Total Maximum Daily Load
For Siltation
Lake Icaria
Adams County, Iowa

December 2002

Iowa Department of Natural Resources
TMDL & Water Quality Assessment Section

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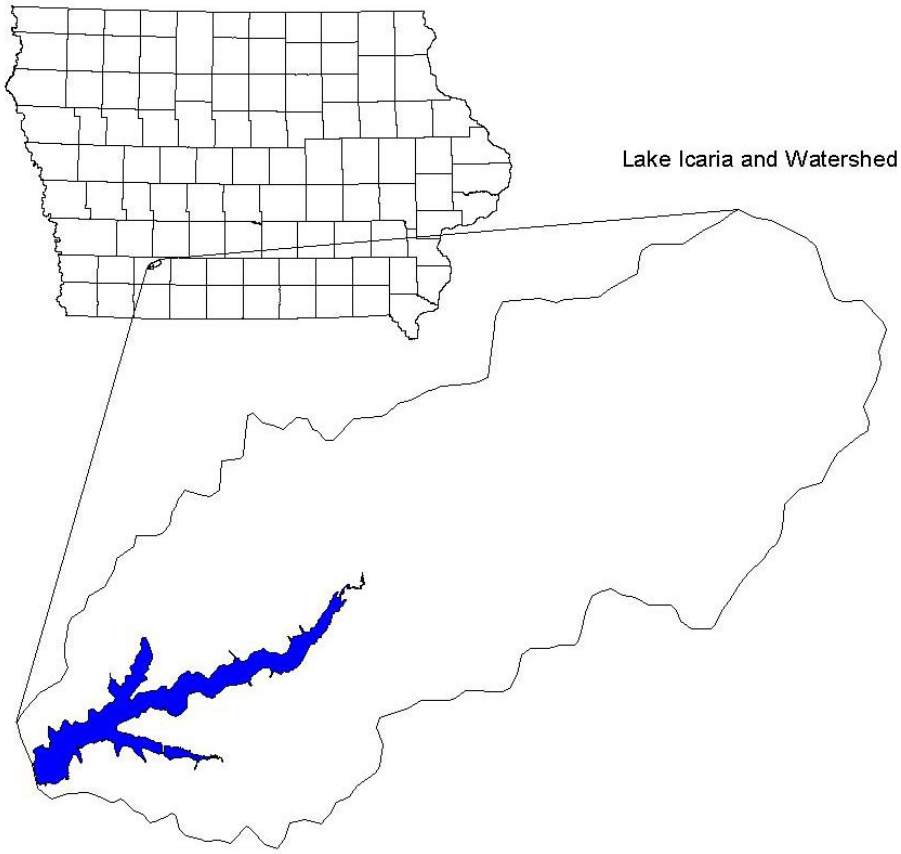
TMDL for Siltation
Lake Icaria
Adams County, Iowa

Waterbody Name:	Lake Icaria
IDNR Waterbody ID:	IA 05-NOD-00550-L
Hydrologic Unit Code:	102400100107
Location:	Section 2 T72N R34W
Latitude:	41 Deg. 3 Min N
Longitude:	94 Deg. 45 Min W
Use Designation Class:	A (primary contact recreation) B(LW) (aquatic life) C (potable water source)
Watershed:	16,649 acres
Lake Area:	669 acres
Major River Basin:	Southern Iowa River River Basin
Tributaries	Kemp (Walter's) Creek, unnamed tribs.
Receiving Water Body:	Kemp Creek
Pollutant:	Siltation
Pollutant Sources:	Agricultural NPS
Impaired Use	Aquatic Life
1998 303d Priority:	High



1. Introduction

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. Lake Icaria has been identified as impaired by siltation. The purpose of this TMDL for Lake Icaria is to calculate the maximum amount of siltation that the lake can receive and still meet water quality standards, and then develop an allocation of that amount of siltation to the sources in the watershed.

Specifically this TMDL for Lake Icaria will:

- Identify the adverse impact that siltation is having on the designated uses of the lake and how the excess sediment load is impairing the water quality standards,
- Identify a target by which the waterbody can be assured to maintain its designated uses,
- Calculate an acceptable sediment load, including a margin of safety, and allocate to the sources, and
- Present a brief implementation plan to offer guidance to Department staff, IDNR partners, and watershed stakeholders in an effort to achieve the goals of the TMDL and maintain the lake's intended uses.

The IDNR believes that sufficient evidence and information is available to protect Lake Icaria from further degradation by siltation. The Department acknowledges, however, that additional information will likely be necessary. Therefore, in order to accomplish the goals of this TMDL, a phased approach will be used. This will allow feedback from future assessments to be incorporated into the plan.

Phase I of this TMDL for Lake Icaria will be to reduce the sediment load that is impairing the aquatic life uses. Phase II will evaluate the effect that the sediment load target has on the intended results. Phase II will include monitoring to evaluate the target sediment load, reevaluating the extent of the sediment impairments, and evaluating if the specific aquatic life impairments originally identified in the TMDL have been remedied.

2. Description of Waterbody and Watershed

2.1 General Information

Lake Icaria was built in 1975 about 4 miles north of Corning, Iowa to provide water to the city of Corning. When constructed, the lake had a surface area of 700 acres, a mean depth of 13.3 feet, a maximum depth of 44 feet, and a storage volume of 9,330 acre-feet.

Lake Icaria is part of the 1,890 acre Lake Icaria Recreation Area, a county park that provides facilities for boating, swimming, fishing, picnicking, hiking, and hunting. Lake Icaria has designated uses of Class A (primary contact recreation), Class B(LW) (aquatic life), and Class C (potable water source).

The Lake Icaria watershed has an area of approximately 16,649 acres and has a watershed-to-lake ratio of 26:1. The landuses and associated areas for the watershed are shown in the table below.

Table 1. Landuse in the Lake Icaria watershed (2001)

Landuse	Area in Acres	Percent of Total Area
Cropland	7,959	48
Pasture & Hayland	5,153	31
CRP	2,073	12
Timber	943	6
Other (roads, etc)	521	3
Total	16,649	100

2.2 Current Conditions

In the fall of 1987 Lake Icaria was drawn down 12'-14' for water quality and fish habitat work. Approximately $454,000 was spent to construct three sediment-nutrient dikes, 5 fishing jetties, 1 handicapped accessible pier, and apply approximately 10,500' of shoreline stabilization (rip-rap). Additionally, numerous cedar trees and stake beds were added to the lake bottom for fish habitat.

The Three Lakes Water Quality Project has been implementing upland conservation measures in the Lake Icaria watershed since 1996. Best management practices installed in the watershed include terraces, grade stabilization structures, and planned grazing systems. Numerous sediment retention structures have been built. In addition to continued work on private lands, areas on public lands have been identified that would benefit from the construction of grade stabilization structures or wetlands. Most recently, the Adams County Soil and Water Conservation District has applied for a grant from Clean Water Act Section 319 to implement a second phase of the Three Lakes Project.

3. Applicable Water Quality Standards

The *Iowa Water Quality Standards* (Iowa, 2000) list the designated uses for Lake Icaria as Primary Contact Recreation (Class A), Aquatic Life (Class B(LW)), and Potable Water Source (Class C). Lake Icaria also has general uses of secondary contact recreation, domestic uses, and wildlife watering.

The State of Iowa does not have numeric water quality criteria for siltation that apply to Lake Icaria. Lake Icaria was included on the list of Iowa impaired waters based on the best professional judgment of IDNR field staff regarding the water quality. Lake Icaria has been assessed as “partially supported” since 1992. The IDNR Fisheries Bureau indicated that siltation is impairing the Class B(LW) designated use. This assessment was based on information collected during the 1990-1991 period. The assessment of partially supporting of Class B (LW) has continued to be used in subsequent biennial reports. In 1996, the "Adams County Three Lakes Water Quality Project" application for Section 319 grant funds also stated that Lake Icaria was being impacted by excess sediment from agricultural lands. The Class B(LW) designated use states that the physical and chemical characteristics are suitable to maintain a balanced community normally associated with lake-like conditions (IAC 567-61.3(1)b(7)). Excess siltation is altering the physical and chemical characteristics of the lake so that a balanced community normally associated with lake-like conditions is not maintained. Excess siltation is impairing the beneficial uses of aquatic habitat, spawning and reproduction, and sport fishing.

The primary impact of sediment at Lake Icaria is identified as interference with reproduction and growth of fish and other aquatic life. IDNR Fisheries biologists cited that siltation impacts aquatic life primarily in the upper portions of the lake. Although the entire lake was listed, it is the excessive sediment deposition in the upper arms of the lake that has lead to the lake being

assessed as not meeting water quality standards. The upper arms of the lake are shallow and were ideal as an aquatic habitat. Those areas are now covered with fine silt that make successful spawning almost impossible. Although this is less than a quarter of the lake area, it is critical habitat for spawning (70%-90% of available habitat), and therefore has a proportionally greater impact. The deposition of sediment in these arms has severely limited the fishery in the entire lake.

Secondarily, the colloidal nature of the sediment delivered to Lake Icaria creates a less than ideal feeding area for sight feeders. Bass and Bluegill primarily feed along the shoreline, and the fry use the vegetative cover along the shoreline for protection from predators. The water clarity inhibits aquatic vegetation from growing, leaving the smaller fish exposed and unable to feed successfully.

4. Water Quality Conditions

4.1 Water Quality Studies

Water quality surveys have been conducted on Lake Icaria in 1979, 1986, 1990, and 2000-01 (Bachmann et al.,1980, Kennedy and Miller, 1987, Bachmann et al., 1994; Downing and Ramstack, 2002). A watershed assessment was completed in 1991 on the Lake Icaria watershed, and evaluated sediment and nutrient delivery under the 1990 conditions as well as under "T" conditions.

Samples were collected three times each summer for the lake studies conducted in 1979 and 1990 (Bachmann et al., 1980, Bachmann et al., 1994). This data is shown in Tables 4 and 6 in the Appendix.

In 1986, the University Hygienic Laboratory sampled Lake Icaria three times near the deepest part of the lake. On each sampling date, samples were collected from the surface and near the bottom. These results are shown in Table 5 (Appendix).

Lake Icaria was sampled again in 2000-01 as part of the Iowa Lakes Survey (Downing and Ramstack, 2002). This survey will sample the lake three times each summer for five years. The data collected in 2000-01 is shown in Tables 7 and 8 (Appendix).

4.2 Angling (Mike McGhee, Fisheries Biologist)

Lake Icaria is generally shallow and while siltation has reduced this depth, the limit to spawning areas has been due to siltation, shoreline erosion and resuspension of silt due to wind and wave action. The resuspension reduces spawning success of nest building species such as bluegill, largemouth bass and crappie. Rooted aquatic vegetation is also severely limited because of the high density of common carp that thrive in the shallow, silt laden areas of the lake. Improvements in water quality at Lake Icaria would benefit from - reducing the silt load entering the lake, deepening shallow shoreline areas, stabilizing lake and stream shoreline banks and restructuring the fish population (permanent carp removal).

5. Desired Target

The listing of Lake Icaria is based on narrative criteria. Lake Icaria was included on the list of Iowa impaired waters based on the best professional judgment of IDNR field staff regarding the water quality. Lake Icaria has been assessed as "partially supported" since 1992. The IDNR Fisheries Bureau indicates that siltation is impairing the Class B(LW) designated use. There are no numeric criteria for siltation applicable to Lake Icaria or its sources in Chapter 61 of the Iowa Water Quality Standards (Iowa, 2000). The targets for Lake Icaria need to include siltation target load as well as a measurement of the aquatic life. This is a phased TMDL and each

phase will incorporate a separate target. Phase I will include a target for sediment delivery to the lake. Monitoring the water quality and the fishery of the lake will be included in both Phase I and Phase II.

5.1 Siltation

The sediment target will deal with direct deposition of eroded sediment delivered to the lake. A direct measure of the sediment load is difficult, given seasonal variability and actual measurement tools. Acceptable estimates using established soil loss equations can be made to predict the erosion rates in the watershed, and subsequent delivery to the lake.

The sources of sediment to be reduced are the contribution from sheet and rill, and that portion from streambank/streambed erosion, primarily in Kemp Creek. Since the primary issue in this watershed is sediment delivered to the three arms of the lake, the watershed was broken down into four subwatersheds (Figure 1, Appendix). Three of the subwatersheds drain directly to the tributaries which become the upper arms of the lake. The fourth subwatershed, (D), includes the land immediately surrounding the lake, and does not provide significant channelized flow.

As stated in Section 3, the primary aquatic life impact is due to excessive sediment deposition to the upper arms of the lake. To be protective of that habitat, this TMDL recognizes that no more than 12" of sediment can be deposited over 75% of each area over a twenty-year period (Figure 1, Appendix). For the purpose of this TMDL, the target addresses sediment delivery only from those Subwatersheds. Table 2 shows the target calculation and the sediment delivery target to each arm of the lake from the corresponding subwatershed.

Table 2. Sediment Delivery Target to the upper arms of Lake Icaria, by subwatershed.

Sub	Calculation	Target Load
A	(79ac) (43,560 $ft^{2/acre}$)(1.0 ft) (0.75) (60 lbs/ft^3)/ (2000lbs/t)(20 yrs)	3,871 t/yr
B	(46.5ac) (43,560 $ft^{2/acre}$)(1.0 ft) (0.75) (60 lbs/ft^3)/ (2000lbs/t)(20 yrs)	2,278 t/yr
C	(29.5ac) (43,560 $ft^{2/acre}$)(1.0 ft) (0.75) (60 lbs/ft^3)/ (2000lbs/t)(20 yrs)	1,446 t/yr

This reduces the need to dredge to no more than 20 years. This is an initial first estimate and may be revised with new information and better technology.

A watershed assessment completed in 1991 by the Division of Soil Conservation indicated that the current sediment delivery in 1991 was 26,399 tons, year (IDALS-DSC, 1991). The assessment also calculated sediment delivery under “T” conditions, and determined that the sediment delivery rate to Lake Icaria under “T” conditions would be 7,502 tons/yr. This corresponds closely with the calculated target load, which is based on the amount of sediment that can be delivered to the arms of the lake each year (7,595 tons/year). Subwatersheds A and C are currently meeting the sediment delivery target. Therefore, the desired target for these subwatersheds is to maintain or continue to reduce the current sediment delivery load to the lake. Subwatershed B is currently exceeding the desired sediment delivery target. A reduction of 87% is needed in subwatershed B from current sediment delivery rates to meet the desired target. The 1991 watershed assessment correlates well with the proposed sediment delivery target, and reaffirms that the target is achievable.

5.2 Aquatic Life

The aquatic life target for this TMDL will be achieved when the fishery of Lake Icaria is determined to be fully supporting the Class B aquatic life uses. This determination will be accomplished through an assessment conducted by the IDNR Fisheries Bureau. The IDNR Fisheries Bureau will conduct an assessment of Lake Icaria in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001). The IDNR Fisheries Bureau is using this

protocol to help develop benchmarks for fishery integrity in Iowa lakes. This assessment will include growth, size structure, body condition, relative abundance, and species composition.

Lake Icaria will not be considered restored until the aquatic life target is achieved. If the aquatic life target is achieved prior to the sediment delivery target, then the level of conservation practices implemented at the time of the assessment may become the baseline for the watershed. If however, after a reasonable time following the completion of the sediment delivery practices the aquatic life use has not been restored, then further study and practices may be necessary.

6. Loading Capacity

The State of Iowa does not have numeric water quality criteria for siltation that apply to Lake Icaria. Lake Icaria was included on the list of Iowa impaired waters based on the best professional judgment of IDNR field staff regarding the water quality. Excess siltation is causing impairment of the Class B(LW) designated use.

As discussed in Section 3, the specific aquatic life impairment caused by excess sediment is loss of spawning areas and the decline to the aquatic life as a result. The sediment target identified limits on the amount of sediment delivered to each arm of the lake, so that reproduction of the aquatic life is not impaired. A sediment target for each arm of the lake has been established, which will allow for at least 20 years between necessary dredging in the spawning areas. Therefore, the annual loading capacity for each arm is identified in the following table.

Subwatershed	Loading Capacity
A	2,827 t/y
B	2,278 t/y
C	503 t/y

As mentioned in section 5.1, subwatersheds A and C are currently meeting the desired sediment delivery target. Therefore, the loading capacity for subwatersheds A and C is to maintain or reduce the current sediment delivery rate. The loading capacity for subwatershed B is the same as the desired target.

7. Pollutant Sources

The primary sources of sediment in this watershed include sediment from sheet and rill, gully, shoreline, and streambank/streambed erosion delivered to the lake. Much of the sheet and rill erosion and gully erosion in this watershed has been addressed either by in-field practices, or by sediment retention structures. Some shoreline stabilization has been done, but more is needed to protect the shoreline from wind and wave action. Unrestricted livestock access to the stream corridors can lead to increased rates of streambank and/or streambed erosion, all with essentially 100% delivery to the lake.

Concerns over additional pollutant sources were raised during the public comment period for the draft TMDL. Commentors are concerned about the current separation distances of rowcrop farming on DNR property next to Lake Icaria. The DNR currently rents land near the lake to producers for row crop agriculture, and commentors feel that conservation plans on this land should take into account the close proximity to the lake, and the potential for nutrient and sediment delivery to Lake Icaria. In addition, manure applications on this land should be carefully examined. This potential source will be examined in greater detail during the implementation phase of this TMDL.

8. Pollutant Allocation

8.1 Point Sources Wasteload Allocation:

There are no point source discharges for sediment within the Lake Icaria watershed, therefore the Wasteload Allocation established under this TMDL is zero.

8.2 Non-Point Source Load Allocation:

All sediment in Lake Icaria comes from non-point source discharges. Cropland accounts for 48% of the land use for the Lake Icaria watershed. Sediment delivery estimates were determined by using the Erosion and Sediment Delivery Procedure, Section I, Erosion Protection (USDA/NRCS, 1998).

Sediment delivery rates were calculated for each subwatershed. A trap efficiency of 90% was calculated for the portions of the watershed protected by sediment retention structures and the silt dam on the southeast arm of the lake. The sediment deliveries from sheet and rill and from streambank/streambed for each subwatershed were added together to obtain the total delivery to Lake Icaria. The target load to support the endpoint of this TMDL is different for each of the subwatersheds. Calculations used to determine sediment delivery loads from streambank and streambed erosion for each stream are in Table 9 in the Appendix.

Table 3. Sediment delivery to Lake Icaria (T/Y).

Subwatershed	Acres	Sheet & Rill	Streambank / Streambed	Current Delivery	Target Sediment Load	Load Allocation
A	1,474	2,339	488	2,827	3,871	2,827
B	10,338	15,591	1,993	17,584	2,278	2,278
C	1,263	82	421	503	1,446	503
D	3,574	1,313	0	1,313	1,313	1,313
Total (Acres)	16,649	19,325	2,902	22,227	8,908	6,921

For the purposes of this TMDL, the Lake Icaria watershed was divided into four subwatersheds (Figure 1, Appendix). Over half of Subwatershed A is protected with structures, reducing that load from sheet and rill erosion to 2,339 tons/yr. Essentially all of Subwatersheds C and D are protected by structures. Subwatershed B is the largest subwatershed, and approximately 15% of the area is protected by sediment retention structures. The Load Allocation is established by watershed. The current sediment delivery rates for subwatershed A and C are less than the calculated targets, therefore the Load Allocation for subwatersheds A and C will be to maintain or reduce the current sediment delivery rates of 2,827 tons/yr for subwatershed A, and 503 tons/yr for subwatershed C. The Load Allocation for subwatershed B is 2,278 tons/yr, an 87% reduction of current rates. Subwatershed D does not contain any channelized flow and does not contribute specifically to the arms of the lake. The Load Allocation for subwatershed D is also to reduce or maintain the current sediment delivery rate of 1,313 tons/yr.

8.3 Margin of Safety

The margin of safety for this TMDL is implicit. The dual targets for this TMDL assures that the aquatic life uses will be restored regardless of the accuracy of the sediment delivery target. Failure to achieve water quality standards will result in review of the TMDL, allocations, and/or sediment management approaches and probable revision. In addition, calculations were made using conservative estimates.

9. Seasonal Variation

This TMDL accounts for seasonal variation by recognizing that (1) loading varies substantially by season and between years, and (2) impacts are felt over multi-year timeframes. Sediment

and nutrient loading and transport are predictable only over long timeframes. Moreover, in contrast to pollutants that cause short-term beneficial use impacts and are thus sensitive to seasonal variation and critical conditions, the sediment and nutrient impacts in this watershed occur over much longer time scales. For these reasons, the longer timeframe (tons per year) used in this TMDL is appropriate.

10. Monitoring

Monitoring will be completed at Lake Icaria as part of the Iowa Lakes Survey. In-lake water monitoring will be completed three times per year for each of the field seasons 2000 – 2004. In addition, the IDNR Fisheries Bureau will conduct an assessment of the fishery of Lake Icaria in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001). At the completion of this assessment, the data will be evaluated to determine the listing status of Lake Icaria.

A lake mapping and sediment core study was undertaken by the IDNR and USGS in the fall of 2002. This data will provide a bathymetric map of Lake Icaria, estimates of sediment volume and location, and sediment core samples from the lake basin. This information will be used to determine more precisely the current amount and location of sediment in the lake, and also serve as a baseline for measuring TMDL implementation success. While this information is not available for the development of the TMDL, it will be very useful in Phase II of the TMDL.

11. Implementation

The Adams County Three Lakes Water Quality Project has been implementing upland conservation measures in the Lake Icaria, Binder Lake, and West Lake - Corning watersheds since 1996. Best management practices installed in the watersheds include terraces, grade stabilization structures, and planned grazing systems. In addition to continued work on private lands, areas on public lands have been identified that would benefit from the construction of grade stabilization structures or wetlands. Most recently, the Adams County Soil and Water Conservation District has applied for a grant from Clean Water Act Section 319 to implement a second phase of the Three Lakes Project.

Although much work has been done in the Lake Icaria watershed, subwatershed B still exceeds the desired sediment delivery target. Current sediment delivery rates need to be reduced by 87% to achieve the desired sediment delivery target. Streambank and streambed erosion can be reduced by excluding livestock from streams and the installation of buffers. Sheet and rill erosion can be addressed through further upland conservation measures, such as terraces or conversion of land to permanent vegetation, but may be best addressed through the installation of large sediment retention structures strategically placed throughout the subwatershed.

12. Public Participation

Public meetings regarding the procedure and timetable for developing the Lake Icaria TMDL were held on January 14, 2002, in Des Moines, Iowa; and on January 29, 2002 at the Community Center in Corning, Iowa. A draft version of the TMDL was available for public notice from November 14 through December 6, 2002. Appropriate comments will be incorporated into the Lake Icaria Sediment TMDL prior to submittal to EPA for final approval.

13. References

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14. Appendix I

Table 4. Data collected in 1979 by Iowa State University (Bachmann, et al, 1980).

Date Collected	7/16/1979	8/7/1979	9/4/1979
Secchi (meters)	0.5	1.3	0.6
Suspended Solids (mg/L)	13.6	7.1	12.4
Dissolved Oxygen (mg/L)	8.3	6.9	10.5
Ammonia Nitrogen (mg/L)	--	--	0.1
Total Phosphorus (mg/L) po4	0.18	0.13	0.17
Chlorophyll a (ug/L) Corrected	34.8	26.9	--

Samples collected near the surface

Table 5. Data collected in 1986 by the University of Iowa Hygienic Laboratory (Kennedy and Miller, 1987).

Date Collected	6/18/86		7/22/86		9/11/86	
Depth (meters)	0	8.5	0	9	0	8.5
Secchi (meters)	1.1		0.6		0.5	
Suspended Solids (mg/L)	6	29	14	46	21	22
Dissolved Oxygen (mg/L)	10.5	0.5	9.8	0.4	7.6	4.4
Ammonia Nitrogen (mg/L)	0.11	0.39	0.01	1.2	0.02	0.05
Nitrate-Nitrite Nitrogen (mg/L)	1.9	1.7	1.2	0.8	0.3	0.3
Total Phosphorus (mg/L)	0.06	0.09	0.13	0.17	0.19	0.19
Chlorophyll a (ug/L) Corrected	11	2	21	7	39	35

Table 6. Data collected in 1990 by Iowa State University (Bachmann, et al, 1994).

Date Collected	6/5/1990			7/8/1990			8/6/1990		
Sample Number	1	2	3	1	2	3	1	2	3
Secchi (meters)	1.7			1.2			0.8		
Suspended Solids (mg	23.9	13.9	57.5	23.4	17.6	15.4	22.1	20.1	14.9
Total Nitrogen (mg/L)	2.3	2.1	2.9	1.9	1.3	2.3	1.5	1.6	1.6
Total Phosphorus (mg	117	122	77	147	95	95	86	86	82
Chlorophyll a (ug/L) Corrected	41.2	27.4	25.5	41.8	41	42.3	84.2	81.9	75.6

Each sample was a composite water sample from all depths of the lake.

Table 7. Data collected in 2000 by Iowa State University (Downing and Ramstack, 2001)

Parameter	**6/21/2000**	**7/18/2000**	**8/8/2000**
Secchi Depth m	0.7	0.9	0.6
Chlorophyll (ug/L)	10	8	20
NH_3+NH_4^+ -N (ug/L)	806	796	412
NH_3 –N (un-ionized) (ug/L)	6	49	27
NO_3+NO_2-N (mg/L)	0.18	0.53	0.17
Total Nitrogen (mg/L as N)	1.21	1.40	1.68
Total Phosphorus (ug/l as P)	84	111	58
Silica (mg/L as SiO_2)	46	22	20
pH	7.2	8.0	8.1
Alkalinity (mg/L)	134	132	109
Total Suspended Solids (mg/L)	23.5	4.6	12.6
Inorganic Suspended Solids (mg/L)	16.2	1.9	9.0
Volatile Suspended Solids (mg/L)	7.2	2.7	3.6

Table 8. Data collected in 2001 by Iowa State University (Downing and Ramstack, 2002)

Parameter	5/22/2001	6/19/2001	7/23/2001
Secchi Depth m	0.6	0.8	1.1
Chlorophyll (ug/L)	--	17	30
NH_3+NH_4^+ -N (ug/L)	1078	549	277
NH_3 –N (un-ionized) (ug/L)	11	26	59
NO_3+NO_2-N (mg/L)	2.63	2.97	1.21
Total Nitrogen (mg/L as N)	3.01	3.38	2.14
Total Phosphorus (ug/l as P)	86	66	50
Silica (mg/L as SiO_2)	10	9	5
pH	7.5	8.0	8.6
Alkalinity (mg/L)	54	110	99
Total Suspended Solids (mg/L)	17.3	22.4	5.1
Inorganic Suspended Solids (mg/L)	13.6	15.0	3.8
Volatile Suspended Solids (mg/L)	3.6	7.4	1.3

15. Appendix II

Current Gross Erosion from the Lake Icaria watershed

Sediment Delivery (tons/year) =

Acres * Gross Erosion Rate (tons/acre/year) * Sediment Delivery Rate

Subwatershed A:

779 acres * 8.0 t/a/y * 34% = 2251 * 90% reduction = 212 t/y protected by structures

695 acres * 9.0 t/a/y * 34% = 2127 t/y not protected by structures

* Gross erosion rates in the Lake Icaria watershed were obtained from a GIS based RUSLE model with input values determined by the local NRCS office and the Adams County 3 Lakes project coordinator.

The Sediment Delivery Ratio (SDR) was obtained from the Erosion and Sediment Delivery Worksheet, (USDA-NRCS, 1998).

Current Streambank / Streambed Erosion in the Lake Icaria watershed

(ft of stream)(erosion rate in ft/yr)(bank / bed in ft)(soil weight in lbs/ ft^3)/(conversion from lbs to tons) = tons/yr

Sample calculation:

(13026ft)(0.2ft/yr)(8ft)(85 lbs/ft^3)/(2000 lbs/ton) = 886 tons/yr

(6513)(0.4)(8)(85)/(2000) = 886 tons/yr

(6513)(0.1)(8)(85)/(2000) = 221 tons/yr

Table 9. Streambank/Streambed Erosion

Subwatershed	Location	Rate	Length Ft(mi)	Tons/yr
A	North Tributary	(assume 0.1 ft/yr)	14,354' (2.72)	488
B	50% moderate	0.2 ft/ yr	13,026' (2.47)	886
	25% severe	0.4 ft/ yr	6,513' (1.23)	886
	25% average	0.1 ft/yr	6,513' (1.23)	221
C	Southeast Tributary	(assume 0.1 ft/yr)	12,396' (2.35)	421

Colo is estimated at 85 lbs/ft^3 dry weight
Assuming an average of 2 ft banks and 4 ft bed (2+2+4)

Figure 1. Lake Icaria and subwatersheds.