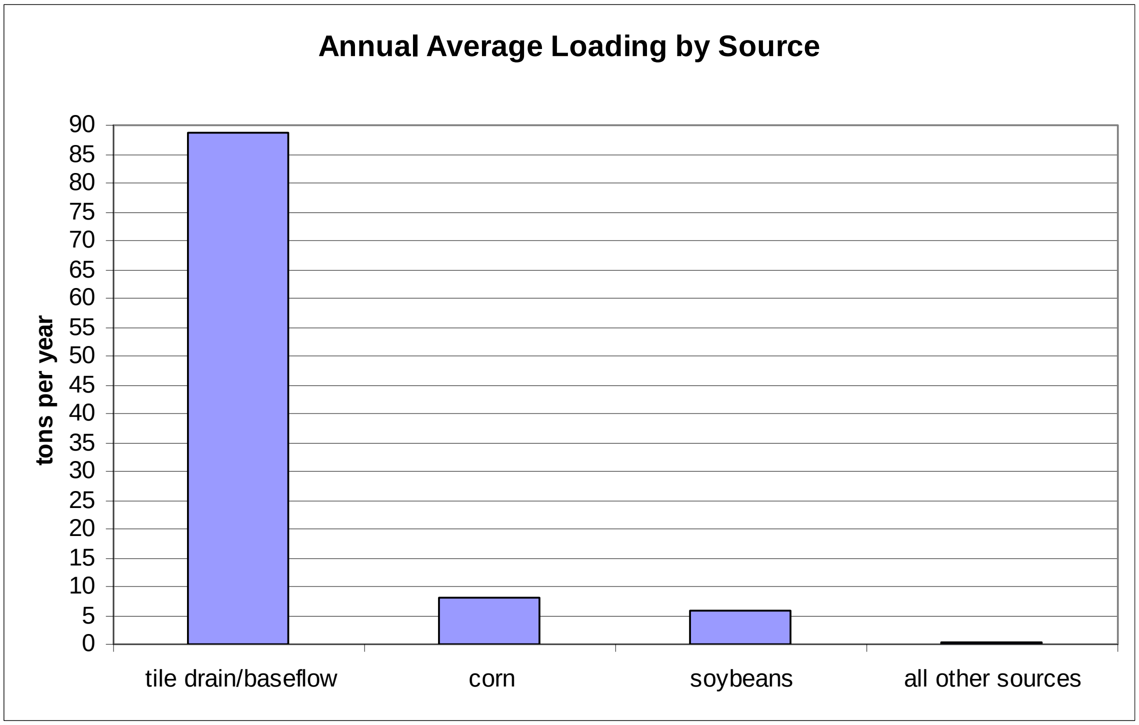


Figure 8. Sub-watersheds

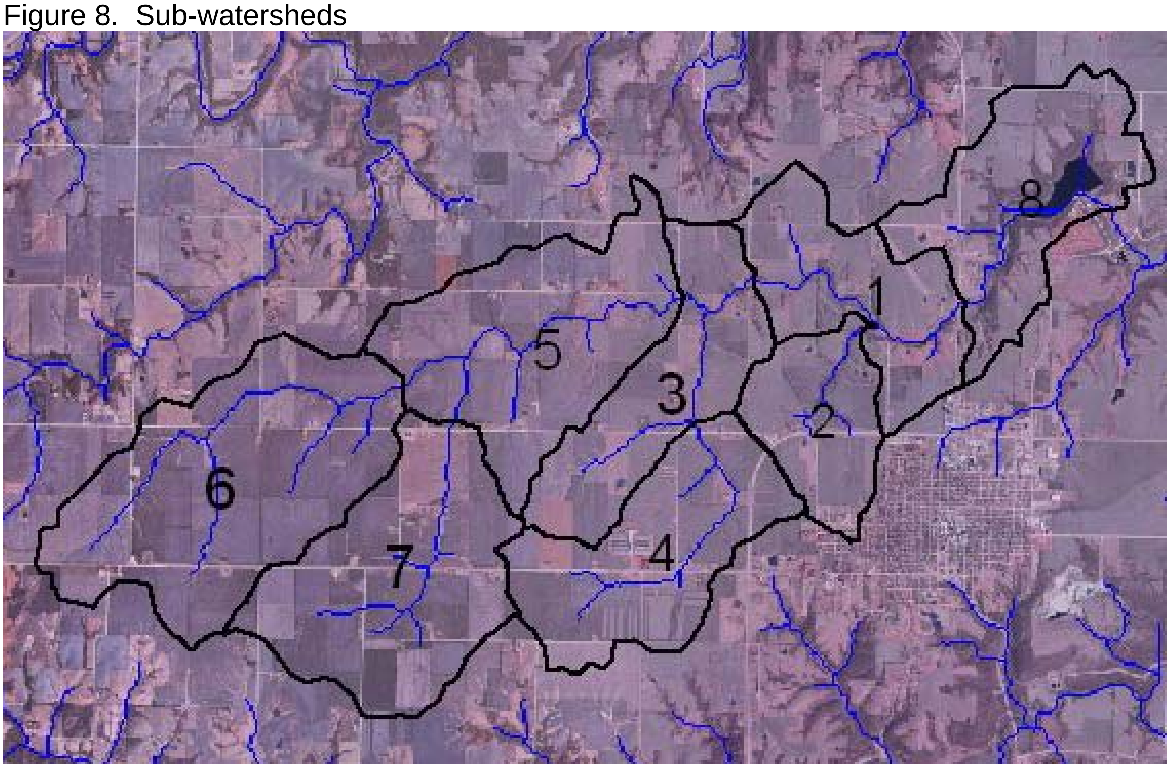
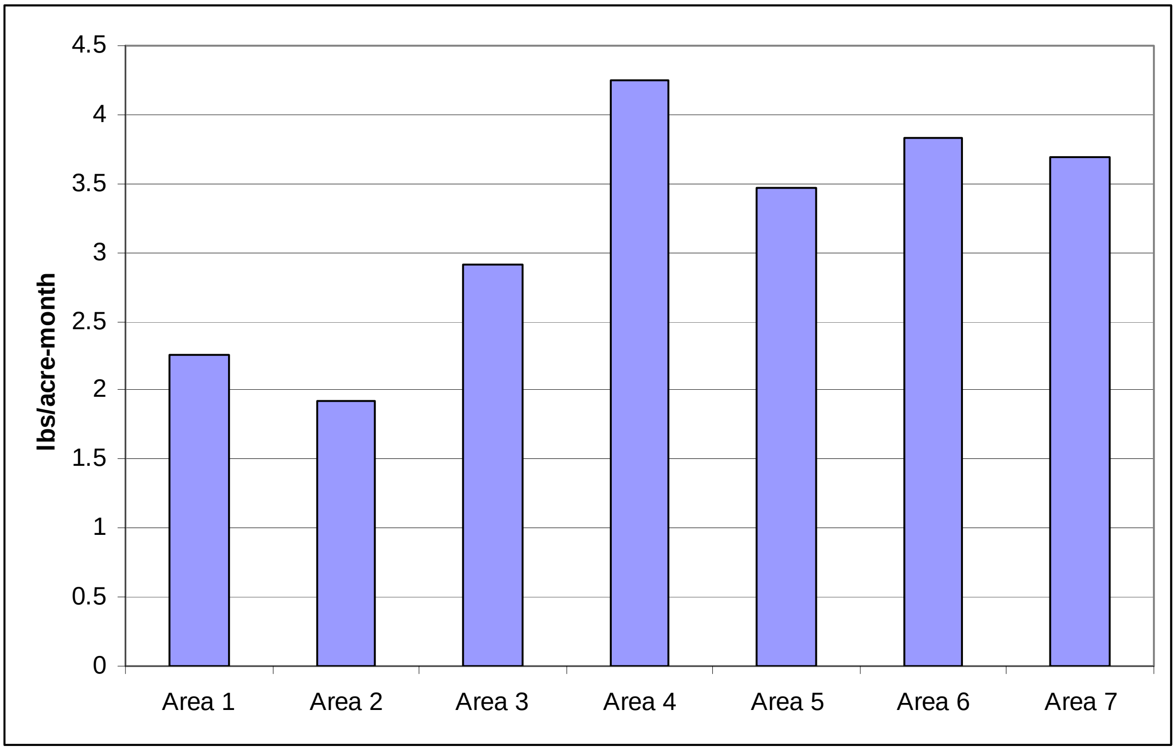


Figure 9. Sub-watershed Sampling - Average Unit Area Loads



While there is minimal gully erosion present in the watershed, there are two areas in the watershed where streambank erosion is a noted problem (see Figure B-1 in Appendix B). While this does not significantly contribute to the nitrate loading in the lake, it does contribute sediment and attached phosphorous to Cedar Lake, as well as cause a general loss of habitat in the stream. The sedimentation is causing a loss of lake volume, which in turn reduces the volume available for water storage and reduction of nitrate through algal uptake and denitrification processes.

Field investigations to determine landuses, cropping patterns, fertilizer use, conservation practices, livestock operations, and gully erosion were made in 2003 by the Madison County SWCD.

Linkage of Sources to Target

The nitrate load to Cedar Lake originates from nonpoint sources. Excluding the margin of safety, the estimated load reduction required to meet the TMDL endpoint is 22 tons per year.

3.4 Pollutant Allocation

Wasteload Allocation

Since there are no nitrate point source contributors in the Cedar Lake watershed, the Waste Load Allocation (WLA) is zero pounds per year.

Load Allocation

The Load Allocation (LA) for this TMDL is 62 tons per year. This is equivalent to a 40% reduction in the estimated existing nonpoint source loading.

Margin of Safety

The margin of safety for this TMDL is explicit. A 90% prediction interval was obtained from statistical analysis of predicted versus measured in-lake nitrate concentrations. Where multiple samples were taken in a month, the maximum monthly value was used in the statistical analysis to account for daily variation in lake nitrate levels. The upper 90% prediction limit was then plotted for various load reduction scenarios until the uppermost point in the prediction interval was less than the 10 mg/L target concentration. Figure 10 shows the results of the statistical analysis. Figure 11 shows a plot of the upper 90% prediction interval for a 40% reduction of the existing load corresponding with the TMDL margin of safety.

Figure 10. Statistical Analysis Results

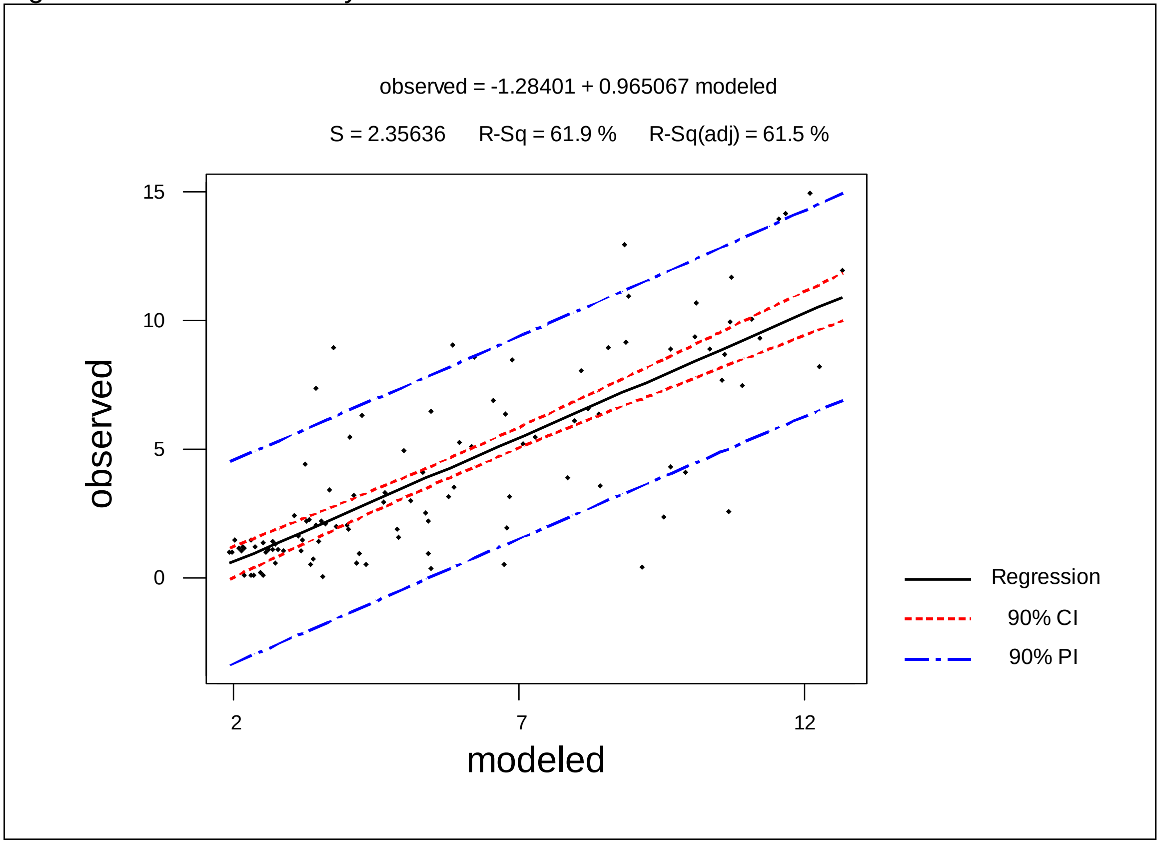
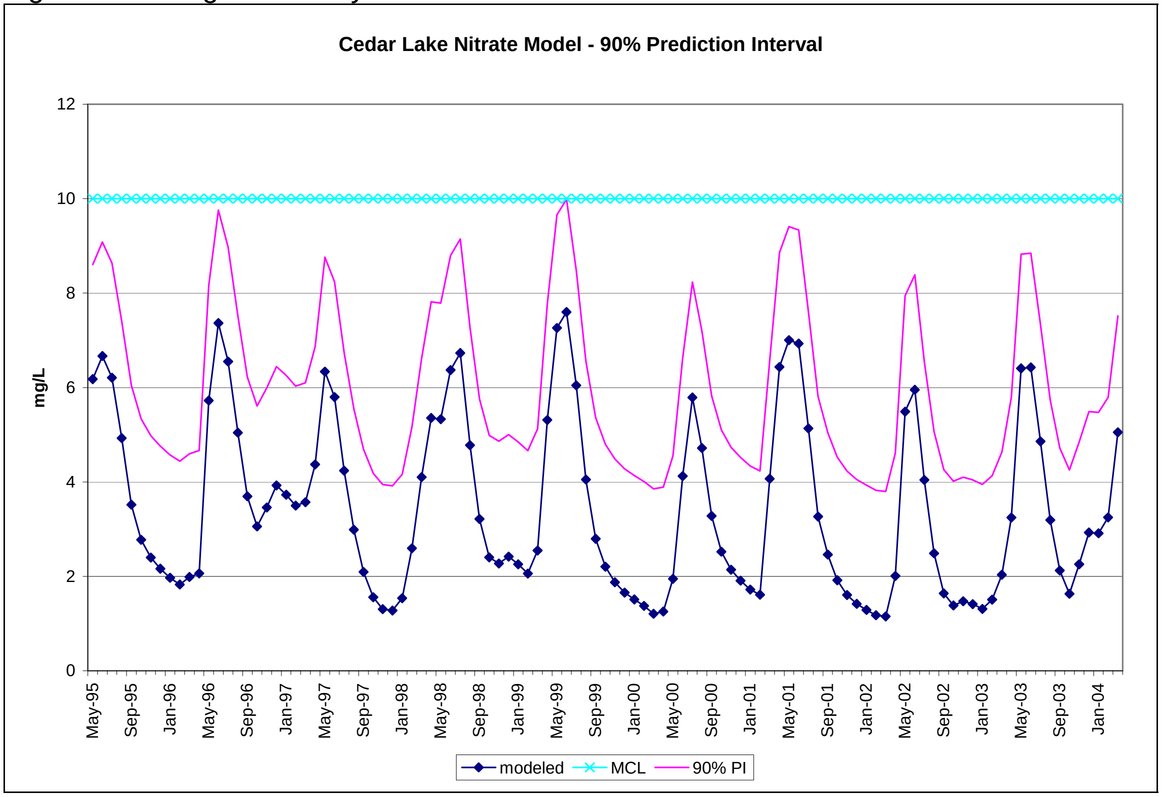


Figure 11. Margin of Safety 90% Prediction Interval Plot



3.5 Nitrate TMDL Summary

The equation for the total maximum daily load shows the lake nitrate load capacity.

TMDL = Load Capacity (81 tons per year) = WLA (0) + LA (62 tons per year) + MOS (19 tons per year)

4. Implementation Plan

An implementation plan is not currently a required component of a Total Maximum Daily Load. However, the Cedar Lake Watershed Project is working with local landowners, the City of Winterset, the NRCS field office, and the IDNR to develop a priority based watershed plan. The project will implement best management practices with the goal of reducing nitrate levels, improving overall water quality in Cedar Lake and meeting the targets of the TMDL.

The Cedar Lake Watershed Project was established in 2001 and is funded by a CWA Section 319 grant from the IDNR and by a Watershed Protection Fund Grant from the Division of Soil Conservation. The project has established project goals and objectives focusing on improving nutrient and pest management on cropland and pasture, reducing overall soil loss from cropland and streambank erosion, and improving manure management application methods.

The establishment of riparian buffers in the watershed of Cedar Lake will slow overland flow during storm events, allowing soil particles being carried by the runoff to settle back onto the land before being carried into the streams, increase infiltration of water, and reduce the ‘flashiness’ of the streams during storms. The increased infiltration will allow nitrate to enter the soil where it may be utilized by plants.

The construction of a number of wetlands along Cedar Creek will provide several benefits. Denitrification within the wetlands will decrease the nitrogen load that reaches Cedar Lake. Wetlands will be able to capture the nitrate that bypasses riparian buffers through tile flow. Wetlands also slow the flow of water, allowing suspended sediment to settle out of the water column.

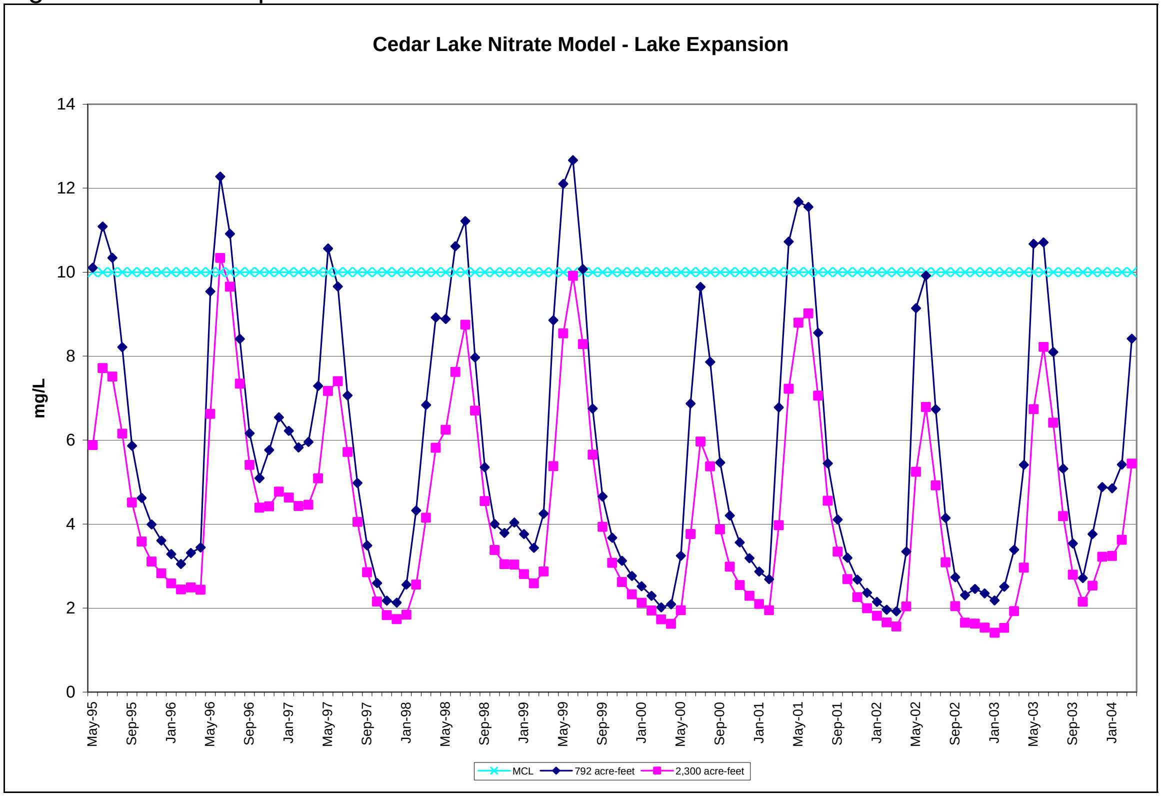
A large portion of the Cedar Lake watershed is used for rowcrop production. Previous studies (9) have shown that nitrate concentrations in Iowa streams are strongly correlated to the percentage of rowcrop within the watershed. Therefore, nutrient management on rowcrop areas in the Cedar Lake watershed is likely to be the biggest factor affecting nitrate loading to the lake and management practices that will reduce source loading should be emphasized. In particular, practices to improve the timing of nitrogen application, the incorporation of nitrogen in the soil, and to match application rates to crop demand are critical. Such practices include:

- Spring or split nitrogen application (in lieu of fall application) to better time nitrogen availability with crop demand.
- Use nitrogen application rates based on the Late-Spring Soil Nitrate Test (LSNT).
- Adoption of no-till or strip-till systems combined with injection of nitrogen fertilizers to improve soil adsorption of nitrogen, crop nitrogen use efficiency and decrease leaching of nitrogen-laden soil water through macropores.

Expansion of the lake has been previously proposed to meet projected water supply demands. Increasing the size of Cedar Lake would also help to reduce nitrate concentrations through increased volume and surface area available for algal uptake and denitrification processes. A model scenario was run for total lake volume of 2,300 acre-feet as previously proposed (11,12) using the modeled existing flows and loads. As shown in Figure 12, the model indicates that the proposed lake expansion would reduce in-lake nitrate concentrations. Accounting for the statistical uncertainty in the model, the lake volume increase alone would not guarantee zero violations of the nitrate standard for existing loads. It would, however, decrease the load reduction required to meet the 10 mg/L standard.

Other alternatives have been or are being investigated to address the drinking water nitrate problem. Nitrates can be removed through ion exchange or reverse osmosis treatment. Aquifer Storage and Recovery (ASR), in which treated water is stored in a deep underground aquifer when excess surface water supply of sufficient quality is available, is also being considered by the City. Finally, construction of a new lake in a different watershed is being considered. Implementation of these alternatives would address the drinking water supply issue; however, nitrate levels in Cedar Lake will not be affected without continuing efforts in the watershed to reduce loads and/or expansion of the existing lake.

Figure 12. Lake Expansion Scenario



5. Monitoring

The Winterset Municipal Utilities routinely monitors nitrate levels as required for operation of the drinking water facility by its water supply operation permit. At minimum, one sample analyzed by a certified laboratory per month is required following a single violation of the MCL of 10 mg/L. If the MCL is not exceeded for a period of 2 years the sampling requirement may be reduced to four times per year if all measured concentrations have been between 5 - 10 mg/L or once per year if all measured concentrations have been less than 5 mg/L. In addition, the Utilities has voluntarily monitored more frequently than required during periods of high nitrate levels and it is anticipated that it will continue to do so. The City of Winterset also monitors nitrate levels at seven designated testing sites throughout the watershed when adequate streamflow is available.

6. Public Participation

A public meeting was held in Winterset regarding the proposed TMDL for nitrate for Cedar Lake on March 25, 2004. A public meeting to present the draft TMDL was held on February 23, 2005. Comments received were reviewed and given consideration and, where appropriate, incorporated into the TMDL.

7. References

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12. Vance & Hochstetler P.C. 1993. Preliminary Report - Cedar Lake Reservoir, City of Winterset, Iowa.

8. Appendix A - Sampling Data

Table A-1. Nitrate concentrations in the Cedar Lake watershed in 2001-03. Data was provided by the City of Winterset.

DATE	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7
4/12/2001	15.3	10.6	16.1	16.5	16.3	16.4	16.4
4/16/2001	13.2	10.9	15.6	18.3	15.3	16.5	13.2
4/18/2001	15.2	10.1	15.8	17.6	16.2	15.4	15.2
4/23/2001	14.2	9.2	15.6	14.6	16.8	15.8	13
4/25/2001	15	8.7	15	16.3	15.2	15.7	14.2
5/11/2001	9.6	9.7	11.5	15.8	15.2	14.8	15.3
5/18/2001	16.4	9.6	16	18.2	15.6	16.2	15.6
5/22/2001	15.4	9	15.2	17.6	16	16.2	15
6/4/2001	16	9.3	17.2	18.2	16.2	16.8	16.6
6/13/2001	15.2	9.1	15.6	17.2	15.6	17.2	15
6/21/2001	15.2	9.4	16.2	17.4	14.8	17	16.2
6/29/2001	13	9.5	14.8	16.4	15.4	17	15
7/5/2001	12.3	9.1	13.5	16.6	14.4	16.1	14.7
7/11/2001	10.3	6.4	10.1	10.1	10.2	10.3	9.9
7/18/2001	8.5	3.9	8.7	8.2	9	8.2	7.8
5/1/2002	6.9	2.9	9.4	11.4	8.7	7.6	6.3
5/13/2002	16.4	10.2	17.2	17.8	16.2	16.6	14.4
5/22/2002	8.9	5.6	9.8	16.2	11.8	13	12.4
5/29/2002	8	5.8	9.5	16.4	9.6	14.4	9.8
6/6/2002	6.4	4.5	8	14.4	8.2	13	9.3
6/12/2002	4.7	2.9	5.9	9.6	6.8	9.4	8.5
7/12/2002	0.6	NA	4.6	8.9	0.4	1.4	8.3
3/25/2003	1.9	NA	2.3	2	2.7	3.1	4.7

Figure A-1. Map of sampling sites in the Cedar Lake Watershed.

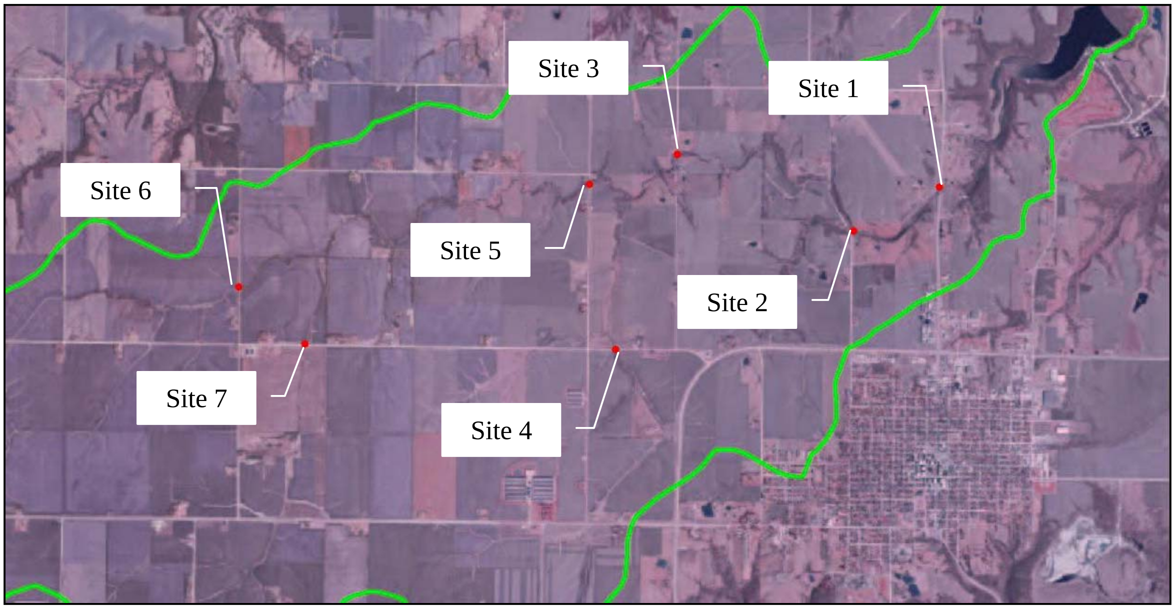


Table A-2. Nitrate sampling at the Winterset Water Treatment Facility, May 1995 - March 2004.

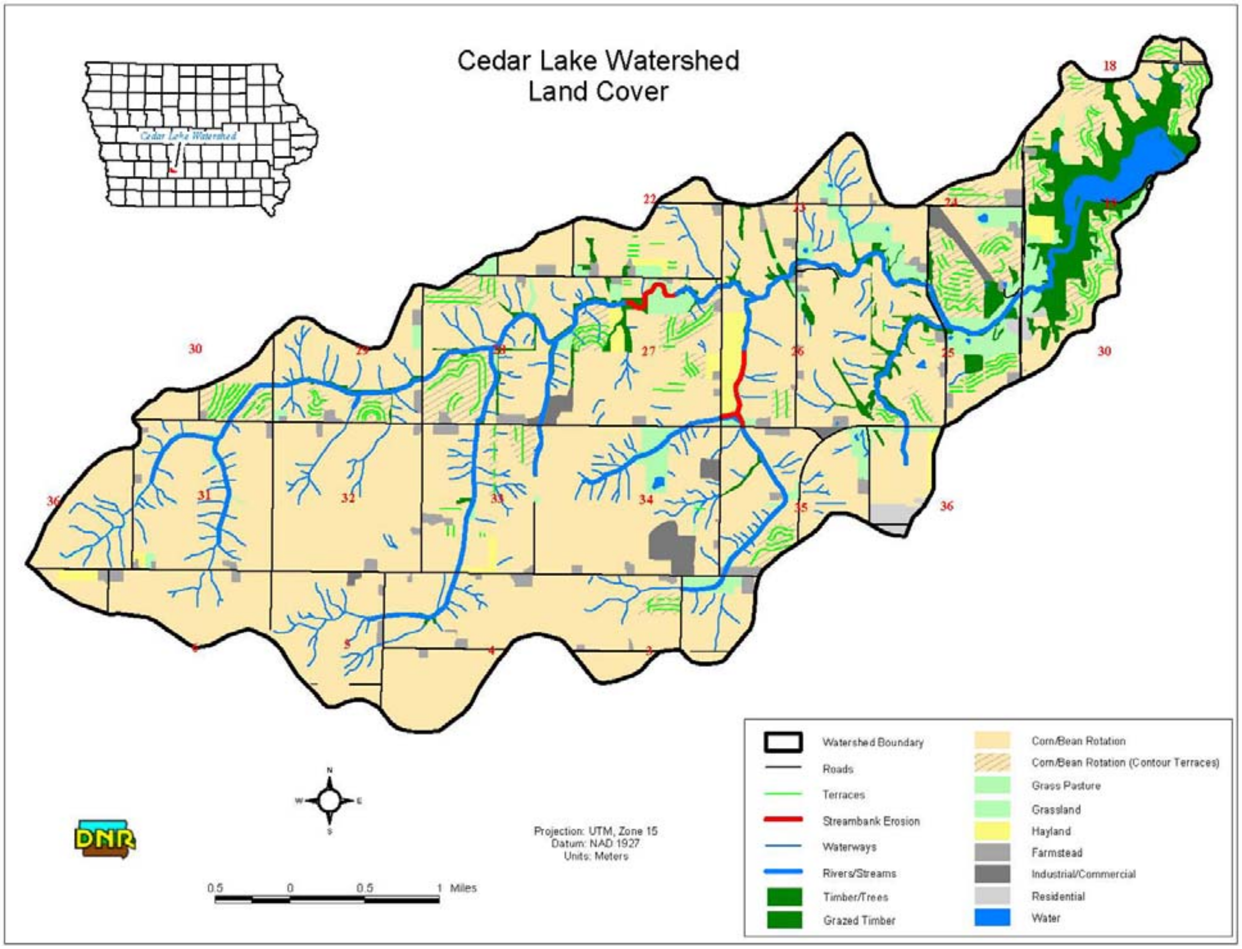
DATE	NO_3-N (mg/L)	DATE	NO_3-N (mg/L)	DATE	NO_3-N (mg/L)
5/8/1995	9.5	5/18/1998	9.2	8/3/2000	3.91
5/15/1995	10.01	6/22/1998	8.2	9/7/2000	0.34
5/22/1995	10.7	6/22/1998	8.73	10/5/2000	0.94
5/30/1995	10.2	7/16/1998	9.37	11/2/2000	0.05
6/5/1995	10.1	7/16/1998	9.29	12/7/2000	1.07
6/12/1995	9.64	7/16/1998	8.8	1/4/2001	1.05
6/20/1995	9.07	7/16/1998	8.6	2/1/2001	1.08
7/10/1995	8.93	7/16/1998	8.6	3/1/2001	1.95
8/1/1995	6.62	8/17/1998	6.14	4/5/2001	11.7
9/5/1995	3.52	9/21/1998	2.55	5/10/2001	14.2
10/2/1995	2.95	10/19/1998	1.92	6/15/2001	14
11/6/1995	2.08	11/2/1998	2	7/23/2001	9
12/4/1995	2.11	12/7/1998	5.49	8/7/2001	6.5
1/7/1996	2.19	1/7/1999	8.98	9/6/2001	3.2
2/5/1996	2.41	2/4/1999	7.4	10/11/2001	1.5
3/4/1996	2.29	2/4/1999	6.1	11/7/2001	1.4
4/1/1996	2.08	3/4/1999	5.9	12/20/2001	1.2
4/9/1996	1.99	3/4/1999	6.36	1/17/2002	1.2
5/6/1996	2.39	4/1/1999	7	2/25/2002	1
6/10/1996	8.22	4/20/1999	12	3/13/2002	1
7/1/1996	7.52	4/22/1999	13	4/10/2002	0.54
8/5/1996	6.37	4/26/1999	13	5/2/2002	0.4
9/3/1996	5.11	5/4/1999	15	6/4/2002	4.1
10/7/1996	2.99	5/11/1999	14	7/23/2002	0.5
11/4/1996	3.19	5/18/1999	12	8/19/2002	0.6
12/2/1996	6.94	5/24/1999	10	9/18/2002	0.6
1/13/1997	8.6	6/1/1999	12	10/17/2002	0.12
2/3/1997	9.09	6/7/1999	12	11/14/2002	0.2
3/17/1997	5.27	6/14/1999	9.3	12/11/2002	0.1
4/7/1997	5.5	6/21/1999	10	1/6/2003	0.1
5/21/1997	7.72	7/7/1999	9.4	2/3/2003	0.1
6/2/1997	8.94	8/4/1999	6.4	3/11/2003	0.75
7/7/1997	5.21	9/1/1999	3.32	4/8/2003	0.93
8/4/1997	4.97	10/7/1999	3.45	5/6/2003	2.6
9/8/1997	1.44	11/4/1999	1.62	6/9/2003	10
10/6/1997	1.12	12/2/1999	1.12	7/7/2003	8.1
11/3/1997	1.15	1/6/2000	1.37	8/12/2003	4.1
12/1/1997	1.04	2/3/2000	1.5	9/8/2003	2.2
1/7/1998	1	3/2/2000	1.45	10/7/2003	1.3
2/2/1998	0.5	4/6/2000	1.18	12/15/2003	1.6
3/16/1998	3.18	4/20/2000	1.07	1/12/2004	1.9
4/15/1998	11	5/4/2000	0.77	2/3/2004	2.2
4/16/1998	8.9	5/25/2000	4.45	3/1/2004	3.6
4/21/1998	10	6/30/2000	8.49	--	--
4/29/1998	7.4	7/13/2000	2.84	--	--

Table A-3. Water temperature data provided by Winterset Municipal Utilities.

Raw Water Temperature, degrees C											
Month		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
January			4.4	4.6	3.6	4.4	4.5	4.2	4.7	4.3	4.4
February			4.5	4.2	5.2	4.6	5.2	3.9	4.7	3.8	4.2
March			5.3	5.8	4.9	6.4	9.2	3.4	5.1	5.7	7.5
April			10.3	9.8	12	11.3	12.8	11.5	12.9	12.9	
May			13.5	13.9	18.7	15.1	19.7	18.2	17.1	16.5	
June			15.9	17.1	20.4	19.9	22.2	20	24.5	21.8	
July			20.7	23	23.8	25.9	24	25.6	27.6	26.3	
August			23.7	22.8	25	24.9	24.9	25.9	25.8	27.1	
September		20	20.8	21.6	23.6	21.2	21.8	21.2	23.2	21.3	
October		14	14.6	15.9	16.7	14	15.4	14.5	14.3	15.2	
November		5.6	5.9	5.2	9.6	10.1	7.5	11.2	6.3	7.1	
December		3.7	4.4	3.3	6.4	4.6	4.3	5.3	3.8	3.8	

9. Appendix B - Land Use Map

Figure B-1. Cedar Lake Watershed 2002 Landuse



10. Appendix C - BasinSim Output

Table C-1. Summary Output

	9	year means		Tot area (h)=	4221		
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)		
apr	9.3	0.94	2.05	0.42	2.47		
may	13.06	1.7	3.65	1.6	5.25		
jun	11.31	3.52	3.46	1.08	4.54		
jul	8.19	6.51	2.26	0.27	2.54		
aug	6	8.53	0.81	0.04	0.85		
sept	7.67	6.67	0.24	0.38	0.62		
oct	5.8	5.34	0.16	0.09	0.25		
nov	5.03	2.07	0.27	0.46	0.73		
dec	2.02	0.67	0.26	0.04	0.3		
jan	2.7	0.21	0.17	0.05	0.22		
feb	3.41	0.26	0.41	0.43	0.84		
mar	4.36	0.46	1.05	0.67	1.73		
ANNUAL	78.84	36.88	14.79	5.54	20.33		
	Erosion	Sediment	Dis. N	Tot. N	Dis. P	Tot. P	
	-(1000 t)-	-(1000 t)-	-(t)-	-(t)-	-(t)-	-(t)-	
apr	1.59	0.09	11.4506	11.9075	0	0	
may	2.93	0.62	27.877	29.4454	0	0	
jun	2.5	0.69	24.2645	25.9462	0	0	
jul	1.73	0.28	12.4777	13.218	0	0	
aug	1.05	0.02	2.8947	3.0844	0	0	
sept	2	0.77	1.3729	3.0933	0	0	
oct	1.16	0.15	0.5384	0.9792	0	0	
nov	1.15	0.72	2.0242	3.604	0	0	
dec	0.04	0.05	0.8303	1.0096	0	0	
jan	0	0.02	0.4986	0.6441	0	0	
feb	0.08	1.11	2.2691	4.6819	0	0	
mar	0.38	0.91	6.7894	8.8168	0	0	
ANNUAL	14.64	5.42	93.2875	106.4303	0	0	
Source	Area (ha)	Runoff (cm)	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	5.37	3.68	5.18	9.01	0	0
corn	1991	5.37	4.41	7.32	13.81	0	0
farmstead	106	3.67	0.14	0.06	0.08	0	0
pasture	140	1.84	2.28	0.09	0.32	0	0
grassland	87	1.84	0.37	0.05	0.07	0	0
grazed timl	13	2.51	1.15	0.01	0.02	0	0
timber	239	1.1	0.55	0	0.1	0	0
hay field	63	1.84	2.72	0.04	0.16	0	0
industrial	52	13.1	0	0	0.58	0	0
residential	20	3.67	0	0	0.08	0	0
road	61	51.39	0	0	1.66	0	0
water	40	0	0	0	0	0	0
GROUNDWATER				80.54	80.54	0	0
POINT SOURCE				0	0	0	0
TOTAL	4221			93.29	106.43	0	0

Table C-2. Annual Output

	Annual	Means		Tot area (h)=	4221	
Year	Precip. (cm)	ET. (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)	
1	77.71	36.78	15.25	3.02	18.27	
2	101.76	35.51	22.39	12.16	34.55	
3	74.9	36.03	12.39	3.32	15.72	
4	80.76	39.85	16.23	6.48	22.72	
5	75.92	38.16	15.69	3.2	18.89	
6	73.81	33.55	11.12	5.1	16.22	
7	68.29	38.85	13.01	4.26	17.27	
8	65.49	36.5	10.44	3.23	13.67	
9	90.91	36.7	16.61	9.04	25.65	
Year	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
1	11.18	4.14	87.91	98.42	0	0
2	24.54	9.08	156.92	177.73	0	0
3	10.34	3.83	65.64	75.81	0	0
4	15.27	5.65	105.97	119.59	0	0
5	14.85	5.49	100.88	114.16	0	0
6	10.69	3.96	69.3	79.33	0	0
7	13.69	5.06	83.34	95.3	0	0
8	13.05	4.83	58.52	70.21	0	0
9	18.13	6.71	111.12	127.33	0	0

Table C-3. Monthly Output

				Tot area (h)=	4221	Rows/Yr=	50
	YEAR	2-9 Mean					
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)		
apr	8.68	0.95	2.06	0.35	2.41		
may	13.3	1.71	3.55	1.76	5.31		
jun	11.48	3.52	3.5	1.21	4.71		
jul	7.53	6.5	2.11	0.29	2.4		
aug	6.22	8.37	0.72	0.04	0.76		
sept	7.62	6.75	0.23	0.42	0.65		
oct	6.23	5.33	0.17	0.1	0.27		
nov	5.12	2.13	0.31	0.51	0.81		
dec	2.12	0.71	0.29	0.04	0.33		
jan	2.19	0.22	0.19	0.06	0.25		
feb	3.78	0.24	0.45	0.31	0.77		
mar	4.71	0.47	1.17	0.76	1.93		
YEAR	78.98	36.89	14.74	5.85	20.59		
	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)	
apr	1.4641	0.0575	11.371	11.7503	0	0	
may	3.071	0.6857	27.7311	29.4408	0	0	
jun	2.6605	0.7738	25.2094	27.0649	0	0	
jul	1.6324	0.313	11.5469	12.341	0	0	
aug	1.1249	0.0199	2.5023	2.7025	0	0	
sept	2.0655	0.859	1.4332	3.3405	0	0	
oct	1.2756	0.1669	0.5801	1.068	0	0	
nov	1.2204	0.8049	2.2718	4.0266	0	0	
dec	0.0483	0.0531	0.9283	1.1091	0	0	
jan	0.0006	0.0186	0.5607	0.7202	0	0	
feb	0.0893	0.7991	2.2288	4.0092	0	0	
mar	0.4173	1.0242	7.5965	9.8579	0	0	
YEAR	15.0699	5.5759	93.9601	107.4311	0	0	
SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	5.71	3.7867	5.5866	9.5349	0	0
corn	1991	5.71	4.5361	7.8942	14.5774	0	0
farmstead	106	3.94	0.1392	0.0705	0.0814	0	0
pasture	140	2	2.3449	0.0976	0.3405	0	0
grassland	87	2	0.3839	0.0526	0.0773	0	0
grazed timl	13	2.71	1.1839	0.0121	0.0235	0	0
timber	239	1.22	0.5636	0.0021	0.1018	0	0
hay field	63	2	2.8019	0.041	0.1716	0	0
industrial	52	13.68	0	0	0.5892	0	0
residential	20	3.94	0	0	0.0835	0	0
road	61	51.78	0	0	1.6466	0	0
water	40	0	0	0	0	0	0
Groundwater				80.2035	80.2035	0	0
Point Source				0	0	0	0
TOTAL	4221			93.9601	107.4311	0	0

Table C-3 (cont.)

New Project

	YEAR	1			
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)
apr	14.23	0.89	1.96	0.97	2.94
may	11.14	1.57	4.51	0.26	4.77
jun	9.99	3.56	3.1	0.1	3.2
jul	13.45	6.63	3.52	0.12	3.64
aug	4.19	9.8	1.53	0.02	1.55
sept	8.02	6.03	0.32	0.06	0.38
oct	2.36	5.42	0.07	0.01	0.08
nov	4.3	1.57	0.02	0.04	0.05
dec	1.24	0.37	0	0.05	0.05
jan	6.75	0.18	0	0	0
feb	0.46	0.36	0.09	1.38	1.47
mar	1.58	0.41	0.12	0.01	0.13
YEAR	77.71	36.78	15.25	3.02	18.27

	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
apr	2.6416	0.3473	12.0873	13.1649	0	0
may	1.8418	0.0616	29.0445	29.4823	0	0
jun	1.2349	0.0122	16.7054	16.9967	0	0
jul	2.5132	0.0239	19.9246	20.2336	0	0
aug	0.449	0.0018	6.0338	6.1396	0	0
sept	1.5182	0.0159	0.89	1.116	0	0
oct	0.2644	0.0011	0.2044	0.2685	0	0
nov	0.6288	0.0096	0.0434	0.2234	0	0
dec	0.0036	0.022	0.0465	0.2131	0	0
jan	0	0.0003	0.0022	0.0348	0	0
feb	0.0051	3.6106	2.592	10.0632	0	0
mar	0.0798	0.0305	0.3328	0.4879	0	0
YEAR	11.1806	4.1368	87.9069	98.4238	0	0

SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	2.64	2.8094	1.9155	4.8448	0	0
corn	1991	2.64	3.3654	2.7068	7.6651	0	0
farmstead	106	1.57	0.1033	0.0199	0.028	0	0
pasture	140	0.54	1.7397	0.0177	0.198	0	0
grassland	87	0.54	0.2848	0.0096	0.0279	0	0
grazed timl	13	0.91	0.8783	0.0028	0.0112	0	0
timber	239	0.2	0.4182	0.0002	0.0742	0	0
hay field	63	0.54	2.0788	0.0075	0.1044	0	0
industrial	52	8.43	0	0	0.4682	0	0
residential	20	1.57	0	0	0.0504	0	0
road	61	48.24	0	0	1.7246	0	0
water	40	0	0	0	0	0	0
Groundwater				83.227	83.227	0	0
Point Source				0	0	0	0
TOTAL	4221			87.9069	98.4238	0	0

Table C-3 (cont.)

New Project							
	YEAR	2					
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)		
apr	6.36	0.98	0.67	0.06	0.73		
may	27.04	1.68	5.12	7.51	12.62		
jun	18.03	3.68	5.9	3.3	9.2		
jul	10.08	6	2.73	0.13	2.86		
aug	8.25	8.05	1.68	0.06	1.73		
sept	9.83	6.55	0.64	0.72	1.36		
oct	7.78	5.77	0.76	0.1	0.87		
nov	6.36	1.28	1.52	0.04	1.56		
dec	1.1	0.42	1.09	0	1.09		
jan	1.68	0.27	0.45	0.04	0.48		
feb	2.91	0.2	0.77	0.19	0.96		
mar	2.34	0.62	1.08	0.01	1.09		
YEAR	101.76	35.51	22.39	12.16	34.55		
	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)	
apr	1.6895	0.0002	1.937	2.1352	0	0	
may	8.7944	2.8162	58.9563	65.1202	0	0	
jun	4.5626	2.4849	51.7921	57.152	0	0	
jul	2.3211	0.0343	14.0699	14.3954	0	0	
aug	1.6287	0.0132	6.9505	7.1718	0	0	
sept	2.6804	2.3135	3.4282	8.3047	0	0	
oct	1.8486	0.2408	2.4148	3.0891	0	0	
nov	0.6367	0.0209	6.0314	6.2463	0	0	
dec	0.0532	0.0013	3.7087	3.7435	0	0	
jan	0.0036	0.0466	1.2422	1.5109	0	0	
feb	0.0079	0.9822	2.7103	4.8637	0	0	
mar	0.3148	0.1262	3.6786	3.9924	0	0	
YEAR	24.5414	9.0803	156.92	177.7251	0	0	
SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	12.22	6.1667	13.546	19.9758	0	0
corn	1991	12.22	7.387	19.1413	30.0249	0	0
farmstead	106	9.51	0.2267	0.1914	0.2092	0	0
pasture	140	6.08	3.8187	0.3285	0.7241	0	0
grassland	87	6.08	0.6251	0.1769	0.2172	0	0
grazed timl	13	7.44	1.9279	0.0371	0.0556	0	0
timber	239	4.41	0.9179	0.0082	0.1705	0	0
hay field	63	6.08	4.5629	0.138	0.3507	0	0
industrial	52	23.64	0	0	0.6997	0	0
residential	20	9.51	0	0	0.1106	0	0
road	61	72.81	0	0	1.8342	0	0
water	40	0	0	0	0	0	0
Groundwater				123.3526	123.3526	0	0
Point Source				0	0	0	0
TOTAL	4221			156.92	177.7251	0	0

Table C-3 (cont.)

New Project					
	YEAR	3			
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)
apr	9.59	0.8	2.13	0.19	2.33
may	11.32	1.53	3.95	0.48	4.44
jun	6.04	3.62	1.55	0.18	1.73
jul	2.29	6.56	0.9	0.01	0.91
aug	4.57	7.87	0.19	0.02	0.22
sept	8.38	7.17	0.04	0.06	0.1
oct	9.89	5.58	0.01	0.19	0.2
nov	2.95	1.61	0	0.02	0.02
dec	3.46	0.38	0.28	0.18	0.46
jan	2.41	0.19	0.42	0.12	0.54
feb	4.71	0.44	1.56	0.09	1.65
mar	9.29	0.3	1.34	1.77	3.12
YEAR	74.9	36.03	12.39	3.32	15.72

	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
apr	1.002	0.0069	10.2425	10.5825	0	0
may	2.3567	0.1147	25.3389	25.8749	0	0
jun	0.9504	0.0387	6.6521	6.9546	0	0
jul	0.2017	0.0002	2.8636	2.9233	0	0
aug	0.5895	0.0012	0.5346	0.6776	0	0
sept	1.6135	0.0075	0.1136	0.349	0	0
oct	1.9217	0.0837	0.1508	0.588	0	0
nov	0.3703	0.0019	0.0055	0.1186	0	0
dec	0.0914	0.119	0.9594	1.3581	0	0
jan	0	0.0492	1.2562	1.5701	0	0
feb	0.3808	0.034	6.4494	6.6398	0	0
mar	0.8668	3.3706	11.0711	18.1701	0	0
YEAR	10.3448	3.8276	65.6379	75.8064	0	0

SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	3.01	2.5994	2.4245	5.1348	0	0
corn	1991	3.01	3.1138	3.4259	8.0136	0	0
farmstead	106	1.65	0.0956	0.0244	0.0319	0	0
pasture	140	0.54	1.6097	0.0218	0.1886	0	0
grassland	87	0.54	0.2635	0.0117	0.0287	0	0
grazed timl	13	0.87	0.8127	0.0032	0.0111	0	0
timber	239	0.24	0.3869	0.0003	0.0688	0	0
hay field	63	0.54	1.9234	0.0092	0.0988	0	0
industrial	52	9.59	0	0	0.5909	0	0
residential	20	1.65	0	0	0.0552	0	0
road	61	47.09	0	0	1.8673	0	0
water	40	0	0	0	0	0	0
Groundwater				59.7169	59.7169	0	0
Point Source				0	0	0	0
TOTAL	4221			65.6379	75.8064	0	0

Table C-3 (cont.)

New Project

	YEAR	4			
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)
apr	3.95	0.95	2.8	0.01	2.81
may	9.02	2.02	1.9	0.26	2.15
jun	15.36	3.3	4.08	2.66	6.73
jul	13.99	6.44	3.63	1.97	5.6
aug	10.79	8.67	1	0.07	1.08
sept	3	8.2	0.5	0.01	0.52
oct	8.44	5.52	0.12	0.08	0.2
nov	6.65	2.77	0.54	0.86	1.4
dec	1.17	1.12	0.24	0.01	0.25
jan	1.28	0.09	0.05	0.05	0.11
feb	3.38	0.35	0.06	0.17	0.22
mar	3.73	0.43	1.31	0.34	1.65
YEAR	80.76	39.85	16.23	6.48	22.72

	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
apr	0.2272	0	14.2589	14.3171	0	0
may	2.0446	0.0102	8.9616	9.2589	0	0
jun	3.1709	0.8271	36.9781	38.9971	0	0
jul	5.3541	2.4347	30.2136	35.3569	0	0
aug	1.6833	0.0061	3.4116	3.6852	0	0
sept	0.242	0.0007	1.3819	1.4388	0	0
oct	1.5139	0.017	0.3418	0.59	0	0
nov	0.9172	1.9439	3.3714	7.5039	0	0
dec	0.0019	0.0004	0.664	0.7111	0	0
jan	0	0.0152	0.1792	0.3695	0	0
feb	0.0782	0.0897	0.3133	0.6835	0	0
mar	0.0333	0.3036	5.8897	6.6789	0	0
YEAR	15.2667	5.6487	105.9651	119.5909	0	0

SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	6.48	3.8362	6.4802	10.48	0	0
corn	1991	6.48	4.5953	9.1569	15.9273	0	0
farmstead	106	4.41	0.141	0.0808	0.0918	0	0
pasture	140	2.04	2.3755	0.101	0.3471	0	0
grassland	87	2.04	0.3889	0.0544	0.0794	0	0
grazed timl	13	2.92	1.1993	0.0133	0.0249	0	0
timber	239	1.08	0.571	0.0018	0.1028	0	0
hay field	63	2.04	2.8385	0.0424	0.1747	0	0
industrial	52	14.55	0	0	0.5756	0	0
residential	20	4.41	0	0	0.1024	0	0
road	61	51.74	0	0	1.6505	0	0
water	40	0	0	0	0	0	0
Groundwater				90.0343	90.0343	0	0
Point Source				0	0	0	0
TOTAL	4221			105.9651	119.5909	0	0

Table C-3 (cont.)

New Project							
	YEAR	5					
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)		
apr	15.64	0.95	3.42	0.95	4.37		
may	12.65	1.7	4.33	0.97	5.3		
jun	14.97	3.57	4.53	0.77	5.3		
jul	6.34	7.07	2.36	0.03	2.39		
aug	6.97	7.82	0.8	0.07	0.86		
sept	7.42	6.42	0.2	0.06	0.26		
oct	0.89	5.07	0.05	0	0.05		
nov	3.26	3.29	0.01	0.03	0.04		
dec	1.61	0.89	0	0.07	0.08		
jan	1.09	0.29	0	0	0		
feb	3.13	0.36	0	0.23	0.23		
mar	1.95	0.73	0	0.01	0.01		
YEAR	75.92	38.16	15.69	3.2	18.89		
	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)	
apr	3.3102	0.3828	23.1201	24.3449	0	0	
may	1.7915	0.7154	31.2569	33.0498	0	0	
jun	4.2932	1.8255	31.8559	35.889	0	0	
jul	0.8224	0.0122	11.1856	11.3656	0	0	
aug	1.8119	0.116	2.464	2.8843	0	0	
sept	1.713	0.1351	0.5452	1.0256	0	0	
oct	0.0413	0.0001	0.1252	0.1292	0	0	
nov	0.8083	0.0687	0.0266	0.2711	0	0	
dec	0.0012	0.3029	0.0708	0.8037	0	0	
jan	0.0005	0.0002	0.0013	0.009	0	0	
feb	0.0794	1.8603	0.226	4.2073	0	0	
mar	0.174	0.0741	0.0001	0.1837	0	0	
YEAR	14.847	5.4934	100.8777	114.1631	0	0	
SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	2.83	3.7307	2.7865	6.6764	0	0
corn	1991	2.83	4.469	3.9375	10.5218	0	0
farmstead	106	1.47	0.1371	0.0261	0.0369	0	0
pasture	140	0.32	2.3102	0.0152	0.2546	0	0
grassland	87	0.32	0.3782	0.0082	0.0325	0	0
grazed timl	13	0.69	1.1663	0.0031	0.0143	0	0
timber	239	0.05	0.5553	0.0001	0.0983	0	0
hay field	63	0.32	2.7605	0.0064	0.1351	0	0
industrial	52	10.31	0	0	0.6214	0	0
residential	20	1.47	0	0	0.0631	0	0
road	61	49.94	0	0	1.6141	0	0
water	40	0	0	0	0	0	0
Groundwater				94.0946	94.0946	0	0
Point Source				0	0	0	0
TOTAL	4221			100.8777	114.1631	0	0

Table C-3 (cont.)

New Project

	YEAR	6					
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)		
apr	6.19	0.96	0.68	0.04	0.72		
may	4.61	1.89	1.07	0.03	1.1		
jun	14.71	3.37	2.54	1.58	4.12		
jul	11.71	6.08	3.59	0.14	3.73		
aug	3.01	8.72	1.21	0.02	1.23		
sept	4.47	5.3	0.26	0.04	0.29		
oct	3.36	5.7	0.06	0.01	0.07		
nov	5.5	1.13	0.01	0.06	0.07		
dec	5.63	0.05	0	0.01	0.02		
jan	4.84	0.12	0	0.16	0.16		
feb	6.1	0	0	0	0		
mar	3.68	0.21	1.69	3.02	4.71		
YEAR	73.81	33.55	11.12	5.1	16.22		
	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)	
apr	0.8091	0.0002	1.9509	2.131	0	0	
may	0.7717	0.0003	3.6628	3.7908	0	0	
jun	4.0979	0.8372	18.9586	21.03	0	0	
jul	2.4493	0.0177	20.6676	20.9352	0	0	
aug	0.4162	0.0009	4.3621	4.4377	0	0	
sept	0.8799	0.0033	0.7082	0.8445	0	0	
oct	0.2384	0.0001	0.1627	0.2258	0	0	
nov	1.0145	0.0077	0.0492	0.228	0	0	
dec	0	0.001	0.0111	0.0928	0	0	
jan	0	0.0275	0.1299	0.4082	0	0	
feb	0	0	0.0004	0.0004	0	0	
mar	0.0128	3.0594	18.6371	25.2076	0	0	
YEAR	10.6898	3.9552	69.3005	79.3321	0	0	
SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	4.95	2.6861	4.8864	7.6871	0	0
corn	1991	4.95	3.2177	6.9047	11.6454	0	0
farmstead	106	3.35	0.0987	0.0598	0.0675	0	0
pasture	140	1.59	1.6633	0.0754	0.2477	0	0
grassland	87	1.59	0.2723	0.0406	0.0581	0	0
grazed timl	13	2.25	0.8398	0.0099	0.018	0	0
timber	239	0.84	0.3998	0.0014	0.0721	0	0
hay field	63	1.59	1.9875	0.0317	0.1243	0	0
industrial	52	12.43	0	0	0.5256	0	0
residential	20	3.35	0	0	0.078	0	0
road	61	47.91	0	0	1.5176	0	0
water	40	0	0	0	0	0	0
Groundwater				57.2906	57.2906	0	0
Point Source				0	0	0	0
TOTAL	4221			69.3005	79.3321	0	0

Table C-3 (cont.)

New Project

	YEAR	7					
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)		
apr	7.82	1.1	3.79	0.78	4.57		
may	15.56	1.75	3.72	0.58	4.3		
jun	7.58	3.42	3.81	0.32	4.13		
jul	3.68	6.7	1.2	0.01	1.21		
aug	4.35	8.68	0.26	0.02	0.28		
sept	14.83	6.34	0.06	2.35	2.41		
oct	4.89	4.94	0.01	0.03	0.04		
nov	1.9	3.63	0	0.01	0.01		
dec	1.09	1.19	0	0	0		
jan	0.82	0.44	0	0	0		
feb	2.44	0.31	0	0.11	0.11		
mar	3.33	0.36	0.16	0.06	0.22		
YEAR	68.29	38.85	13.01	4.26	17.27		
	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)	
apr	1.7778	0.0569	25.6013	25.9023	0	0	
may	2.8301	0.0749	23.7551	24.3537	0	0	
jun	0.9394	0.0461	23.391	23.6857	0	0	
jul	0.2996	0.0001	4.3003	4.3721	0	0	
aug	0.4804	0.0004	0.7121	0.8302	0	0	
sept	6.1084	4.3903	4.9522	14.0218	0	0	
oct	0.7082	0.0137	0.0348	0.2083	0	0	
nov	0.1531	0.0015	0.0074	0.0567	0	0	
dec	0.0444	0.0001	0.0017	0.0105	0	0	
jan	0.0005	0	0.0004	0.0047	0	0	
feb	0.1682	0.3069	0.1001	0.8741	0	0	
mar	0.1788	0.174	0.4842	0.9769	0	0	
YEAR	13.6888	5.0649	83.3406	95.297	0	0	
SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	4.18	3.4397	3.528	7.1144	0	0
corn	1991	4.18	4.1204	4.9852	11.0559	0	0
farmstead	106	2.68	0.1264	0.04	0.0499	0	0
pasture	140	1.07	2.13	0.0406	0.2613	0	0
grassland	87	1.07	0.3487	0.0219	0.0443	0	0
grazed timl	13	1.65	1.0754	0.0059	0.0162	0	0
timber	239	0.51	0.512	0.0006	0.0912	0	0
hay field	63	1.07	2.5451	0.0171	0.1357	0	0
industrial	52	10.37	0	0	0.4247	0	0
residential	20	2.68	0	0	0.0661	0	0
road	61	39.9	0	0	1.3359	0	0
water	40	0	0	0	0	0	0
Groundwater				74.7013	74.7013	0	0
Point Source				0	0	0	0
TOTAL	4221			83.3406	95.297	0	0

Table C-3 (cont.)

New Project

	YEAR	8			
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)
apr	8.8	0.91	1.35	0.15	1.5
may	14.09	1.56	3.71	1.75	5.47
jun	3.86	3.93	2.74	0.09	2.83
jul	6.56	6.92	0.8	0.04	0.84
aug	8.72	8.03	0.17	0.07	0.25
sept	4.4	7.59	0.04	0.04	0.08
oct	11.32	4.43	0.35	0.37	0.72
nov	0.33	1.52	0.12	0	0.12
dec	0.46	0.86	0.03	0	0.03
jan	1.07	0.13	0.01	0	0.01
feb	3.86	0.11	0.25	0.66	0.91
mar	2.02	0.5	0.88	0.05	0.93
YEAR	65.49	36.5	10.44	3.23	13.67

	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
apr	1.2198	0.0037	5.4186	5.7097	0	0
may	3.3176	1.2901	29.7724	32.7606	0	0
jun	0.6197	0.015	14.0705	14.2281	0	0
jul	1.0384	0.0048	2.434	2.6039	0	0
aug	2.0104	0.0215	0.4723	0.7362	0	0
sept	1.2144	0.0185	0.1001	0.2652	0	0
oct	3.5119	0.9797	1.3568	3.5669	0	0
nov	0	0.0003	0.3248	0.3616	0	0
dec	0.0277	0	0.076	0.0816	0	0
jan	0.0005	0	0.0164	0.0164	0	0
feb	0	2.4236	1.6349	6.771	0	0
mar	0.0936	0.0727	2.8429	3.1045	0	0
YEAR	13.054	4.83	58.5197	70.2056	0	0

SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	2.97	3.2802	2.5712	5.9913	0	0
corn	1991	2.97	3.9293	3.6333	9.4224	0	0
farmstead	106	1.84	0.1206	0.03	0.0395	0	0
pasture	140	0.8	2.0312	0.0368	0.2472	0	0
grassland	87	0.8	0.3325	0.0198	0.0412	0	0
grazed timl	13	1.14	1.0255	0.0048	0.0147	0	0
timber	239	0.43	0.4882	0.0007	0.087	0	0
hay field	63	0.8	2.4271	0.0155	0.1286	0	0
industrial	52	9	0	0	0.5283	0	0
residential	20	1.84	0	0	0.0557	0	0
road	61	40.95	0	0	1.4418	0	0
water	40	0	0	0	0	0	0
Groundwater				52.2077	52.2077	0	0
Point Source				0	0	0	0
TOTAL	4221			58.5197	70.2056	0	0

Table C-3 (cont.)

New Project

	YEAR	9			
	Precip (cm)	ET (cm)	Groundwater (cm)	Runoff (cm)	Stream (cm)
apr	11.08	0.97	1.62	0.59	2.21
may	12.07	1.58	4.57	2.53	7.1
jun	11.29	3.27	2.88	0.77	3.65
jul	5.62	6.24	1.63	0.02	1.66
aug	3.13	9.15	0.41	0.02	0.42
sept	8.66	6.4	0.09	0.08	0.16
oct	3.24	5.61	0.02	0.02	0.04
nov	14.02	1.8	0.25	3.05	3.3
dec	2.43	0.74	0.68	0.02	0.7
jan	4.36	0.18	0.57	0.1	0.66
feb	3.69	0.17	0.99	1.06	2.06
mar	11.32	0.61	2.9	0.78	3.68
YEAR	90.91	36.7	16.61	9.04	25.65

	Erosion (kt)	Sediment (	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
apr	1.6769	0.0095	8.439	8.8797	0	0
may	2.6614	0.4642	40.1447	41.3172	0	0
jun	2.6497	0.1157	17.9772	18.5831	0	0
jul	0.5725	0.0002	6.6402	6.776	0	0
aug	0.3786	0.0002	1.1114	1.1972	0	0
sept	2.0727	0.0029	0.2362	0.4744	0	0
oct	0.4209	0.0003	0.0542	0.1467	0	0
nov	5.8628	4.3939	8.3577	17.4264	0	0
dec	0.167	0.0005	1.9343	2.0718	0	0
jan	0	0.0099	1.6601	1.873	0	0
feb	0	0.6965	6.3958	8.0339	0	0
mar	1.6643	1.0131	18.1686	20.549	0	0
YEAR	18.1267	6.7069	111.1195	127.3284	0	0

SOURCE	Area (ha)	Runoff (cm	Erosion (t/h)	Dis. N (t)	Tot. N (t)	Dis. P (t)	Tot. P (t)
soy beans	1409	9.06	4.5548	8.47	13.2191	0	0
corn	1991	9.06	5.4562	11.9686	20.0074	0	0
farmstead	106	6.59	0.1674	0.1116	0.1247	0	0
pasture	140	3.57	2.8205	0.1613	0.4535	0	0
grassland	87	3.57	0.4617	0.0868	0.1166	0	0
grazed timl	13	4.74	1.424	0.0198	0.0335	0	0
timber	239	2.18	0.678	0.0034	0.1233	0	0
hay field	63	3.57	3.3703	0.0677	0.2249	0	0
industrial	52	19.56	0	0	0.7473	0	0
residential	20	6.59	0	0	0.1368	0	0
road	61	63.92	0	0	1.9111	0	0
water	40	0	0	0	0	0	0
Groundwater				90.2303	90.2303	0	0
Point Source				0	0	0	0
TOTAL	4221			111.1195	127.3284	0	0