Appendix A

Methods

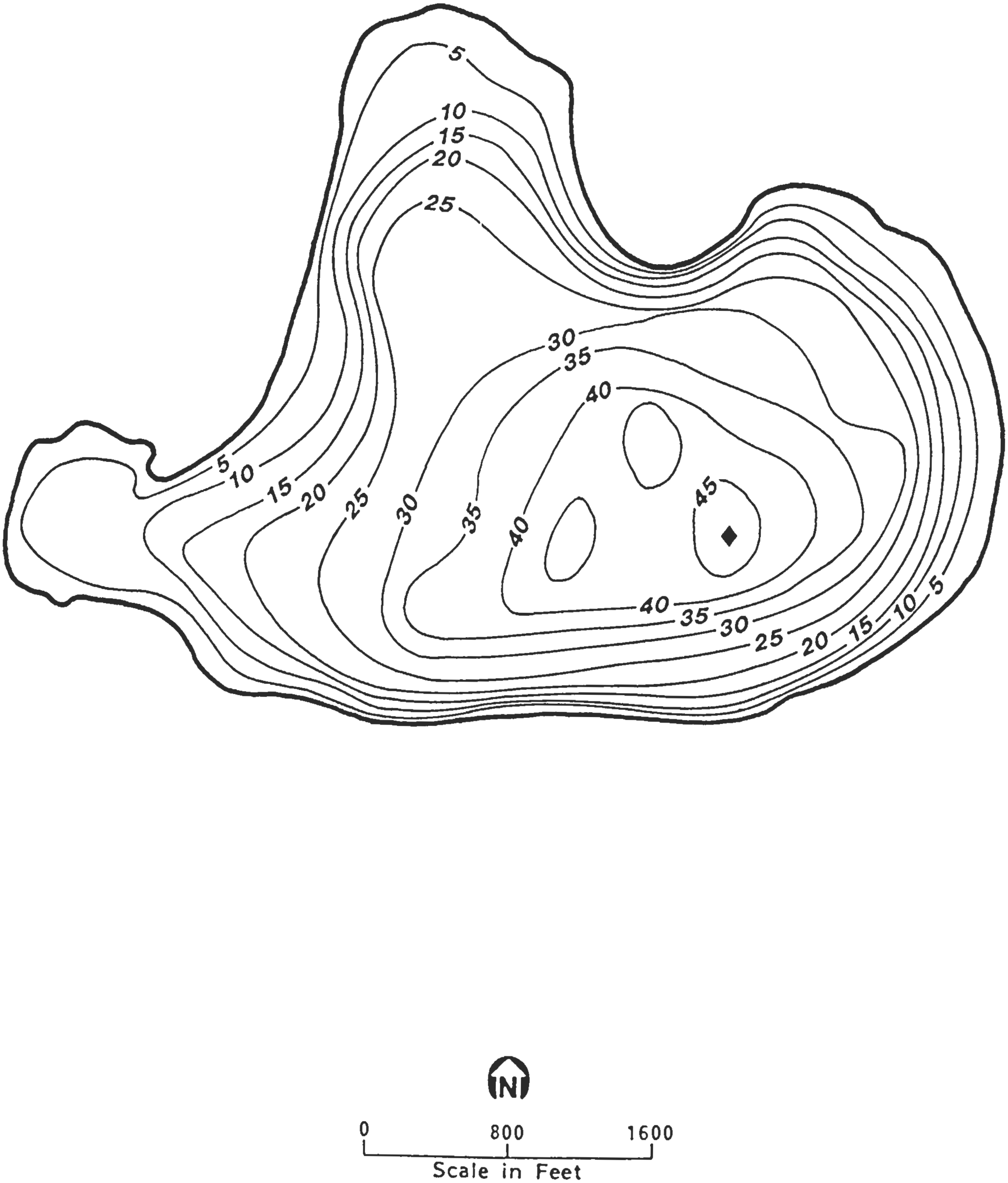
Methods

The Lake Riley UAA included the collection and analysis of data from the lake and its watershed. The methods discussion includes:

- Lake water quality data collection
- Ecosystem data collection
- Continuous stormwater monitoring methods, data reduction and total phosphorus loading determinations
- Watershed stormwater and total phosphorus loadings
- Atmospheric Deposition

A.1 Lake Water Quality Data Collection

In 1997, a representative Lake Riley sampling station was selected (i.e., located at the deepest location in the lake basin, see Figure A-1). Samples were collected monthly during October 1997, and during January and March, 1998. Samples were collected biweekly during May through September and monthly during October of 1998. A total of nine water quality parameters were measured at the Lake Riley sampling station. Table A-1 lists the water quality parameters and specifies at what depths samples or measurements were collected. Dissolved oxygen, temperature, specific conductance, and Secchi disc transparency were measured in the field; whereas, water samples were analyzed in the laboratory for total phosphorus, soluble reactive phosphorus, total nitrogen, chlorophyll *a*, and pH. The procedures for chemical analyses of the water samples are shown in Table A-2. Generally, the methods can be found in Standard Methods for Water and Wastewater Analysis.



◆ Monitoring Station

Figure A-1

LAKE RILEY BASIN
MORPHOLOGY AND SAMPLE
LOCATION

Table A-1 Lake Riley Water Quality Parameters

Parameters	Depth (Meters)	Sampled or Measured During Each Sample Event
Dissolved Oxygen	Surface to bottom profile	X
Temperature	Surface to bottom profile	X
Specific Conductance	Surface to bottom profile	X
Secchi Disc	—	X
Total Phosphorus	0 2 Meter Composite Sample	X
Total Phosphorus	Profile at 1 meter intervals from 3 meters to 0.5 meters above the bottom	X
Soluble Reactive Phosphorus	0-2 Meter Composite Sample	X
Total Nitrogen	0-2 Meter Composite Sample	X
pH	0-2 Meter Composite Sample	X
pH	Profile at 1 meter intervals from 3 meters to 0.5 meters above the bottom	X
Chlorophyll *a*	0-2 Meter Composite Sample	X

Table A-2 Procedures for Chemical Analyses Performed on Water Samples

Analysis	Procedure	Reference
Total Phosphorus	Persulfate digestion, manual ascorbic acid	Standard Methods, 18th Edition (1992) modified per Eisenreich, et al., Environmental Letters 9(1), 43-53 (1975)
Soluble Reactive Phosphorus	Manual ascorbic acid	Standard Methods, 18th Edition modified per Eisenreich, et al., Environmental Letters 9(1), 43-53 (1975)
Total Nitrogen	Persulfate digestion, scanning spectrophotometric	Bachman, Roger W. and Daniel E. Canfield, Jr., 1991. A Comparability Study of a New Method for Measuring Total Nitrogen in Florida Waters. Report submitted to the Florida Department of Environmental Regulation.
Chlorophyll *a*	Spectrophotometric	Standard Methods, 18th Edition, 1992, 10200 H
pH	Potentiometric measurement, glass electrode	Standard Methods, 16th Edition, 1985, 423
Specific Conductance	Wheatstone bridge	Standard Methods, 16th Edition, 1985, 205
Temperature	Thermometric	Standard Methods, 16th Edition, 1985, 212
Dissolved Oxygen	Electrode	Standard Methods, 16th Edition, 1985, 421F
Phytoplankton Identification and Enumeration	Inverted Microscope	Standard Methods, 16th Edition, 1985, 1002F (2-d), 1002H (2)
Zooplankton Identification and Enumeration	Sedgewick Rafter	Standard Methods, 16th Edition, 1985, 1002F (2-d), 1002H
Transparency	Secchi disc	

A.2 Ecosystem Data Collection

Ecosystem describes the community of living things within Lake Riley and their interaction with the environment in which they live and with each other. During the period October 1, 1997 through October 14, 1998, ecosystem data collection included:

- **Phytoplankton**—A composite 0-2 meter sample was collected during each water quality sample event during the period October 1997 through September, 1998.
- **Zooplankton**—A zooplankton sample was collected (i.e., bottom to surface tow) during each water quality sample event during the period January through October, 1998.
- **Macrophytes**—Macrophyte surveys were completed during June and August, 1998.

Phytoplankton and zooplankton samples were identified and enumerated to provide information on species diversity and abundance. The macrophyte community was surveyed to determine species locations, composition, and abundance.

A.3 Continuous Stormwater Monitoring Methods, Data Reduction and Total Phosphorus Loading Determinations

Automatic stormwater monitoring equipment was installed in 1997 at two sites (Station 1 near the boat launch and Station 2 on Riley Creek, See Figure A-2). The equipment measured flow and collected water samples during the period October through November 1997 and March through September 1998. The equipment installed at Station 1 consisted of an automatic sampler and an area velocity flow meter which measured the flow entering Lake Riley via a storm sewer. The equipment installed at Station 2 consisted of an automatic sampler and a flow logger measuring the level of flow in Riley Creek. Hand held flow and staff gage measurements in Riley Creek during October of 1997 and during March through September of 1998 were used to calculate stage-discharge information. The stage discharge information was used to convert the sampler depth measurements to flow rates. The flow meters provided flow pacing for the automatic samplers. The automatic samplers at both stations collected samples based on preprogrammed flow intervals and the discrete samples were combined into flow- weighted composite samples for each storm event.

The data from the monitoring equipment was assembled and average daily discharges were computed for each station. Missing values were replaced with estimated values whenever equipment malfunction caused gaps in the data recorded during the monitoring study.

The U.S. Army Corps of Engineer's FLUX model was used to determine the total phosphorus loadings from each station. The FLUX model uses the average daily discharges and flow-weighted composite concentrations from each site to determine the constituent loadings during the monitored time period. The model uses five different loading calculation methods and computes the variances of the estimated mean loadings to provide relative indications of error in the estimated loads. The calculation method with the smallest amount of bias and variance was used to estimate the annual phosphorus loadings for each of the monitored sites during 1997 through 1998.

Barr: Arcview 3.1 PIIIAF, I:\Client\Rpbcwd\gis\Project\2327053R01\lake_riley_figures.apr, Layout: Inflow Locations, lkp, Wed Oct 10 12:39:42 2001

☆ Inflow Location Stations

Watershed Boundary

Municipal Boundary

N W E S

750 0 750 1500 Feet

Figue A-2

LAKE RILEY INFLOW LOCATIONS

A.4 Watershed Pond Survey

During the winter of 1998 through 1999, approximately 54 ponds (i.e., 43 wet detention ponds and 11 extended dry ponds) throughout the Lake Riley direct watershed were surveyed. The survey located extended dry ponds and determined the bathymetry of wet detention basins. This work was completed to help establish the current conditions of water bodies that affect the flow of storm water runoff from the Lake Riley watershed. The wet detention pond surveys began by recording the type and size of outlet that existed and an estimate of the height to the low overflow point. A grid was then marked off on the pond with points approximately 20 feet apart. An ice auger was used to drill through the ice and a depth gage was dropped to the bottom to get the water depth. The grid points and associated water depths were then recorded on a map of the pond. The maps were then placed in the Geographical Information System (GIS) and pond volumes, both dead and live storage, were determined. Pond data are summarized in Appendix B. The information was used in the water quality modeling of the Lake Riley watershed.

Bathymetry and pond volumes of ponds within the Lake Lucy, Lake Ann, Lake Susan, and Rice Marsh Lake watersheds were determined during completion of the Use Attainability Analyses (UAAs) of the lakes.

A.5 Watershed Stormwater and Total Phosphorus Loadings

The P8 computer model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP, Inc., 1990) was used to estimate both the water and phosphorus loads introduced from the entire watershed of Lake Riley. P8 is a useful diagnostic tool for evaluating and designing watershed improvements and best management practices (BMPs). The model was used instead of the XP-SWMM model (i.e., discussed in the District Water Management Plan) because it is a better predictor of phosphorus loading, the primary focus of the Lake Riley Use Attainability Analysis.

The model requires hourly precipitation and temperature data; long-term climatic data can be used so that watersheds and BMPs can be evaluated for varying hydrologic conditions. Hourly precipitation data were obtained from a gage located in Eden Prairie near T.H. 212 and I-494 and from the National Weather Service (NWS) gage in Chanhassen. The modeling precipitation file used a combination of Eden Prairie and Chanhassen data. The daily precipitation totals from the Chanhassen gage were used and the rainfall intensities from the Eden Prairie gage were used for the hourly precipitation data file. Hourly temperature data were obtained from the NWS site at the Minneapolis-St. Paul International Airport.

When evaluating the results of the modeling, it is important to consider that the results provided are more accurate in terms of relative differences than in absolute results. The model will predict the percent difference in phosphorus reduction between various BMP options in the watershed fairly accurately. It also provides a realistic estimate of the relative differences in phosphorus and water loadings from the various subwatersheds and major inflow points to the lake. However, since runoff quality is highly variable with time and location, the phosphorus loadings estimated by the model for a specific watershed may not necessarily reflect the actual loadings, in absolute terms. Various site-specific factors, such as lawn care practices, illicit point discharges and erosion due to construction are not accounted for in the model. The model provides values that are considered typical of the region, given the watershed's respective land uses.

A.5.1 Water Quality Model (P8) Calibration

A.5.1.1 Stormwater Volume Calibration

The 1998 annual runoff volume in the model was calibrated to the monitoring data collected from the Lake Riley watershed during the period October 1, 1997 through September 30, 1998 (i.e., 1998 water year). Selection of model parameters during the calibration process is detailed in Appendix C. Following model calibration, the relationship between the modeled and observed water volumes during each precipitation event during the 1998 water year were evaluated. The results of a regression analysis of modeled and observed values are presented in Figures A-3 and A-4. The regression analysis indicates excellent agreement between observed and modeled volumes. The modeled annual volume of water discharging to Lake Riley from its direct watershed, from Riley Creek, and from seven storm sewers during the 1998 water year is summarized in Table A-3. Inflow locations are shown on Figure A-5.

Table A-3 Annual Volume of Water Discharging to Lake Riley During 1998 Water Year

Lake Riley Inflow Location	Annual Water Load (Acre-Feet/Year)
Direct Watershed	180.7
Riley Creek	3,584.4
2.11	87.3
3.11	29.4
SP3	19.5
P445	255.6
9.11	48.8
6.11	7.3
Station 1	69.2
TOTAL	**4,282.2**

The modeled water load from the Lake Riley watershed during the 1998 water year is equivalent to 0.9 inches of runoff over the 5,035-acre contributing watershed area.

Lake Riley Station 1 Inflow Volume
Modeled Vs. Observed

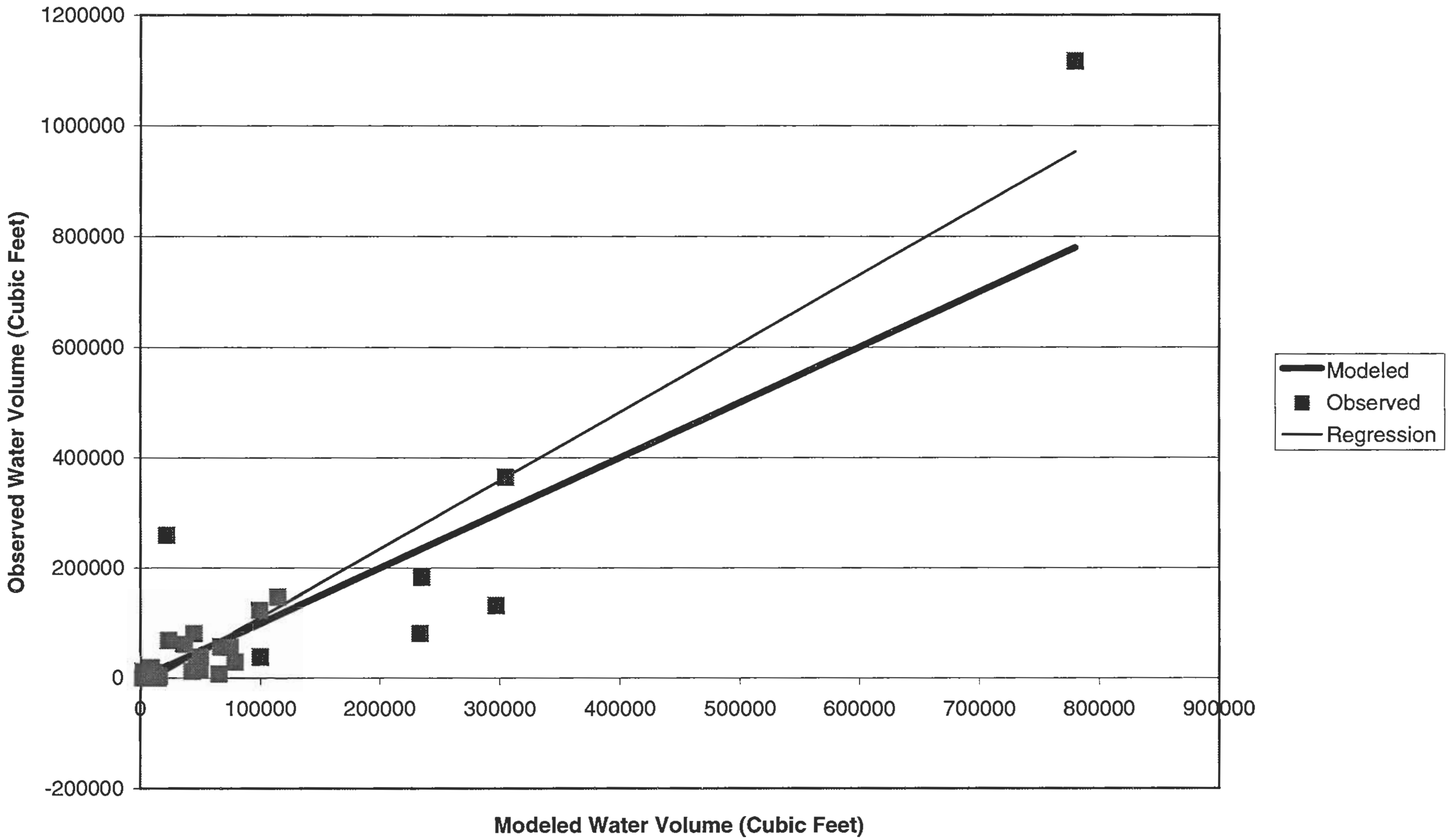
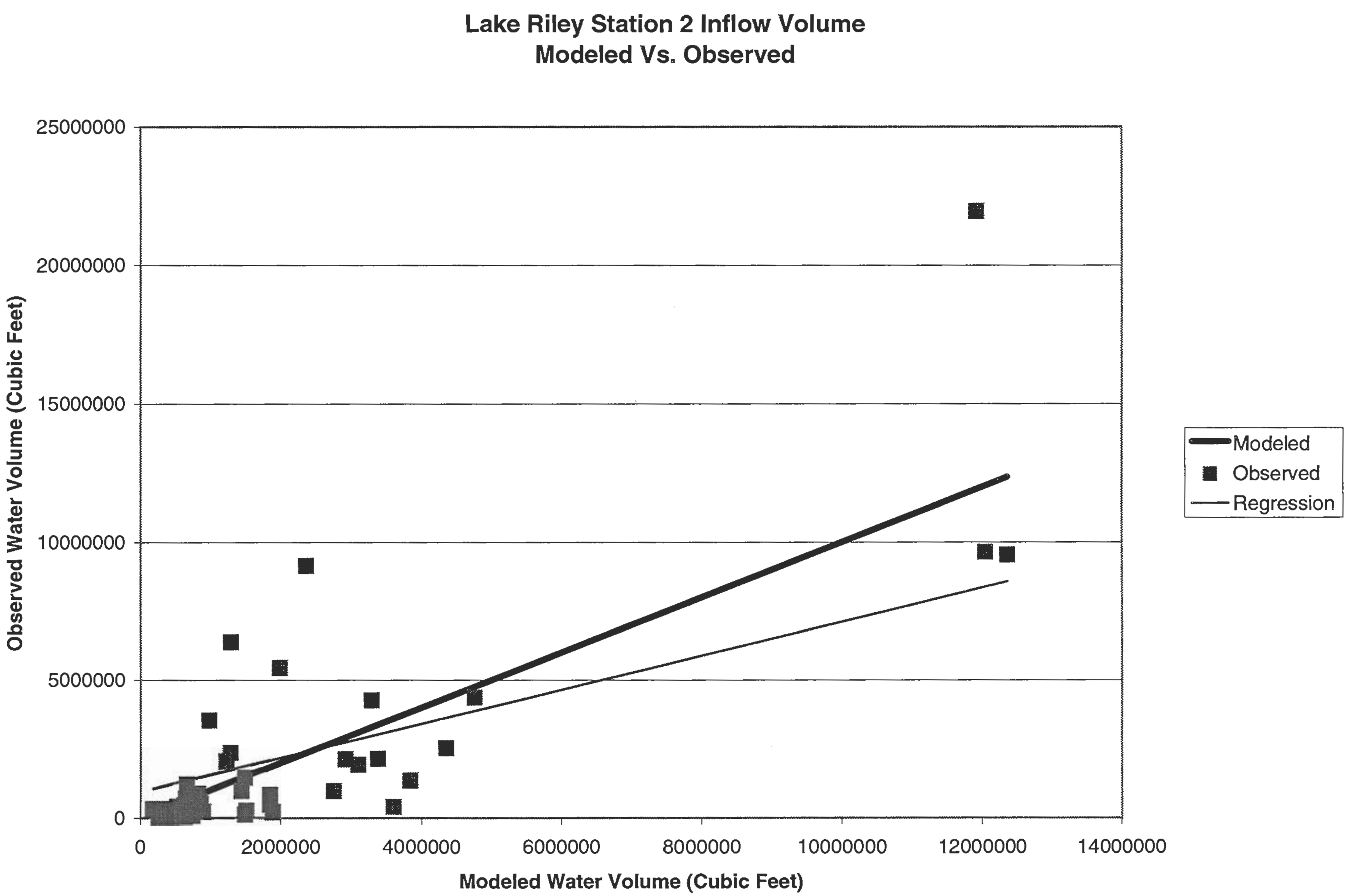
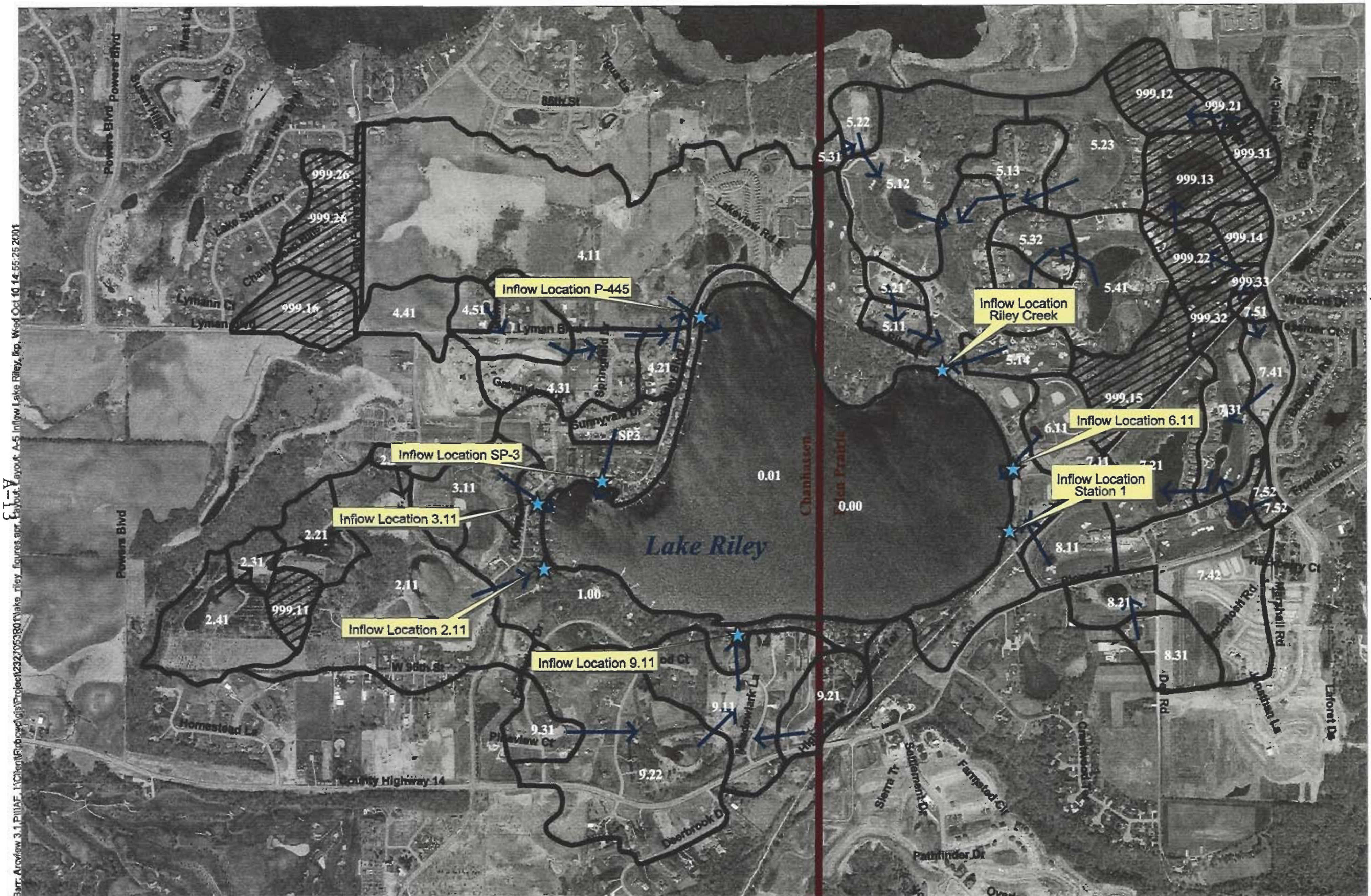


Figure A-3



Lake Riley Station 2 Inflow Volume
Modeled Vs. Observed
Observed Water Volume (Cubic Feet)
25000000
20000000
15000000
10000000
5000000
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
Modeled Water Volume (Cubic Feet)
Modeled
Observed
Regression

Figure A-4



Inflow Locations

Watershed Boundaries

Municipal Boundary

N W E S

750 0 750 1500 Feet

Figue A-5
LAKE RILEY INFLOW LOCATIONS

A.5.1.2 Phosphorus Loading Calibration

The phosphorus loads predicted by the P8 model were calibrated using the stormwater monitoring data collected during the 1998 water year. The observed annual total phosphorus load from Sample Stations 1 and 2 during the 1998 water year, determined from FLUX results (See 2.3 Continuous Stormwater Monitoring Methods, Data Reduction and Total Phosphorus Loading Determinations), were compared with the modeled loads. The observed and modeled annual loads were the same. Hence, the observed and modeled annual loads from Station 1 were 31.4 pounds. The observed and modeled annual loads from Station 2 were 367 pounds. Following the calibration, the relationship between the observed and modeled values during each monitoring event during the 1998 water year were evaluated. The results of a regression analysis of modeled and observed values are presented in Figures A-6 and A-7.

A.5.1.3 Atmospheric Deposition

An atmospheric wet and dry deposition rate of 0.56 kg/ha/yr. (Tetra Tech. 1982) was applied to the surface area of Lake Riley to determine annual phosphorus loading. An annual total phosphorus load from atmospheric deposition of 65 pounds was estimated for Lake Riley.

A.6 In-Lake Water Quality Model

AQUATOX (Version 1.69) was used as the in-lake water quality model for Lake Riley. A detailed discussion of the AQUATOX model and Lake Riley in-lake water quality modeling are found in Appendix D.

Lake Riley St. 1 Total Phosphorus Modeled and Observed Mass

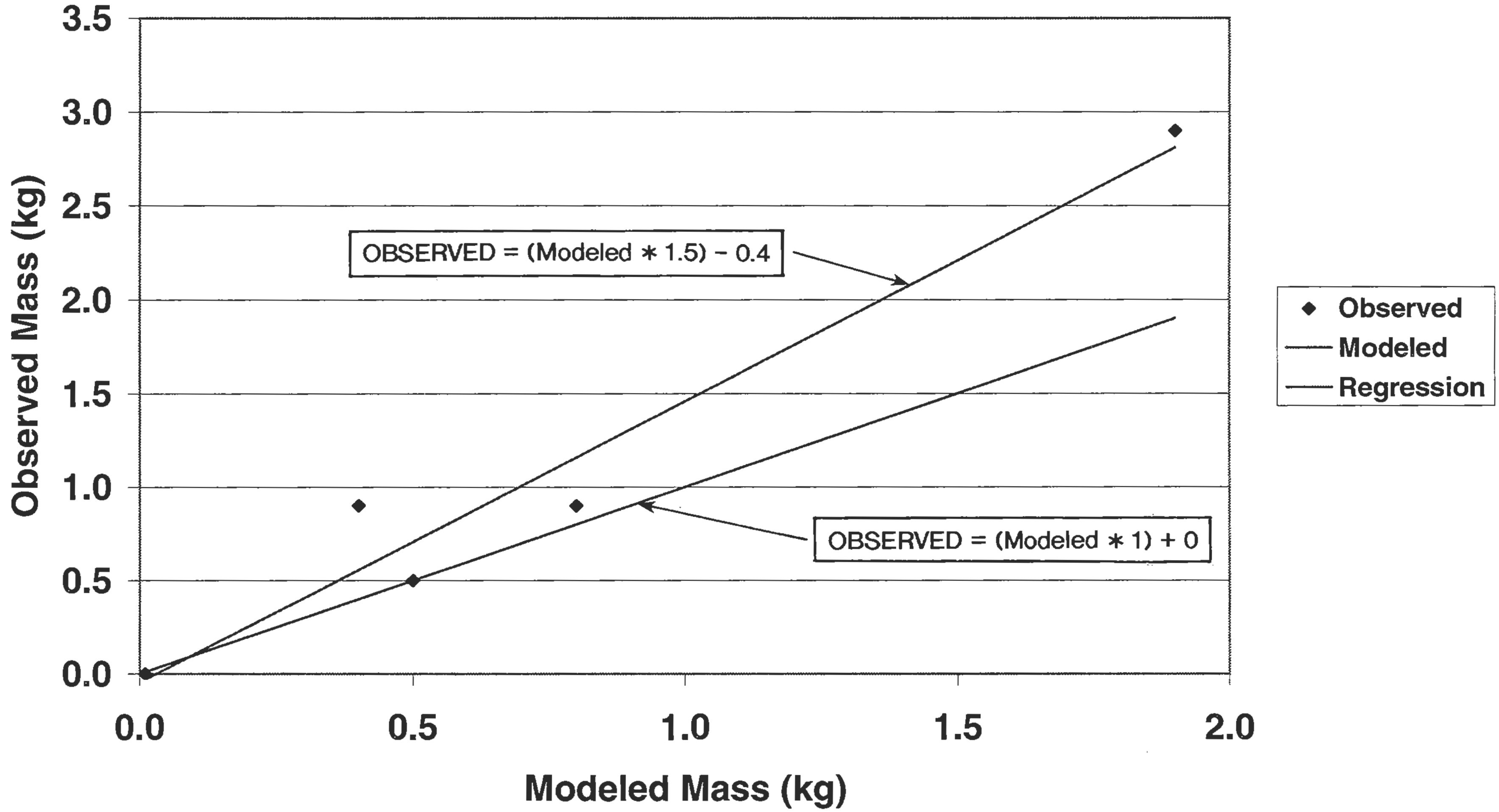
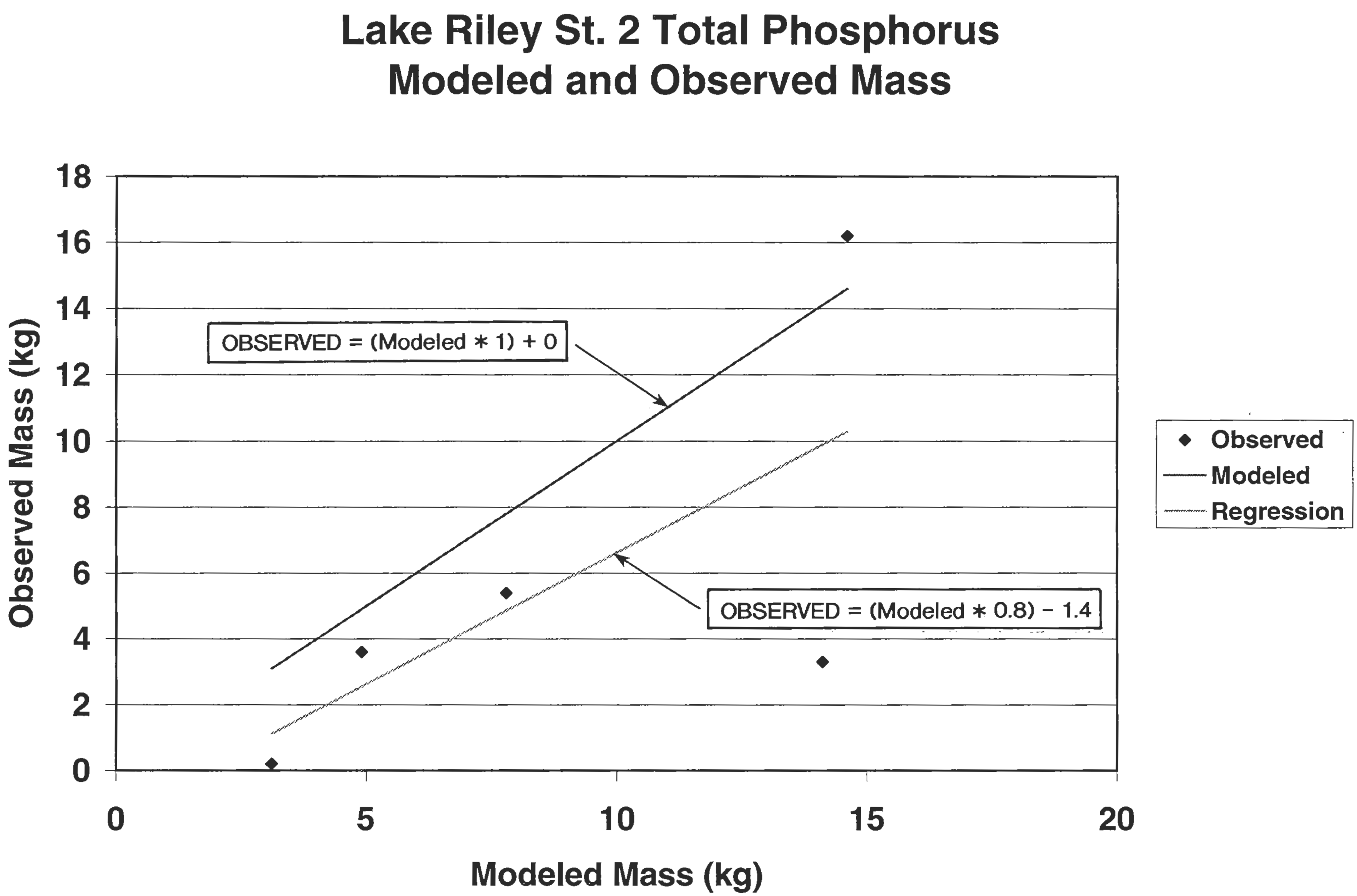


Figure A-6



Lake Riley St. 2 Total Phosphorus
Modeled and Observed Mass
Observed Mass (kg)
18
16
14
12
10
8
6
4
2
0
0
5
10
15
20
Modeled Mass (kg)
OBSERVED = (Modeled * 1) + 0
OBSERVED = (Modeled * 0.8) - 1.4
Observed
Modeled
Regression

Figure A-7

Appendix B

Lake Riley Watershed Pond Data

Lake Riley Watershed Ponds--Direct Watershed

Label	Pond #	Device Specifications Pond Bottom Surface Area acres	Permanent Pool Surface Area acres	Permanent Pool Storage Volume acre-feet	Flood Pool Surface Area acres	Flood Pool Increment acre-feet	Flood Pool Storage Volume acre-feet	Normal Outlet Orifice Diameter inches	Weir Length feet
2.41	1	1.4	5.6	18.7	6.7	10.1	28.8	15	
2.31	2	0	0.5	1	0.7	0.4	1.4	none	6
2.21	4	0.3	4.5	11.4	6.3	12.6	24	15	
2.11	6	0	6.2	53.4	6.6	6.7	60.1	24	
2.22	7	0	0.2	0.5	0.3	0.7	1.2	none	
9.31	8	0	0.4	0.7	0.5	0.5	1.2	none	
9.22	9	0.2	2.2	13	2.4	1.2	14.2	Natural Channel	3
9.11	10	0	0.4	0.8	0.4	0	0.8	24	
9.21	11	0	1.8	3.9	2.6	2.6	6.5	none	
3.11	12	0	0.1	0.1	0.3	0.5	0.6	none	
4.51	14	0	0.3	0.7	0.4	0.6	1.3	15	
9999.42	SP1	0	0.3	1.6	0.5	1.8	3.4	12	
9999.43	SP2	0	0.2	0.4	0.2	0.2	0.6	14	
SP3	SP3	0	0.2	0.5	0.1	-0.2	0.3	12	
SP4	SP4	0	0.2	0.2	0.6	1.8	2	18	
4.11	17A	0.1	0.2	0.4	0.2	0	0.4	15	
4.12	17B	0.3	1.1	1.4	1.1	0	1.4	none	
4.13	17C	0.1	2.3	8.2	3	2.9	11.1	none	
4.14	17D	0	0.2	0.2	0.7	1.4	1.6	none	
4.15	17E	0.1	0.5	1.8	0.8	3	4.8	36	
4.21	18	0	0.2	0.5	0.5	0.7	1.2	12	
5.31	20	0	0.3	0.4	0.3	0.2	0.6	15	
5.12	22	0.3	4.2	5.4	7.3	14.7	20.1	Natural Channel	6
5.21	23	0	0.4	0.6	0.5	0.1	0.7	15	
5.11	24	0	0.4	1.6	0.4	0.5	2.1	Natural Channel	6
5.01	25	0	0.2	0.3	0.3	0.4	0.7	24	
5.23	27	0.002	10	7.7	20	20	27.7	12	
5.13	61	0	0.3	0.4	0.4	0.4	0.8	Man Made Channel	2.5
5.03	62	0	0.1	0.1	0.2	0.2	0.3	12	
5.41	31	0.4	7.5	25.2	8.6	8.5	33.7	12	
5.32	32	0	0.5	1.9	0.6	1.2	3.1	18	
5.24	33	0.1	0.9	3.9	1	1	4.9	24	
5.14	26	0	0.6	1.2	0.9	1.8	3	21	
6.11	47	0.1	0.3	1.7	0.4	0.3	2	none	
7.42	49	0.2	1.3	1.3	2.4	2.4	3.7	12	
7.52	50	0	0.2	0.3	0.3	0.6	0.9	12	
7.31	45	0	0.7	3.2	0.7	0.1	3.3	Natural Channel	9
7.21	46	0	1.5	2.3	3.9	9.7	12	48	
7.11	48	0.7	8.9	18.7	12.8	12.8	31.5	12	
7.01	55	0	0.3	0.6	0.3	0.1	0.7	24	
8.31	54	0	0.2	0.1	0.7	1	1.1	12	
8.21	52	0	1.8	1	10.8	32.5	33.5	15	
8.11	51	0	0.4	0.5	0.5	0.3	0.8	24	

Appendix C

P8 Model Parameter Selection

P8 Model Parameter Selection

P8 version 2.4 was used for Lake Riley watershed modeling. Because of the large size and complexity of the Lake Riley watershed, three separate P8 models were used. Results of the three models were then tabulated to determine total watershed loading to Lake Riley.

Because primary data were collected for the Lake Riley UAA, model calibration afforded the opportunity to select P8 parameters that resulted in a good fit between modeled and observed data. The parameters selected for the Lake Riley P8 model are discussed in the following paragraphs. P8 parameters not discussed in the following paragraphs were left at the default setting.

Time Step, Snowmelt, and Runoff Parameters (Case-Edit-Other)

- **Time Steps Per Hour (Integer)—2**. Selection was based upon the number of time steps required to eliminate continuity errors greater than 2 percent.
- **Minimum Inter-Event Time (Hours)—10.** During 1998 frequent storms were noted during the summer. The selection of this parameter was based upon an evaluation of storm hydrographs to determine which storms should be combined and which storms should be separated to accurately depict runoff from the lake's watershed. It should be noted that the average minimum inter-event time for the Minneapolis area is 6. In a more typical climatic year a value of 6 would be used.
- **Snowmelt Factors—Melt Coef (Inches/Day-Deg-F)—0.06**. The selection was based upon the snowmelt rate that provided the best match between the observed and predicted snowmelt.
- **Snowmelt Factors—Scale Factor For Max Abstraction—1.** This factor controls the quantity of snowmelt runoff (i.e., controls losses due to infiltration). Selection was based upon the factor that resulted in the closest fit between modeled and observed runoff volumes.
- **Growing Season/Non-Growing Season AMC-II = 0 and AMC-III = 0**. Selection of this factor was based upon the observation that the model accurately predicted runoff water volumes from monitored watersheds when the Antecedent Moisture Condition III was selected (i.e., curve numbers selected by the model are based upon antecedent moisture conditions). Modeled water volumes were less than observed volumes when Antecedent Moisture Condition I or II was selected. The selected parameters tell the model to only use Antecedent Moisture Condition III.

Particle Scale Factor (Case-Edit-Components)

- **Scale Fac.—tp—1.42 for the Lake Riley direct watershed (i.e., Models 1 and 2) and 0.92 for the Lake Riley indirect watershed (Model 3).** The particle scale factor determines the total phosphorus load generated by the particles predicted by the model in watershed runoff. The factor for total phosphorus was selected to match the observed annual total phosphorus load with modeled total phosphorus loads. Phosphorus removal by the chain of lakes located in the lake's indirect watershed resulted in a lower scale factor for the indirect watershed than the direct watershed.

Particle File Selection (Case—Read—Particles)

- **NURP50PAR**. The NURP 50 particle file was found to most accurately predict phosphorus loading to Lake Riley.

Precipitation File Selection (Case—Edit—First—Prec. Data File

- **MS4999CH.PCP**. The precipitation file MS4999CH.PCP is comprised of hourly precipitation. The precipitation in the file is a combination of data from two different gages: The Eden Prairie gage located near T.H. 212 and I-494 and the Chanhassen gage located at the National Weather Service in Chanhassen. The total daily precipitation from the Chanhassen gage was used and the rainfall intensity from the Eden Prairie gage was used to create the hourly precipitation file.

Air Temperature File Selection (Case—Edit—First—Air Temp. File)

- **2MSP4998.TMP**. The temperature file was comprised of temperature data from the Minneapolis—St. Paul International airport during the period 1949 through 1998.

Devices Parameter Selection (Case—Edit—Devices—Data—Select Device)

- **Pond Bottom**—The surface area of the pond bottom of each detention pond was determined and entered here.
- **Detention Pond—Permanent Pool—Area and Volume**—The surface area and dead storage volume of each detention pond was determined and entered here.
- **Detention Pond—Flood Pool—Area and Volume**—The surface area and storage volume under flood conditions (i.e., the storage volume between the normal level and flood elevation) was determined and entered here.
- **Detention Pond—Orifice Diameter and Weir Length**—The orifice diameter or weir length was determined for each detention pond and entered here.
- **Detention Pond or Generalized Device—Particle Removal Scale Factor**—0.3 for ponds less than 2 feet deep, 0.6 for ponds from 2 to 3 feet deep, and 1 for all ponds 3 feet deep or greater. The particle removal factor for watershed devices determines

particle removal by devices. The factor was selected to match observed and modeled loads.

- **Detention Pond or Generalized Device—Outflow Device No's**—The number of the downstream device receiving water from the detention pond outflow was entered for infiltration, normal, and spillway.
- **Generalized Device**—Infiltration Outflow Rates (cfs)—0 for all ponds.
- **Detention Pond—Infiltration Rate (in/hr)**—0 for all ponds.
- **Pipe/Manhole—Time of Concentration**—The time of concentration for each pipe/manhole device was determined and entered here. A "dummy" pipe/manhole device was placed immediately upstream of each pond and a time of concentration of 0.5 hours per "dummy" pipe was selected to enable the model to accurately time the release of waters from each pond. Failure to use a "dummy" pipe/manhole for this purpose will result in a much faster release of waters from ponds and resultant reductions in treatment than actually occurs. A " dummy pipe" was placed downstream of Rice Marsh Lake and a time of concentration of 24 hours was selected. This time of concentration enabled the model to accurately time the release of waters from the upstream watershed to Lake Riley. Finally, a "dummy" pipe called Lake Riley was used in each of the three models. The Lake Riley pipe in each model received all water and phosphorus loads that enter Lake Riley. A time of concentration of 0 was used for the Lake Riley pipe in each model. Use of the pipe forced each model to total the water and phosphorus loads entering the lake, thus avoiding hand tabulation.

Watersheds Parameter Selection (Case—Edit—Watersheds—Data—Select Watershed)

- **Outflow Device Number**—The device number of the device receiving runoff from the watersheds was selected.
- **Pervious Curve Number**—A weighted SCS curve number was used as outlined in the following procedure. The P8 Pre-Processor was used to compute a SCS curve number for each watershed. The computation was based upon soil types in the watershed, land use, and hydrologic conditions. The computation also weighted the pervious curve number with indirect (i.e., disconnected) impervious areas in each subwatershed as follows:

WCN = {[(Indirect Impervious Area) * (98)] + [(Pervious Area) * (Pervious Curve Number)]}/(Total Area)

The assumptions for direct, indirect, and total impervious areas were based upon measurements from representative areas within the Lake Riley watershed.

- **Swept/Not Swept**—An "unswept" assumption was made for the entire impervious watershed area. A sweeping frequency of 0 was selected for swept. Hence, selected parameters were placed in the unswept category, including impervious fraction, depression storage, impervious runoff coeff, and scale factor for particle loads.
- **Impervious Fraction**—The direct or connected impervious fraction for each subwatershed was determined and entered here. The direct or connected impervious fraction includes driveways and parking areas that are directly connected to the storm sewer system. The P8 pre-processor performed the computations to determine impervious fractions for the subwatersheds. The direct impervious fraction for each subwatershed was based upon measurements from representative areas within the Lake Riley watershed. The direct impervious fraction for each land use type was weighted with the acres of each land use to obtain a weighted average for each subwatershed.
- **Depression Storage**—0.0065
- **Impervious Runoff Coef.**—1

Passes Through the Storm File (Case—Edit—First—Passes Thru Storm File)

- **Passes Thru Storm File—10**. The number of passes through the storm file was determined after the model had been set up and a preliminary run completed. The selection of the number of passes through the storm file was based upon the number required to achieve model stability. Multiple passes through the storm file were required because the model assumes that dead storage waters contain no phosphorus. Consequently, the first pass through the storm file results in lower phosphorus loading than occurs with subsequent passes. Stability occurs when subsequent passes do not result in a change in phosphorus concentration in the pond waters. It was determined that all three P8 models achieved stability at 10 passes.

Appendix D

AQUATOX Model for Eutrophication Modeling

AQUATOX MODEL FOR EUTROPHICATION MODELING

Introduction

AQUATOX (Version 1.69) was used as the in-lake water quality model for Lake Riley. AQUATOX is a modular, process-based, fate and effects model for aquatic ecosystems. The model characterizes the significant functions of an aquatic ecosystem and then simulates the transfer of biomass, energy, and chemicals among the functional compartments. The model simulates the fate of pollutants, such as nutrients and organic chemicals, and their effects on invertebrates, fish, and plants (phytoplankton and macrophytes). The modeled aquatic environments include ponds, stratified lakes, reservoirs, and rivers. The model can accept constant input values or continuous (dynamic) records. Model features include uncertainty analysis that can be used to assess the sensitivity of output to various input parameters.

In AQUATOX, "detritus" is used to include all non-living organic material and associated decomposers (bacteria and fungi). Detritus is modeled through the remineralization algorithms. There are eight compartments for detritus in AQUATOX, making detritus a relatively complicated and crucial part of the AQUATOX model. The eight detrital compartments are modeled dynamically and include: refractory (resistant) dissolved, suspended, sedimented, and buried detritus; and labile (readily decomposed) dissolved, suspended, sedimented, and buried detritus. Nutrients are received into the lake as dissolved or bound to particulates, and in organic matter, which decomposes and releases (remineralizes) nutrients.

AQUATOX has the capability of using the daily time step loading data from the P8 Urban Catchment Model to predict daily or seasonal changes in chlorophyll a, and the biomass of algae groups, such greens and blue-greens. Furthermore, the model calculates daily water transparency (Secchi depth), and dissolved oxygen in the epilimnion and hypolimnion.

U.S. EPA has supported the development of AQUATOX, provides the model and documentation on the EPA web site, and continues to support upgrades of the model. The U.S. EPA encourages use of the model for ecological risk assessments, eutrophication modeling, and studies of total maximum daily load (TMDL).

Modeling Approach

Study Setup and Scenarios

Three general categories of information serve as input to an AQUATOX study. The first is the site data for the lake. The site data for Lake Riley, shown Table D1, served as the basis for all AQUATOX modeling scenarios. The other information categories are driving (input) variables and state (modeled) variables. The driving variables includes physical measurements, such as light and temperature. Both the driving and state variables are shown in Table D2. The table includes the initial conditions (I.C.), which are described in more detail below. Some of the variables are constants and others are dynamic (i.e., vary with time).

AQUATOX was calibrated to the Lake Riley Calibration year (1997), using the daily loading output of P8 as input to AQUATOX. The utilized output from P8 includes water (inflow), soluble reactive phosphorus (SRP), and total Kjeldahl nitrogen (TKN). TKN is comprised of organic nitrogen and ammonia. It was used in AQUATOX as an indicator of ammonia (TKN x 0.1), nitrates (TKN x 1.0), and detritus (TKN x 16).

Once the model was calibrated to 1997 results, P8 output from the Average, Wet, and Dry hydrologic years were used to create new study files for AQUATOX. For each precipitation year, five BMP modeling studies were created to compare the relative impact of each BMP under the various precipitation conditions. Table D3 is a matrix of precipitation years and BMP scenarios to show the convention used for file names. A total of 48 AQUATOX studies were created for Lake Riley.

Antecedent Period

A three month summer period (June – August) is the period of interest for comparing precipitation years and BMP scenarios. To accurately predict and compare this period among the various model scenarios, the study files for AQUATOX were initiated in May of the preceding year. May 1st to September 30th of 1997 was used as the antecedent period for all precipitation years to maintain consistency among the scenarios. The antecedent period can have a substantial influence on the following summer outcome, but it is important to model the antecedent period to minimize the affect of the initial conditions on the output.

Conversion from P8 output files to AQUATOX input files

A protocol was developed for converting P8 files to AQUATOX input files. The flow diagram (Figure D1) shows the path of file conversions from P8 case and trace files, to spreadsheet summary files, to AQUATOX study and export files, and lastly to final summary spreadsheet files. This set of file conversions was completed for each precipitation year (calibration, average, wet, and dry). When model results are exported from AQUATOX, a pair of database files (*.dbf) are created: one for the epilimnion and a second file for the hypolimnion. The hypolimnetic data were not used in the summary of results Lake Riley BMP scenarios.

AQUATOX models orthophosphate, not total phosphorus; whereas, P8 computes the total phosphorus as a sum of dissolved and particulate phosphorus. Soluble reactive phosphorus (SRP) was assumed equal to orthophosphate-phosphorus, and was calculated by subtracting the particulate phosphorus from the total phosphorus concentration. The P8 model uses a factor of 0.00385 as the phosphorus fraction of the mid-range particulates (P10%, P30%, and P50%); therefore, the following equation was used to calculate SRP from the daily loading output of P8:

$$\text{SRP (mg/L)} = \text{TP (mg/L)} - 0.00385*(\text{P10\%} + \text{P30\%} + \text{P50\%})$$

Initial Conditions

To establish initial conditions for input variables, the calibration year was repeated for 12 years to achieve a steady state. This exercise showed a steady state was achieved within four years. Therefore, additional model runs were done with the calibration year repeated for six years. The modeled concentrations on May 1st of the fifth year were used as initial conditions for the regular model BMP scenarios, which started on May 1st of the year preceding the output year. The initial conditions derived in this manner are shown in Table D2.

Internal Load

Internal phosphorus load in Lake Riley was estimated from measured phosphorus mass buildup in the hypolimnion during the calibration year. The total phosphorus mass from internal load was estimated at 509.87 kg/yr, but 93 percent of the phosphorus precipitates back to the sediments during the autumnal overturn and only seven percent of the internal load phosphorus mass (35.69 kg) becomes entrained in the water column for potential use by algae.

AQUATOX does not provide an internal load input parameter, but the model does allow for dynamic point source or nonpoint source loads. Therefore, internal loading was added as a point source load for 15 days in the first half of October of the previous year. In other words, for the calibration year, 1997, a point source phosphorus loading of 2380 g/day was added in 1996, from October 1 to October 15, to give a total of 35.7 kg. This internal load was included in all Lake Riley model scenarios. In the BMP scenario for alum treatment to the lake, the internal load was multiplied by 0.1 to account for 90 percent of the internal phosphorus load being inactivated by the aluminum hydroxide floc covering the sediments.

Model Calibration: Adjusted Coefficients

Very few default parameters and coefficients were changed to calibrate the model to Lake Riley; however, there were a few key changes that are described here. The parameters for remineralization are listed in Table D4; phytoplankton parameters are listed in Table D5; and animal parameters (e.g., zooplankton and fish) are summarized in Table D6. The parameters are based on either the model defaults for lakes or specifically, the defaults for Lake Onondaga, which was a model validation study included with the model.

Maximum degradation rates for labile and refractory organic material were higher for Lake Onondaga than they were for the default lake data and the higher values were used for the Lake Riley studies. Detrital sedimentation rate was increased from the default value of 0.15 g/g·d to 0.6 g/g·d. The referenced paper for the default sedimentation rate actually gives a recommended value of 0.69 rather than the 0.15 used in the model's default database.

The sedimentation rate for diatoms was also increased from the default database value because the model initially predicted diatom blooms in the spring but they were not observed in Lake Riley. Another phytoplankton parameter adjusted for Lake Riley calibration year was the phosphorus half-saturation constant for blue-green algae, which was reduced to more closely match the half-saturation constants for greens and diatoms. The only other adjusted phytoplankton parameter was light extinction for blue-green algae. The light extinction was increased to 1.0 to force Secchi depth to more accurately reflect blue-green biomass in Lake Riley.

The default animal parameters were not altered for Lake Riley studies.

Model Calibration Output

AQUATOX output is exported as a database (*.dbf) file. To calculate total phosphorus, the daily loads for phosphate (PO4) and the water detritus (labile, refractory, dissolved, and particulate) compartments must be combined using the following equation:

$$TP_{out} = PO4 + 0.018(L\_PART\_DETR + L\_DISS\_DETR + R\_PART\_DETR + R\_DISS\_DETR)$$

The factor, 0.018, is the fraction of phosphorus in organic material, based on the Redfield ratio, which is used in AQUATOX algorithms. This equation for TP was developed from comparisons of observed and predicted output for Lake Riley. Phosphate alone under-predicted total phosphorus. Adding phytoplankton to the sum with detritus over-predicted the TP.

The comparison of calibration year modeled results with measured phosphorus, chlorophyll a, and Secchi depth showed a very good match to average summer values for phosphorus and chlorophyll *a* (see Figure D2). The observed and predicted average summer total phosphorus concentrations differed by only 5 percent. The observed and predicted average summer chlorophyll *a* concentrations differed by 12 percent. Observed and predicted summer averages for Secchi depth differed by 30 percent. The predicted Secchi depth appeared to not adjust accurately for the BMP scenarios. For example, when chlorophyll *a* concentration was reduced substantially because of an applied BMP, the Secchi depth did not change in the proportion that would be expected. Therefore, the modeled results for Secchi Depth were not used for the evaluation of BMP scenarios. Instead Secchi depth was predicted from the modeled chlorophyll *a* concentration using an empirical regression model for Minnesota Lakes, developed by Heiskary and Wilson (1990):

$$\mathrm{Log}_{10}\ \mathrm{SD} = -0.59\ \mathrm{Log}_{10}\ [\mathrm{Chl}] + 0.89$$

References

U.S. EPA. 2000. AQUATOX For Windows: A Modular Fate And Effects Model For Aquatic Systems. Release 1. Volume 2: Technical Documentation. EPA-823-R-00-008. September 2000. U.S. EPA Office of Water, Office of Science and Technology, Washington DC 20460

Heiskary, S.A. and C.B.Wilson 1990. Minnesota Lake Water Quality Assessment Report. Second Edition. A Practical Guide for Lake Managers. Minnesota Pollution Control Agency

Table D1

Lake Riley Site Data for AQUATOX

Parameter	Value	Units	Reference
Maximum Length	1.658	km	Barr 1996, p.140 (map)
Volume	7,615,517	m^3	Barr 1996, p. 139 (table)
Surface Area	1,189,776	m^2	"
Mean Depth	6.4	m	"
Maximum Depth	15	m	"
Avg. Epilimnetic Temp.	12	°C	"
Epilimnetic Temp. Range	24	°C	"
Avg. Hypolimnetic Temp.	8	°C	"
Hypolimnetic Temp. Range	8	°C	"
Latitude	44.8347	deg	www.topozone.com
Average Light	300	Ly/d	Estimate based on Coralville IA
Annual Light Range	450	Ly/d	"

Table D2

AQUATOX Input and State variables

Variable	Type (Constant or Dynamic)	I.C.*
Ammonia	Dynamic loading (TKN x 0.01) from P8; daily in-lake concentration modeled	0.06 mg/L
Nitrate	Dynamic loading (TKN x 1.0) from P8; daily in-lake concentration modeled	0.84 mg/L
Phosphate	Dynamic loading [TP- 0.00385 x (P10% + P30% + P50%)] from P8; daily in-lake concentration modeled	0.176 mg/L
Carbon Dioxide	No loading; daily concentration modeled	1.252 mg/L
Oxygen	"	10.03 mg/L
Total Suspended Solids	Constant	7 mg/L
Organic Matter ("Detritus") – 8 Compartments		
Labile-Dissolved	Dynamic loading from P8's TKN output; daily concentration modeled	0.736 mg/L
Refractory-Dissolved	"	0.272 mg/L
Labile-Particulate	"	0.023 mg/L
Refractory-Particulate	"	0.008 mg/L
Labile-Sediment	Constant input; daily concentration modeled	1.3 g/sq.m
Refractory-Sediment	"	1140 g/sq.m
Buried-Labile	"	2 Kg/cu.m
Buried-Refractory	"	2 Kg/cu.m
Diatoms	Daily concentration modeled	0 mg/L
Blue Greens	"	0.019 mg/L
Greens	"	0 mg/L
Zooplankton (Daphnia)	"	0.321 mg/L
Forage Fish (Bluegill)	"	0.674 mg/L
Large Game Fish (Walleye)	"	4.2 mg/L
Water Volume	Constant	
Water Inflow	Dynamic loading from P8 output	
Secchi Depth	Modeled	
Chlorophyll *a*	"	
pH	Measured values from calibration year used as "valuations" in model	
Light	Modeled as average langleys/day based on latitude	
Temperature	Modeled based on average epilimnetic and hypolimnetic temperatures in calibration year	
Wind	Modeled as average daily wind speed based on input of mean wind speed	

*I.C. Initial Condition set for calibration year and used for all subsequent Lake Riley model studies

Table D3
File Names for Model Studies

Precipitation Year:		Calibration	Average	Dry	Wet
Land Use	**Existing**	exca	exav	exdr	exwe
	Ultimate	ulca	ulav	uldr	ulwe

BMP Scenario

NO BMP	exca NO BMP	exav NO BMP	exdr NO BMP	exwe NO BMP
	ulca NO BMP	ulav NO BMP	uldr NO BMP	ulwe NO BMP
RM60	exca RM60	exav RM60	exdr RM60	exwe RM60
	ulca RM60	ulav RM60	uldr RM60	ulwe RM60
RM90	exca RM90	exav RM90	exdr RM90	exwe RM90
	ulca RM90	ulav RM90	uldr RM90	ulwe RM90
ALSTRM	exca ALSTRM	exav ALSTRM	exdr ALSTRM	exwe ALSTRM
	ulca ALSTRM	ulav ALSTRM	uldr ALSTRM	ulwe ALSTRM
ATR-ALSTRM	exca ATR-ALSTRM	exav ATR-ALSTRM	exdr ATR-ALSTRM	exwe ATR-ALSTRM
	ulca ATR-ALSTRM	ulav ATR-ALSTRM	uldr ATR-ALSTRM	ulwe ATR-ALSTRM
NURP	exca NURP	exav NURP	exdr NURP	exwe NURP
	ulca NURP	ulav NURP	uldr NURP	ulwe NURP

Table D4

Remineralization Record

Parameter		Units
Max. Degradation Rate, Labile	0.29	g/g·d
Max. Degradation Rate, Refractory	0.04	g/g·d
Optimum Temperature	30	°C
Maximum Temperature	65	°C
Min. Adaptation Temp.	20	°C
Min. pH for Degradation	5	S.U.
Max. pH for Degradation	8.5	S.U.
Organics to P	0.018	fraction
Organics to N	0.079	fraction
O_2:Biomass, Respiration	0.575	ratio
O_2:N, Nitrification	4.57	ratio
Detrital Sedimentation Rate	0.6	g/m·d

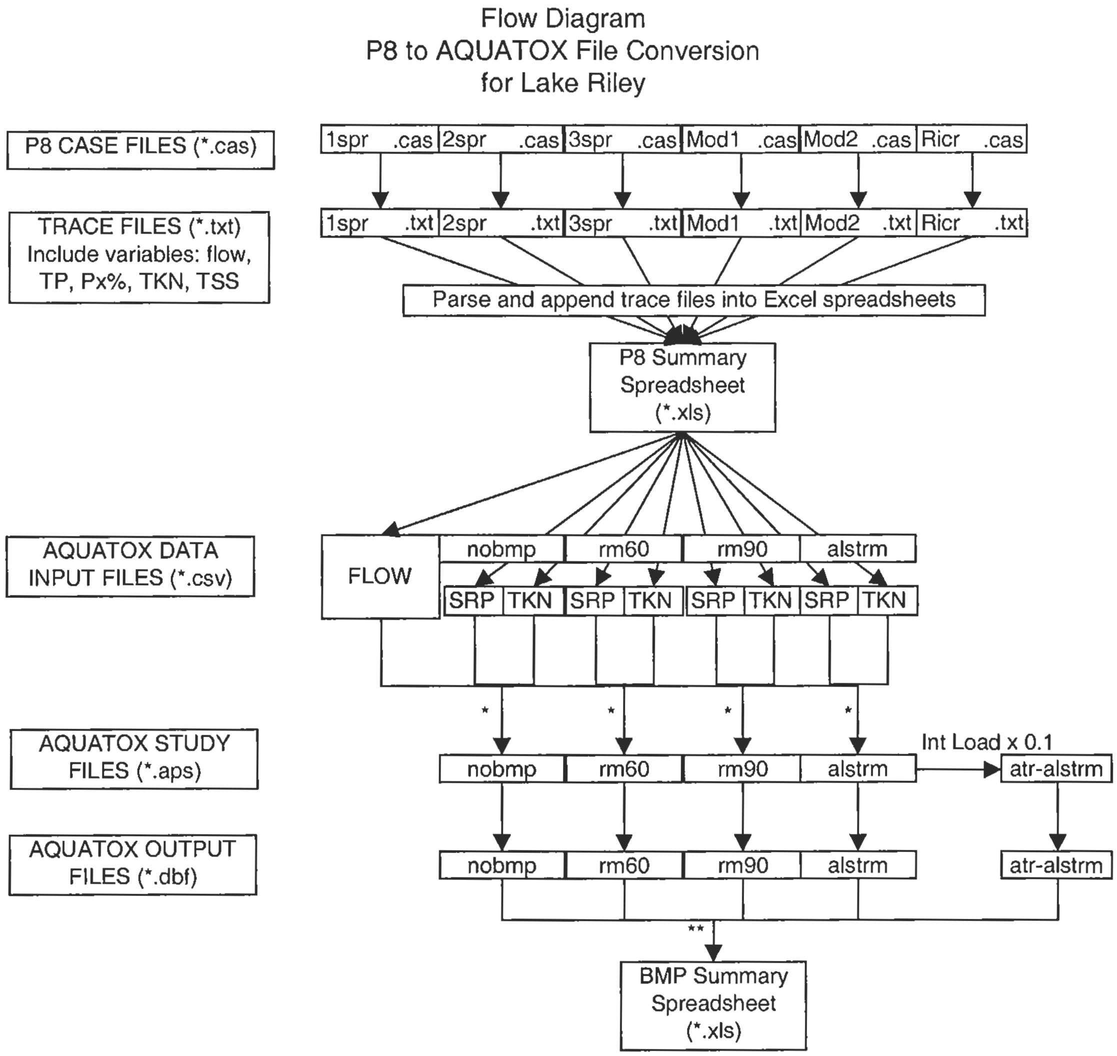
Table D5
Phytoplankton Parameters

Parameter	Units	Greens	Diatoms	Blue-Greens
Saturating Light	Ly/d	150	150	300
P Half-saturation	mg/L	0.002	0.002	0.003
N Half-saturation	mg/L	0.006	0.007	0.56
Inorg. C Half-saturation	mg/L	0.054	0.054	0.024
Temp. Response Slope		2	1.8	2
Optimum Temperature	°C	25	20	30
Maximum Temperature	°C	42	35	41
Min. Adaptation Temp.	°C	15	5	5
Max. Photosynthetic Rate	1/d	1.8	3.1	3.9
Respiration Coefficient	1/d	0.03	0.026	0.02
Mortality Coefficient	frac/d	0.003	0.03	0.001
Exponential Mort. Coeff.	max/d	0.04	0.04	0.2
P: Photosynthate	ratio	0.018	0.018	0.018
N: Photosynthate	ratio	0.079	0.079	0.079
Light Extinction	1/m	0.024	0.144	1
Sedimentation Rate	1/d	0.04	0.3	0.01
Exp. Sedimentation Coeff.		0.693	0.693	0.693

Table D6

Animal Parameters

Parameter	Units	Invertebrate: Daphnia	Forage Fish: Bluegill	Large Game Fish: Walleye
Half Saturation Feeding	mg/L	1	0.25	5
Maximum Consumption	g/g·d	1.2	0.048	0.05
Min. Prey for Feeding	mg/L	0.03	0.3	0.5
Temp. Response Slope		2.4	2.3	2.3
Optimum Temperature	°C	26	22	22
Maximum Temperature	°C	34	33.8	28
Min. Adaptation Temp.	°C	5	2.5	5
Respiration Rate	1/d	0	0.006	0.0035
Specific Dynamic Action	unitless	0.18	0.172	0.172
Excretion:Respiration	ratio	0.17	0.05	0.05
Gametes:Biomass	ratio	0.01	0.09	0.1
Gamete Mortality	1/d	0.0001	0.8	0.85
Mortality Coefficient	max/d	0.002	0.001	0.0001
Carrying Capacity	mg/L	8	0.6	0.5
Tropic Interactions (Preference ratio/Egestion fraction)				
Sed. Refractory Detritus		0/0	0/0	0/0
Sed. Labile Detritus		0/0	0/0	0/0
Particulate Refrac. Detritus		0.09/1	0/1	0/0
Particulate Labile Detritus		0.3/0.3	0/0.6	0/0
Diatoms		0.3/0.3	0/0	0/0
Blue-Greens		0.01/0.7	0/0	0/0
Greens		0.3/0.3	0/0	0/0
Macrophytes		0/0	0.1/0.5	0/0
Detritivorous Invertebrates		0/0	0.64/0.158	0.01/0.158
Herbivorous Invertebrates		0/0	0.21/0.158	0/0
Predatory Invertebrates		0/0	0.35/0.158	0.01/0.158
Forage Fish		0/0	0/0.05	0.33/0.05
Bottom Fish		0/0	0/0	0.33/0.05
Small Game Fish		0/0	0/0	0.33/0.05
Mean age or lifetime	days	14	730	1460
Initial fraction that is lipid	(wet wt)	0.05	0.045	0.05
Mean Weight	g	0.000206	125	280



*-SRP is input for phosphate
*-TKN is input for ammonia (x 0.1), nitrate (x 1.0), detritus (x 16)

** Macro deletes all data except for DATE, PO4, L_PART_DETR, R_PART_DETR, L_DISS_DETR, R_DISS_DETR, B_GREENS, CHL, and SECCHI

Total Phosphorus = PO4 + 0.018*(LPART DETR + RPART DETR + LDISS DETR + RDISS DETR)

Figure D1

Flow Diagram for File Conversions

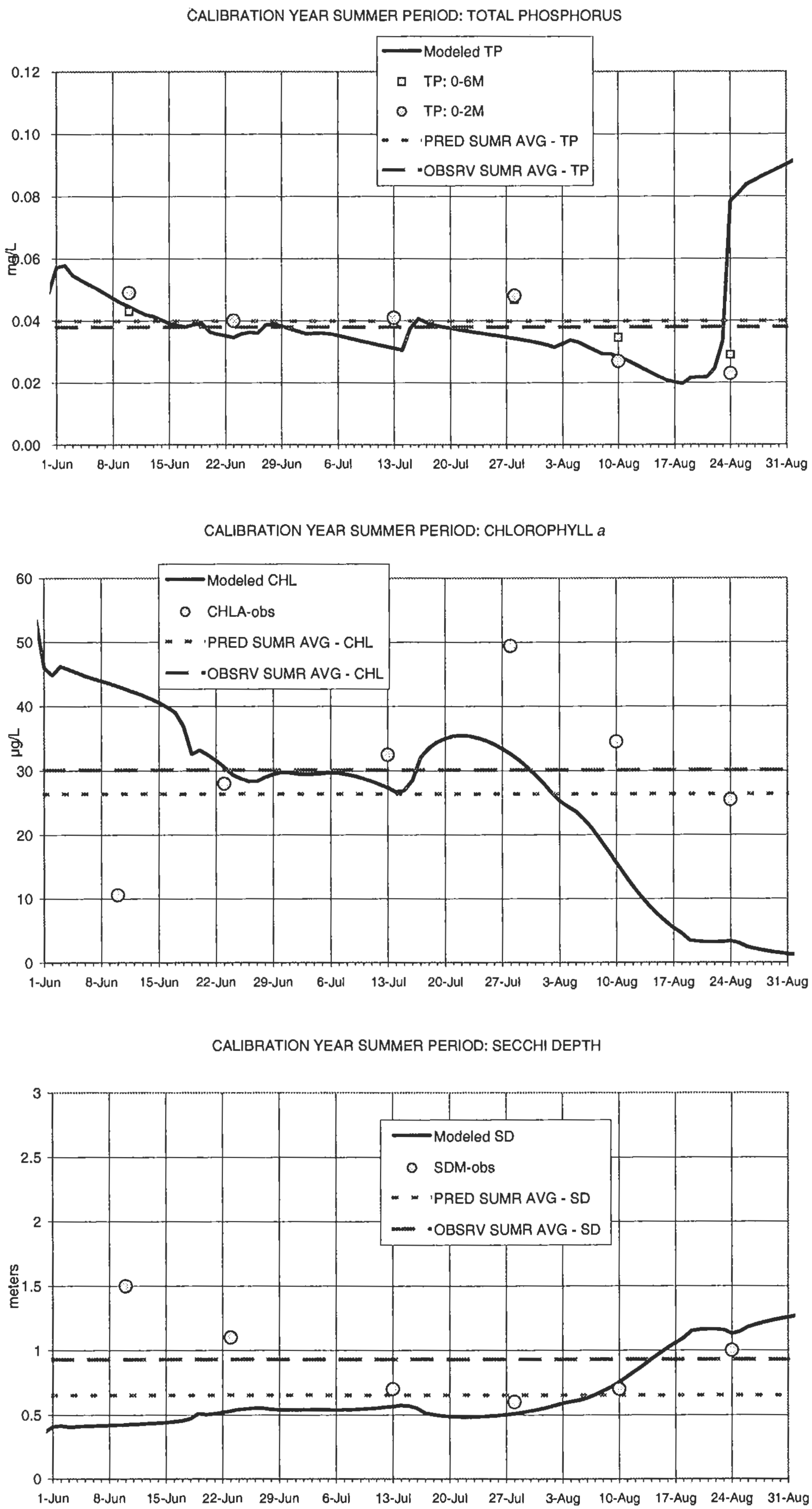
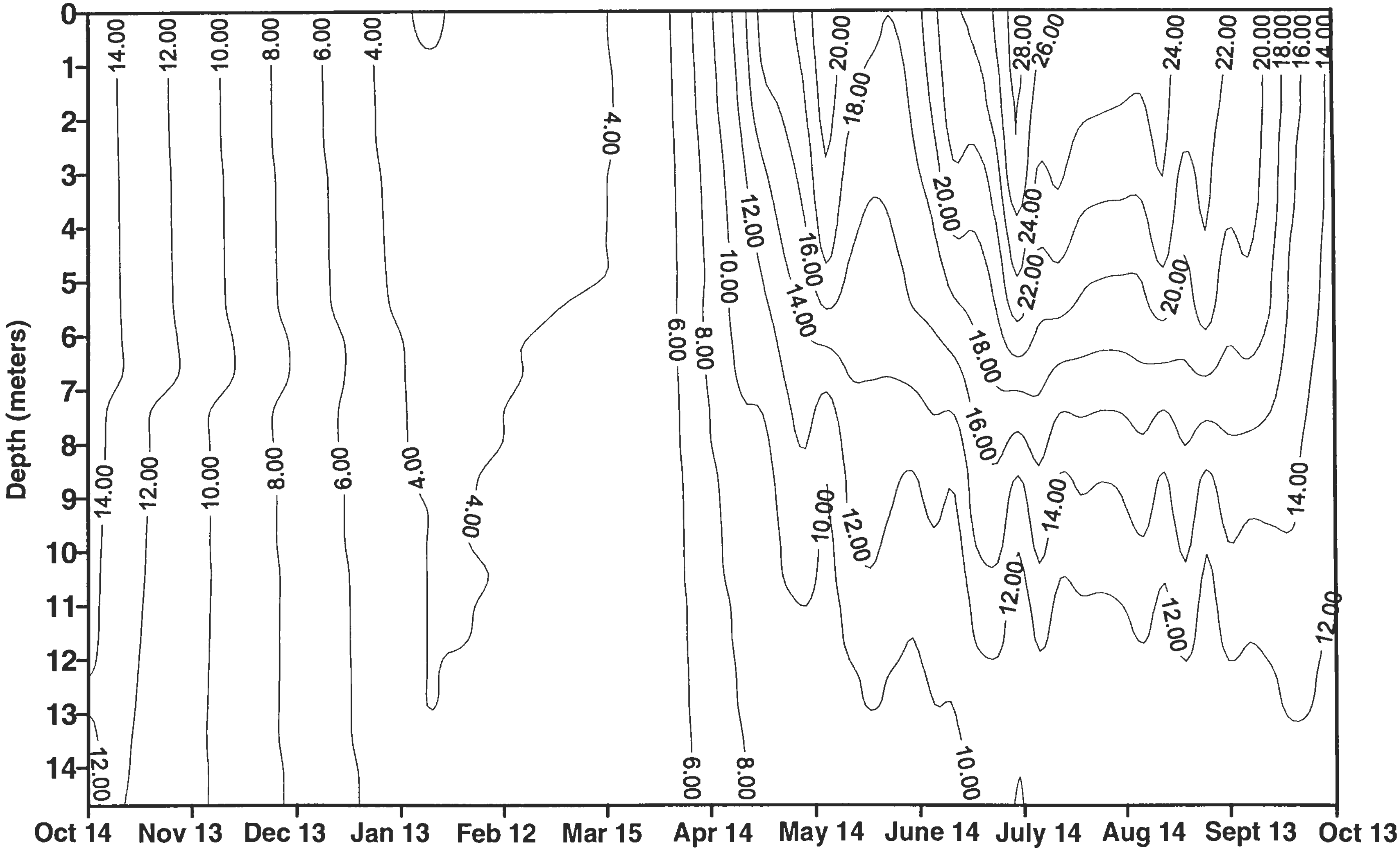


Figure D2
Predicted and Observed Results for Lake Riley Calibration Year Summer Period

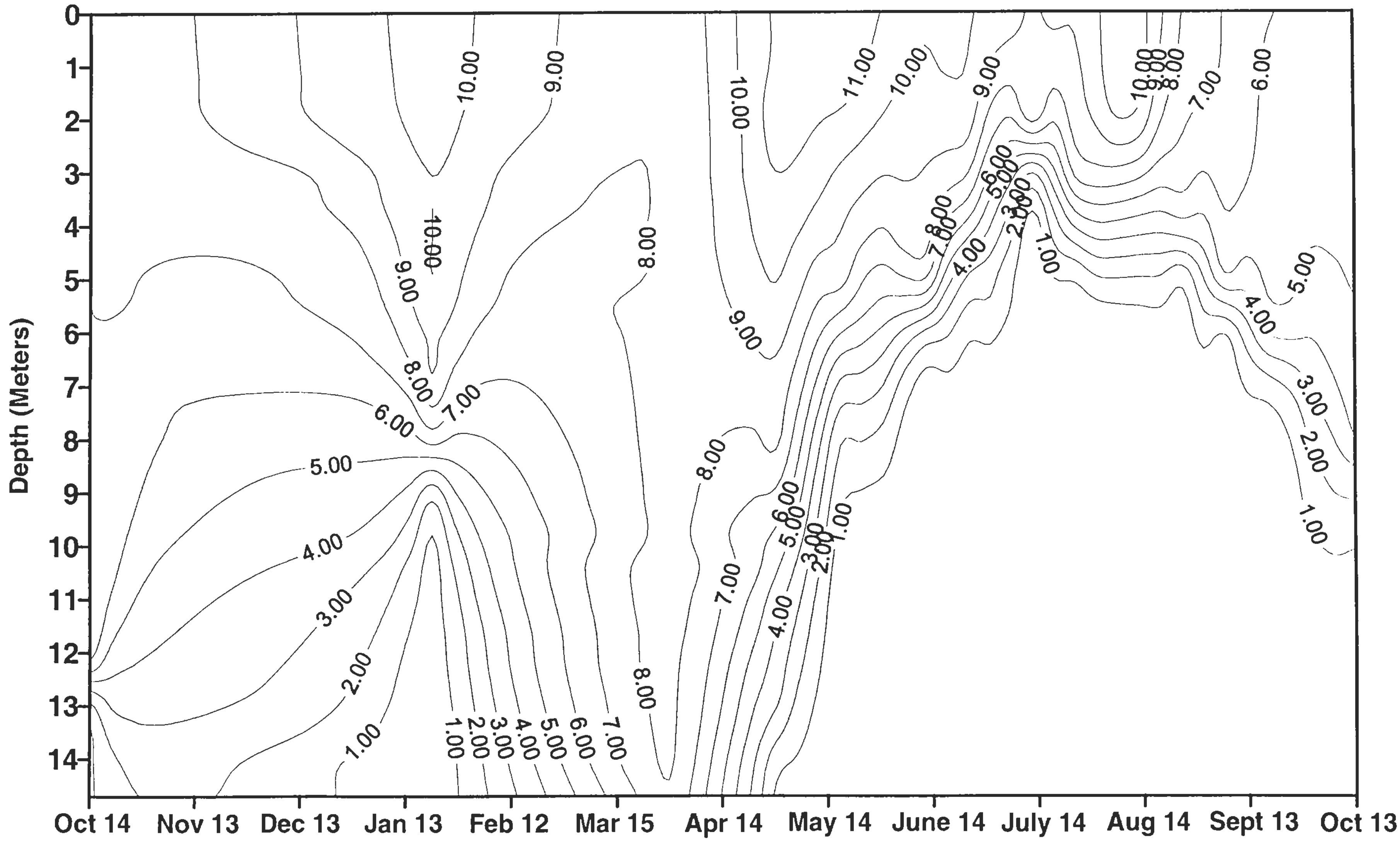
Appendix E

1997-1998 Lake Riley Water Quality and Biological Data Summary

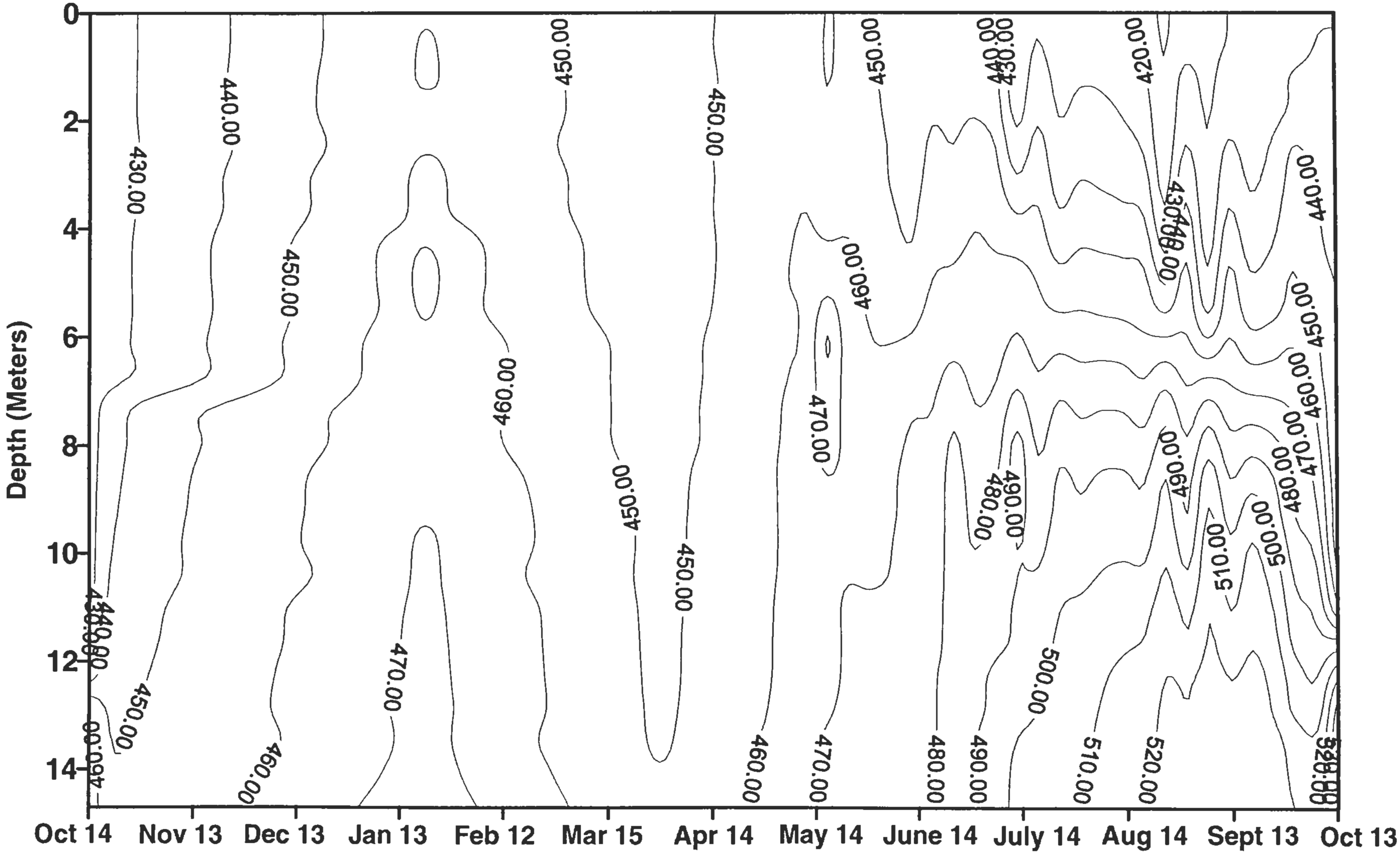
Riley Lake - 1997-1998
Temperature Isotherms (Degrees Celcuis)



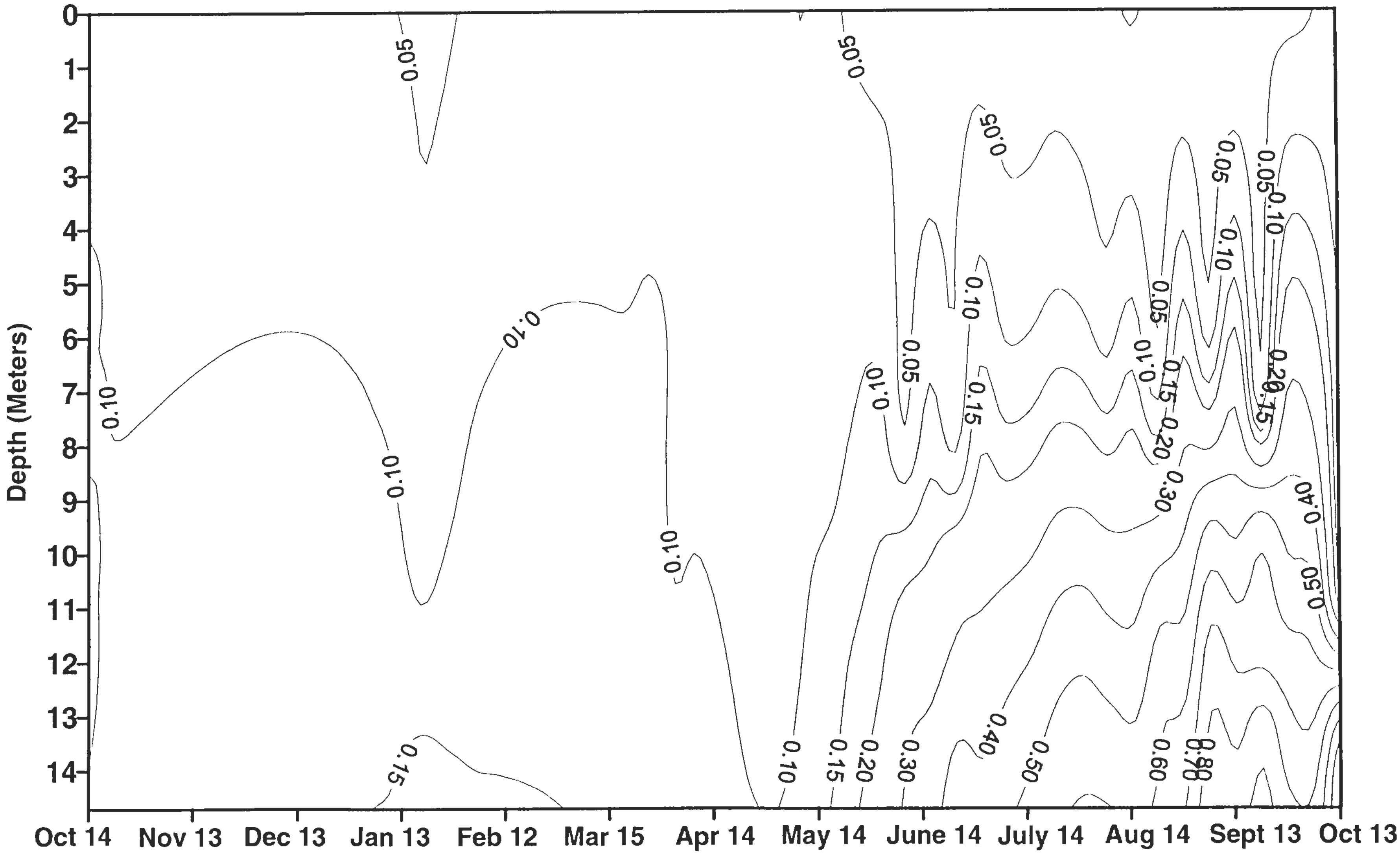
Riley Lake - 1997-1998
Dissolved Oxygen Isopleths (mg/L)



Riley Lake - 1997-1998
Specific Conductance Isopleths (umhos/cm)



Riley Lake - 1997-1998
Total Phosphorous Isopleths (mg/L)



Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (mg/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
10/14/97	13.6	1.0									
			0-2	30.2	--	--	--	0.086	0.048	1.56	8.0
			0.0	--	7.1	15.0	425	--	--	--	--
			1.0	--	7.1	15.0	425	--	--	--	--
			2.0	--	7.1	15.0	425	--	--	--	--
			3.0	--	7.1	15.0	425	0.101	--	--	7.9
			4.0	--	7.1	15.0	425	0.097	--	--	8.0
			5.0	--	7.0	15.0	425	0.108	--	--	7.9
			6.0	--	7.0	15.0	426	0.101	--	--	7.8
			7.0	--	7.0	15.0	426	0.106	--	--	7.9
			8.0	--	7.0	15.0	426	0.101	--	--	7.8
			9.0	--	7.0	15.0	426	0.099	--	--	7.8
			10.0	--	7.0	15.0	426	0.097	--	--	7.8
			11.0	--	7.0	15.0	426	0.097	--	--	7.8
			12.0	--	7.0	15.0	426	0.095	--	--	7.8
			13.1	--	0.9	11.5	466	0.097	--	--	7.8
01/21/98	14.8	5.1									
			0-2	3.3	--	--	--	0.047	0.026	0.80	7.2
			0.0	--	10.5	1.0	459	--	--	--	--
			1.0	--	10.4	2.5	462	--	--	--	--
			2.0	--	10.2	3.0	457	--	--	--	--
			3.0	--	10.0	3.0	462	0.049	--	--	7.3
			4.0	--	10.0	3.0	462	0.055	--	--	7.5
			5.0	--	10.0	3.5	456	0.051	--	--	7.6
			6.0	--	9.1	3.5	462	0.047	--	--	7.6
			7.0	--	9.0	3.5	464	0.045	--	--	7.6
			8.0	--	6.4	3.5	460	0.051	--	--	7.7
			9.0	--	2.2	4.0	466	0.047	--	--	7.7
			10.0	--	0.7	4.0	474	0.070	--	--	7.6
			11.0	--	0.7	4.0	474	0.102	--	--	7.4
			12.0	--	0.6	4.0	476	0.115	--	--	7.3
			13.0	--	0.5	4.0	476	0.121	--	--	7.2
			14.0	--	0.1	4.5	476	0.194	--	--	7.2
			14.3	--	0.1	4.5	476	0.201	--	--	7.2

Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (ug/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
03/31/98	15.0	1.8									
			0-2	11.6	--	--	--	0.096	0.029	1.60	7.1
			0.0	--	8.0	5.0	439	--	--	--	--
			1.0	--	8.1	5.0	444	--	--	--	--
			2.0	--	8.2	5.0	446	--	--	--	--
			3.0	--	8.2	5.0	446	0.087	--	--	7.3
			4.0	--	8.2	5.0	446	0.090	--	--	7.3
			5.0	--	8.2	5.0	446	0.129	--	--	7.3
			6.0	--	8.3	5.0	446	0.107	--	--	7.3
			7.0	--	8.4	5.0	446	0.094	--	--	7.3
			8.0	--	8.4	5.0	446	0.109	--	--	7.3
			9.0	--	8.4	5.0	446	0.087	--	--	7.3
			10.0	--	8.4	5.0	446	0.098	--	--	7.3
			11.0	--	8.3	5.0	446	0.105	--	--	7.3
			12.0	--	8.1	5.0	446	0.101	--	--	7.3
			13.0	--	8.1	5.0	446	0.085	--	--	7.3
			14.0	--	8.1	5.0	450	0.103	--	--	7.3
			14.5	--	8.0	5.0	454	0.116	--	--	7.3
05/01/98	15.2	3.8									
			0-2	20.6	--	--	--	0.076	<0.010	1.45	8.0
			0.0	--	11.2	17.0	455	--	--	--	--
			1.0	--	11.1	17.0	455	--	--	--	--
			2.0	--	11.8	15.5	456	--	--	--	--
			3.0	--	11.0	13.5	460	0.054	--	--	8.2
			4.0	--	10.5	13.0	457	0.049	--	--	8.2
			5.0	--	10.1	12.5	456	0.058	--	--	8.1
			6.0	--	9.4	11.0	464	0.085	--	--	8.0
			7.0	--	8.5	10.5	457	0.090	--	--	8.0
			8.0	--	8.4	9.5	461	0.051	--	--	7.9
			9.0	--	6.8	9.0	458	0.035	--	--	7.7
			10.0	--	5.5	9.0	457	0.045	--	--	7.6
			11.0	--	4.2	9.0	457	0.058	--	--	7.5
			12.0	--	3.5	9.0	459	0.065	--	--	7.4
			13.0	--	3.1	9.0	459	0.063	--	--	7.3
			14.0	--	1.2	8.5	464	0.090	--	--	7.2
			14.7	--	0.5	8.5	464	0.099	--	--	7.2

Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (ug/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
05/19/98	14.5	0.9									
			0-2	53.6	--	--	--	0.062	<0.010	1.54	8.7
			0.0	--	12.0	21.5	450	--	--	--	--
			1.0	--	11.8	21.0	448	--	--	--	--
			2.0	--	10.8	20.5	452	--	--	--	--
			3.0	--	9.8	20.0	452	0.053	--	--	8.6
			4.0	--	9.0	19.0	459	0.065	--	--	8.5
			5.0	--	8.5	18.0	462	0.044	--	--	8.4
			6.0	--	6.0	14.5	488	0.055	--	--	8.3
			7.0	--	3.6	12.0	474	0.047	--	--	7.8
			8.0	--	2.0	10.0	476	0.094	--	--	7.5
			9.0	--	1.2	10.0	465	0.084	--	--	7.3
			10.0	--	0.5	9.5	468	0.111	--	--	7.2
			11.0	--	0.2	9.5	466	0.145	--	--	7.1
			12.0	--	0.1	9.0	466	0.136	--	--	7.1
			13.0	--	0.1	9.0	470	0.132	--	--	7.1
			14.0	--	0.1	9.0	473	0.143	--	--	7.0
06/10/98	14.5	1.5									
			0-2	10.6	--	--	--	0.049	<0.010	1.2	8.4
			0.0	--	10.0	18.0	441	--	--	--	--
			1.0	--	10.0	18.0	441	--	--	--	--
			2.0	--	9.4	17.5	443	--	--	--	--
			3.0	--	9.0	17.5	443	0.043	--	--	8.3
			4.0	--	8.9	17.5	443	0.041	--	--	8.3
			5.0	--	8.9	17.5	443	0.039	--	--	8.2
			6.0	--	2.2	16.0	458	0.043	--	--	8.1
			7.0	--	0.2	13.5	477	0.035	--	--	8.0
			8.0	--	0.2	11.5	480	0.041	--	--	7.8
			9.0	--	0.2	10.5	472	0.123	--	--	7.6
			10.0	--	0.1	10.0	473	0.177	--	--	7.4
			11.0	--	0.1	9.5	474	0.220	--	--	7.3
			12.0	--	0.1	9.5	474	0.267	--	--	7.1
			13.0	--	0.1	9.5	474	0.296	--	--	7.0
			14.0	--	0.1	9.5	474	0.304	--	--	7.0

P:\23\27\053\LAKES98\RILEY98\97-98DAT.WB2

Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (ug/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
06/23/98	14.5	1.1									
			0-2	28.0	--	--	--	0.040	<0.010	1.15	8.7
			0.0	--	10.1	23.5	441	--	--	--	--
			1.0	--	10.2	23.0	446	--	--	--	--
			2.0	--	9.8	23.0	446	--	--	--	--
			3.0	--	8.6	22.5	450	0.035	--	--	8.5
			4.0	--	6.2	21.0	455	0.051	--	--	8.4
			5.0	--	2.8	18.0	462	0.044	--	--	8.3
			6.0	--	1.2	17.0	458	0.033	--	--	8.2
			7.0	--	0.5	14.5	478	0.042	--	--	7.7
			8.0	--	0.2	12.0	494	0.038	--	--	7.6
			9.0	--	0.2	10.5	486	0.117	--	--	7.5
			10.0	--	0.1	10.5	480	0.293	--	--	7.3
			11.0	--	0.1	10.0	483	0.307	--	--	7.2
			12.0	--	0.1	10.0	479	0.261	--	--	7.2
			13.0	--	0.1	10.0	479	0.375	--	--	7.1
			14.0	--	0.1	9.5	484	0.452	--	--	7.1
07/13/98	14.5	0.7									
			0-2	32.5	--	--	--	0.041	<0.010	1.23	8.5
			0.0	--	8.9	28.5	423	--	--	--	--
			1.0	--	8.8	28.5	423	--	--	--	--
			2.0	--	8.8	28.0	428	--	--	--	--
			3.0	--	3.0	28.0	440	0.043	--	--	8.5
			4.0	--	0.2	25.5	454	0.041	--	--	8.0
			5.0	--	0.2	24.0	465	0.039	--	--	7.8
			6.0	--	0.2	21.5	470	0.032	--	--	7.7
			7.0	--	0.2	18.0	480	0.032	--	--	7.5
			8.0	--	0.1	15.5	494	0.049	--	--	7.5
			9.0	--	0.1	13.0	494	0.177	--	--	7.3
			10.0	--	0.1	12.0	489	0.354	--	--	7.3
			11.0	--	0.1	11.0	491	0.391	--	--	7.2
			12.0	--	0.1	10.5	491	0.381	--	--	7.2
			13.0	--	0.1	10.5	498	0.444	--	--	7.2
			14.0	--	0.1	10.0	503	0.527	--	--	7.3

Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (ug/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
07/28/98	14.5	0.6									
			0-2	49.4	--	--	--	0.048	<0.010	1.29	7.8
			0.0	--	9.0	26.0	419	--	--	--	--
			1.0	--	9.0	25.5	426	--	--	--	--
			2.0	--	9.0	25.5	426	--	--	--	--
			3.0	--	8.8	25.5	426	0.054	--	--	7.8
			4.0	--	4.7	25.5	426	0.046	--	--	7.8
			5.0	--	0.5	23.5	439	0.044	--	--	7.8
			6.0	--	0.2	19.0	474	0.042	--	--	7.1
			7.0	--	0.2	15.5	492	0.054	--	--	6.6
			8.0	--	0.2	13.0	502	0.124	--	--	6.5
			9.0	--	0.2	12.0	494	0.269	--	--	6.4
			10.0	--	0.1	11.0	499	0.459	--	--	6.4
			11.0	--	0.1	10.5	504	0.456	--	--	6.4
			12.0	--	0.1	10.5	504	0.542	--	--	6.4
			13.0	--	0.1	10.5	504	0.614	--	--	6.4
			14.0	--	0.1	10.0	510	0.608	--	--	6.4
08/10/98	14.5	0.7									
			0-2	34.5	--	--	--	0.027	<0.010	1.33	8.6
			0.0	--	10.6	26.5	427	--	--	--	--
			1.0	--	11.3	25.0	421	--	--	--	--
			2.0	--	10.8	24.5	424	--	--	--	--
			3.0	--	8.0	23.5	427	0.029	--	--	8.5
			4.0	--	4.7	22.5	430	0.031	--	--	8.6
			5.0	--	1.5	22.0	440	0.029	--	--	8.2
			6.0	--	0.2	20.0	461	0.057	--	--	7.9
			7.0	--	0.2	15.0	502	0.065	--	--	7.6
			8.0	--	0.1	13.5	491	0.122	--	--	7.3
			9.0	--	0.1	12.0	500	0.281	--	--	7.0
			10.0	--	0.1	11.5	506	0.368	--	--	7.1
			11.0	--	0.1	11.0	507	0.356	--	--	7.0
			12.0	--	0.1	10.5	511	0.445	--	--	7.0
			13.0	--	0.1	10.5	514	0.538	--	--	6.9
			14.0	--	0.1	10.5	518	0.591	--	--	7.0

Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (ug/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
08/24/98	14.5	1.0									
			0-2	25.5	--	--	--	0.023	<0.010	1.24	8.3
			0.0	--	8.1	25.0	408	--	--	--	--
			1.0	--	8.0	25.0	410	--	--	--	--
			2.0	--	7.3	25.0	410	--	--	--	--
			3.0	--	6.8	25.0	410	0.027	--	--	8.4
			4.0	--	5.3	24.5	409	0.023	--	--	8.3
			5.0	--	0.5	23.0	426	0.045	--	--	8.3
			6.0	--	0.2	20.0	461	0.027	--	--	8.1
			7.0	--	0.2	15.5	498	0.055	--	--	7.9
			8.0	--	0.2	14.5	496	0.128	--	--	7.8
			9.0	--	0.2	12.5	510	0.286	--	--	7.7
			10.0	--	0.2	12.0	508	0.356	--	--	7.6
			11.0	--	0.2	11.0	519	0.553	--	--	7.5
			12.0	--	0.2	11.0	519	0.531	--	--	7.4
			13.0	--	0.2	10.5	524	0.664	--	--	7.3
			14.0	--	0.2	10.5	524	0.589	--	--	7.3
09/08/98	14.5	1.6									
			0-2	11.6	--	--	--	0.027	<0.010	1.06	7.8
			0.0	--	6.8	23.5	417	--	--	--	--
			1.0	--	6.9	23.0	416	--	--	--	--
			2.0	--	6.7	22.5	420	--	--	--	--
			3.0	--	6.5	22.5	420	0.035	--	--	8.0
			4.0	--	5.9	22.5	420	0.025	--	--	8.0
			5.0	--	5.5	22.0	424	0.023	--	--	7.9
			6.0	--	0.6	21.0	433	0.037	--	--	7.3
			7.0	--	0.4	17.0	493	0.122	--	--	7.1
			8.0	--	0.2	15.0	496	0.190	--	--	6.8
			9.0	--	0.2	12.0	520	0.571	--	--	6.8
			10.0	--	0.2	11.5	519	0.531	--	--	6.7
			11.0	--	0.2	11.0	521	0.738	--	--	6.7
			12.0	--	0.2	11.0	521	0.788	--	--	6.7
			13.0	--	0.2	10.5	527	0.818	--	--	6.7
			14.0	--	0.2	10.5	531	0.886	--	--	6.7

Riley Lake

Date	Max. Depth (M)	Secchi Disc (M)	Sample Depth (M)	Chl a (ug/L)	D.O. (mg/L)	Temp. (C)	Specific Cond. umho/cm @ 25 C)	Total P (ug/L)	Soluble Reactive P (mg/L)	Total N (mg/L)	pH (Std. Units)
09/22/98	14.5	1.0									
			0-2	19.2	--	--	--	0.040	<0.010	1.31	7.1
			0.0	--	6.0	20.5	423	--	--	--	--
			1.0	--	5.6	21.0	421	--	--	--	--
			2.0	--	5.6	21.0	422	--	--	--	--
			3.0	--	5.5	21.0	422	0.036	--	--	7.3
			4.0	--	5.5	21.0	423	0.038	--	--	7.2
			5.0	--	5.5	21.0	423	0.032	--	--	7.2
			6.0	--	5.5	21.0	423	0.046	--	--	7.2
			7.0	--	0.8	17.5	454	0.046	--	--	7.1
			8.0	--	0.5	14.0	521	0.152	--	--	6.8
			9.0	--	0.3	14.0	521	0.476	--	--	6.6
			10.0	--	0.2	12.0	520	0.620	--	--	6.3
			11.0	--	0.2	11.5	526	0.636	--	--	6.3
			12.0	--	0.2	11.0	525	0.645	--	--	6.3
			13.0	--	0.2	11.0	525	0.851	--	--	6.3
			14.0	--	0.2	11.0	525	0.905	--	--	6.3
10/14/98	14.5	1.2									
			0-2	18.6	--	--	--	0.082	0.030	1.67	7.7
			0.0	--	5.8	13.5	428	--	--	--	--
			1.0	--	5.5	13.5	435	--	--	--	--
			2.0	--	5.4	13.5	435	--	--	--	--
			3.0	--	5.4	13.5	435	0.081	--	--	7.8
			4.0	--	5.2	13.5	435	0.086	--	--	7.8
			5.0	--	5.1	13.5	440	0.098	--	--	7.8
			6.0	--	4.8	13.5	440	0.100	--	--	7.8
			7.0	--	4.7	13.5	440	0.111	--	--	7.8
			8.0	--	4.0	13.5	440	0.104	--	--	7.8
			9.0	--	2.2	13.0	444	0.104	--	--	7.8
			10.0	--	1.0	13.0	444	0.116	--	--	7.8
			11.0	--	0.5	11.5	462	0.159	--	--	7.7
			12.0	--	0.3	11.0	512	0.535	--	--	7.4
			13.0	--	0.2	11.0	538	0.900	--	--	7.3
			14.0	--	0.2	11.0	538	1.107	--	--	7.1

RILEY LAKE PHYTOPLANKTON COUNT (UNITS/ML)

SAMPLE: 0-2 METERS (INT. TUBE)
STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	10/14/97 units/mL	01/21/98 units/mL	03/31/98 units/mL	05/01/98 units/mL	05/19/98 units/mL	06/10/98 units/mL	06/23/98 units/mL	07/13/98 units/mL	07/28/98 units/mL	08/10/98 units/mL	08/24/98 units/mL	09/08/98 units/mL	09/22/98 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Actinastrum Hantzschii*	0	0	0	0	0	0	21	0	0	0	0	0	0
	Ankistrodesmus falcatus	0	0	0	0	0	0	0	42	78	0	0	0	0
	Carteria sp.	0	0	0	0	0	0	0	0	0	126	0	39	0
	Chlamydomonas globosa	611	0	4,720	42	253	337	1,622	1,770	1,640	506	78	664	2,108
	Closterium sp.	42	0	0	0	0	42	21	42	78	0	39	0	0
	Cosmarium sp.	0	0	42	0	0	0	21	0	0	0	0	0	0
	Elakatothrix gelatinosa	0	0	0	0	0	0	63	0	156	0	0	0	39
	Oocystis parva	0	0	0	0	0	84	42	0	0	0	0	39	0
	Oocystis sp.	21	0	0	0	84	0	0	0	0	0	0	0	0
	Pandorina morum	0	0	21	0	0	169	0	0	0	0	0	0	0
	Quadrigula sp.	0	0	0	0	0	0	0	0	0	0	0	78	0
	Pediastrum duplex v. clathratum	0	0	0	0	0	21	0	0	0	0	0	0	0
	Rhizoclonium hieroglyphicum	0	0	0	0	0	0	63	84	78	253	0	0	0
	Schroederia Judayi	0	0	0	190	128	63	527	42	78	0	0	0	0
	Selenastrum minutum	0	0	21	0	0	0	0	42	0	0	0	0	0
	Sphaerocystis Schroeteri (Colony)	0	0	21	0	0	0	0	0	0	0	0	0	0
	Selenastrum sp.	0	0	0	0	0	0	42	0	0	0	0	0	0
	Staurastrum sp.	0	0	0	0	0	0	42	0	78	0	0	0	0
	Unidentified Green Flagellate													
	CHLOROPHYTA TOTAL	**674**	**0**	**4,825**	**232**	**464**	**716**	**2,465**	**2,023**	**2,186**	**885**	**117**	**820**	**2,147**
CHRYSOPHYTA (GOLDEN-BROWN AI	*Dinobryon sociale*	0	0	84	0	0	0	0	42	0	0	0	0	0
	CHRYSOPHYTA TOTAL	**0**	**0**	**84**	**0**	**0**	**0**	**0**	**42**	**0**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE	*Anabaena affinis*	63	0	0	0	42	737	126	2,233	1,249	759	156	273	429
	Anabaena flos-aquae	0	0	0	0	84	274	274	126	312	253	0	0	0
	Anabaenopsis raciborski	0	0	0	0	0	0	0	2,149	23,346	47,913	20,964	11,204	15,616
	Aphanizomenon flos-aquae	10,809	632	927	12,515	37,209	5,963	7,417	8,891	10,541	8,596	2,967	2,694	2,186
	Coelosphaerium Naegelianum	0	0	0	0	0	0	379	0	78	0	0	0	117
	Lyngbya sp.	0	0	0	0	0	21	0	0	0	0	0	0	0
	Merismopedia tenuissima	0	0	0	0	0	0	0	674	78	0	0	0	0
	Microcystis aeruginosa	42	0	126	0	211	0	105	337	156	0	39	39	0
	Microcystis incerta	0	0	0	0	0	42	21	253	0	0	0	0	0
	Oscillatoria Agardhii	0	0	0	0	0	0	0	5,099	6,403	2,276	156	156	351
	Oscillatoria limnetica	0	0	358	0	0	0	1,370	801	2,186	1,896	508	0	0
	Oscillatoria redekii	21	0	0	0	0	0	0	0	0	0	0	0	0
	CYANOPHYTA TOTAL	**10,935**	**632**	**1,412**	**12,515**	**37,546**	**7,037**	**9,692**	**20,564**	**44,349**	**61,692**	**24,790**	**14,367**	**18,700**
BACILLARIOPHYTA (DIATOMS)	*Asterionella formosa*	42	0	0	0	0	0	0	0	0	0	0	0	0
	Melosira granulata	63	0	0	0	0	0	0	0	0	0	39	0	0
	Navicula sp.	21	0	21	0	0	21	0	0	0	0	0	0	0
	Rhizosolenia sp.	0	0	0	0	0	0	0	0	78	0	0	0	0
	Stephanodiscus Hantzschii	0	0	969	0	0	0	0	0	0	0	0	0	0
	Stephanodiscus sp.	232	0	63	0	0	0	0	0	0	0	0	0	0
	Synedra ulna	21	0	21	0	0	0	0	0	0	0	0	0	78
	BACILLARIOPHYTA TOTAL	**379**	**0**	**1,075**	**0**	**0**	**21**	**0**	**0**	**78**	**0**	**39**	**0**	**78**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	232	716	3,455	548	169	464	7,332	1,770	625	1,138	312	390	1,444
	CRYPTOPHYTA TOTAL	**232**	**716**	**3,455**	**548**	**169**	**464**	**7,332**	**1,770**	**625**	**1,138**	**312**	**390**	**1,444**
EUGLENOPHYTA (EUGLENOIDS)	*Phacus sp.*	0	0	0	0	0	0	0	42	0	0	0	0	0
	EUGLENOPHYTA TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**42**	**0**	**0**	**0**	**0**	**0**
PYRRHOPHYTA (DINOFLAGELLATES	*Ceratium hirundinella*	21	0	0	0	42	21	253	84	0	0	0	39	0
	Peridinium cinctum	0	0	0	0	0	21	0	0	0	0	0	0	0
	PYRRHOPHYTA TOTAL	**21**	**0**	**0**	**0**	**42**	**42**	**253**	**84**	**0**	**0**	**0**	**39**	**0**
	TOTALS	**12,242**	**1,348**	**10,851**	**13,295**	**38,221**	**8,280**	**19,742**	**24,525**	**47,238**	**63,715**	**25,259**	**15,616**	**22,370**

RILEY LAKE PHYTOPLANKTON VOLUME (MM3/M3)

SAMPLE: 0-2 METERS (INT. TUBE)
STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	10/14/97 MM3/M3	01/21/98 MM3/M3	03/31/98 MM3/M3	05/01/98 MM3/M3	05/19/98 MM3/M3	06/10/98 MM3/M3	06/23/98 MM3/M3	07/13/98 MM3/M3	07/28/98 MM3/M3	08/10/98 MM3/M3	08/24/98 MM3/M3	09/08/98 MM3/M3	09/22/98 MM3/M3
CHLOROPHYTA (GREEN ALGAE)	*Actinastrum Hantzschii*	0	0	0	0	0	0	4	0	0	0	0	0	0
	Ankistrodesmus falcatus	0	0	0	0	0	0	0	3	5	0	0	0	0
	Carteria sp.	0	0	0	0	0	0	0	0	0	38	0	12	0
	Chlamydomonas globosa	177	0	1,364	12	73	97	469	511	474	146	23	192	609
	Closterium sp.	59	0	0	0	0	59	29	59	109	0	55	0	0
	Cosmarium sp.	0	0	148	0	0	0	74	0	0	0	0	0	0
	Elakatothrix gelatinosa	0	0	0	0	0	0	9	0	23	0	0	0	6
	Oocystis parva	0	0	0	0	0	116	58	0	0	0	0	54	0
	Oocystis sp.	29	0	0	0	116	0	0	0	0	0	0	0	0
	Pandorina morum	0	0	11	0	0	88	0	0	0	0	0	0	0
	Quadrigula sp.	0	0	0	0	0	0	0	0	0	0	0	6	0
	Pediastrum duplex v. clathratum	0	0	0	0	0	89	0	0	0	0	0	0	0
	Rhizoclonium hieroglyphicum	0	0	0	0	0	0	0	0	0	0	0	0	0
	Schroederia Judayi	0	0	0	48	32	16	133	11	20	0	0	0	0
	Selenastrum minutum	0	0	0	0	0	0	0	1	0	0	0	0	0
	Sphaerocystis Schroeteri (Colony)	0	0	20	0	0	0	0	0	0	0	0	0	0
	Selenastrum sp.	0	0	0	0	0	0	1	0	0	0	0	0	0
	Staurastrum sp.	0	0	0	0	0	0	40	0	75	0	0	0	0
	Unidentified Green Flagellate													
	CHLOROPHYTA TOTAL	**264**	**0**	**1,543**	**60**	**221**	**465**	**817**	**585**	**706**	**184**	**77**	**263**	**615**
CHRYSOPHYTA (GOLDEN-BROWN ALGA	*Dinobryon sociale*	0	0	296	0	0	0	0	79	0	0	0	0	0
	CHRYSOPHYTA TOTAL	**0**	**0**	**296**	**0**	**0**	**0**	**0**	**79**	**0**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	515	0	0	0	343	6,006	1,030	18,189	10,174	6,177	1,272	2,226	3,497
	Anabaena flos-aquae	0	0	0	0	294	956	956	441	1,090	883	0	0	0
	Anabaenopsis raciborski	0	0	0	0	0	0	0	3,439	37,353	76,660	33,543	17,927	24,986
	Aphanizomenon flos-aquae	17,683	1,034	1,517	20,475	60,874	9,755	12,134	14,546	17,245	14,064	4,854	4,407	3,577
	Coelosphaerium Naegelianum	0	0	0	0	0	0	5,889	0	1,212	0	0	0	1,819
	Lyngbya sp.	0	0	0	0	0	3,891	0	0	0	0	0	0	0
	Merismopedia tenuissima	0	0	0	0	0	0	0	27	3	0	0	0	0
	Microcystis aeruginosa	1,440	0	4,320	0	7,200	0	3,600	11,520	5,336	0	1,334	1,334	0
	Microcystis incerta	0	0	0	0	0	131	65	785	0	0	0	0	0
	Oscillatoria Agardhii	0	0	0	0	0	0	0	17,591	22,089	7,851	539	539	1,212
	Oscillatoria limnetica	0	0	45	0	0	0	174	102	278	241	64	0	0
	Oscillatoria redekii	4	0	0	0	0	0	0	0	0	0	0	0	0
	CYANOPHYTA TOTAL	**19,642**	**1,034**	**5,882**	**20,475**	**68,712**	**20,739**	**23,847**	**66,640**	**94,781**	**105,876**	**41,606**	**26,433**	**35,090**
BACILLARIOPHYTA (DIATOMS)	*Asterionella formosa*	31	0	0	0	0	0	0	0	0	0	0	0	0
	Melosira granulata	107	0	0	0	0	36	0	0	0	0	66	0	0
	Navicula sp.	88	0	88	0	0	88	0	0	0	0	0	0	0
	Rhizosolenia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
	Stephanodiscus Hantzschii	0	0	401	0	0	0	0	0	0	0	0	0	0
	Stephanodiscus sp.	4,530	0	1,235	0	0	0	0	0	0	0	0	0	0
	Synedra ulna	3	0	3	0	0	0	0	0	0	0	0	0	11
	BACILLARIOPHYTA TOTAL	**4,759**	**0**	**1,727**	**0**	**0**	**124**	**0**	**0**	**0**	**0**	**66**	**0**	**11**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	684	2,115	10,204	1,618	498	1,369	21,652	5,226	1,845	3,360	922	1,153	4,266
	CRYPTOPHYTA TOTAL	**684**	**2,115**	**10,204**	**1,618**	**498**	**1,369**	**21,652**	**5,226**	**1,845**	**3,360**	**922**	**1,153**	**4,266**
EUGLENOPHYTA (EUGLENOIDS)	*Phacus sp.*	0	0	0	0	0	0	0	72	0	0	0	0	0
	EUGLENOPHYTA TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**72**	**0**	**0**	**0**	**0**	**0**
PYRRHOPHYTA (DINOFLAGELLATES)	*Ceratium hirundinella*	576	0	0	0	1,152	576	6,912	2,304	0	0	0	1,067	0
	Peridinium cinctum	0	0	0	0	0	1,932	0	0	0	0	0	0	0
	PYRRHOPHYTA TOTAL	**576**	**0**	**0**	**0**	**1,152**	**2,508**	**6,912**	**2,304**	**0**	**0**	**0**	**1,067**	**0**
	TOTALS	**25,925**	**3,150**	**19,652**	**22,153**	**70,583**	**25,205**	**53,229**	**74,905**	**97,331**	**109,420**	**42,672**	**28,916**	**39,982**

ZOOPLANKTON COUNT (#/sq. meter)

LAKE: **Riley**

DIVISION TAXON	SAMPLE DATE 01/21/98	03/31/98	05/01/98	05/19/98	06/10/98	06/23/98	07/13/98	07/28/98	08/10/98	08/24/98	09/08/98	09/22/98	10/14/98
CLADOCERA													
Daphnia galeata mendotae	9,908	7,615	54,727	16,285	4,100	1,683	385	9,135	13,231	17,000	12,438	2,437	9,350
Daphnia pulicaria	1,415	0	8,585	2,527	1,892	3,365	769	0	0	327	0	348	0
Daphnia retrocurva	0	0	0	0	0	0	0	731	331	0	754	348	1,079
Bosmina sp.	0	0	1,431	842	1,262	1,010	385	365	6,615	981	3,392	0	1,438
Chydorus sp.	0	1,142	1,788	1,404	1,577	2,019	0	0	0	0	754	0	0
Diaphanosoma sp.	0	0	0	562	1,892	0	3,462	6,212	6,285	3,596	754	0	719
Leptodora sp.	0	0	0	0	0	0	0	0	0	327	0	0	0
Total Cladocera	11,323	8,758	66,531	21,619	10,723	8,077	5,000	16,442	26,462	22,231	18,092	3,133	12,587
COPEPODA													
Nauplii	32,200	106,615	98,723	9,827	23,338	12,788	9,615	28,500	24,146	15,692	2,262	11,487	12,227
Cyclops sp.	14,154	14,850	129,842	24,427	2,523	2,356	3,077	1,827	992	981	1,131	7,658	21,937
Mesocyclops sp.	354	0	0	281	1,577	3,365	5,000	4,019	1,323	2,288	754	1,392	2,517
Diaptomus sp.	3,892	9,900	12,519	9,265	1,262	1,683	11,154	5,115	18,192	9,481	754	5,221	16,902
Total Copepoda	50,600	131,365	241,085	43,800	28,700	20,192	28,846	39,462	44,654	28,442	4,900	25,758	53,583
ROTIFERA													
Keratella cochlearis	344,292	14,850	205,315	30,323	12,300	25,577	22,692	23,019	45,977	22,885	17,338	47,687	223,321
Keratella quadrata	6,015	16,754	435,669	22,181	4,731	1,346	385	0	0	0	0	0	0
Asplanchna sp.	354	762	21,104	1,404	315	0	0	0	0	0	0	0	0
Kellicottia sp.	20,877	6,473	66,531	13,758	0	1,010	769	4,019	2,977	981	1,508	2,088	27,690
Polyarthra vulgaris	354	1,523	40,419	0	0	0	769	1,096	3,638	3,269	377	2,437	9,710
Conochilus sp.	0	0	358	0	48,885	11,779	58,846	10,231	64,500	9,154	9,423	27,846	2,877
Trichocerca sp.	0	0	0	0	2,523	1,010	0	0	0	0	1,508	1,044	0
Filinia sp.	0	762	7,512	1,965	2,838	0	1,923	15,712	8,931	0	0	0	0
Brachionus sp.	0	0	0	0	0	0	385	2,558	5,623	6,212	0	3,133	8,631
Lecane sp.	0	0	0	0	0	0	0	0	0	327	0	0	0
Total Rotifera	371,892	41,123	776,908	69,631	71,592	40,721	85,769	56,635	131,646	42,827	30,154	84,235	272,229
TOTAL ZOOPLANKTON	433,815	181,246	1,084,523	135,050	111,015	68,990	119,615	112,538	202,762	93,500	53,146	113,125	338,398