US Army Corps of Engineers

ENVIRONMENTAL & WATER QUALITY
OPERATIONAL STUDIES

TECHNICAL REPORT E-81-9

EMPIRICAL METHODS FOR PREDICTING EUTROPHICATION IN IMPOUNDMENTS

Report 2

PHASE II: MODEL TESTING

by

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September 1982

Report 2 of a Series

Approved For Public Release; Distribution Unlimited

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under Contract DACW39-78-C-0053
(EWQOS Work Unit IE)

Monitored by Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report E-81-9

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
EMPIRICAL METHODS FOR PREDICTING EUTROPHICATION IN IMPOUNDMENTS; Report 2, PHASE II: MODEL TESTING

5. TYPE OF REPORT & PERIOD COVERED
Report 2 of a series

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
William W. Walker, Jr.

8. CONTRACT OR GRANT NUMBER(s)
Contract No. DACW39-78-C-0053

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Dr. William W. Walker, Jr., Environmental Engineer
1127 Lowell Road
Concord, Mass. 01742

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
EWQOS Work Unit IE

11. CONTROLLING OFFICE NAME AND ADDRESS
Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

12. REPORT DATE
September 1982

13. NUMBER OF PAGES
380

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
U. S. Army Engineer Waterways Experiment Station
Environmental Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Data bases	Models
Eutrophication	Predictions
Impoundments	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Methods for predicting eutrophication and related water quality effects are required to aid in the design and operation of U. S. Army Corps of Engineers (CE) reservoirs in ways compatible with water quality and use objectives. In many instances, simple empirical techniques are favored over complex simulation models because they require less extensive data. This report compiles existing empirical techniques and model structures from the literature

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

and evaluates them using an extensive data base describing 299 CE reservoirs. Models evaluated were designed to predict phosphorus and chlorophyll-a concentration, transparency, and hypolimnetic oxygen depletion.

Models are tested herein with both original and optimized parameter estimates. Residuals (errors) and parameter stability are analyzed to assess model generality and regional influences. The needs for restructuring models to improve generality and/or reduce prediction error are outlined.

A model network relating reservoir-average water quality conditions to external loadings is presented and tested using independent data sets compiled from the literature.

Empirical eutrophication models, it is found, can be adapted for use for reservoirs, with expected errors which are similar in magnitude to those reported in global studies of natural lakes.

The first report in this series, Technical Report E-81-9, is entitled "Empirical Methods for Predicting Eutrophication in Impoundments; Report 1, Phase I: Data Base Development."

PREFACE

This report was prepared by Dr. William W. Walker, Jr., Environmental Engineer, Concord, Mass., for the U. S. Army Engineer Waterways Experiment Station (WES) under Contract No. DACW39-78-C-0053 dated 7 June 1978. It is one of a series of reports, the first of which was entitled "Empirical Methods for Predicting Eutrophication in Impoundments; Report 1, Phase I: Data Base Development." The study forms part of the Environmental and Water Quality Operational Studies (EWQOS) Work Unit IE, Simplified Techniques for Predicting Reservoir Water Quality and Eutrophication Potential. The EWQOS Program is sponsored by the Office, Chief of Engineers, and is assigned to the WES under the purview of the Environmental Laboratory (EL).

The study was conducted under the direct WES supervision of Dr. Robert H. Kennedy and the general supervision of Mr. Donald L. Robey, Chief, Ecosystem Research and Simulation Division, and Dr. John Harrison, Chief, EL. Dr. Jerry Mahloch was the EWQOS Program Manager.

The Commander and Director of WES during this study was COL Tilford C. Creel, CE. The Technical Director was Mr. Fred R. Brown.

This report should be cited as follows:

Walker, W. W., Jr. 1982. "Empirical Methods for Predicting Eutrophication in Impoundments; Report 2, Phase II: Model Testing," Technical Report E-81-9, prepared by William W. Walker, Jr., Environmental Engineer, Concord, Mass., for the U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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CONVERSION FACTORS, INCH-POUND TO METRIC (SI) UNITS OF MEASUREMENT

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	0.4047	hectares
acre feet	1233.489	cubic metres
cubic feet per second	0.028317	cubic metres per second
feet	0.3048	metres
square miles (U. S. statute)	2.5899	square kilometres

EMPIRICAL METHODS FOR PREDICTING EUTROPHICATION IN IMPOUNDMENTS

PART I: INTRODUCTION

1. Eutrophication has several important effects on impoundment water quality and potential uses. There are direct causal linkages between algal growth in reservoirs and water transparency, organic matter content, and hypolimnetic oxygen concentrations. The loss of oxygen from the bottom waters of stratified reservoirs is partially attributed to the respiration and decay of algae which have settled out of the surface layers. Oxygen depletion promotes the recycling of nutrients, iron, manganese, and trace metals from bottom sediments, limits biological habitat, and is conducive to the formation of hydrogen sulfide, methane, and other reduced organic compounds. These processes may have direct implications for potential uses of the water in and downstream of the impoundment, including recreation, water supply, and wildlife propagation. Methods for predicting eutrophication and related water quality effects are required to aid in the design and operation of reservoirs in ways which are consistent with water quality and use objectives.

2. Complex simulation models have been developed for this purpose, based upon hydrodynamic and ecological theory. While appropriate in some management situations, their roles have been limited primarily to research because of extensive data requirements and the subjective decisions and expertise required for calibration in each application. They are the only alternatives for applications requiring high spatial and temporal resolution and/or simulation of cause-effect relationships which cannot be represented using simpler models. The complexity of these models does not guarantee, however, that they are more accurate for predicting average water quality conditions than are the simpler models discussed below.

3. Simpler, empirical techniques, derived largely from the original concepts of Vollenwieder (1968), have much lower data requirements, principally because they deal with average conditions and do not (or should not) have to be recalibrated and retested in each application. These are based upon the annual phosphorus balance of the

impoundment and empirical relationships among average phosphorus, chlorophyll, transparency, and oxygen depletion measurements derived from groups of lakes and/or reservoirs. Vollenweider's original work and most of the numerous modifications which have followed in the literature have been based upon data from natural lakes. When data from collections of lakes and reservoirs are compared, significant differences have been found in many factors which may influence nutrient and algal dynamics and which are not explicitly accounted for in these models, including hydrodynamics, sediment accumulation rate, region, and certain morphometric characteristics (such as shoreline development and length/width ratio) (Thornton, et al., 1980). Since these methods are essentially "interpolation" schemes, there are possible needs for recalibration and/or restructuring for use for reservoirs.

4. These needs are supported by analysis of data from the U. S. Environmental Protection Agency's (EPA) National Eutrophication Survey (NES) indicating that, on the average, Corps of Engineers (CE) reservoirs have higher normalized phosphorus loadings, but lower average concentrations of phosphorus and chlorophyll, as compared with natural lakes (Walker, 1981). Regional analysis shows, however, that CE reservoirs tend to be located, on the average, at latitudes where there are relatively few natural lakes (Walker, 1980a). Thus, it is difficult to distinguish the potential effects of impoundment type from those of region. Canfield and Bachman (1981) also found statistically significant differences between lakes and reservoirs in the parameters of a model for predicting phosphorus sedimentation rate and suggested that the differences could be attributed to "qualitative differences in the phosphorus inputs related to geographic location," specifically referring to the fact that the populations of reservoirs examined were, on the average, located in regions where particulate phosphorus loadings were more important.

5. Canfield and Bachman also suggested that lakes and reservoirs "represent a range of limnological conditions and should not be treated as distinctly different lake types." While it seems feasible that a single model or set of models could be devised for use in both lakes and reservoirs, most of those existing consider only total phosphorus

loading, mean depth, and hydraulic residence time as independent variables, and do not account for variations in particulate phosphorus or other important factors related to region and/or to impoundment type. Structural modifications would have to be made and tested to account for these additional factors if one model is to be used over the "continuum of limnological conditions" discussed by Canfield and Bachman without risk of bias at one end or the other.

6. Regardless of lake/reservoir differences, the limnological literature presents a wide range of empirical eutrophication models, some of which may be of use in reservoir management. The objective of the research described in this report is to identify those methods which seem appropriate for use in reservoirs operated by the U.S. Army Corps of Engineers. An extensive data base describing 299 CE impoundments has been compiled under Phase I of this study and used here as the primary source of information (Walker, 1981). The data base (Figure 1) includes the morphometric, hydrologic, and water quality information required for model testing. Table 1 lists 108 CE reservoirs which were sampled by the EPA's National Eutrophication Survey between 1972 and 1975. Because of relatively stringent data requirements for estimation of nutrient balances, these projects represent the primary focus of this study, although data from other projects are also used in testing models which do not require nutrient loading estimates.

7. Scope is limited to evaluation of existing model structures compiled from the literature and summarized in Appendix E. The models are designed to predict the following eutrophication-related water quality characteristics:

a. phosphorus concentration
b. chlorophyll-a concentration
c. transparency
d. hypolimnetic oxygen depletion

This work does not cover classification systems, index systems, or any of the various methods for predicting "trophic state", definitions of which are variable, subjective, misleading, and of questionable

Figure 1

Elements and Structure of the CE Reservoir Data Base

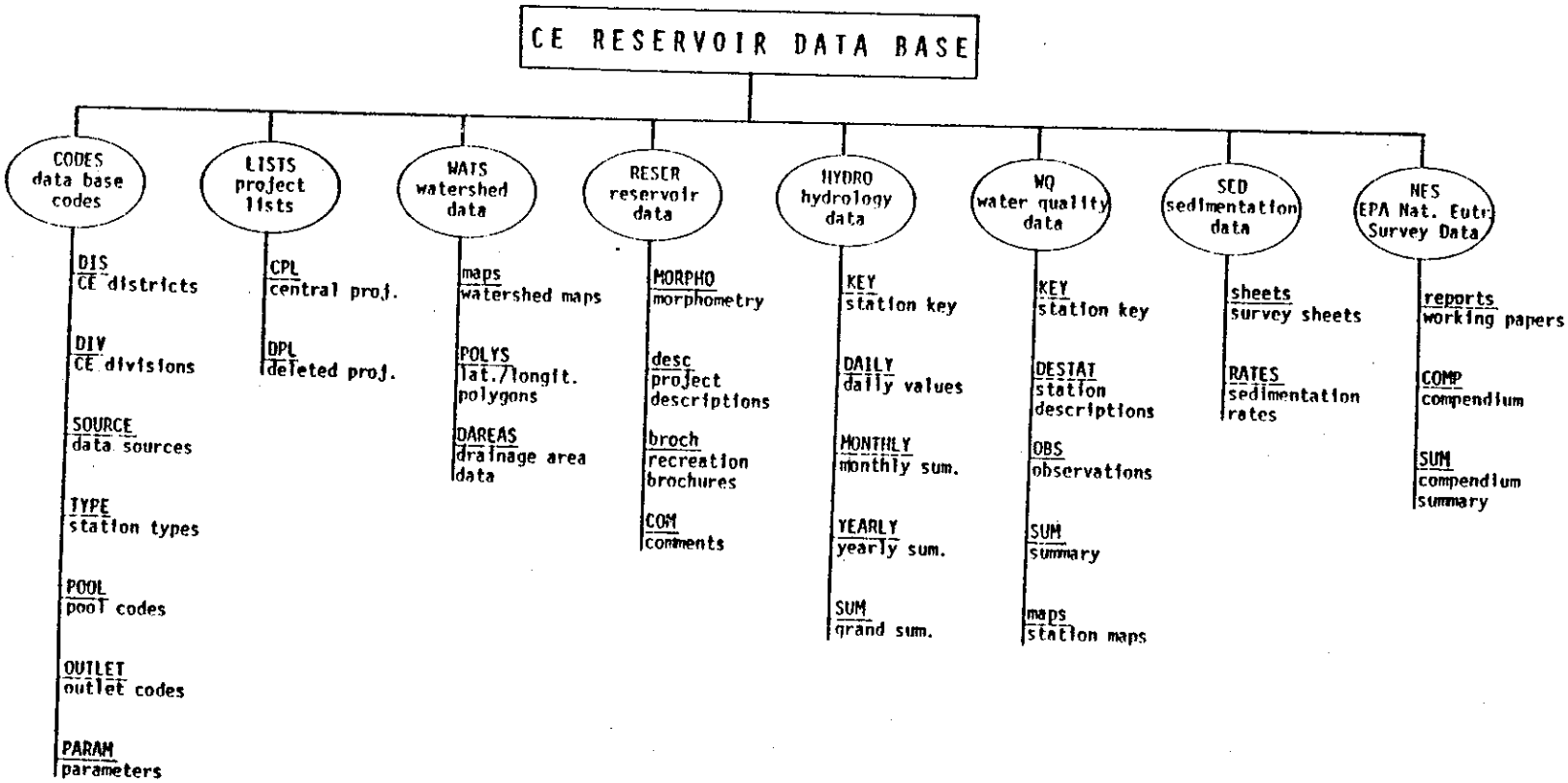

Table 1

CE Reservoirs Sampled by the EPA National Eutrophication Survey

DISTRICT	RESERVOIR
02 NEW YORK	176 WATERBURY
03 PHILADELPHIA	307 BELTZVILLE
04 BALTIMORE	312 F J SAYERS (BLA
06 WILMINGTON	372 JOHN H KERR
08 SAVANNAH	074 CLARK HILL
08 SAVANNAH	330 HARTWELL
10 MOBILE	003 HOLT
10 MOBILE	069 ALLATOONA
10 MOBILE	071 SEMINOLE (WOODR
10 MOBILE	072 WALTER F GEORGE
10 MOBILE	076 SIDNEY LANIER
10 MOBILE	411 BANKHEAD
14 ROCK ISLAND	099 RED ROCK
15 ST PAUL	178 GULL
15 ST PAUL	181 LEECH
15 ST PAUL	237 ASHTABULA (BALD
16 PITTSBURGH	243 BERLIN
16 PITTSBURGH	254 MOSQUITO CREEK
16 PITTSBURGH	317 SHENANGO RIVER
16 PITTSBURGH	328 ALLEGHENY (KINZ
16 PITTSBURGH	393 TYGART
17 HUNTINGTON	241 ATWOOD
17 HUNTINGTON	242 BEACH CITY
17 HUNTINGTON	245 CHARLES MILL
17 HUNTINGTON	247 DEER CREEK
17 HUNTINGTON	248 DELAWARE
17 HUNTINGTON	249 DILLON
17 HUNTINGTON	256 PLEASANT HILL
17 HUNTINGTON	258 TAPPAN
17 HUNTINGTON	373 JOHN W FLANNAGA
17 HUNTINGTON	389 BLUESTONE
17 HUNTINGTON	391 SUMMERSVILLE
18 LOUISVILLE	092 MISSISSINEWA
18 LOUISVILLE	093 MONROE
18 LOUISVILLE	120 BARREN RIVER
19 NASHVILLE	119 BARKLEY
19 NASHVILLE	122 CUMBERLAND (WOL
19 NASHVILLE	338 CHEATHAM
19 NASHVILLE	340 J PERCY PRIEST
19 NASHVILLE	342 OLD HICKORY
19 NASHVILLE	343 DALE HOLLOW
20 ST LOUIS	081 CARLYLE
20 ST LOUIS	087 SHELBYVILLE
20 ST LOUIS	088 REND
21 MEMPHIS	196 WAPPAPELLO
22 VICKSBURG	014 DE GRAY
22 VICKSBURG	019 OUACHITA (BLAKE
22 VICKSBURG	188 ARKABUTLA
22 VICKSBURG	189 ENID
22 VICKSBURG	190 GRENADA
22 VICKSBURG	192 SARDIS
23 NEW ORLEANS	352 LAKE OF THE PIN
23 NEW ORLEANS	353 TEXARKANA(WRIGH
23 NEW ORLEANS	413 CADDO
24 LITTLE ROCK	011 BEAVER
24 LITTLE ROCK	012 BLUE MOUNTAIN
24 LITTLE ROCK	013 BULL SHOALS
24 LITTLE ROCK	016 GREERS FERRY
24 LITTLE ROCK	021 NIMROD
24 LITTLE ROCK	022 NORFOLK
24 LITTLE ROCK	193 CLEARWATER
24 LITTLE ROCK	200 TABLE ROCK
25 TULSA	020 MILLWOOD
25 TULSA	102 COUNCIL GROVE
25 TULSA	103 ELK CITY
25 TULSA	104 FALL RIVER
25 TULSA	105 JOHN REDMOND
25 TULSA	107 MARION
25 TULSA	112 TORONTO
25 TULSA	267 EUFAULA
25 TULSA	269 FORT SUPPLY
25 TULSA	273 KEYSTONE
25 TULSA	275 OOLOGAH
25 TULSA	278 TENKILLER FERRY
25 TULSA	281 WISTER
25 TULSA	348 TEXOMA (DENNISO
25 TULSA	370 KEMP
26 FORT WORTH	345 BELTON(BELL)
26 FORT WORTH	347 CANYON
26 FORT WORTH	354 LAVON
26 FORT WORTH	355 LEWISVILLE(GARZ
26 FORT WORTH	359 SAM RAYBURN (MC
26 FORT WORTH	360 O C FISHER (SAN
26 FORT WORTH	361 SOMERVILLE
26 FORT WORTH	362 STILLHOUSE HOLL
26 FORT WORTH	364 WHITNEY
28 ALBUQUERQUE	219 CONCHAS
29 KANSAS CITY	100 RATHBUN
29 KANSAS CITY	106 KANOPOLIS
29 KANSAS CITY	108 MILFORD
29 KANSAS CITY	109 MELVERN
29 KANSAS CITY	110 PERRY
29 KANSAS CITY	111 POMONA
29 KANSAS CITY	113 TUTTLE CREEK
29 KANSAS CITY	114 WILSON
29 KANSAS CITY	194 POMME DE TERRE
29 KANSAS CITY	195 STOCKTON
29 KANSAS CITY	207 HARLAN COUNTY
30 OMAHA	064 CHERRY CREEK
30 OMAHA	215 PAWNEE
30 OMAHA	217 BRANCHED OAK
30 OMAHA	235 SAKAKAWEA(GARRI
31 WALLA WALLA	077 DWORSHAK
32 SEATTLE	204 KOOKANUSA(LIBBY
33 PORTLAND	300 HILLS CREEK
34 SACRAMENTO	048 NEW DON PEDRO
35 SAN FRANCISCO	029 MENDOCINO
35 SAN FRANCISCO	039 SANTA MARGARITA

applicability (Maloney, 1979, Taylor et. al, 1980). Each model is tested both with original and with optimized parameter estimates. Residuals (errors) and parameter stability are analyzed to assess model generality and regional influences. Based upon the results of model testing, needs for restructuring to improve model generality and/or reduce prediction error are outlined herein; these needs are being pursued in current research.

8. The report is organized in nine sections. Parts II, III, and IV describe data base refiniments, data reduction procedures, and model testing methods, respectively. Part V evaluates "internal models", or relationships among water quality measurements within the reservoirs. Part VI tests models which relate water quality to external phosphorus loading, morphometric variables, and hydrologic variables. Part VII evaluates methods for predicting hypolimnetic oxygen depletion. Key results for each model category are summarized at the ends of Parts V, VI, and VII, respectively. Part VIII summarizes and extends the results of previous sections in the form of a model "network" relating reservoir-average water quality conditions to external nutrient loadings. The network is tested using independent data sets compiled from the literature. Multivariate and error analyses also provide additional insights into model structure and adequacy. Part IX outlines some general conclusions and recommendations. Appendices A-D contain supplementary tables, including the data sets used in testing and error statistics by model category. A compilation of models derived from a literature survey is presented in Appendix E. Appendix F lists and displays the independent data sets used in testing the network presented in Part VIII.

PART II: DATA BASE REFINEMENTS

Introduction

9. The CE reservoir data base developed previously (Walker, 1981) has been augmented with additional morphometric and hydrologic data obtained from various sources, including CE District offices, project brochures, and USGS District offices. Because these sources are relatively diffuse, the additional data compilation has been directed specifically at reservoirs, time periods, and characteristics which were not available from centralized sources, such as WATSTORE. The objective has been to fill in missing hydrologic and morphometric information for projects and time periods with adequate water quality data to support model testing. Some additional data base refinements have been made, as discussed below.

Morphometric Data

10. A review of the morphometric data file indicated that pool and shoreline length data were missing for 57 and 13 projects, respectively, out of 108 projects sampled by the EPA/NES. Additional pool and shoreline length data have been compiled and added to the existing morphometric data file. This effort has relied primarily upon District contacts and project brochures. The final tally includes length data and shoreline length data for 101 and 100 EPA/NES projects, respectively. A few additional modifications have also been made to the morphometric data file in response to District feedback. The modified file contains 4100 records referenced to project and elevation, with pool length data for 259 projects and shoreline length data for 234 projects, out of a total of 299 reservoirs in the data base.

11. Reservoirs with significant pool areas extending up secondary tributaries have potentially greater spatial variations in water quality than those with simpler morphometry. These variations may, in turn, influence loading model performance, especially if nutrient

concentrations in the secondary tributary inflow are significantly different from those in the major tributary inflow and advection dominates over dispersion. To provide a basis for assessing the effects of morphometric complexity on loading model performance, each reservoir has been classified according to the number of major tributary arms. This work has been based upon the project map file. Note that the classification system is based upon the number of reservoir arms, not upon the number of tributaries, i.e., the reservoir surface must extend for a significant distance up a secondary tributary in order for it to be included in the classification.

Hydrologic Data

12. In attempting to formulate hydrologic balances for 108 projects sampled by the EPA/NES, data on reservoir discharge and elevation/volume were found to be lacking in 8 projects and 42 projects, respectively. An additional 19,000 daily or monthly records of pool elevation and discharge have been obtained from CE District offices. Daily records have been summarized on a monthly basis, including mean flows, mean elevations, and month-end elevations. Data requests have also been filed with 16 USGS District offices, which have provided an additional 1008 monthly records. After merging the new information with the existing data base, project coverage has increased substantially. During the periods of tributary sampling by the EPA/NES, the data base contains monthly discharge records for all 108 projects and elevation/contents records for 107 projects. During the hydrologic year which brackets the period of pool water quality sampling by the EPA/NES in each project, monthly discharge records are available for 103 projects and elevation/contents records, for 107 projects.

13. The drainage area file has been updated to include information on total, water-contributing, and sediment-contributing areas for 287, 280, and 256 projects, respectively. USGS monitoring station descriptions have been reviewed to estimate water-contributing areas. Sediment-contributing (or direct) drainage has been estimated from

sediment survey sheets and from drainage basin maps, by identifying upstream impoundments and subtracting their water-contributing drainage areas and the project surface area from the project water-contributing drainage area.

Water Quality Data

14. Spatial gradients in water quality are important in many reservoirs. A preliminary classification system which permits sorting of water quality stations in downstream order within each major tribuary arm has also been developed and coded. It is based upon the water quality station map file, station descriptions, and latitude/longitude coordinates. Sort keys have been added to the existing water quality station key file, but additional verification of the coding system is needed. This system will be useful in future studies of spatial gradients and their controlling factors, but has not been applied in the model testing completed thus far.

PART III: DATA REDUCTION AND SUMMARY

Morphometric Data

15. In calculating water and nutrient balances, the elevation/volume/area points listed in the morphometric file have been used to estimate changes in volume or area as functions of elevation and vice-versa. To facilitate these calculations and other uses of the morphometric file, elevation/volume/area data points contained in the data file have been summarized as polynomial functions of the general form:

$$LZ^* = \ln(Z) = \ln(E - E0) \quad (1)$$

$$\log(V) = C1 + C2\ LZ + C3\ LZ^2 + C4\ LZ^3 + C5\ LZ^4 \quad (2)$$

where,

ln = base-e logarithm
Z = total depth (feet)
V = total volume (acre-feet)
E = elevation (feet above mean sea level)
E0 = elevation at zero volume (feet above msl)
C1 - C5 = polynomial coefficients

These curves are used essentially for interpolation and smoothing of the elevation/volume profile. While previous work (Walker, 1981) indicated that a third-degree equation generally provided an adequate fit, adding a fourth degree significantly improved the fit of many of the volume/elevation curves in the current version of the morphometric file. Differentiation of the volume polynomial can be used to estimate area at any elevation:

$$A_s = [C2 + 2\ C3\ LZ + 3\ C4\ LZ^2 + 4\ C5\ LZ^3]\ V\ /\ (E - E0) \quad (3)$$

where,

A_s = surface area at elevation E (acres)

* For convenience, symbols and unusual abbreviations are listed and defined in the Notation, Appendix G.

A weighted polynomial regression has been done on logarithmic scales to estimate the parameters C1 - C5 for each reservoir. Since only volume/elevation points have been used in the regressions, the consistency of a given morphometric curve can be checked by comparing reported and estimated surface areas. To reflect the relative accuracy and importance of morphometric data points at higher elevations in a given reservoir and to offset the greater weights inherently given to lower elevation points in logarithmic regressions, points have been weighted by the square of the total depth (E - E0) in performing the regressions. Lower-order polynomial regressions have been used for reservoirs with an insufficient number of data points to justify a fourth-order fit. Generally, the curve fitting process has been iterative, with reference to residuals plots to assess fit adequacy for each reservoir.

16. For reservoirs without reported E0 values, a single-term power function has been fit to the first two complete sets of elevation, area, volume points in order to estimate E0. According to this model, mean depth is proportional to total depth:

$$Y = (V1/A1) / (V2/A2) = (E1 - E0) / (E2 - E0) \quad (4)$$

$$E0 = (E1 - Y\ E2)/(1 - Y) \quad (5)$$

where,

E1,A1,V1 = elevation, area, and volume at first level
E2,A2,V2 = elevation, area, and volume at second level
Y = mean depth ratio

In a few cases, there were insufficient data to apply this estimation procedure and E0 values have been estimated based upon maximum reservoir depths and surface elevations reported by Leidy and Jenkins (1977).

17. For five reservoirs in St. Paul District (Lac Qui Parle (179), Gull(178), Pine River(187), Winnibigoshish(186), and Pokegama(184)), useable volumes above specified elevations are listed in the morphometric file. To estimate dead storage for these projects, total volume development has been assumed to follow a single-term power

function in total depth. The following equation has been solved for VD:

$$[(VU1+VD)/A1] \ / \ [(VU2+VD)/A2] = (E1-E0) \ / \ (E2-E0) \qquad (6)$$

where,

VU1 = useable volume below first listed elevation point
VU2 = useable volume below second listed elevation point
VD = dead storage (acre-feet)

Estimated dead storage values have been added to the reported useable volumes prior to estimating the coefficients of the morphometric curves.

18. To test the adequacy of each fit, plots of observed and estimated volume and area profiles have been generated for each reservoir. These have been assembled in a notebook for future reference by data-base users. Examination of these plots has provided a basis for refining the fits, where necessary, by (1) identifying errant values in the morphometric file; (2) increasing or decreasing the degree of the polynomial; or (3) supplementing the morphometric file with additional volume/elevation points derived from USGS Water Resources Data Reports (USGS,1977).

19. A file describing these curves has been created containing the following information:

a. district code
b. reservoir code
c. minimum elevation used in regression
d. maximum elevation used in regression
e. zero-volume elevation
f. coefficients (C1 - C5)

In applying these functions to estimate volume or area at any elevation, tests should be performed to insure that the elevation is within the range used in the regression. A listing of estimated morphometric curve parameters is given in Appendix A for the 285 projects with sufficient data.

20. Accuracies of these curves have been assessed by computing the

following statistics for three types of applications:

a. estimating volume from elevation: $|V - V'|/V'$

b. estimating area from elevation: $|A_s - A_s'|/A_s'$

c. estimating elevation from volume: $|E - E'|$

where,

$'$ = superscript denoting estimated value

$|X-X'|$ = absolute value of $X-X'$

Since the polynomials cannot be solved explicitly for E as a function of V, an iterative procedure is used to estimate elevation consistent with a given total volume. The third type of application has been included because elevations must be estimated from total volumes in completing the hydrologic data file, which contains many USGS stations with volume but without elevation data.

21. Median estimation errors have been calculated for each project and type of application and summarized in Table 2. At the 50th percentile, estimation errors amount to 1.0% for total volume, 3.2% for surface area, and .21 feet for elevation. At the 95% percentile, the errors are 5.3%, 13.3%, and .99 feet, respectively. The relative inaccuracy of the area estimation is attributed to the fact that reported areas were not used in estimating the coefficients and some inconsistencies in the area and volume data may remain in the morphometric data file. Percentage estimation errors generally decrease at higher elevations in a given reservoir, owing to the greater accuaracy of morphometric information at elevations nearer the surface.

22. Table 3 lists twelve projects included in the data base but without sufficient data for estimation of morphometric curves. These are primarily run-of-the-river impoundments or locks and dams, which have not been used in model testing because of water quality data limitations. Future refinements of the data base could involve compilation of additional data for these projects and for others with relatively limited morphometric information. Available data are generally adequate, however, for the purposes of this research.

Table 2

Summary of Morphometric Curve Error Statistics
(Within-Project Median Absolute Deviations)

Variable:	Volume	Area	Elevation	
Statistic:	$\lvert V-V' \rvert / V'$	$\lvert A_s - A_s' \rvert / A_s'$	$\lvert E-E' \rvert$	
Units:	-	-	feet	
100%*	.095	.434	2.95	maximum
95%	.053	.133	0.99	
90%	.037	.087	0.77	
75%	.019	.057	0.44	upper quartile
50%	.0098	.032	0.21	median
25%	.0042	.015	0.081	lower quartile
10%	.0017	.0078	0.030	
5%	.00069	.0056	0.013	
0%	.00002	.0004	0.0005	minimum
Number of Projects	285	277	285	

* Percentile

Table 3

Projects Lacking Sufficient Data for
Estimation of Morphometric Curves

Code	District	Project
10-002	Mobile	Coffeeville
10-005	"	Demopolis
10-007	"	Warrior
10-191	"	Okatibbee
10-415	"	Gainesville
15-180	St. Paul	Traverse
15-181	"	Leech
15-183	"	Cross
15-185	"	Sandy
17-127	Huntington	Greenup
17-394	"	Winfield
17-416	"	Alum Creek
33-289	Portland	Bonneville
33-301	"	John Day

Water Balances

23. Reasonably accurate hydrologic balances are required as bases for formulating reservoir nutrient balances and testing nutrient load/trophic state response relationships. Unlike nutrient balances, water balances can be checked by comparing estimates of total inflow and outflow over a given period, while correcting for any change in storage within the reservoir. The basic water balance equation is:

$$\text{INPUT} = \text{OUTPUT} + \text{CHANGE IN STORAGE} \tag{7}$$

where a change in storage is positive if the total volume of the reservoir at the end of the period is greater than the total volume at the beginning and the output term includes evaporation, discharge, and withdrawal. Because of fluctuations in pool levels, the change in storage term is of potential importance to the short-term water and nutrient balances of many reservoirs, although it should be relatively small over an average annual period in reservoirs with stable operating policies.

24. A water balance has been estimated for each of the 108 CE reservoirs sampled by the EPA National Eutrophication Survey during the year monitored (see Table 1). Data sources for the water balance calculations include the following:

a. EPA/NES (mean monthly flows in gauged tributaries and discharges, mean precipitation, drainage area)
b. USGS (discharge flows, elevations/contents)
c. CE District offices (discharge flows, elevations)
d. US Weather Bureau (Kohler et al.,1959) (evaporation)

Calculations are outlined and results are presented in metric units for use in nutrient balance estimation and model testing. The potential implications of errors in the data and/or estimation methods used in formulating these balances are discussed following the calculations.

25. The first step involves the formulation of a drainage area "balance":

$$AT = AG + AU + AR \tag{8}$$

where,

AT = drainage area at reservoir discharge (km2)
AG = drainage area of gauged tributaries (km2)
AU = drainage area of ungauged tributaries (km2)
AR = reservoir surface area (km2)

The above drainage areas are water-contributing. Reservoir areas correspond to mean surface elevations over the monitoring period. Ungauged areas are estimated by difference, according to the above equation.

26. Available data permit estimation of the following water input components:

$$QI = QG + QU + QP \tag{9}$$

where,

QI = total water input (hm3/yr = 10^6 m3/yr)
QG = gauged tributary input (hm3/yr)
QU = ungauged tributary input (hm3/yr)
QP = precipitation input (hm3/yr)

Ungauged inflows are estimated based upon gauged inflows and drainage areas:

$$QU = AU\ QG\ /\ AG \tag{10}$$

This assumes that the runoff coefficient (QG/AG) is a regional characteristic. In the case of a mainstem reservoir, much of the gauged drainage area may be remote from the waterbody and not representative of local watersheds; the runoff coefficient is estimated from the total flows and drainage areas of immediate tributaries only.

27. Precipitation inputs are estimated from reservoir areas and annual precipitation rates:

$$QP = AR\ YP \tag{11}$$

where,

YP = precipitation rate (m/yr)

Bases for estimating direct groundwater and point source inflows are not available. While some of the former are accounted for in the ungauged inflow estimates, these components contribute to errors in the water balances.

28. The output term of each water balance is estimated as the sum of the following components:

$$QO = QD + QW + QE \tag{12}$$

where,

QO = total output (hm3/yr)

QD = discharge from reservoir (hm3/yr)

QW = withdrawal from reservoir (hm3/yr)

QE = evaporation (hm3/yr)

Discharge rates are based upon reported values. Withdrawals reflect uses for water supply, irrigation, etc.,and are based upon estimates in the EPA/NES working papers. Evaporation losses are estimated from:

$$QE = YE\ AR \tag{13}$$

where,

YE = average evaporation rate (m/yr)

Evaporation rates are assumed to be regional characteristics, estimated from maps compiled by Kohler et al. (1959) and reflect average conditions from 1946 to 1955. Year-to-year variations in climate and local variations in watershed/reservoir morphology (as they may determine wind fetch, etc.) may influence evaporation rates and contribute to the error term in the water balance equation.

29. The change-in-storage term of the water balance is calculated from:

$$QV = (V2 - V1) / T \tag{14}$$

where,

QV = change in storage (hm3/yr)

V2 = reservoir volume at end of period (hm3)

V1 = reservoir volume at beginning of period (hm3)

T = length of monitoring period (yrs)

Reservoir volumes refer to month-end values immediately before and after the sampling period. The length of the monitoring period generally ranges from 12 to 13 months for the sampling schedules employed by the EPA/NES in these reservoirs.

30. Using the above framework, an error term can be calculated for each balance:

$$QN = QI - QO - QV \tag{15}$$

$$QN = QG + QU + QP - QD - QW - QE - (V2 - V1)/T \tag{16}$$

where,

QN = net inflow (hm3/yr)

Net inflow results from the influences of the following error sources:

a. errors in the drainage areas, reservoir volumes, and gauged flows

b. local morphologic or climatologic factors which may influence precipitation and evaporation

c. year-to-year climatologic variations which may cause evaporation rates to deviate from long-term regional averages

d. variations in watershed characteristics which may contribute to errors in estimates of ungauged tributary flows

e. diversions from or to the reservoirs which are not noted in the EPA/NES reports

31. To aid in water balance computations and permit examination of within-year variations in hydrologic conditions, a file of monthly values has been assembled, covering the monitoring periods. It includes the following:

a. mean reservoir discharge, estimated from each of three sources (where available):

1. EPA/NES
2. USGS/WATSTORE
3. CE District offices

b. mean and month-end elevations, estimated from (2) & (3)

c. mean and month-end volumes, estimated from (2) & (3)

d. mean and month-end surface areas, estimated from elevations (b) and morphometric curves

In most cases, agreement among the various sources of monthly discharge data has been found to be good (within 10%) and the EPA/NES estimates have been used. Other sources have been used in cases where the EPA/NES data were incomplete or apparently in error, based upon comparison with other sources and resultant errors in the water balances. Polynomials derived from the CE morphometric file (see above) have been applied to estimate missing elevations, volumes, and/or surface areas based upon elevations or volumes reported by the USGS. A summary of this file is given in Table 4, which also identifies the periods of tributary monitoring by the EPA/NES.

32. The terms of the water balance for each of the 108 projects sampled by the EPA/NES are listed along with corresponding terms in the nutrient balances in Appendix B. Elevation/contents data were not available for Caddo Lake (23-413), which is not currently under CE control. Accordingly, the change-in-storage term for this reservoir has not been estimated and data from this project have not been used in testing loading models.

33. Considering the error sources mentioned above, the following statistics can be used as measures of the relative reliability of a given flow balance:

QN / QI	= net flow (error) significance	(17)
QU / QI	= ungauged inflow significance	(18)
QP / QI	= precipitation significance	(19)
QE / QO	= evaporation significance	(20)

These represent net, ungauged, and precipitation inflows expressed as

Table 4

Reservoir Operating Ranges During Tributary Monitoring Period

Symbol	Meaning
YR	year tributary sampling began
MO	month tributary sampling began
EMIN*	minimum pool elevation (ft,msl)
EMAX*	maximum pool elevation (ft,msl)

* derived from month-end measurements

DIS	RES		YR	MO	EMIN	EMAX
02	176	WATERBURY	72	7	573.8	593.0
03	307	BELTZVILLE	73	5	622.6	629.6
04	312	F J SAYERS (BLA	73	5	610.1	630.0
06	372	JOHN H KERR	73	7	297.1	304.0
08	074	CLARK HILL	73	3	326.3	331.5
08	330	HARTWELL	73	2	657.1	662.3
10	003	HOLT	73	3	186.7	187.0
10	069	ALLATOONA	73	3	826.2	843.7
10	071	SEMINOLE (WOODR	73	3	76.9	77.5
10	072	WALTER F GEORGE	73	3	185.6	189.4
10	076	SIDNEY LANIER	73	3	1066.5	1072.5
10	411	BANKHEAD	73	3	254.5	255.0
14	099	RED ROCK	74	8	724.8	746.9
15	178	GULL	72	10	1192.7	1194.0
15	181	LEECH	72	10	1293.7	1294.9
15	237	ASHTABULA (BALD	74	9	1263.3	1266.6
16	243	BERLIN	73	5	1015.7	1026.5
16	254	MOSQUITO CREEK	73	5	898.1	902.0
16	317	SHENANGO RIVER	73	5	885.9	899.2
16	328	ALLEGHENY (KINZ	73	5	1294.1	1328.8
16	393	TYGART	73	7	1025.6	1095.5
17	241	ATWOOD	73	5	923.9	928.8
17	242	BEACH CITY	73	5	948.7	953.0
17	245	CHARLES MILL	73	5	997.2	1001.3
17	247	DEER CREEK	73	5	790.7	815.9
17	248	DELAWARE	73	5	910.1	915.9
17	249	DILLON	73	5	735.4	747.1
17	256	PLEASANT HILL	73	5	1017.5	1021.5
17	258	TAPPAN	73	5	894.1	899.1
17	373	JOHN W FLANNAGA	73	7	1410.5	1428.0
17	389	BLUESTONE	73	7	1410.3	1444.0
17	391	SUMMERSVILLE	73	7	1536.2	1652.7
18	092	MISSISSINEWA	73	6	727.9	749.5
18	093	MONROE	73	6	536.9	546.6
18	120	BARREN RIVER	73	3	529.1	559.2
19	119	BARKLEY	73	3	354.6	367.3
19	122	CUMBERLAND (WOL	73	3	694.5	732.3
19	338	CHEATHAM	73	4	384.2	385.6
19	340	J PERCY PRIEST	73	4	483.2	494.1
19	342	OLD HICKORY	73	4	444.1	445.4
19	343	DALE HOLLOW	73	3	639.8	654.6
20	081	CARLYLE	73	6	444.0	455.3
20	087	SHELBYVILLE	73	6	595.6	616.6
20	088	REND	73	6	403.7	409.3
21	196	WAPPAPELLO	74	9	351.6	371.8
22	014	DE GRAY	74	6	400.9	410.9
22	019	OUACHITA (BLAKE	74	6	573.2	580.9
22	188	ARKABUTLA	73	8	213.3	232.1

Table 4 (continued)

DIS	RES		YR	MO	EMIN	EMAX
22	189	ENID	73	8	237.2	265.7
22	190	GRENADA	73	8	208.6	227.9
22	192	SARDIS	73	8	260.0	276.6
23	352	LAKE OF THE PIN	74	9	228.8	231.7
23	353	TEXARKANA(WRIGH	74	9	221.0	232.9
23	413	CADDO	74	6	.	.
24	011	BEAVER	74	6	1116.2	1125.7
24	012	BLUE MOUNTAIN	74	6	384.9	403.9
24	013	BULL SHOALS	74	6	652.5	676.2
24	016	GREERS FERRY	74	6	454.7	474.2
24	021	NIMROD	74	6	342.0	364.8
24	022	NORFOLK	74	6	551.2	568.9
24	193	CLEARWATER	74	9	494.4	518.8
24	200	TABLE ROCK	74	9	909.0	919.2
25	020	MILLWOOD	74	6	255.2	262.3
25	102	COUNCIL GROVE	74	10	1269.4	1276.1
25	103	ELK CITY	74	10	787.7	811.9
25	104	FALL RIVER	74	10	948.1	961.2
25	105	JOHN REDMOND	74	10	1036.8	1046.1
25	107	MARION	74	10	1349.5	1351.3
25	112	TORONTO	74	10	901.2	917.6
25	267	EUFAULA	74	11	580.4	589.2
25	269	FORT SUPPLY	74	11	2001.8	2004.5
25	273	KEYSTONE	74	11	716.2	733.8
25	275	OOLOGAH	74	11	636.2	648.3
25	278	TENKILLER FERRY	74	11	628.4	647.4
25	281	WISTER	74	11	474.5	487.7
25	348	TEXOMA (DENNISO	74	11	613.7	620.2
25	370	KEMP	74	9	1126.6	1140.9
26	345	BELTON(BELL)	74	9	592.5	605.2
26	347	CANYON	74	9	904.5	914.6
26	354	LAVON	74	9	470.5	484.6
26	355	LEWISVILLE(GARZ	74	9	513.1	524.7
26	359	SAM RAYBURN (MC	74	9	157.5	166.6
26	360	O C FISHER (SAN	74	9	1863.0	1890.5
26	361	SOMERVILLE	74	9	237.6	246.9
26	362	STILLHOUSE HOLL	74	9	621.6	635.4
26	364	WHITNEY	74	9	523.0	534.6
28	219	CONCHAS	74	12	4157.9	4173.6
29	100	RATHBUN	74	8	902.0	906.2
29	106	KANOPOLIS	74	10	1455.0	1468.4
29	108	MILFORD	74	10	1141.7	1146.8
29	109	MELVERN	74	10	1029.9	1037.6
29	110	PERRY	74	10	888.9	895.6
29	111	POMONA	74	10	972.3	979.9
29	113	TUTTLE CREEK	74	10	1069.2	1081.4
29	114	WILSON	74	10	1514.4	1517.1
29	194	POMME DE TERRE	74	9	837.9	843.7
29	195	STOCKTON	74	9	863.1	872.4
29	207	HARLAN COUNTY	74	8	1938.2	1947.9
30	064	CHERRY CREEK	74	9	5548.5	5551.2
30	215	PAWNEE	74	8	1243.8	1244.6
30	217	BRANCHED OAK	74	8	1283.0	1284.4
30	235	SAKAKAWEA(GARRI	74	9	1838.7	1853.7
31	077	DWORSHAK	74	10	1443.9	1597.0
32	204	KOOKANUSA(LIBBY	74	10	2286.7	2457.1
33	300	HILLS CREEK	74	10	1453.1	1541.2
34	048	NEW DON PEDRO	74	11	758.0	816.7
35	029	MENDOCINO	74	11	721.7	749.1
35	039	SANTA MARGARITA	74	11	1289.7	1303.5

fractions of the total inflow and evaporation expressed as a fraction of the total outflow, respectively. The first statistic is a direct measure of error, while the last three are indicators of potential error.

34. The distributions of these error statistics are summarized in Table 5. To provide a basis for screening the data set, a cutpoint has been selected for each statistic and used to tag projects with potentially greater water balance errors. Cutpoints (generally in the 90-95 percentile range) have been selected to isolate outliers, after examining histograms of the error statistics. Because the first statistic is the only direct measure of error, it has been given greater weight in data screening.

35. As shown in Table 5, eight out of 108 projects have water balances errors exceeding 25%. Some of these are attributed to severe data limitations (e.g., 93% of the drainage area of Lake Kookanusa, 32-204, is ungauged). Attempts have been made to identify the sources of errors through additional data compilation and verification. In some cases, additional data compilation effort not feasible within the scope of this project might be helpful in resolving water balance errors. The possiblity of other sources of error and the subjective nature of the cutpoint selection indicate that the screening procedure applied above is only approximate. The error statistics have been carried through the loading model evaluations in order to provide a means for testing whether differences between model predictions and observations can be partially explained by errors in the hydrologic balances.

36. The water balances formulated above cover the period of tributary sampling by the EPA/NES in each project. For most projects, this period does not include the period in which pool water quality measurements were made by the EPA/NES, i.e., tributary and pool surveys were generally conducted in different (though adjacent) hydrologic years. There is a potential problem in relating the loadings to the pool measurements because of the effects of year-to-year variations in hydrologic conditions. The data base permits comparisons of reservoir discharges and volumes during the two monitoring periods. This

Table 5

Summary of Water Balance Ranking Statistics

Statistic	Percentile 10%	50%	90%	Screening Criterion	Number * Satisfying Criterion
|net flow|/total inflow	.010	.045	.212	<.25	100
ungd. flow/total inflow	.027	.130	.357	<.40	102
prec. flow/total inflow	.007	.035	.181	<.25	104
evap./total outflow	.007	.035	.336	<.25	96

* out of 108 projects

information has been used to modify the above water balances to correspond with the hydrologic year which includes the period of EPA/NES pool monitoring. Corresponding estimates have also been developed for "normal" hydrologic years, based upon average annual outflows estimated from the period of record and normal pool elevations.

37. Since direct inflow measurements are available only for the tributary sampling period, annual inflows during other years have been inferred from outflow, change-in-storage, and evaporation. In order to permit adjustment of water and nutrient balances estimates, it is assumed that the error term (QN) in the water balance formulated above can be attributed primarily to errors in the inflow estimates. Annual inflows during the pool monitoring periods are based upon the annual water balance, assuming no net error:

$$QI' = QD' + QV' + QE \tag{21}$$

where,

QI' = total inflow (hm3/yr)

QD' = total discharge (including withdrawals) (hm3/yr)

QV' = change in storage (hm3/yr)

$'$ = superscript denoting pool monitoring year

Evaporation rates are assumed to be constant from year to year. The above calculations have been repeated for an average hydrologic year, using average annual discharge in place of QD' and assuming no net change in storage over an average year. Outflows during the tributary and pool sampling periods each tended to be greater than average outflows by about 50% (median value). Sufficient data are available to characterize hydrologic conditions during each monitoring period for all but six projects, five of which lack outflow data for the pool monitoring period. Appendix E lists the terms in equation (21), along with average morphometric and nutrient inflow characteristics, for each hydrologic period.

38. The procedures used above to screen project water balances for potential errors are based upon calculated net water balances. Because of the possiblities for offsetting errors, there is no guarantee that a

water balance which balances is "correct". Error components are introduced by gauging errors, data recording errors, missing data, morphometric errors, and by the required estimation of evaporation and ungauged flows. While nominal estimates for these types of errors might be employed (Winter, 1980), existing data do not permit assessment of how they might vary from project to project. Thus, direct consideration of these types of errors would be of little use in data screening.

39. In applications of empirical eutrophication models, the effects of flow balance errors are generally not as significant as one might expect, especially in relation to other error sources (e.g., those inherent in the models or in the average tributary phosphorus concentration estimates). This results from the fact that predictions of impoundment response are more sensitive to the average inflow total phosphorus concentration (mass/volume) than to loading (mass/time). The average inflow concentration is essentially calculated as the flow-weighted average of all concentration estimates made in tributary streams, adjusted for effects of direct and atmospheric loadings. In this calculation, flows appear as weighting factors, i.e., both in the numerator and in the denominator, so that the effects of flow balance errors on inflow concentrations are always less than proportional and far less than proportional in reservoirs with tributaries which are more or less of uniform quality. In the case of a reservoir with a short residence and one major tributary, estimates of impoundment phosphorus or chlorophyll concentration derived from a typical loading model are completely independent of biases in the average tributary flow or reservoir discharge estimates.

40. Thus, because of generally lower sensitivity and lack of an independent basis for estimating and comparing the unknown error components of each flow balance, screening for hydrologic data errors has been limited to a check on the net flow balance. Checks for representative sampling of tributaries and flow regimes are incorporated into the nutrient balance screening procedures described in the next section. A greater emphasis has been placed on errors associated with estimating average tributary concentrations based upon limited numbers

of grab samples, because loading model predictions are more sensitive to these types of errors, which can be estimated directly from the data using the methods employed in the next section.

Nutrient Balances

41. Nutrient balance calculations are built largely upon the water balances described in the previous section. For a non-conservative material, the basic mass balance equation is:

$$\text{INPUT} = \text{OUTPUT} + \text{CHANGE IN STORAGE} + \text{ACCUMULATION} \qquad (22)$$

where the accumulation term reflects non-conservative behavior and is positive if there is a net loss of the material within the reservoir. The mass balance is formulated such that a net internal loading (net phosphorus release from bottom sediments, for example) would show up as a negative accumulation rate. Since it is determined by difference from the other terms, however, the accumulation term is subject to considerable estimation error. An attempt has been made to quantify this estimation error in formulating the nutrient budgets.

42. A nutrient balance has been estimated for each CE reservoir sampled by the EPA National Eutrophication Survey (see Table 1) during the year monitored. The EPA/NES has provided flow and concentration data from gauged and ungauged tributaries and outflows, as well as estimates of point sources and other direct or indirect sources (septic tanks, wild fowl, etc.). Balances have been estimated for the following components:

- a. total phosphorus
- b. dissolved orthophosphorus
- c. total nitrogen
- d. inorganic (ammonia + nitrite + nitrate) nitrogen

While they do not include organic fractions, components b and d are referred to as "dissolved" forms of phosphorus and nitrogen, respectively, in the remainder of this report. These have been included

in the nutrient balance calculations to provide bases for assessing the impacts of nutrient availability on load/response relationships.

43. Errors in the water balances propagate to the corresponding nutrient balances, though, as discussed in the previous section, average inflow concentrations are most important in empirical model applications and are generally not very sensitive to errors in average flow estimates. More important errors are introduced when grab-sample concentration data (in this case 10-14 samples per station-year) are used along with a continuous flow record to estimate average mass flux (or flow-weighted average concentration) over a yearly period. The regression/error analysis method described in the Phase I report (Walker,1981) has been applied to quantify the latter type of error. In formulating the mass balances, the mean and standard error of each term has been estimated. This has required subjective estimation of some error terms (precipitation and point-source loading errors, for example), but has provided an approximate basis for ranking the reservoirs with respect to data adequacy for use in model testing.

44. Total nutrient input consists of the following elements:

$$WI = WG + WU + WP + WX + WA \tag{23}$$

where,

WI = total input (metric tons/yr)
WG = input from gauged tributaries (mt/yr)
WU = input from ungauged tributaries (mt/yr)
WP = input from point source discharges (mt/yr)
WX = input from septic tanks and wildfowl (mt/yr)
WA = input from atmosphere (mt/yr)

The first term, WG, is estimated from flow and concentration measurements at each gauged tributary stream using a regression analysis procedure described previously (Walker, 1981). Estimates of ungauged tributary inputs are based upon:

$$WU = QU\ (WGN/QGN) \tag{24}$$

where,

QU = estimated inflow from ungauged tributaries (hm3/yr)

WGN = nutrient input from gauged tributaries not under the influence of upstream point sources (mt/year)

QGN = inflow from gauged tributaries not under the influence of point sources (hm3/yr)

This assumes that the flow-weighted nutrient concentration (WGN/QGN) is representative of local watersheds. In order to apply this method, gauged tributaries not under point-source influence have been identified for each reservoir, based upon the EPA/NES reports and watershed maps. In some cases, no flow data were available for non-point-source tributaries and ungauged loadings have been estimated from:

$$WU = QU\ CGN \tag{25}$$

where,

CGN = average nutrient concentration in sampled, but ungauged tributaries not under point source influence (g/m3)

To carry the error terms, the above equations have been applied to the mean and variance of each estimate. To reflect their relative uncertainty, variance estimates for ungauged loadings have been doubled relative to estimates derived from variances of gauged loadings. For example, the squared coefficient of variation WU is given by:

$$CV^2(WU) = 2\ CV^2(WGN) \tag{26}$$

if equation (24) is used, or

$$CV^2(WU) = 2\ CV^2(CGN) \tag{27}$$

if equation (25) is used. Note that these error variances reflect only the errors associated with integrating flow and concentration to estimate the flow-weighted-average concentration for each tributary.

45. Estimates of point sources, WP, and other direct inputs, WX, are derived from EPA/NES working papers. In formulating nutrient budgets, the EPA/NES included many point sources which were relatively remote from the reservoirs and often above tributary monitoring sites.

The loadings used here include only those point sources which discharge directly to the reservoir, to ungauged tributaries, or to gauged tributaries below the monitoring stations. These sources have been isolated using EPA/NES watershed maps, which indicate locations of point sources and tributary stations. It is assumed that the influences of point sources above monitoring stations on gauged tributaries are reflected in the concentration measurements made at those stations. The WP and WX estimates are assumed to have coefficients of variation of .1 and .2, respectively. Both are assumed to be in or eventually converted to dissolved (available) forms.

46. Estimates of precipitation input are derived from:

$$WA = .001\ AR\ YA \tag{28}$$

where,

AR = reservoir surface area (km2)

YA = atmospheric nutrient loading (kg/km2-yr)

Atmospheric loadings include precipitation and dustfall. Loading rates of 30 and 1000 kg/km2-yr have been assumed for total phosphorus and total nitrogen, respectively. (Reckhow, 1980, EPA/NES,1974). Half of the total loadings are assumed to be in dissolved form. Literature values for atmospheric loadings are highly variable, owing to regional variations as well as sampling difficulties. These estimates are assumed to have coefficients of variation equal to .4.

47. The outflow term of the nutrient balance is estimated from measured flows and concentrations in reservoir discharges and withdrawals using the same calculation procedure employed for gauged tributary loadings. In cases where concentration data are not available for one or more withdrawals, each withdrawal is assumed to have the same flow-weighted concentration as the reservoir discharge.

48. In order to permit detailed quantification of the change-in-storage term of the nutrient balance equation, reservoir quality surveys at the beginning and end of the monitoring period would be required. Since these are generally not available, this term can be quantified only with respect to the influences of change in reservoir

Table 6

Format Used in Nutrient Balance Calculations

Symbol	Meaning
OBS	sequence number in file
STA	station code
NESTA	EPA/NES station code
TYPE	station type code (0,1 = input; 3 = output)
NPS	non-point-source code (1 = used to estimate ungauged flow and concentration) (2 = used to estimate ungauged flow)
LOC	location description
DAREA	drainage area or surface area (mi2)
OFLOW	mean flow during year sampled (cfs)
LOAD	estimated loading (cfs*g/m3)
VLOAD	variance of above loading estimate
CLOAD	coefficient of variation of loading estimate
ORUN	water runoff rate (cfs/mi2)
EXPORT	nutrient export coefficient ((cfs*g/m3)/mi2)
CQW	flow-weighted nutrient concentration (g/m3)
N	number of water quality samples used to estimate loading
QMEAN	mean flow on water quality sampling days (cfs)
B	slope of log(concentration) vs. log(flow) regression

CE DISTRICT CODE=31 CE RESERVOIR CODE=077

OBS	STA	NESTA	TYPE	NPS	LOC	DAREA	OFLOW	LOAD	VLOAD	CLOAD	ORUN	EXPORT	CQW	N	QMEAN	B
1731	000	1604AA	0		DWORSHAK RESERVOIR	22.01	41.42	1.910	0.58	0.400	1.882	0.087	0.046	.	41.42	0.000
1732	000	1604AB	3		EVAPORATION	.	43.77	0.000	0.00	.	.	.	0.000	.	0.00	0.000
1733	301	1604A1	3		CLEARWATER RIVER	2440.00	6158.00	102.487	370.34	0.188	2.524	0.042	0.017	11	7470.00	0.069
1734	302	1604A2	1	1	N FK CLEARWATER RIVER	1360.00	3476.50	52.645	182.81	0.257	2.556	0.039	0.015	7	3020.00	0.005
1735	303	1604B1	1	2	ELK CREEK	92.79	237.08	7.364	2.88	0.230	2.555	0.079	0.031	7	305.00	0.191
1736	307	1604F1	1	2	REEDS CREEK	62.39	175.00	5.938	255.48	2.692	2.805	0.095	0.034	8	1190.00	-0.155
1737	308	1604G1	1	1	BREAKFAST CREEK	129.00	369.67	7.700	7.92	0.366	2.866	0.060	0.021	8	436.00	0.118
1738	309	1604H1	1	1	LTTL N FK CLRWATER RIV	262.00	857.83	24.816	196.01	0.564	3.274	0.095	0.029	8	1020.00	0.285
1739	666				POINT SOURCES	.	.	0.000	0.00	.	.	.	.	.	.	.
1740	777				OTHER LOADING	.	.	0.000	0.00	.	.	.	.	.	.	.
1741	901	.	.		UNGAUGED INPUT	511.81	1373.68	24.869	65.96	0.327	2.684	0.049	0.016	.	1603.22	0.000
1742	902	.	.		***TOTAL INPUT	2440.00	6531.18	125.242	711.64	0.213	2.677	0.051	0.019	.	7615.64	0.063
1743	903	.	.		***TOTAL OUTPUT	2440.00	6201.77	102.487	370.34	0.188	2.542	0.042	0.017	.	7470.00	0.069
1744	904	.	.		***CHANGE IN STORAGE	.	-213.90	-3.560	.	.	.	.	.	.	.	.
1745	905	.	.		***NET	0.00	543.31	26.315	1081.98	1.250	.	.	0.003	.	.	.
1746	906	.	.		***PERCENT ERROR	0.00	8.32	21.012	.	.	.	.	13.823	.	.	.

$$CIC = (WP + WX) / QIC + (WI - WP - WX) / QI \quad (32)$$

where,

QIC = corrected total inflow (hm3/yr)

QN = net inflow (error, see equation (15)) (hm3/yr)

WIC = corrected total loading (mt/yr)

CIC = corrected inflow concentration (g/m3)

Equation(30) adjusts the total inflow estimate to force a water balance. Equation (31) assumes that the point-source and septic-tank loading component (WP + WX) is independent of inflow (and inflow errors) and that other components are proportional to inflow. Table 7 lists the corrected inflow concentrations and outflow concentrations for each reservoir and nutrient, along with the terms of the water balance during the tributary monitoring period.

51. Adjustments to the above inflow concentration estimates are required in order to estimate average inflow concentrations during the pool monitoring periods or during normal hydrologic years because of the influences of year-to-year flow variations on inflow water quality. These adjustments are based upon the calculated sensitivities of inflow concentrations to flow during the tributary monitoring period. Modified inflow concentration estimates are estimated from:

$$CI' = CIC\ (QIC/QI')\ [\ F + (1-F)\ (QI'/QIC)^{b+1}] \quad (33)$$

$$F = (WP + WX) / WIC \quad (34)$$

where,

CI′ = inflow concentration estimate at QI′ (g/m3)

QI′ = total inflow during pool monitoring period (hm3/yr)

F = fraction of loading attributed to point sources, septic tanks, and wildfowl

b = sensitivity of inflow concentration to flow

The inflows QI′ have been estimated according to equation (21). The sensitivity parameter (b) has been estimated for each reservoir and nutrient. It represents the flow-weighted-average slope of the

Table 7

Listing of Corrected Water and Nutrient Balances for Tributary Monitoring Period

Symbol	Definition
DIS	CE district code
RES	CE reservoir code
GP	data screening code (A = high priority, B = low priority)
QIN	total inflow (hm3/yr)
QEVAP	evaporation (hm3/yr)
QOUT	total discharge and withdrawal (hm3/yr)
QSTOR	change-in-storage (hm3/yr)
QNET	net inflow (error) (hm3/yr)
IPTL	inflow total P (mg/m3)
OPTL	outflow total P (mg/m3)
IPDS	inflow ortho P (mg/m3)
OPDS	outflow ortho P (mg/m3)
INTL	inflow total N (mg/m3)
ONTL	outflow total N (mg/m3)
ININ	inflow inorganic N (mg/m3)
ONIN	outflow inorganic N (mg/m3)

Table 7 (continued)

WATER AND NUTRIENT BALANCES - TRIBUTARY MONITORING PERIOD

DIS	RES	GP	QIN	QEVAP	QOUT	QSTOR	QNET	IPTL	OPTL	IPDS	OPDS	INTL	ONTL	ININ	ONIN
20	087 SHELBYVILLE	A	1694.4	47.2	1589.8	128.9	-71.4	170	106	95	54	8008	6194	7325	4788
20	088 REND	A	517.8	75.8	462.9	-51.1	30.2	259	86	47	23	2279	1418	781	371
21	196 WAPPAPELLO	B	1790.2	25.1	1982.3	-21.4	-195.8	86	49	16	10	1501	1357	348	328
22	014 DE GRAY	B	1373.1	60.5	1345.7	-41.3	8.2	16	20	6	6	190	554	73	86
22	019 OUACHITA (BLAKE	B	2887.7	170.7	2697.3	-51.8	71.5	21	16	12	7	671	457	162	168
22	188 ARKABUTLA	B	3209.3	66.1	1617.9	-26.1	1551.4	106	279	47	76	967	1267	797	486
22	189 ENID	A	1548.0	75.2	1308.1	136.3	28.4	271	65	78	23	1570	875	455	372
22	190 GRENADA	B	4001.2	180.7	2854.7	-151.0	1116.8	115	106	32	25	714	939	200	209
22	192 SARDIS	B	3696.5	185.3	3636.9	-235.1	109.5	76	18	15	10	642	687	262	75
23	352 LAKE OF THE PIN	B	1678.6	110.6	1594.9	-12.0	-14.8	94	27	50	8	919	730	190	71
23	353 TEXARKANA(WRIGH	B	6043.7	171.8	5109.8	-9.1	771.2	116	129	52	56	885	864	216	207
23	413 CADDO	B	4352.9	164.8	4637.4	.	-449.3	50	46	18	15	686	835	82	44
24	011 BEAVER	A	2318.4	129.8	2219.3	-134.7	104.0	59	16	16	6	954	773	453	279
24	012 BLUE MOUNTAIN	B	767.4	19.7	742.5	2.3	2.8	25	74	12	22	806	788	90	183
24	013 BULL SHOALS	A	9577.3	213.6	9881.6	-609.1	91.3	18	12	7	6	748	777	463	370
24	016 GREERS FERRY	B	2292.7	139.0	2135.1	-29.7	48.2	32	11	10	5	460	1070	129	160
24	021 NIMROD	B	1362.0	16.3	1302.1	13.4	30.2	30	39	12	11	1051	643	224	89
24	022 NORFOLK	B	2431.0	92.9	2557.3	-301.5	82.2	15	19	8	11	1018	1042	660	346
24	193 CLEARWATER	B	1029.2	6.4	1074.0	-4.6	-46.5	14	34	8	7	1408	1356	360	194
24	200 TABLE ROCK	A	5379.7	180.5	5703.1	-296.5	-207.4	47	18	45	13	2033	1418	900	556
25	020 MILLWOOD	A	10619.6	142.0	10501.4	0.0	-23.9	62	48	17	12	713	459	197	118
25	102 COUNCIL GROVE	B	133.8	18.3	107.0	1.2	7.2	342	99	75	41	5379	1647	2554	538
25	103 ELK CITY	B	963.4	21.2	811.9	-8.9	139.1	80	146	19	30	1653	1535	753	518
25	104 FALL RIVER	B	601.2	15.1	549.0	-2.7	39.8	48	107	17	20	1493	1352	394	426
25	105 JOHN REDMOND	A	1837.5	48.8	1753.0	0.6	35.1	366	178	103	71	3357	1976	1338	741
25	107 MARION	B	92.1	34.8	49.2	3.0	5.1	159	60	49	18	2378	1229	739	162
25	112 TORONTO	B	576.5	16.1	719.1	-1.7	-157.1	52	88	13	18	1240	1486	349	404
25	267 EUFAULA	A	9164.8	536.7	9593.9	-757.4	-208.4	340	191	78	59	1825	1475	266	484
25	269 FORT SUPPLY	A	30.8	12.1	23.9	-5.5	0.3	44	52	12	15	901	892	272	77
25	273 KEYSTONE	A	13117.2	153.8	13870.8	-437.4	-469.9	382	109	123	85	3095	1463	865	771
25	275 OOLOGAH	B	4401.6	174.4	4823.4	-134.9	-461.3	220	86	45	33	1906	1825	450	481
25	278 TENKILLER FERRY	A	2506.0	66.6	2511.4	-47.8	-24.2	91	48	53	21	1906	1843	760	631
25	281 WISTER	A	1635.1	44.7	1594.4	-42.8	38.8	69	71	21	26	929	903	129	166
25	348 TEXOMA (DENNISO	A	8139.9	561.3	8490.5	-651.1	-260.9	376	92	79	16	2525	1188	420	245
25	370 KEMP	B	213.8	56.0	68.3	142.9	-53.4	43	28	13	6	853	671	487	75
26	345 BELTON(BELL)	B	736.0	77.2	1080.1	11.9	-433.2	387	23	312	8	1535	838	865	302
26	347 CANYON	A	885.8	49.8	829.5	-38.1	44.6	17	11	8	6	1320	727	901	425
26	354 LAVON	A	1155.0	91.2	956.9	-28.5	135.4	208	49	69	24	1968	888	618	203
26	355 LEWISVILLE(GARZ	A	1538.1	157.3	1458.6	0.2	-78.1	233	77	82	44	1795	956	505	449
26	359 SAM RAYBURN (MC	B	4533.8	586.6	3627.8	152.0	167.4	83	27	29	10	897	759	197	171
26	360 O C FISHER (SAN	B	88.3	19.0	9.0	42.3	18.0	53	130	22	25	4006	2113	10242	26
26	361 SOMERVILLE	A	731.7	69.2	747.0	0.0	-84.5	111	66	45	20	1679	1225	249	90

Table 7 (continued)

WATER AND NUTRIENT BALANCES - TRIBUTARY MONITORING PERIOD

DIS	RES		GP	QIN	QEVAP	QOUT	QSTOR	QNET	IPTL	OPTL	IPDS	OPDS	INTL	ONTL	ININ	ONIN
02	176	WATERBURY	B	300.9	2.1	292.8	10.8	-4.8	23	18	7	6	917	607	500	397
03	307	BELTZVILLE	A	210.5	3.1	208.0	-1.9	1.3	13	11	7	7	1143	1149	694	739
04	312	F J SAYERS (BLA	A	478.6	3.5	460.9	-7.5	21.8	167	83	106	42	2670	2032	1790	1236
06	372	JOHN H KERR	A	7412.7	196.2	7262.4	-78.5	32.5	129	26	36	13	1315	1225	354	302
08	074	CLARK HILL	A	12064.8	300.7	11483.1	112.6	168.5	54	24	16	9	679	892	267	225
08	330	HARTWELL	A	5781.9	228.9	5801.8	122.9	-371.6	52	9	20	6	669	1004	248	208
10	003	HOLT	A	10077.9	14.2	10372.6	-0.4	-308.5	39	34	11	10	1272	1676	622	824
10	069	ALLATOONA	A	2454.8	42.1	2480.1	22.7	-90.0	75	26	16	9	722	562	297	220
10	071	SEMINOLE (WOODR	A	26483.7	180.2	26808.1	6.7	-511.3	94	76	30	23	1397	1334	442	314
10	072	WALTER F GEORGE	A	12843.2	192.0	12518.1	-11.7	144.8	93	90	33	33	1017	1145	423	462
10	076	SIDNEY LANIER	A	3434.2	161.5	2646.5	80.2	546.1	75	19	31	5	986	801	447	412
10	411	BANKHEAD	A	9272.3	41.4	9522.7	5.9	-297.7	64	53	15	11	1672	1557	911	728
14	099	RED ROCK	A	4964.5	48.5	4981.3	-202.6	137.3	606	217	179	120	9375	7298	7059	5952
15	178	GULL	B	176.3	37.4	148.8	1.8	-11.8	28	19	10	8	937	647	242	52
15	181	LEECH	B	751.5	300.0	368.6	-58.3	141.2	34	22	17	9	1569	1134	367	436
15	237	ASHTABULA (BALD	A	184.0	16.0	163.4	1.3	3.3	269	225	142	174	2627	2211	708	512
16	243	BERLIN	A	276.6	9.5	280.2	-9.1	-4.0	253	58	146	21	2808	2109	1736	1165
16	254	MOSQUITO CREEK	B	116.3	22.7	94.8	-1.6	0.3	148	59	64	15	1862	1747	922	370
16	317	SHENANGO RIVER	A	665.2	10.2	812.0	-6.9	-150.0	96	70	35	13	1497	1491	698	656
16	328	ALLEGHENY (KINZ	A	3893.9	31.4	3647.9	-60.0	274.6	45	31	12	9	682	1301	371	640
16	393	TYGART	B	2938.0	4.5	2912.9	0.7	19.8	20	32	6	9	604	676	451	497
17	241	ATWOOD	A	108.3	4.9	89.5	-2.0	15.9	84	28	20	9	2296	948	1479	362
17	242	BEACH CITY	A	310.7	2.0	288.3	-0.4	20.8	256	210	53	36	4082	3811	2979	2565
17	245	CHARLES MILL	A	279.5	4.9	280.2	-2.2	-3.3	173	156	50	26	3235	2920	1862	1411
17	247	DEER CREEK	B	379.3	3.9	368.1	-0.2	7.5	91	128	35	59	3180	3920	2342	3113
17	248	DELAWARE	A	424.7	4.0	425.9	-0.1	-5.1	265	175	94	72	4461	4001	3214	2868
17	249	DILLON	A	1023.3	5.8	1020.7	-1.7	-1.5	168	130	91	49	2562	2588	1661	1750
17	256	PLEASANT HILL	A	221.8	2.4	205.3	-1.1	15.2	55	56	25	28	2023	1560	1397	1006
17	258	TAPPAN	B	57.9	8.0	61.6	0.0	-3.9	29	30	10	9	996	1088	623	139
17	373	JOHN W FLANNAGA	A	424.0	5.4	397.5	2.9	18.1	77	12	7	5	1291	1341	431	382
17	389	BLUESTONE	A	6991.1	12.0	6611.7	132.5	234.9	46	46	18	19	1387	1418	1013	1062
17	391	SUMMERSVILLE	A	2311.2	5.4	2353.7	-1.0	-46.9	24	15	7	7	914	858	698	701
18	092	MISSISSINEWA	A	1020.8	10.5	1032.6	0.0	-22.3	333	132	106	61	5639	3955	3397	2908
18	093	MONROE	A	546.7	39.3	515.8	-15.3	7.0	28	13	8	6	869	701	553	351
18	120	BARREN RIVER	A	2314.2	33.7	1797.6	123.7	359.2	54	47	45	18	1987	1239	1067	877
19	119	BARKLEY	A	48061.6	219.9	50941.7	48.4	-3148.4	133	122	48	42	1182	1138	634	505
19	122	CUMBERLAND (WOL	A	14746.2	171.0	15174.7	-826.6	227.1	57	34	12	8	1026	905	373	608
19	338	CHEATHAM	B	34315.9	28.9	35726.5	16.7	-1456.2	170	255	61	75	1147	969	487	449
19	340	J PERCY PRIEST	A	2427.3	52.1	2190.7	-79.0	263.4	136	103	90	56	859	886	682	522
19	342	OLD HICKORY	A	27504.0	82.8	28375.0	-10.8	-943.0	106	94	32	26	1006	927	452	414
19	343	DALE HOLLOW	A	2986.7	97.7	2348.4	-68.1	608.7	17	8	7	6	635	1485	362	818
20	081	CARLYLE	A	3822.7	117.0	3956.2	-210.6	-39.9	192	121	60	57	4078	3599	2873	2100

Table 7 (concluded)

WATER AND NUTRIENT BALANCES - TRIBUTARY MONITORING PERIOD

DIS	RES		GP	QIN	QEVAP	QOUT	QSTOR	QNET	IPTL	OPTL	IPDS	OPDS	INTL	ONTL	ININ	ONIN
26	362	STILLHOUSE HOLL	A	695.2	38.1	714.1	-26.1	-30.9	46	17	14	6	1295	649	423	258
26	364	WHITNEY	B	2154.2	121.4	1985.0	193.6	-145.8	285	14	45	10	1633	1219	363	818
28	219	CONCHAS	B	18.2	28.2	53.2	-59.3	-3.8	85	37	30	6	1662	1535	633	59
29	100	RATHBUN	B	256.3	42.3	175.2	-3.7	42.6	384	53	122	10	2808	1734	1847	831
29	106	KANOPOLIS	A	267.7	18.9	193.8	37.9	17.2	543	90	128	29	2475	1584	569	436
29	108	MILFORD	A	574.2	89.1	456.7	30.4	-2.0	449	60	178	28	2339	1491	832	237
29	109	MELVERN	B	262.7	36.6	210.3	31.7	-16.0	199	36	40	13	3638	1734	851	386
29	110	PERRY	B	379.2	60.3	370.8	-9.1	-42.8	410	62	117	20	2844	1188	1465	671
29	111	POMONA	A	217.1	20.8	243.5	-5.1	-42.1	128	59	49	15	2983	2280	982	722
29	113	TUTTLE CREEK	A	1522.3	94.6	1491.7	65.5	-129.5	990	136	256	77	4604	2298	1754	1197
29	114	WILSON	B	96.8	53.4	83.5	-8.3	-31.7	204	38	39	12	1794	1083	504	237
29	194	POMME DE TERRE	B	678.6	35.3	676.9	-3.7	-30.0	41	65	42	31	1758	1776	482	411
29	195	STOCKTON	B	1367.0	111.8	1376.4	14.8	-136.1	70	20	31	7	2508	2754	1410	582
29	207	HARLAN COUNTY	A	253.4	65.4	172.7	-24.7	40.0	304	122	261	66	5182	1235	693	178
30	064	CHERRY CREEK	B	2.4	4.1	2.4	0.0	-4.1	246	161	108	83	2758	1480	1292	365
30	215	PAWNEE	B	8.0	3.3	3.0	0.2	1.5	278	251	163	76	1898	1691	665	689
30	217	BRANCHED OAK	B	21.4	8.0	9.4	1.0	2.9	291	255	176	189	2981	1470	1188	714
30	235	SAKAKAWEA(GARRI	A	32990.3	1341.9	28651.0	1515.6	1481.7	341	27	21	12	1369	547	170	167
31	077	DWORSHAK	A	5847.7	39.2	5513.5	-191.5	486.5	19	17	8	8	689	387	35	78
32	204	KOOKANUSA(LIBBY	B	4962.8	85.3	9670.4	-0.6	-4792.3	23	24	8	20	252	434	36	86
33	300	HILLS CREEK	A	1139.1	5.4	1127.8	-24.9	30.8	40	36	31	24	189	246	32	48
34	048	NEW DON PEDRO	B	2071.6	61.7	2042.9	163.1	-196.1	34	16	18	8	815	1069	87	122
35	029	MENDOCINO	A	407.7	6.5	365.9	18.3	17.0	127	63	26	25	931	750	149	118
35	039	SANTA MARGARITA	B	10.1	3.8	4.9	-3.8	5.2	69	26	33	9	487	463	302	30

log(concentration) vs. log(flow) relationship across all gauged tributaries, precipitation, and ungauged inputs. In computing the average b values, precipitation and ungauged inputs are assumed to have b values of zero. The above calculations have been repeated to calculate inflow concentrations for normal hydrologic years. No reasonable means of correcting average outflow concentrations for changes in flow regime are available, since they would depend upon reservoir nutrient dynamics. Thus, outflow concentrations can be validly compared only with inflow concentrations corresponding to periods of tributary and outflow sampling.

52. Results of the above calculations are tabulated in Appendix B, Table B2, which lists the terms of the water balance, estimated inflow concentrations, and average morphometric characteristics for each monitoring period and reservoir. Morphometric properties during "normal" hydrologic years refer to normal summer pool levels, as identified in the morphometric file; otherwise summer pool levels typical of the EPA/NES monitoring periods have been used. Supplementary files describing average spring and summer morphometric and hydrologic characteristics during the tributary and pool monitoring periods have also been assembled for use in model testing.

53. In relating inflow concentrations to outflow or pool concentrations, evaporation may have significant effects. If the nutrient behaved conservatively, for example, the outflow and pool concentrations would tend to be higher than the inflow concentrations, especially if evaporation accounts for a large portion of the total outflow. In using the inflow concentration data for model testing, a final adjustment has been applied for each time period, nutrient, and reservoir:

$$CICE = CIC / (1-FE) \tag{35}$$

where,

CICE = inflow concentration, adjusted for evaporation (g/m3)

FE = evaporation / total inflow

With some algebra, it can be shown that the above adjustment scheme is

equivalent to defining the average inflow concentration as the total loading divided by the reservoir discharge (when the flow-balance error and change-in-storage terms are negligible).

54. The significance of the correction depends upon the inflow ratio (QI′/QIC), point-source significance (F), flow/concentration sensitivity (b), and evaporation significance (FE). Table 8 summarizes the distributions of the hydrologic correction factors applied above. In the case of total phosphorus, inflow concentrations are modified by less than 10% in all but 9 of the 102 projects with sufficient data to make the corrections to pool monitoring year. The significance of the concentration corrections in relation to the errors which are inherent in this modelling approach seems small, but will be examined. Of potentially greater importance are the year-to-year variations in inflow rates and their resultant impacts on pool hydraulic residence times. Table 8 indicates that inflows during the tributary and pool monitoring periods tended to be greater than average by roughly 50% in both cases (median values). Formulating the inflow conditions in terms of concentration and flow shows that average inflow concentrations are much less sensitive to hydrologic variations than are average loadings. This is fortunate, since model predictions are more sensitive to inflow concentrations than to loadings (see Water Balances).

55. As a means of selecting projects with relatively reliable information for use in model testing, a set of screening criteria has been designed and applied to the total phosphorus budget of each reservoir. The definitions and distributions of the ranking statistics are given in Table 9. The first three criteria reflect water balance accuracy, loading accuracy, and significance of ungauged nutrient sources. The fourth is the ratio of the mean tributary flows on days when concentrations were measured to the mean tributary flows over the entire monitoring period. This has been included to reflect the potential errors involved in estimating loadings if the streamflows on the days in which concentration samples were taken were not representative of the annual period. To some extent, the calculation procedure used in estimating loadings corrects for the effects of flow

Table 8

Distributions of Water and Phosphorus Inflow Adjustment Factors for Pool Sampling, Tributary Sampling, and Normal Hydrologic Years

Variable*	PERCENTILE 1%	5%	10%	25%	50%	75%	90%	95%	99%
Inflow Ratios									
pool/trib	0.23	0.43	0.63	0.93	1.04	1.23	1.79	2.40	6.20
pool/normal	0.33	0.54	0.86	1.25	1.48	1.75	1.92	2.12	2.41
trib/normal	0.09	0.67	0.87	1.18	1.47	1.68	2.00	2.28	2.46
Inflow Total P Concentration Ratios									
pool/trib	0.61	0.93	0.96	0.99	1.00	1.02	1.06	1.20	1.66
pool/normal	0.80	0.84	0.87	0.98	1.01	1.04	1.15	1.20	1.44
trib/normal	0.81	0.86	0.90	0.97	1.00	1.03	1.14	1.14	1.31

* pool = pool monitoring year
trib = tributary monitoring year
normal= normal hydrologic year

Table 9

Statistics Used for Screening Nutrient Budgets

Definitions:

K1 = error in water balance = QN/QI
K2 = coef. of variation of total P loading = CV(WI)
K3 = ungauged loading fraction = (WP + WU)/WI
K4 = inflow sampling ratio = QIS/QIM
K5 = total P retention coefficient = 1 - Po (1-FE) / Pi
K6 = pool year inflow/tributary year inflow = QI′/QI

where,

Po = average outflow total P concentration, gm/m^3
Pi = average inflow total P concentration, gm/m^3
QIS = mean inflow on tributary sampling days, hm^3/yr
QIM = mean inflow over monitoring period, hm^3/yr
FE = evaporation/total inflow

	Percentile						
	5%	10%	50%	90%	95%	criterion	number*
K1	-.26	-.11	.01	.15	.20	|K1| < .25	100
K2	.05	.06	.14	.39	.58	K2 < .40	99
K3	.01	.02	.11	.37	.47	K3 < .25	84
K4	.43	.53	.93	1.47	1.60	.5 < K4 < 2.0	97
K5	-.78	-.40	.47	.85	.91	K5 > -.2	94
K6			-			K6 is nonmissing	102
all						-	62 **

* number of reservoirs satisfying criterion (total = 108)
** satisfy all criteria applied simultaneously

variations; these corrections are limited, however, particularly if important flow regimes (e.g., high-flow seasons or events) were not included in the range of conditions sampled. The fifth criterion has been included to eliminate those projects in which unsteady-state conditions and/or omissions of significant nutrient sources in the sampling program might have resulted in retention coefficients which are considerably less than zero. The sixth criterion requires hydrologic data availability during both the tributary and the pool monitoring periods.

56. Reservoirs have been placed into group A when all of the above criteria have been satisfied, and group B when they have not. A listing of the criteria values and groupings is given in Table 10. Groupings are also identified in Appendix B, Tables B2-B4. The 62 "A" projects conforming to each of the above criteria have been keyed into the nutrient budget files and used as the principal data base for model testing. The distributions of various morphometric, hydrologic, and nutrient concentration statistics for reservoirs in this group are summarized in Table 11.

Water Quality Data

57. To provide a basis for testing internal and load/response relationships, water quality data have been retrieved from the OBS file (see Figure 1) and averaged by station and growing season. Station-year averages have been used for testing internal models (relationships among trophic state indicators measured within reservoir pools). In testing load/response models, station-year averages have been averaged by reservoir. Because of the significance of spatial gradients in many reservoirs, spatial averaging can be difficult without detailed consideration of reservoir morphometry in relation to sampling station location. This type of detail has not been feasible within the current project scope. Thus, the reservoir-average water quality conditions do not include spatial weighting factors or account for possible variations in water quality, either along the mainstem or among tributary arms.

Table 10

Listing of Nutrient and Water Balance Screening Criteria

(note: statistics defined in Table 9)

DIS	RES		GP	K1	K2	K3	K4	K5	K6
02	176	WATERBURY	B	-0.02	0.18	0.33 *	0.71	0.22	. *
03	307	BELTZVILLE	A	0.01	0.10	0.14	0.94	0.19	1.02
04	312	F J SAYERS (BLA	A	0.05	0.27	0.01	1.24	0.51	1.04
06	372	JOHN H KERR	A	0.00	0.08	0.02	0.93	0.80	1.47
08	074	CLARK HILL	A	0.01	0.17	0.05	1.12	0.56	1.05
08	330	HARTWELL	A	-0.06	0.07	0.09	1.03	0.83	0.94
10	003	HOLT	A	-0.03	0.13	0.02	0.84	0.11	0.92
10	069	ALLATOONA	A	-0.04	0.12	0.11	0.99	0.66	1.04
10	071	SEMINOLE (WOODR	A	-0.02	0.05	0.02	0.89	0.20	1.08
10	072	WALTER F GEORGE	A	0.01	0.05	0.01	1.12	0.05	1.03
10	076	SIDNEY LANIER	A	0.16	0.16	0.17	0.82	0.77	1.04
10	411	BANKHEAD	A	-0.03	0.14	0.01	0.87	0.18	0.92
14	099	RED ROCK	A	0.03	0.17	0.01	1.35	0.65	1.93
15	178	GULL	B	-0.07	0.14	0.34 *	0.99	0.46	1.29
15	181	LEECH	B	0.19	0.22	0.60 *	1.05	0.66	1.45
15	237	ASHTABULA (BALD	A	0.02	0.22	0.08	1.74	0.24	1.26
16	243	BERLIN	A	-0.01	0.09	0.14	0.98	0.78	1.14
16	254	MOSQUITO CREEK	B	0.00	0.60 *	0.47 *	2.43 *	0.68	1.07
16	317	SHENANGO RIVER	A	-0.23	0.11	0.02	1.00	0.28	1.01
16	328	ALLEGHENY (KINZ	A	0.07	0.20	0.04	1.17	0.32	1.03
16	393	TYGART	B	0.01	0.11	0.13	1.04	-0.59 *	0.88
17	241	ATWOOD	A	0.15	0.11	0.15	0.52	0.69	0.88
17	242	BEACH CITY	A	0.07	0.21	0.15	1.37	0.18	1.32
17	245	CHARLES MILL	A	-0.01	0.19	0.04	1.04	0.11	1.12
17	247	DEER CREEK	B	0.02	0.14	0.03	0.92	-0.39 *	1.07
17	248	DELAWARE	A	-0.01	0.12	0.14	0.85	0.34	1.24
17	249	DILLON	A	-0.00	0.17	0.02	0.67	0.23	1.06
17	256	PLEASANT HILL	A	0.07	0.11	0.06	0.78	0.01	1.23
17	258	TAPPAN	B	-0.07	0.13	0.58 *	0.87	0.11	1.38
17	373	JOHN W FLANNAGA	A	0.04	0.16	0.21	0.97	0.84	0.80
17	389	BLUESTONE	A	0.03	0.07	0.02	0.99	0.01	0.98
17	391	SUMMERSVILLE	A	-0.02	0.13	0.05	1.08	0.37	1.10
18	092	MISSISSINEWA	A	-0.02	0.25	0.04	0.78	0.61	1.05
18	093	MONROE	A	0.01	0.09	0.21	0.72	0.58	1.27
18	120	BARREN RIVER	A	0.16	0.04	0.08	0.77	0.15	0.95
19	119	BARKLEY	A	-0.07	0.09	0.01	0.99	0.08	1.00
19	122	CUMBERLAND (WOL	A	0.02	0.17	0.12	1.14	0.42	0.86
19	338	CHEATHAM	B	-0.04	0.15	0.05	1.10	-0.50 *	0.91
19	340	J PERCY PRIEST	A	0.11	0.10	0.11	0.53	0.26	1.00
19	342	OLD HICKORY	A	-0.03	0.17	0.11	1.10	0.11	0.87
19	343	DALE HOLLOW	A	0.20	0.05	0.12	0.60	0.52	0.91
20	081	CARLYLE	A	-0.01	0.09	0.05	0.90	0.39	1.01
20	087	SHELBYVILLE	A	-0.04	0.12	0.10	0.83	0.39	0.98
20	088	REND	A	0.06	0.18	0.16	1.00	0.72	0.94
21	196	WAPPAPELLO	B	-0.11	0.90 *	0.07	1.59	0.44	1.15
22	014	DE GRAY	B	0.01	0.06	0.31 *	0.42 *	-0.25 *	0.36
22	019	OUACHITA (BLAKE	B	0.02	0.09	0.34 *	0.67	0.28	0.93
22	188	ARKABUTLA	B	0.48 *	0.05	0.08	0.33 *	-1.54 *	1.43
22	189	ENID	A	0.02	0.23	0.01	1.00	0.77	1.07
22	190	GRENADA	B	0.28 *	0.04	0.01	0.45 *	0.14	1.05
22	192	SARDIS	B	0.03	0.04	0.06	0.41 *	0.77	1.13
23	352	LAKE OF THE PIN	B	-0.01	0.14	0.26 *	1.21	0.74	. *
23	353	TEXARKANA(WRIGH	B	0.13	0.16	0.28 *	1.26	-0.07	. *
23	413	CADDO	B	-0.10	0.11	0.06	1.09	0.10	. *

Table 10 (continued)

DIS	RES		GP	K1	K2	K3	K4	K5	K6
24	011	BEAVER	A	0.04	0.20	0.16	0.94	0.74	1.01
24	012	BLUE MOUNTAIN	B	0.00	0.17	0.09	0.57	-1.88 *	0.75
24	013	BULL SHOALS	A	0.01	0.14	0.12	0.91	0.32	0.98
24	016	GREERS FERRY	B	0.02	0.42 *	0.42 *	1.51	0.67	0.98
24	021	NIMROD	B	0.02	0.11	0.13	0.57	-0.29 *	0.75
24	022	NORFOLK	B	0.03	0.10	0.18	0.77	-0.25 *	1.23
24	193	CLEARWATER	B	-0.05	0.13	0.14	0.98	-1.50 *	1.33
24	200	TABLE ROCK	A	-0.04	0.09	0.07	1.24	0.63	1.09
25	020	MILLWOOD	A	-0.00	0.14	0.22	0.58	0.23	0.84
25	102	COUNCIL GROVE	B	0.05	0.46 *	0.36 *	1.48	0.75	1.81
25	103	ELK CITY	B	0.14	0.05	0.26 *	0.32 *	-0.79 *	0.97
25	104	FALL RIVER	B	0.07	0.07	0.28 *	0.56	-1.18 *	1.09
25	105	JOHN REDMOND	A	0.02	0.11	0.10	0.81	0.53	1.43
25	107	MARION	B	0.06	0.39	0.36 *	2.55 *	0.77	2.02
25	112	TORONTO	B	-0.27 *	0.06	0.25	0.78	-0.65 *	1.23
25	267	EUFAULA	A	-0.02	0.06	0.06	0.98	0.47	0.76
25	269	FORT SUPPLY	A	0.01	0.23	0.19	1.17	0.30	1.09
25	273	KEYSTONE	A	-0.04	0.15	0.04	0.76	0.72	1.00
25	275	OOLOGAH	B	-0.10	0.62 *	0.03	1.56	0.62	1.07
25	278	TENKILLER FERRY	A	-0.01	0.14	0.07	0.88	0.49	1.07
25	281	WISTER	A	0.02	0.12	0.11	0.61	0.01	0.93
25	348	TEXOMA (DENNISO	A	-0.03	0.31	0.02	1.17	0.77	0.61
25	370	KEMP	B	-0.25	0.49 *	0.20	0.77	0.47	0.54
26	345	BELTON(BELL)	B	-0.59 *	0.06	0.21	0.63	0.95	0.25
26	347	CANYON	A	0.05	0.19	0.11	1.05	0.39	0.58
26	354	LAVON	A	0.12	0.32	0.02	1.47	0.79	0.60
26	355	LEWISVILLE(GARZ	A	-0.05	0.30	0.11	1.30	0.70	0.42
26	359	SAM RAYBURN (MC	B	0.04	0.06	0.32 *	0.99	0.72	. *
26	360	O C FISHER (SAN	B	0.20	0.05	0.21	0.15 *	-0.78 *	1.01
26	361	SOMERVILLE	A	-0.12	0.09	0.16	0.59	0.46	0.56
26	362	STILLHOUSE HOLL	A	-0.04	0.34	0.05	0.71	0.65	0.36
26	364	WHITNEY	B	-0.07	1.32 *	0.01	1.59	0.95	0.22
28	219	CONCHAS	B	-0.21	0.56 *	0.41 *	2.26 *	1.12	6.31
29	100	RATHBUN	B	0.17	0.06	0.35 *	0.65	0.89	2.24
29	106	KANOPOLIS	A	0.06	0.15	0.08	0.51	0.85	2.44
29	108	MILFORD	A	-0.00	0.08	0.08	0.85	0.89	2.47
29	109	MELVERN	B	-0.06	0.26	0.46 *	0.68	0.84	. *
29	110	PERRY	B	-0.11	0.06	0.05	0.49 *	0.87	2.05
29	111	POMONA	A	-0.19	0.27	0.18	0.93	0.57	1.04
29	113	TUTTLE CREEK	A	-0.09	0.07	0.02	0.85	0.87	1.61
29	114	WILSON	B	-0.33 *	0.18	0.06	0.70	0.89	1.75
29	194	POMME DE TERRE	B	-0.04	0.25	0.13	0.60	-0.51 *	0.92
29	195	STOCKTON	B	-0.10	0.22	0.41 *	1.08	0.73	1.08
29	207	HARLAN COUNTY	A	0.16	0.09	0.03	0.58	0.72	1.28
30	064	CHERRY CREEK	B	-1.71 *	0.96 *	0.23	1.62	0.76	0.99
30	215	PAWNEE	B	0.19	0.08	0.30 *	0.60	0.55	2.43
30	217	BRANCHED OAK	B	0.14	0.11	0.37 *	0.49 *	0.50	2.76
30	235	SAKAKAWEA(GARRI	A	0.04	0.24	0.03	1.16	0.92	0.67
31	077	DWORSHAK	A	0.08	0.21	0.21	1.17	0.14	1.01
32	204	KOOKANUSA(LIBBY	B	-0.97 *	0.07	0.79 *	0.88	-0.05	1.07
33	300	HILLS CREEK	A	0.03	0.12	0.20	1.17	0.11	1.03
34	048	NEW DON PEDRO	B	-0.09	0.23	0.47 *	0.90	0.53	0.99
35	029	MENDOCINO	A	0.04	0.35	0.10	1.36	0.52	1.01
35	039	SANTA MARGARITA	B	0.52 *	0.39	0.36 *	0.73	0.92	1.45

*SCREENING CRITERION VIOLATED

Table 11

Statistical Summary of Nutrient Concentration, Morphometric, and Hydrologic Data from 62 Reservoirs

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
IPTL	INFLOW TOTAL P (MG/M3)	62	179.13	185.85	13.46	1050.46
OPTL	OUTFLOW TOTAL P (MG/M3)	62	72.17	56.67	8.29	224.80
IPDS	INFLOW DISSOLVED P (MG/M3)	62	61.97	67.92	6.68	375.65
OPDS	OUTFLOW DISSOLVED P (MG/M3)	62	30.52	30.44	5.22	174.14
INTL	INFLOW TOTAL N (MG/M3)	62	2214.49	1824.22	190.25	9469.81
ONTL	OUTFLOW TOTAL N (MG/M3)	62	1596.49	1266.84	245.54	7298.11
CVI	COEF. OF VAR. OF INFLOW TOTAL P	62	0.15	0.08	0.04	0.35
CVO	COEF. OF VAR. OF OUTFLOW TOTAL P	62	0.19	0.10	0.04	0.55
RPTL	TOTAL P RETENTION COEF.	62	0.46	0.27	0.01	0.92
RNTL	TOTAL N RETENTION COEF.	62	0.18	0.34	-1.24	0.83
SEDM	SEDIMENTATION RATE (KG/M2-YR)	17	35.79	39.80	3.97	142.10
ZMAX	MAXIMUM DEPTH (M)	62	30.04	26.45	4.09	174.77
ZMEA	MEAN DEPTH (M)	62	9.81	8.97	1.53	57.59
THYD	RESIDENCE TIME (YR)	62	0.32	0.33	0.01	1.89
QSOV	OVERFLOW RATE (M/YR)	62	81.59	123.88	3.23	779.14
SHDV	SHORELINE DEVELOPMENT RATIO	59	10.92	8.06	2.57	34.18
LNWD	LENGTH/WIDTH RATIO	59	60.49	72.11	2.20	387.78
DAWCSA	WATER CONTR DA / SURFACE AREA	62	256.44	370.09	15.08	1966.83

The effects of the averaging procedures on the model evaluations warrant additional analysis. Thus, the accuracy of the reservoir averages depends, in part, upon reasonable distribution of sampling stations among representative areas of each reservoir, as was a key objective of the EPA/NES survey designs.

58. In reducing the station-year-average file, the first step has been to retrieve data for 1509 station-years with at least three total phosphorus sampling dates at pool monitoring locations. Additional requirements for at least two sampling dates for chlorophyll-a and transparency (Secchi depth) have been applied to yield a total of 525 station-years. The retrieval includes data from April through October at depths less than 15 feet, i.e., growing-season, surface-layer concentrations. In the first reduction stage, the data from each station, year, and sampling date have been averaged over depth:

$$Csi = \sum_{j=1}^{Nsi} Csij \,/\, Nsi \qquad (36)$$

where,

Csij = measurement for station s, date i, depth j

Nsi = number of depths sampled on date i

Csi = depth-averaged value on date i

The above variables refer to a given year and water quality variable. Because averaging is done within the surface layer, there is little point in applying areal weighting factors with depth. Depth-averaging is generally not applicable to chlorophyll because the samples themselves are depth-integrated. The next step is to average across dates within each year:

$$Cs = \sum_{i=1}^{Ns} Csi \,/\, Ns \qquad (37)$$

where,

Cs = station-year average

Ns = number of sampling dates for station-year s

The standard error of Cs has also been estimated (as the standard deviation divided by the square root of Ns) for total phosphorus, total nitrogen, chlorophyll-a, and transparency. Standard errors provide approximate means for assessing the reliability of the station-year summaries and are useful in error analyses. Estimates of maximum, spring-average, and summer-average conditions have also been computed for nutrients, chlorophyll, and transparency, where sampling schedules permit. Seasonal averages are of relatively low reliability, however, because they are based upon minimal data.

59. The following screening criteria have been applied to divide the station-year-average data set into two groups reflecting data reliability:

$$Ns(P,N,B,S) > 2 \tag{38}$$

$$CV(P,N,B,S) < .5 \tag{39}$$

where,

P = total phosphorus (mg/m3)

N = total N (mg/m3)

B = chlorophyll-a (mg/m3)

S = transparency (m)

CV(X) = coefficient of variation for mean X

The high-priority ("group A") data set used for model testing includes 258 station-years with at least 3 sampling dates and with coefficients of variation less than 0.5 for the above variables. All of the high-priority station-years also include measurements of ortho (or dissolved) phosphorus and inorganic nitrogen. In addition, the unaveraged data have been inspected to identify a few station-years with high percentages of low accuracy phosphorus measurements, based upon frequent recordings of < 20 mg/m3; for example. These data are derived from agencies other than the EPA/NES and have been placed in the low priority data set. A listing of the data is given in Appendix B, Table B3; the high-priority data are summarized in Table 12.

Table 12

Statistical Summary of High-Priority ("group A") Pool Water Quality Data from 258 Station-Years Passing Screening Procedures

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CPTL	TOTAL PHOSPHORUS (MG/M3)	258	56.63	52.23	4.89	293.19
CPOT	ORTHO PHOSPHORUS (MG/M3)	223	18.82	25.92	2.83	220.91
CPDS	DISSOLVED PHOSPHORUS (MG/L)	35	25.44	28.98	10.00	155.00
CNTL	TOTAL NITROGEN (MG/M3)	258	981.94	857.06	236.45	6075.00
CNIN	INORGANIC NITROGEN (MG/M3)	258	521.15	704.99	39.96	5064.16
CCHA	CHLOROPHYLL-A (MG/M3)	218	10.61	11.77	0.97	83.41
CCFU	UNCORRECTED CHLOROPHYLL-A (MG/M3)	40	13.85	7.91	2.68	31.25
CCHAMX	MAXIMUM CHLOROPHYLL-A (MG/M3)	218	16.11	16.67	1.30	97.00
CSEC	SECCHI DEPTH (M)	258	1.50	1.23	0.16	6.97
NPTL	NUMBER OF TOTAL P SAMPLING DATES	258	3.66	1.70	3.00	21.00
NCHA	NUMBER OF CHL-A SAMPLING DATES	258	3.40	0.68	3.00	7.00
NNTL	NUMBER OF TOTAL N SAMPLING DATES	258	3.57	1.26	3.00	13.00
NSEC	NUMBER OF SECCHI SAMPLING DATES	258	3.46	0.78	3.00	6.00
EPTL	CV OF MEAN TOTAL P ESTIMATE	258	0.18	0.10	0.01	0.48
ECHA	CV OF MEAN CHL-A ESTIMATE	258	0.28	0.12	0.01	0.50
ENTL	CV OF MEAN TOTAL N ESTIMATE	258	0.15	0.08	0.01	0.37
ESEC	CV OF MEAN SECCHI ESTIMATE	258	0.18	0.10	0.00	0.49
CDEP	STATION DEPTH (M)	227	21.25	27.38	1.22	175.38
CPHF	PH (STANDARD UNITS)	258	7.85	0.47	6.27	8.70
CCNF	CONDUCTIVITY (UMHOS/CM)	258	493.30	548.24	22.50	4948.16
CALK	ALKALINITY (MG/L)	255	96.61	57.36	10.00	309.28
CTMP	TEMPERATURE (DEG-C)	258	20.69	2.96	13.18	27.89
CTRJ	TURDIBITY (JTU)	3	17.89	2.59	16.37	20.88
CTRH	HACH TURBIDITY (NTU)	46	10.16	11.31	1.60	40.00
CTRN	-LOG(% TRANS./100)	209	0.35	0.43	0.02	2.48
CTCO	TRUE COLOR (PT-CO UNITS)	17	56.49	37.62	15.00	105.00
CALPH	NON-ALGAL TURBIDITY (1/M)	258	0.87	0.79	0.08	6.02
CRTL	TOTAL SOLIDS (MG/L)	24	159.25	78.42	5.00	389.58
CRFL	DISSOLVED SOLIDS (MG/L)	33	115.46	51.34	44.80	208.50
CRNF	SUSPENDED SOLIDS (MG/L)	41	11.60	10.18	1.00	39.33
CALG	ALGAL COUNT (NO/LITER)	2	178350.00	157614.10	66900.00	289800.00
CBIO	ALGAL VOLUME (ML/LITER)	2	0.04	0.01	0.04	0.05

60. Means by reservoir-year have been calculated directly from the station-year averages. Based upon the variance component analyses conducted previously (Walker, 1980a, 1981), on the average, about half of within-station variance (expressed in logarithmic terms or, approximately, as coefficients of variation) can be attributed to variance between dates and about half to random effects. The following formula has been used to estimate the coefficients of variation of the reservoir mean phosphorus, nitrogen, chlorophyll, and transparency values computed from the station data summaries:

$$CV^2 = .5\ CVS^2\ [\ 1 + 1/M\ ]\ /\ N \qquad (40)$$

where,

CV = coefficient of variation of reservoir mean estimate
CVS^2 = mean squared within-station coefficient of variation
N = average number of sampling dates
M = total number of stations in the reservoir

The effects of spatial variance on errors in the the reservoir means have not been included because of lack of spatial weighting factors and because serial, spatial correlation would tend to reduce their significance (Walker, 1980a, 1981). The above error equation assumes reasonable distribution of the stations among representative areas of the reservoir.

61. The screening procedures described above have also been applied to the reservoir-average data set, yielding a total of 86 high-priority and 72 low-priority reservoir-years for use in model testing. A listing is given in Appendix B, Table B4; the high-priority ("group A") data are summarized in Table 13.

62. In the high-priority data set, chlorophyll-a measurements for 50 out of 258 station-years were not corrected for phaeophytin, based upon the codes used in entering the data into STORET or the Ohio River Division (ORD) data base. The EPA/NES chlorophyll data are measured and corrected for phaeophytin according to the fluorometric method described by Yentch and Mentzel (1963) (personal communication, Frank

Table 13

Statistical Summary of High-Priority ("group A") Pool Water Quality Data from 85 Reservoir-Years Passing Screening Procedures

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CPTL	TOTAL PHOSPHORUS (MG/M3)	85	66.83	58.21	5.63	277.04
CPOT	ORTHO PHOSPHORUS (MG/M3)	67	22.70	28.12	3.83	187.72
CPDS	DISSOLVED PHOSPHORUS (MG/L)	18	21.34	17.57	10.00	79.05
CNTL	TOTAL NITROGEN (MG/M3)	85	1159.05	973.24	247.34	6075.00
CNIN	INORGANIC NITROGEN (MG/M3)	85	651.38	800.26	44.54	5064.16
CCHA	CHLOROPHYLL-A (MG/M3)	65	13.04	11.52	1.18	67.13
CCFU	UNCORRECTED CHLOROPHYLL-A (MG/M3)	20	9.73	6.56	2.68	27.47
CCHAMX	MAXIMUM CHLOROPHYLL-A (MG/M3)	65	20.97	17.48	1.73	84.19
CSEC	SECCHI DEPTH (M)	85	1.33	0.96	0.19	4.32
NPTL	NUMBER OF TOTAL P SAMPLING DATES	85	3.80	1.89	2.11	16.80
NCHA	NUMBER OF CHL-A SAMPLING DATES	85	3.28	0.71	2.11	6.00
NNTL	NUMBER OF TOTAL N SAMPLING DATES	85	3.70	1.52	2.11	12.40
NSEC	NUMBER OF SECCHI SAMPLING DATES	85	3.53	1.07	2.11	6.00
EPTL	CV OF MEAN TOTAL P ESTIMATE	85	0.18	0.09	0.04	0.42
ECHA	CV OF MEAN CHL-A ESTIMATE	85	0.26	0.10	0.06	0.49
ENTL	CV OF MEAN TOTAL N ESTIMATE	85	0.14	0.06	0.05	0.35
ESEC	CV OF MEAN SECCHI ESTIMATE	85	0.17	0.09	0.03	0.45
CDEP	STATION DEPTH (M)	66	18.90	27.11	2.18	175.40
CPHF	PH (STANDARD UNITS)	85	7.84	0.49	6.37	8.48
CCNF	CONDUCTIVITY (UMHOS/CM)	85	512.29	589.18	23.50	4599.87
CALK	ALKALINITY (MG/L)	82	97.05	59.24	10.50	293.75
CTMP	TEMPERATURE (DEG-C)	85	20.46	2.80	14.85	27.56
CTRJ	TURDIBITY (JTU)	1	17.62	.	17.62	17.62
CTRH	HACH TURBIDITY (NTU)	22	9.29	10.76	2.25	34.81
CTRN	-LOG(% TRANS./100)	62	0.48	0.49	0.05	2.15
CTCO	TRUE COLOR (PT-CO UNITS)	6	54.09	38.19	13.33	98.65
CALPH	NON-ALGAL TURBIDITY (1/M)	85	0.98	0.84	0.15	5.24
CRTL	TOTAL SOLIDS (MG/L)	8	155.36	115.94	9.50	389.58
CRFL	DISSOLVED SOLIDS (MG/L)	8	101.02	47.64	48.42	165.32
CRNF	SUSPENDED SOLIDS (MG/L)	20	8.52	9.32	1.00	38.56
CALG	ALGAL COUNT (NO/LITER)	3	166558.33	113305.93	66900.00	289800.00
CBIO	ALGAL VOLUME (ML/LITER)	3	0.03	0.02	0.01	0.05

Morris, USEPA Environmental Monitoring and Support Laboratory, Las Vegas). Chlorophyll model testing and calibrations are based exclusively upon data from the 218 station-years with corrected measurements. One would expect, therefore, that the calibrated models would tend to under-predict chlorophyll-a measurements which are not corrected for phaeophytin. About 15% of the station-years employed total dissolved phosphorus, as opposed to orthophosphorus, as a measure of the available fraction. These have been used in combination with inorganic nitrogen (nitrate+nitrate+ammonia) for assessment of limiting nutrients.

63. Operating within the constraints of available data, the median sampling frequency in the high-priority data set used for model testing is 3 per station per year. Considering within-station variability, a higher sampling frequency would have been desirable to provide better estimates of average conditions at each station or in each reservoir for use in model testing. Average coefficients of variation of average phosphorus, chlorophyll, and transparency estimates are 18%, 28%, and 18%, respectively. These errors are of concern in model calibration because they influence the accuracies of model parameter estimates. The variances of parameter estimates derived from a given data set are proportional to the gross error variance of the model and inversely related to the number of cases (stations) (Snedecor and Cochran, 1972). Thus, while the limited sampling regime at each station increases the gross error variance of the model, effects on the variance of parameter estimates (and on model testing conclusions) can be partially offset by using data from a large number of stations (258). These relationships are demonstrated further in the error analyses conducted in Part VIII. While more than three sampling dates per station per growing season would be advisable for model applications, the data set assembled above is adequate for testing purposes.

Sediment Accumlation Rates

64. Appendix C (Table C1) contains a listing of sediment accumulation rates which have been extracted from the data base (Figure 1) for

use in model testing. Sediment survey sheets have been reviewed and the data screened to eliminate estimates which were pre-1950 and/or based upon inconsistent survey designs, with respect to range number or calculation method. Sediment accumulation data from a total of 17 projects with relatively reliable nutrient balances have survived the data screening procedure and have been used in model testing. Rates are expressed in terms of mass per unit area of reservoir per year and reflect long-term averages. These estimates are probably less accurate than the nutrient balances developed above and do not necessarily reflect the hydrologic or meteorologic conditions present during the periods of sampling by the EPA/NES.

Data Inventories

65. Table 14 inventories and classifies the model testing data sets developed above, according to priority group, region, year, station type, and monitoring agency. The data sets include the following:

a. water quality summary by station-year
b. water quality summary by reservoir-year
c. nutrient balances by reservoir-year
d. load/response by reservoir-year

In the fourth data set, which is a cross between data sets b and c, observations have been placed in the high-priority group only if both the nutrient balances and the water quality summaries are also classified as high-priority. The resultant data set includes a total of 43 high-priority reservoir-years for use in evaluating load/response relationships.

66. In Table 14, "regions" are defined based upon CE Divisions, with the exceptions of the Ohio River and Southwest Divisions, which have been subdivided by District to reflect data densities and geographic diversities. In all data sets, regional weaknesses are apparent in the East and Far West. The New England Division is not represented in any of the data sets because no chlorophyll,

Table 14

Inventory and Classification of Model Testing Data Sets

Code:		a			b			c			c x b (d)		
Data Set:		Water Quality			Water Quality			Loadings			Load/Response		
Basis:		Station-Yrs			Reservoir-Yrs			Reservoir-Yrs			Reservoir-Yrs		
Group:*	N	A	B	All	A	B	All	A	B	All	A	B	All
Total	299	258	267	525	85	73	158	62	46	108	43	53	96
Region**													
NED	22	0	0	0	0	0	0	0	0	0	0	0	0
NAD	15	4	6	10	2	2	4	2	1	3	2	1	3
SAD	24	24	54	78	8	6	14	9	0	9	3	6	9
NCD	16	4	21	25	2	8	10	2	2	4	1	3	4
ORD - Pitts.	14	15	4	19	5	1	6	3	2	5	3	2	5
ORD - Hunt.	28	22	12	34	10	1	11	9	2	11	8	3	11
ORD - Louis.	15	31	19	50	17	15	32	3	0	3	3	0	3
ORD - Nash.	7	38	19	57	9	0	9	5	1	6	5	1	6
LMVD	15	16	25	41	4	6	10	4	9	13	3	6	9
SWD - L. Rock	10	36	5	41	6	2	8	3	5	8	3	5	8
SWD - Other	56	36	57	93	10	19	29	13	12	25	6	14	20
MRD	31	24	35	59	10	5	15	6	9	15	5	10	15
NPD	27	8	3	11	2	1	3	2	1	3	1	2	3
SPD	19	0	7	7	0	7	7	1	2	3	0	0	0
Year													
71		0	1	1	0	1	1						
72		0	11	11	0	5	5	0	4	4	0	4	4
73		98	100	198	32	13	45	35	8	43	27	16	43
74		97	106	203	26	26	52	24	29	53	15	38	53
75		24	21	45	9	10	19	3	5	8	1	7	8
76		7	6	13	1	4	5						
77		21	8	29	14	7	21						
78		11	8	19	3	5	8						
79		0	6	6	0	2	2						
Agency													
EPA/NES		209	207	416									
ORD		32	22	54									
Other		17	38	55									
Station Type													
Upper Pool		58	65	123									
Mid Pool		128	126	254									
Near Dam		72	76	148									

* N = total number of projects included in CE data base
A = data passing screening procedures (high-priority)
B = data not passing screening procedures (low-priority)
All = all data

** Regions are CE Divisions, except ORD and SWD, which are divided by District

transparency, or nutrient budget estimates were available from NED during Phase I of this project. The South Pacific Division is not represented in the fourth data set because the monitoring program design employed by the EPA/NES in that Division involved pool sampling in March, mid-summer, and November. Thus, these data did not survive screening for at least two sampling rounds per growing season, defined as April-October. Future analyses might incorporate these data, since seasonal factors might not be as important in California as in other regions.

67. The intent of the screening procedures employed above has been to assemble data sets with reliable information for use in preliminary model testing. "Reliable" is defined relatively and within the constraints of available data. The screening procedure is based upon relative data values, sampling designs, and internal checks (e.g. water balances). Other types of errors, such as biases or systematic errors in the sampling designs or analytical measurements, may have gone undetected.

68. In some cases, the screening procedure may have been too conservative, resulting in rejection of data which may be adequate for some purposes. For example, some reservoir-years have been eliminated from data sets c and d because of high variability in the mean chlorophyll-a estimates. These data might still be adequate, for testing models which predict other response variables (e.g.,phosphorus, transparency). These observations could be considered in future studies and refinements of the work described below.

PART IV: MODEL TESTING METHODS

69. Appendix E contains a compilation of empirical eutrophicatic models derived from the general literature. Models are identified wit respect to variables, equation(s), author(s), data set characteristics percent of dependent variablility explained, and, when available, erro statistics. A systematic approach has been designed for calibrating an testing these models using the data sets described in Part III. Th following steps are involved:

a. Model Classification
b. Preliminary Testing
c. Parameter Estimation
d. Residuals Analysis
e. Parameter Stability Analysis

Each of these steps is outlined below.

70. The models compiled in Appendix E have been reviewed and classified according to predicted variable and functional form. This reduces the number of separate equations to be evaluated, since many of the models are similar in structure but differ only with respect to parameter estimates, which depend upon the data sets and methods used for calibration. A model coding system has been designed in order to keep track of the equations, parameter estimates, and calibration data sets. Each model is represented by a 6-digit code, as defined below:

Digits	Code
1	predicted variable:
	P = pool phosphorus R = outflow phosphorus
	B = chlorophyll S = secchi depth
	D = oxygen depletion
2-3	model formulation number
4	parameter estimates:
	A = original parameters
	X = optimal parameters
5-6	sequence number, reflecting data sets and/or sources

For example, model B01A02 predicts chlorophyll, using formulation number 1 (log(Chlorophyll) vs. log(Phosphorus) regression), with original parameters reported by investigator 2. Models B01X01, B01X02, and B01X03 represent the same model with parameters optimized for different subsets of reservoir data. Model codes are identified according to formulation, source, and sequence number at the beginning of each analysis. The codes are used to identify and store residuals in model testing data sets.

71. In the preliminary testing stage, each model is applied to the data with its original parameter estimates. Residuals are characterized with respect to bias (mean), variance, and fraction of dependent variablility explained (R-Squared). Note that in cases of poorly fitting models with their respective original coefficients, it is possible for computed R-Squared values to be less than zero. This indicates that the variance of the residuals is greater than the variance of the dependent variable. Median absolute deviations, more robust estimates of error, (Mosteller and Tukey, 1977) are also calculated.

72. For a given formulation and data set, parameters are optimized using least-squares regression, with the dependent variable consistently transformed to base-10 logarithmic scales. Thus, the objective function minimized is the sum of the squares of the logarithmic deviations. Predicted variables and residuals from these models generally tend to be log-normally distributed. This results from the fact that errors associated with measurement, sampling, and the models themselves are more stable when expressed on a percentage basis than on an absolute basis. Stability of variance (homoscedasticity) is a desirable property for parameter estimation purposes (Snedecor and Cochran, 1972). In cases where non-linear estimation methods are required the SAS procedure NLIN is used (SAS Institute, 1979). Grid searches are employed to determine reasonable starting points for implemetation of the Marquardt optimization algorithm. Estimates of parameter standard errors are approximate when non-linear estimation methods are required. The special parameter estimation procedures used for the oxygen depletion

models, which are posed as discriminant functions, are described in Part VII.

73. In some cases, model parameters are estimated for several alternative data sets, defined by various morphometric, hydrologic, and water quality characteristics. Some formulations are appropriate only under certain conditions. For example, the chlorophyll/phosphorus model has been fit to several data sets, based upon turbidity concentrations and N/P ratios. This provides insights into parameter stability, model error, and model applicability under various conditions. Data set limits are defined by plotting residuals against potentially important factors (e.g., N/P) and identifying factor levels at which systematic deviations begin to occur.

74. Residuals from a given model and data set are subjected to a standard battery of tests, which includes the following:

a. statistical summary
b. plotting
c. correlations
c. stepwise regressions
d. regional tests

These analyses, generally conducted for models with optimized coefficients, provide additional insights into model adequacy under various conditions and suggest possible improvements. Results are tabulated in Appendix D and discussed in appropriate areas of the text.

75. The SAS procedure UNIVARIATE is used to calculate a standard set of statistics for each calibrated model:

a. number of observations
b. bias (mean error)
c. t-test for significance of bias
d. standard deviation
e. mean squared error
f. minimum
g. maximum
h. median absolute deviation

For example, model B01A02 predicts chlorophyll, using formulation number 1 (log(Chlorophyll) vs. log(Phosphorus) regression), with original parameters reported by investigator 2. Models B01X01, B01X02, and B01X03 represent the same model with parameters optimized for different subsets of reservoir data. Model codes are identified according to formulation, source, and sequence number at the beginning of each analysis. The codes are used to identify and store residuals in model testing data sets.

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- d. regional tests

These analyses, generally conducted for models with optimized coefficients, provide additional insights into model adequacy under various conditions and suggest possible improvements. Results are tabulated in Appendix D and discussed in appropriate areas of the text.

75. The SAS procedure UNIVARIATE is used to calculate a standard set of statistics for each calibrated model:

- a. number of observations
- b. bias (mean error)
- c. t-test for significance of bias
- d. standard deviation
- e. mean squared error
- f. minimum
- g. maximum
- h. median absolute deviation

i. Chi-squared

In some cases, these are calculated for different data groupings, defined by data reliability and averaging method. The median absolute deviation is an alternative measure of error spread which is less sensitive to outlying values than the mean squared error (Mosteller and Tukey, 1977).

76. The Chi-squared statistic (Bevington, 1969) is a weighted mean squared error, with weights calculated as the inverses of the estimated data error variances. Estimates of model dependent variables and some independent variables generally represent averages over space and/or time in a given reservoir or its tributaries. Because of variability within the averaging realm and limited number of sampling dates and/or locations, estimates of average conditions are subject to error. Approximate methods used for estimating these "data errors" are described in Part III. For a given model and observation, the weighting factor used in the Chi-Squared calculation is given by:

$$W = 1 / [Var(Y) + D^2 Var(X)] \tag{41}$$

where,

W = weighting factor used for a given observation
Var(Y) = variance of estimated dependent variable
Var(X) = variance of estimated independent variable
D = derivative of predicted Y with respect to X

In a linear model, for example, the D factor represents the coefficient for variable X. Ranking models based upon Chi-squared puts less weight on observations which are less reliable and provides an indication of error sources. For example, a Chi-squared statistic approaching 1.0 indicates that all of the residual variance can be explained by potential errors in the data, i.e., model error is insignificant. A Chi-squared of 2.0 indicates that the error is partitioned equally between model and data error effects.

77. Model residuals are tested for association with various morphometric, hydrologic, and water quality characteristics by a

combination of plotting, correlation, and stepwise regression analyses. These analyses provide general indications of conditions under which a given model may be biased and suggest modifications which may improve model generality. Plotting and examination of residuals is perhaps the most important of these analyses, although it is not feasible to reproduce these displays in a report context.

78. Interpretation of these association tests can be difficult because of correlations among the factors investigated. If two factors are highly correlated with each other, both may be correlated with a model residual, but only one may be significant from a causation standpoint. A statistically significant correlation coefficient is not, in itself, adequate evidence of a real effect. Similarly, the stepwise regressions include only statistically significant terms ($p<.05$), but direct interpretation of the coefficients can be misleading. The multivariate R-squared statistic derived from the stepwise regressions is a indicator of model generality over the range of reservoir characteristics.

79. Analyses of variance have been conducted to test for significant regional effects on model residuals. With some exceptions, regions are defined by CE Divisions. Because the Ohio River and Southwest Divisions are relatively rich in data and diverse in terrain, they are subdivided by CE District. Schematic plots generated by the SAS procedure SPLOT have been used to display regional variations in residuals and important related variables. Regional groupings have been identified using Duncan's multiple-range test (Snedecor and Cochran,1972). In many cases, regional variations in residuals can be explained by corresponding variations in reservoir morphometric, hydrologic, and/or water quality characteristics, as identified through the association tests described above.

80. A final test involves an examination of parameter stability. One characteristic of a "good" model is that its parameter or coefficient values are stable over the range of model application. Fitting the model to different subsets of data provides a basis for assessing parameter stability. Subsets may be defined by region,

impoundment type, or ranges of important independent variables. Basically, this test attempts to determine whether the model "constants" are constant. This type of test is more elaborate and potentially more powerful than those discussed above and has been applied to the models which seem to work best in each category.

PART V: INTERNAL MODELS

Introduction

81. This report defines "internal models" as relationships among nutrient concentrations, transparency, chlorophyll-a, and hypolimnetic oxygen depletion, measured within impoundments. In some cases, morphometric and hydrologic factors are also included in these models. These are distinguished from "external models", which relate water quality measurements to external nutrient loadings and are discussed in Part VI. Internal models are classified into three categories, based upon predicted variables:

a. Transparency
b. Chlorophyll
c. Oxygen Depletion

The first two categories are treated in the following sections. The fourth section analyzes regional variations in these measurements and related factors. Because the models and testing methods employed for the oxygen depletion models are of a unique character, they are described and tested separately in Part VII.

Transparency Models

82. In many impoundments, absorption and scattering of light by phytoplankton limits water transparency. Other biological materials, dissolved humic materials (color), and inorganic suspended solids may also regulate transparency. While not necessarily proportional to algal biomass, chlorophyll-a is the most widely used measure of phytoplankton standing crop. The relationship between chlorophyll-a and transparency is important to assessing the roles of algae vs. other materials in the partitioning of light extinction and nutrients. As demonstrated in subsequent sections, this partitioning has important implications for calibrating and applying empirical eutrophication models to reservoirs.

83. The relationship between station-year-average chlorophyll and transparency measurements is shown in Figure 2. The following model formulations have been tested for summarizing this relationship:

Model Code	Equation
S01	$\log(S) = K1 + K2 \log(B)$
S02	$1/S = K1 + K2\ B$
S03	$1/S = K1 + K2\ B^{K3}$

Parameter estimates and error statistics for these models are summarized in Table 15. For model S03, the best estimate of parameter K1 is zero, so that the model is equivalent to model S01, which explains 31 percent of the variance in the transparency data, as compared with 26 percent for model S02. It is apparent from these error statistics and from Figure 2 that transparency is regulated in many of these reservoirs by factors which are not related to chlorophyll-a. The parameter K1 in models S01 and S02 varies significantly from station to station, as influenced by allocthonous suspended solids, dissolved color, and biological materials which are not related to chlorophyll-a. These variations are important because they influence the availability of light and nutrients for photosynthesis. To some extent, the slope parameter, K2, may also vary because of fluctuations in chlorophyll/biomass ratios, as influenced by algal species, environmental factors, and growth stage. Available data do not permit assessment of K2 variations or their effects, however.

84. The S02 model has been recalibrated in order to provide a means for estimating the effects of non-chlorophyll-related materials on light extinction at each station. This has been done by transposing the model equation:

$$A = 1/S - K2\ B \tag{42}$$

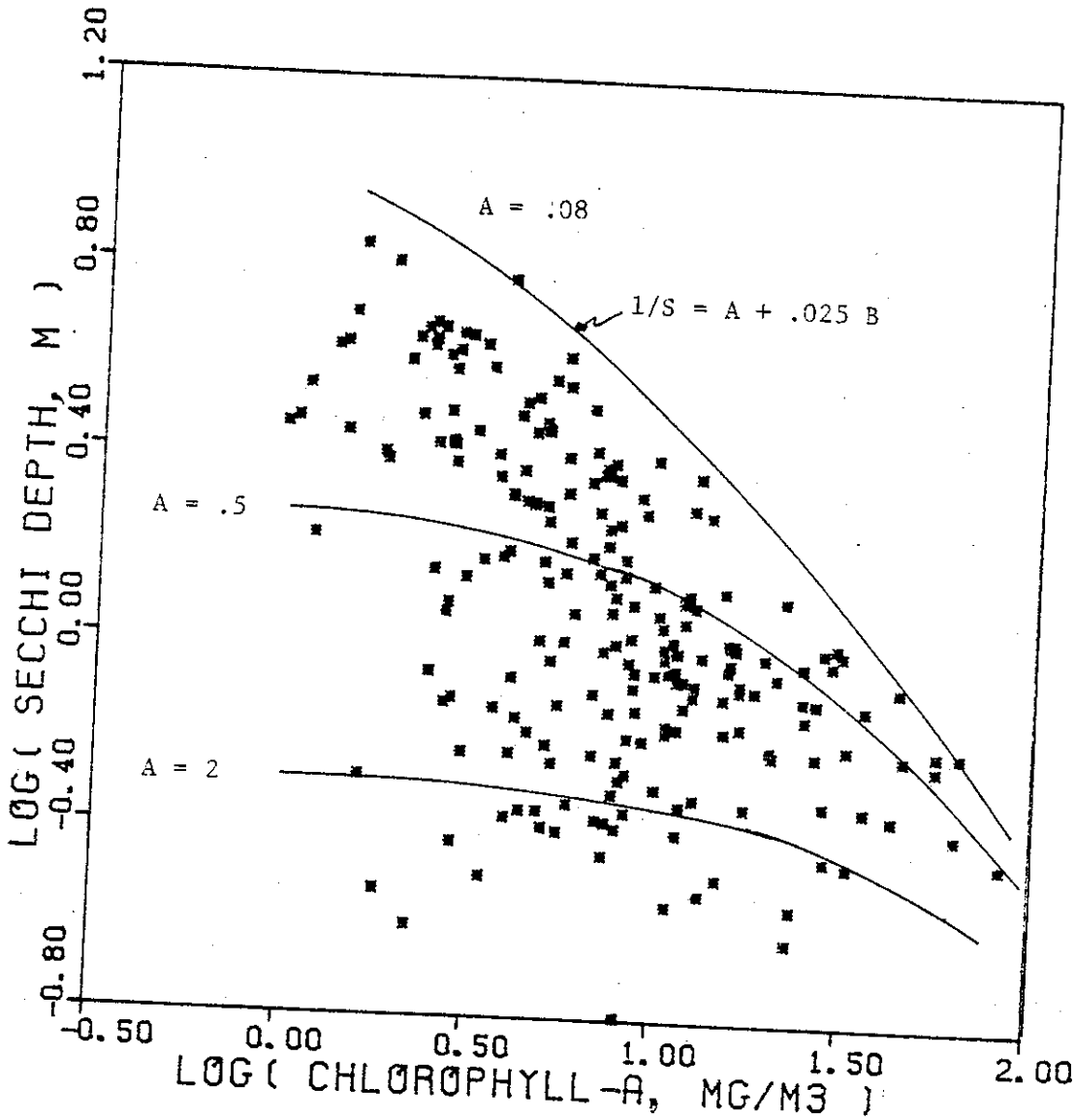
where,

A = effect of non-chlorophyll-related materials on S (1/m)

K2 = slope parameter = .025 m2/mg

Figure 2

Transparency vs. Chlorophyll-a



A = effect of nonchlorophyll-related materials on S (1/m)

B = chlorophyll

S = transparency

Table 15

Formulations, Parameter Estimates, and Error Statistics for Internal Chlorophyll/Transparency Models

Definitions :

K1-K3 = model parameter values
N= number of station-years
R2 = fraction of variance explained
MSE = mean squared error (log10)

Model S01: Log Transparency vs. Chlorophyll

Equation: $\log(S) = K1 + K2 \log(B)$

Code	Coefficients	K1	K2	N	R2	MSE
S01A01	Carlson (1977)	.89	-.68	218	-.39	.145
S01A02	Jones & Bachman (1978)	.81	-.55	218	-.50	.156
S01X01	Optimal - All Data	.49	-.49	218	.31	.082
	standard errors	.046	.050			

Model S02: Linear Transparency vs. Chlorophyll

Equation: $1/S = K1 + K2\ B$

Code	Coefficients	K1	K2	N	R2	MSE
S02A01	Classen (1980)	.21	.014	218	-1.42	.252
S02X01	Optimal - All Data	.41	.052	218	.26	.087
	standard errors	.051	.070			

Model S03: Log/Linear Transparency vs. Chlorophyll

Equation: $1/S = K1 + K2\ B^{K3}$

Code	Coefficients	K1	K2	K3	N	R2	MSE
S03A01	Walker (1979)	.08	.059	.74	218	-1.29	.239
S03X01	Optimal - All Data	.00	.32	.49	218	.31	.082
	standard errors	.30	.24	.10			

For simplicity, the variable "A" is referred to as "turbidity" in the remainder of this report, although it may be influenced by color and nonchlorophyll-related biological materials at some stations.

85. Use of the least squares K2 estimate in Table 15 (K2=.052 m2/mg) is not appropriate in this case, because it does not represent the relationship at low turbidity and many stations would have calculated turbidity values less than zero. In the absence of algae, other suspended solids, and color, there is an upper limit to transparency, because of light extinction by pure water. In terms of the above model, this translates into a minimum calculated A value. The slope parameter estimate (K2=.025 m2/mg) has been selected so that the predicted transparency at a minimum A value of .08 1/m follows the upper edge of the chlorophyll/transparency relationship in Figure 2. The minimum A value corresponds to a maximum transparency of 12.5 meters in the absence of chlorophyll-a and turbidity, a practical upper limit for most reservoirs. The slope parameter is higher than values derived from pure algal cultures (approximately .014 m2/mg, Lorenzen, 1980), possibly because it accounts for light extinction both by chlorophyll-a and by other related substances, including other pigments, biomass, and detritus. Literature estimates for the slope parameter derived from regression analyses of data from individual lakes range from .008 to .054 m2/mg (Carlson,1980).

86. The lines in Figure 2 depict the chlorophyll/transparency relationship for different levels of turbidity. Based upon this relationship, a turbidity value has been calculated for each station-year and used in subsequent analyses. Turbidity values calculated according to equation (42) are positively correlated with Hach turbidity, (r=.76, n=74), total suspended solids (r=.57, n=79), and true color (r=.54, n=23), where all correlation coefficients are calculated on logarithmic scales.

87. It is apparent that the class of models for predicting transparency as a function of chlorophyll (or vice-versa) is not generally useful in these reservoirs because of the influences of

factors unrelated to chlorophyll. Additional analysis is needed to develop predictive models for turbidity, which is expected to be regulated by regional factors (erosion rates, soil types, land use, topography, etc.), as well as reservoir morphometric and hydrologic characteristics which influence the sedimentation process.

88. An alternative set of models relates transparency directly to total phosphorus concentration. The relationship would reflect the combined influences of the partitioning of phosphorus and light extinction between algal cells and substances unrelated to algae. The formulations tested are analogous to those employed for predicting transparency as a function of chlorophyll:

Model Code	Equation
S04	$\log(S) = K1 + K2 \log(P)$
S05	$1/S = K1 + K2\ P$
S06	$1/S = K1 + K2\ P^{K3}$

Residuals analyses suggest that these models tend to under-predict transparency at stations with N/P ratios (inorganic or total) less than about 8, which corresponds to a typical algal physiologic ratio (Wetzel, 1975). To eliminate possible nitrogen-limitation effects, each model has been fit to two data sets: one containing all station-years and the other containing station years with N/P ratios greater than 8. Parameter estimates and statistics for each data set and model are summarized in Table 16. For a given data set, it is difficult to distinguish among these models, since the error statistics are nearly identical. Model S05 has been selected for further analysis because of its relative simplicity and theoretical appeal. It suggests that the light extinction coefficient (inversely related to transparency) is a linear function of phosphorus and that the intercept (K1) is attributed to light extinction by factors unrelated to phosphorus, including extinction by water alone.

89. The transparency/phosphorus relationship is displayed in Figure 3. The regression line (model S05X02) has been fit to data from stations with N/P ratios exceeding 8. To illustrate the typical effects

Table 16

Formulations, Parameter Estimates, and Error Statistics for Internal Phosphorus/Transparency Models

Model S04: Log Transparency vs. Phosphorus

Equation: $\log(S) = K1 + K2 \log(P)$

Code	Coefficients	K1	K2	N	R2	MSE
S04A01	Placke et al. (1980)	1.05	-.61	258	.66	.036
S04A02	Oglesby et al. (1978)	1.36	-.76	258	.59	.043
S04X01	Optimal - All Data	1.20	-.72	258	.67	.034
	standard errors	.031	.051			
S04X02*	Optimal	1.40	-.87	212	.77	.024
	standard errors	.050	.032			

Model S05: Linear Transparency vs. Phosphorus

Equation: $1/S = K1 + K2\ P$

Code	Coefficients	K1	K2	N	R2	MSE
S05A01	Carlson (1977)	0	.021	258	.57	.045
S05A02	Carlson (1977)	0	.015	258	.29	.075
S05X01	Optimal - All Data	.18	.017	258	.64	.036
	standard errors	.027	.001			
S05X02*	Optimal	.082	.022	212	.77	.024
	standard errors	.023	.001			

Model S06: Log/Linear Transparency vs. Phosphorus

Equation: $1/S = K1 + K2\ P^{K3}$

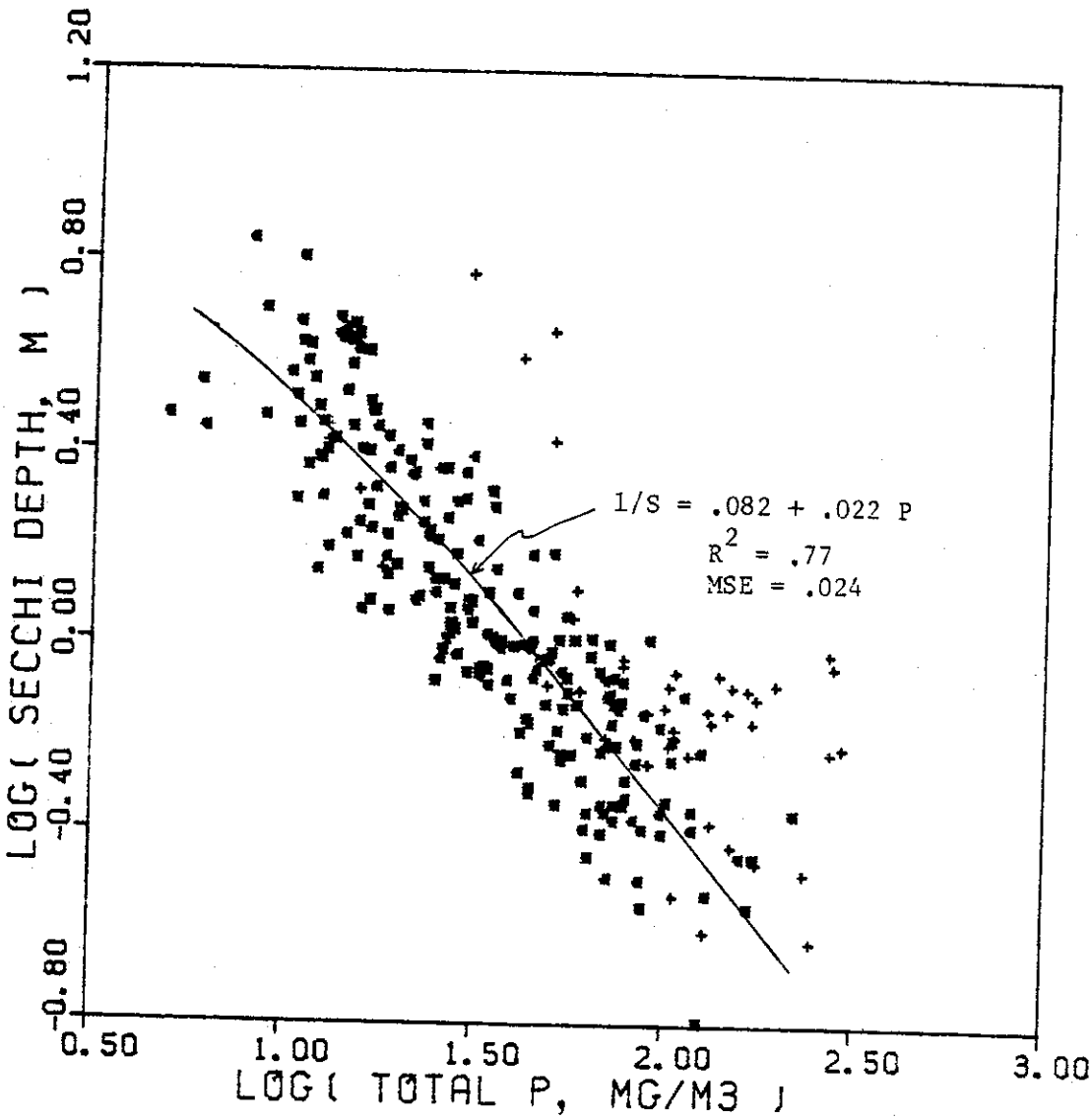
Code	Coefficients	K1	K2	K3	N	R2	MSE
S06A01	Walker (1979)	.08	.0093	1.03	258	.11	.093
S06X01	Optimal - All Data	.00	.063	.72	258	.68	.034
	standard errors	.10	.029	.093			
S06X02*	Optimal	.030	.033	.91	212	.77	.024
	standard errors	.064	.014	.091			

* Data set restrictions:
Inorganic N/P > 8
Total N/P > 8

Figure 3

Transparency vs. Total Phosphorus

(* N/P > 8, + N/P < 8)



MSE = mean squared error
P = total phosphorus
R^2 = fraction of variance explained
S = transparency

of nitrogen limitation, different symbols to distinguish stations with N/P ratios less than 8. The relationship (R^2=.77, SE^2=.024) is much stronger than the transparency/chlorophyll relationship (R^2=.31, SE^2=.082). This results from the correlation between total phosphorus and non-algal turbidity, which is described in more detail below. The partitioning of phosphorus and light extinction between chlorophyll-related components and non-chlorophyll-related components is more critical for correlating chlorophyll to transparency (or to phosphorus) than for correlating phosphorus to transparency.

90. Residuals analyses have indicated, however, that the transparency/phosphorus relationship is somewhat sensitive to the partitioning of light extinction between chlorophyll and turbidity. According to the chlorophyll/transparency model described above, the product of chlorophyll and transparency is proportional to the fraction of light extinction attributed to chlorophyll. Assuming that transparency is inversely related to the light extinction coefficient, the product is also proportional to the daily photosynthesis integral under light-limited conditions (Vollenweider, 1970; Vollenweider and Kerekes, 1980). This product averages about 9 mg/m^2, which corresponds to 23% light extinction attributed to chlorophyll-a and related substances. A plot of residuals from model S05X02 against the chlorophyll-transparency product indicates negative bias for products less than about 5 mg/m^2. The following table summarizes the residual distributions above and below this value:

B×S Group	N	Mean	Std. Dev.	t*	Prob(t)
> 5	144	.060	.136	5.29	<.001
< 5	45	-.152	.091	-11.20	<.001

* t test for Ho: Mean=0

Thus, the phosphorus/transparency model tends to over-predict transparency by an average of .15 log units (35 %) at stations where

algae account for less than about 12% of the total light attenuation. This effect accounts for about 25% of the total variance in the residuals from model S05X02. This suggests that phosphorus associated with algae has somewhat less of an impact on transparency than phosphorus associated with turbidity.

91. Stepwise regressions explain 39% of the variance in residuals from model S05X02 (see Appendix D), with positive terms for station total depth, pH, shoreline development, and total nitrogen, and a negative term for inorganic nitrogen. The positive term for station total depth is the most significant. The signs of the nitrogen terms suggest a positive correlation with organic nitrogen. Since higher pH and organic nitrogen levels would tend to be found at stations with higher chlorophyll levels (and chlorophyll-Secchi products), these effects are consistent with those discussed above. The depth effect may be also be related to the chlorophyll-Secchi product, since resuspension of bottom sediments would tend to raise turbidity and lower the product at shallow stations.

92. The following model accounts for biases in model S05 discussed above and is useful for representing the partitioning of phosphorus:

$$P = K1 + K2\ B + K3\ A \tag{43}$$

where,

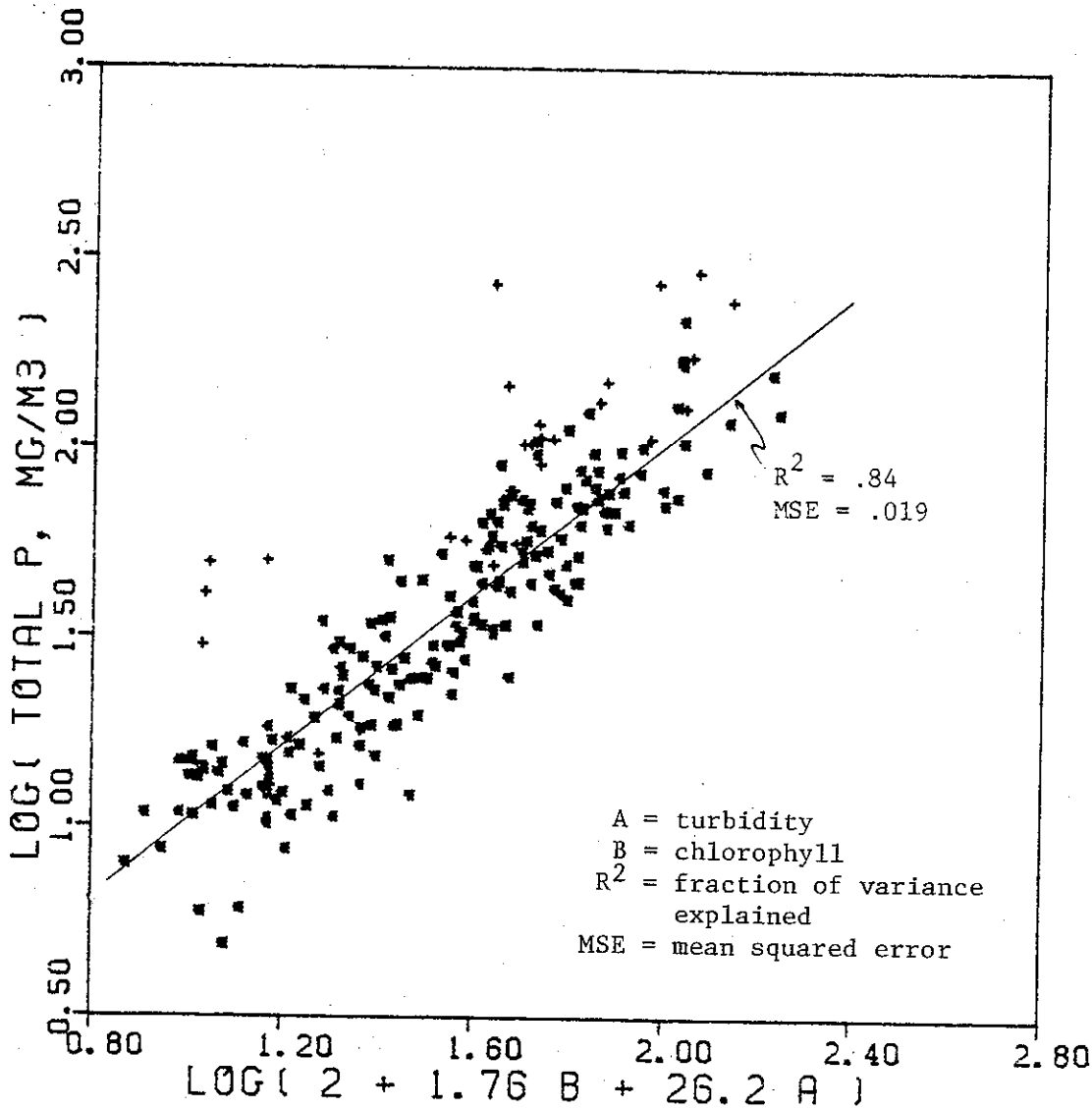
K1 = 2.0 (Std. Error = .80)
K2 = 1.76 (Std. Error = .13)
K3 = 26.2 (Std. Error = 1.71)

Based upon data from 189 station-years with inorganic and total (N/P) ratios exceeding 8, this equation explains 84% of the variance in the total phosphorus data. The residual mean squared error, .019 in logarithmic units, is considerably lower than the errors in the other transparency or chlorophyll models evaluated. Observed and predicted phosphorus concentrations are plotted in Figure 4. The intercept, 2 mg/m3, represents the phosphorus which is not associated with chlorophyll or turbidity. This value tends to be higher at N-limited

Figure 4

Total Phosphorus vs. Turbidity and Chlorophyll-a

(* N/P > 8, + N/P < 8)



stations. The slope parameters indicate that, on the average, 1.76 mg/m3 of phosphorus is associated with each mg/m3 of chlorophyll-a, and 26.2 mg/m3 of phosphorus is associated with each unit of turbidity (1/m). The biases in the phosphorus/transparency model S05 can be explained by multiplying both sides of equation (43) by transparency and substituting equation (42) for turbidity, yielding:

$$P\ S = 26.2 + 2\ S + 1.11\ B\ S \tag{44}$$

This equation predicts that the product of transparency and phosphorus will be higher for reservoirs in which chlorophyll accounts for a greater fraction of the total light extinction. Despite the relatively low errors characteristic of equation (43), the equation cannot be transposed, to permit equally accurate chlorophyll predictions, for example, without a predictive basis for non-algal turbidity.

Chlorophyll Models

93. The direct relationship between algal standing crop and nutrient concentrations (specifically, phosphorus) is the basis of the empirical eutrophication modelling approach. More complex models relating chlorophyll to phosphorus, nitrogen, turbidity, and reservoir morphometric and hydrologic variables also fall in this category, as outlined in Part I of Appendix E.

94. A variety of seasonal averaging schemes have been used in developing phosphorus/chlorophyll models (Appendix E). For chlorophyll, these include growing-season means, summer means, and maximum values. Spring phosphorus and growing-season-mean phosphorus have been used as independent variables. Table 17 summarizes the results of regression analyses relating each pair of variables using two data sets; one contains all station-years and the other, station-years with mean inorganic and total N/P ratios greater than 8 and non-algal turbidities less than 1.0 1/m. The basis for the turbidity cut-point is developed in detail below. In each case, the best correlation is found by averaging both chlorophyll and phosphorus over the growing season.

Table 17

Seasonal Chlorophyll/Phosphorus Regressions

Dependent Variable	Independent Variable	Slope	Intercept	N	R-Squared	MSE
All Data						
B	P	.699	-.251	218	.437	.084
B	Pspring	.563	-.018	203	.297	.108
Bmax	P	.697	-.064	218	.427	.087
Bmax	Pspring	.557	.178	203	.288	.110
Bsummer	P	.603	-.053	194	.310	.114
Bsummer	Pspring	.437	.235	179	.167	.140
N/P > 8, A < 1.0 1/m						
B	P	1.13	-.76	137	.720	.045
B	Pspring	0.76	-.25	131	.359	.104
Bmax	P	1.11	-.55	137	.665	.055
Bmax	Pspring	.74	-.04	131	.328	.112
Bsummer	P	1.04	-.57	124	.604	.066
Bsummer	Pspring	0.63	.01	118	.235	.129

MSE = Mean Squared Error

Restricting the sampling periods to summer and/or spring reduces the average number of samples per station and, thus, the reliability of the station summary values. Based upon these results, growing-season-mean values are used in further model testing below.

95. The seasonal maximum chlorophyll value is of interest as an indicator of the most severe condition at a given station. Various regression models have been used for estimating maximum chlorophyll-a as a function of the mean value (Lee, Rast, and Jones, 1977). One problem with these models is that the maximum chlorophyll detected at a given location over a given period is not independent of the number of samples taken. For a given average value, the maximum estimated from 6 sampling dates is likely to be greater than the maximum estimated from 3 dates, for example.

96. Table 18 outlines and tests a method for calculating the maximum-to-mean chlorophyll ratio as a function of the number of sampling dates. Observed ratios increase consistently with the number of sampling dates, with the exception of the last categories (6 and 7), which are based upon only 3 and 5 station-years of data, respectively. The relationship has been fit by treating the sampling process as independent draws from a log-normal distribution. Application of the scheme beyond 5 sampling dates is an extrapolation beyond the range of the data and may be invalid because of possible violations in the independent sample assumption. At high sampling frequencies, serial correlation between successive samples may be significant. In the range of 2 to 5 sampling dates, however, the scheme works well and explains 97% of the variance in the maximum chlorophyll levels (Figure 5). The Lee, Rast, and Jones (1977) model suggests a (Bmax/B) ratio of 1.6, or .2 on a log scale. This agrees well with the model predictions for 3-4 sampling dates.

97. The chlorophyll models compiled in Appendix E can be classified by the following scheme:

Table 18

Scheme for Predicting Ratio of Maximum-to-Mean Chlorophyll-a as a Function of Number of Sampling Dates

number of dates	Mean log (Bmax/B) Observed**	Mean log (Bmax/B) Predicted	number of station-yrs
2	.11	.12	124
3	.19	.19	257
4	.23	.24	50
5	.29	.27	9
6	.40	.30	3
7	.30	.32*	5
8	–	.34*	0
9	–	.36*	0

* extrapolation

** analysis of variance indicates significant differences among groups ($F=28.9$, $p<.001$)

<u>Model:</u>

$$\log(Bmax/B) = .28\ Y$$

where Y is chosen such that:

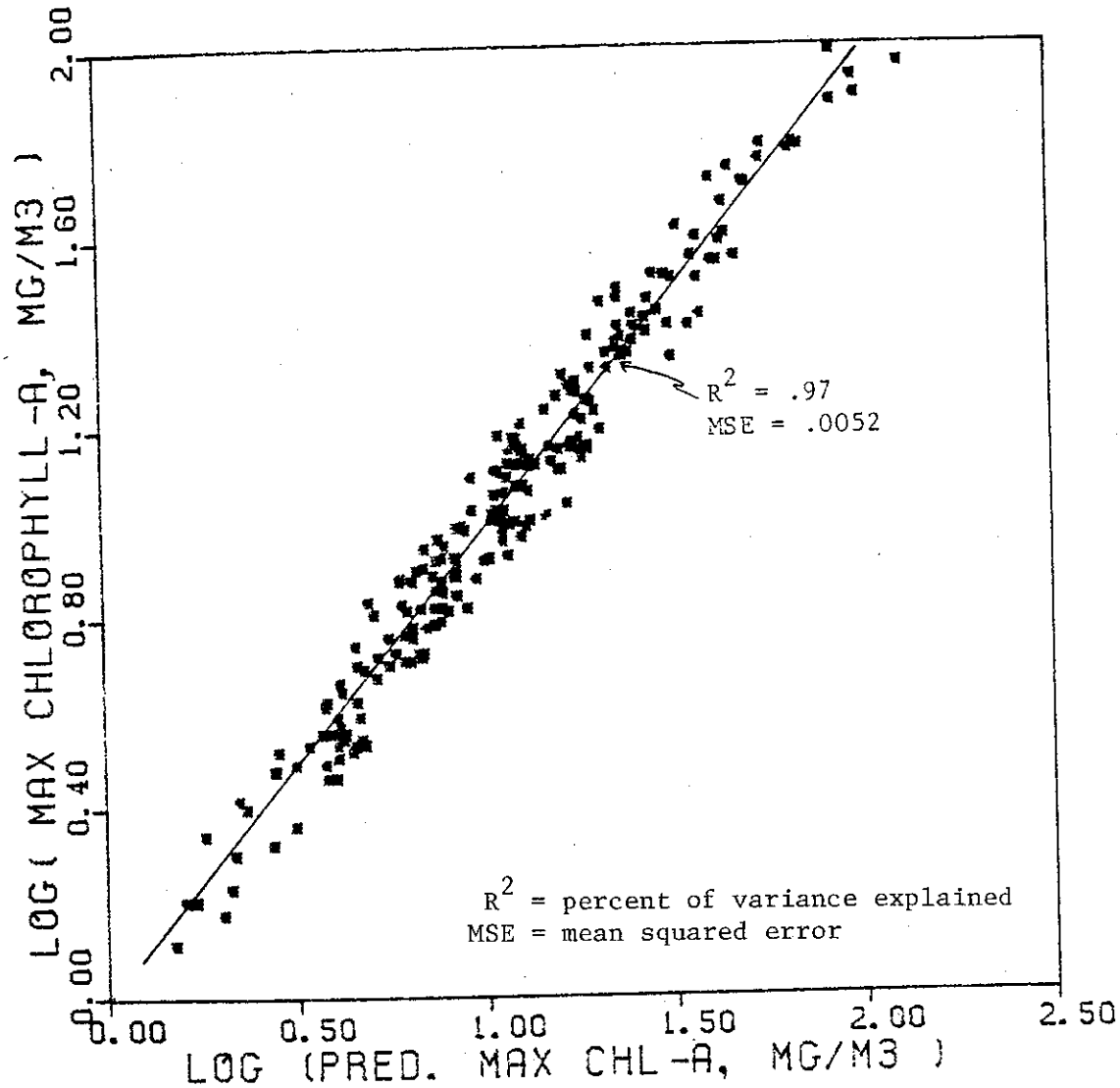
$$\int_{y=-\infty}^{y=Y} f(y)\ dy = n / (n+1)$$

where,

y = standard normal variable (mean=0, standard deviation=1)
f(y) = normal frequency distribution function
n = number of sampling dates / growing season

Figure 5

Observed vs. Predicted Maximum Chlorophyll-a



Model Code	Equation
B01	$\log(B) = K1 + K2 \log(P)$
B02	$B = K1 + K2\ P$
B03	$\log(B) = K1 + K2 \log(N + K3\ P)$
B04	$\log(B) = K1 + K2 \log(P) + K3\ A + K4 \log(Z) + K5\ Qs$
B05	$1/B = K1/Bp + K2/Bn + K3/Bl$

Models B01 and B02 relate chlorophyll to total phosphorus on logarithmic and linear scales, respectively, and have been calibrated to several different lake and reservoir data sets by various authors (see Appendix E). Model B03, developed by Smith (1980), relates chlorophyll to nitrogen and phosphorus. Model B04, developed by Walker and Kuhner (1978), includes terms for the influences of phosphorus, turbidity, mean depth, and surface overflow rate on chlorophyll-a levels. Model B05, developed by Meta Systems (1979), is a theoretical formulation which considers the effects of phosphorus (Bp), nitrogen (Bn), and light (Bl) limitation on algal growth. Original and optimal parameter estimates for these models and various data categories are given in Table 19.

98. Models B01 and B02 assume a direct relationship between chlorophyll and phosphorus, when averaged over a growing season at a given location. Figure 6 depicts this relationship on logarithmic scales, using data from all station-years with at least three sampling dates. Stations with inorganic or total N/P ratios less than 8 are distinguished by different symbols and tend to lie in the lower, right-hand portion of the plot. Also shown in Figure 6 are regression lines calculated for other lake and reservoir data sets by Jones and Bachman (1976), the OECD Eutrophication Progam (Kerekes,1981), and Hern et al. (1981). These models are representative of the ranges of slopes and yields in the models listed in Appendix E. The regression line for this data set, also shown in Figure 6, explains 44% of the chlorophyll variance and is nearly identical to the line calculated by Hern et al.(1981), based upon EPA National Eutrophication Survey data from over 700 U.S. lakes and reservoirs. It is apparent from the variability in

Table 19

Formulations, Parameter Estimates, and Error Statistics for Internal Models Predicting Chlorophyll-a

Model B01: Log Phosphorus/Chlorophyll
Equation: log(B) = K1 + K2 log(P)

Code	Coefficients	Data*	K1	K2	N	R2	MSE
B01A01	Hern et al. (1981)	1	-.11	.64	218	.42	.086
B01A02	Kerekes (1981)	1	-.55	.96	218	.29	.104
B01A03	Jones & Bachman (1976)	1	-1.09	1.46	218	-.95	.288
B01X01	Optimal- all data	1	-.25	.70	218	.44	.084
	standard errors		.087	.054			
B01X02	Optimal- N/P>8	2	-.38	.80	187	.51	.071
	standard errors		.090	.058			
B01X03	Optimal- N/P>8, A<1.58 1/m	3	-.60	.98	161	.64	.057
	standard errors		.088	.059			
B01X04	Optimal- N/P>8, A<1.0 1/m	4	-.76	1.13	157	.72	.045
	standard errors		.087	.060			
B01X05	Optimal- Ni/Pi>10, A<.37 1/m	5	-1.09	1.44	62	.76	.039
	standard errors		.131	.105			

Model B02: Linear Phosphorus/Chlorophyll
Equation: B = K1 + K2 P

Code	Coefficients	Data	K1	K2	N	R2	MSE
B02A01	Oglesby et al. (1978)	1	-2.90	.57	218	-.81	.267
B02X01	Optimal - all data	1	1.65	.13	218	.41	.087
	standard errors		.37	.012			
B02X02	Optimal - Ni/Pi>10,A<.37 1/m	5	-.97	.35	62	.72	.045
	standard errors		.37	.035			

Model B03: Smith (1980), variable yield model
Equation: log(B) = K1 + K2 log(N + K3 P)

Code	Coefficients	Data	K1	K2	K3	N	R2	MSE
B03A01	Smith (1980)	1	-3.71	1.55	16.4	218	-.64	.242
B03X01	Optimal - all data	1	-1.96	.81	55.5	218	.45	.082
	standard errors		.21	.068	27.7			
B03X02	Optimal - A < .37 1/m	6	-4.09	1.53	35.7	73	.66	.059
	standard errors		.41	.15	12.7			

(continued)

Table 19 (continued)

Model B04: Walker and Kuhner (1978), Multivariate Model
Equation: log(B) = K1 + K2 log(P) + K3 A + K4 log(Z) + K5 Qs

Code	Coefficients	Data	K1	K2	K3	K4	K5	N	R2	MSE
B04A01	Walker & Kuhner (1978)	1	.49	.88	-.23	-.59	-.00070	218	.27	.108
B04X01	Optimal - All Data	1	.44	.70	-.21	-.51	-.00047	218	.67	.049
	standard errors		.14	.064	.023	.065	.00014			
B04X02	Optimal- N/P > 8	2	.22	.83	-.23	-.46	-.00046	189	.72	.041
	standard errors		.16	.075	.025	.07	.00017			

Model B05: Meta Systems (1979), Limiting Factor Model
Equation: Bp = P-limited biomass, mg/m3 = P - 2.2
Bn = N-limited biomass, mg/m3 = (N - 2.2)/7
Bl = Light-limited biomass, mg/m3 = 440/Zm - A/b >= 20 mg/m3
b = algal light extinction coef. = .025 m2/mg
A = non-algal turbidity, 1/m = 1/S - .025 B
Zm = mid-thermocline depth (m)
As = surface area (km2)
Z = mean depth (m)

log(Zm) = .587 + .084 log(As) + .203 log(Z) **

1/B = K1/Bp + K2/Bn + K3/Bl

Code	Coefficients	Data	K1	K2	K3	N	R2	MSE
B05A01	Meta Systems (1979)	1	1.89	0	1.36	218	.51	.072
B05X01	Optimal - All Data	1	2.28	1.91	1.24	218	.57	.063
	standard errors		.29	1.21	.20			

* Summary of Data Set Codes

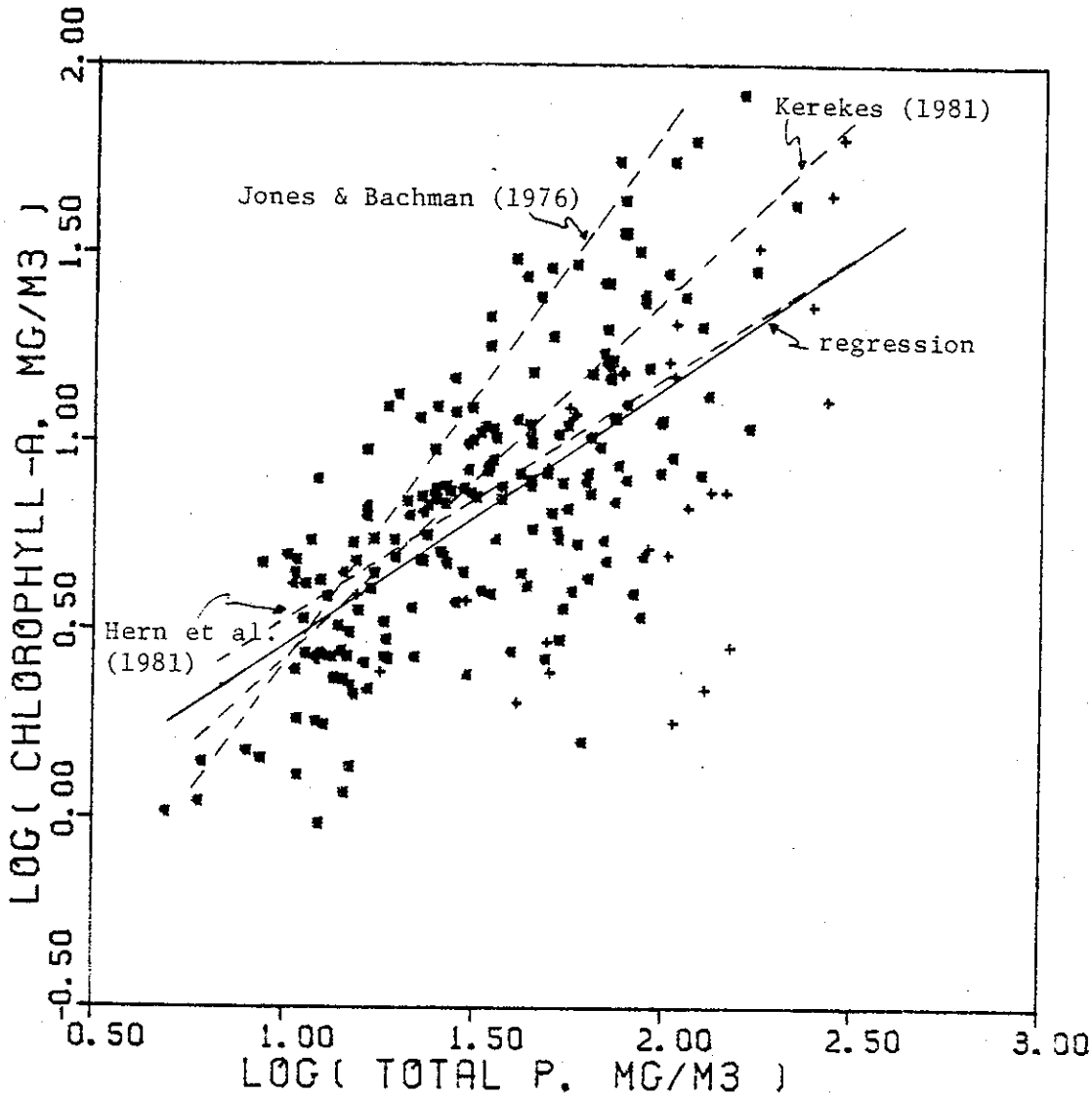
	Constraint				
	Inorganic N/P	Total N/P	Turbidity	Other	N
1	-	-	-	-	218
2	>8	>8	-	-	189
3	>8	>8	<1.58	-	161
4	>8	>8	<1.00	-	137
5	>10	-	<.37	-	62
6	-	-	<.37	-	73

** formulation for thermocline depth based upon regression analysis of data from 86 reservoirs (R2=.45, MSE=.012); used if measured Zm values are missing (see Part VII)

Figure 6

Chlorophyll-a vs. Total Phosphorus

(* N/P > 8, + N/P < 8)



the regression lines and the data scatter that the chlorophyll/phosphorus relationship is not stable across data sets and that this model is of limited use in this collection of reservoirs as a whole.

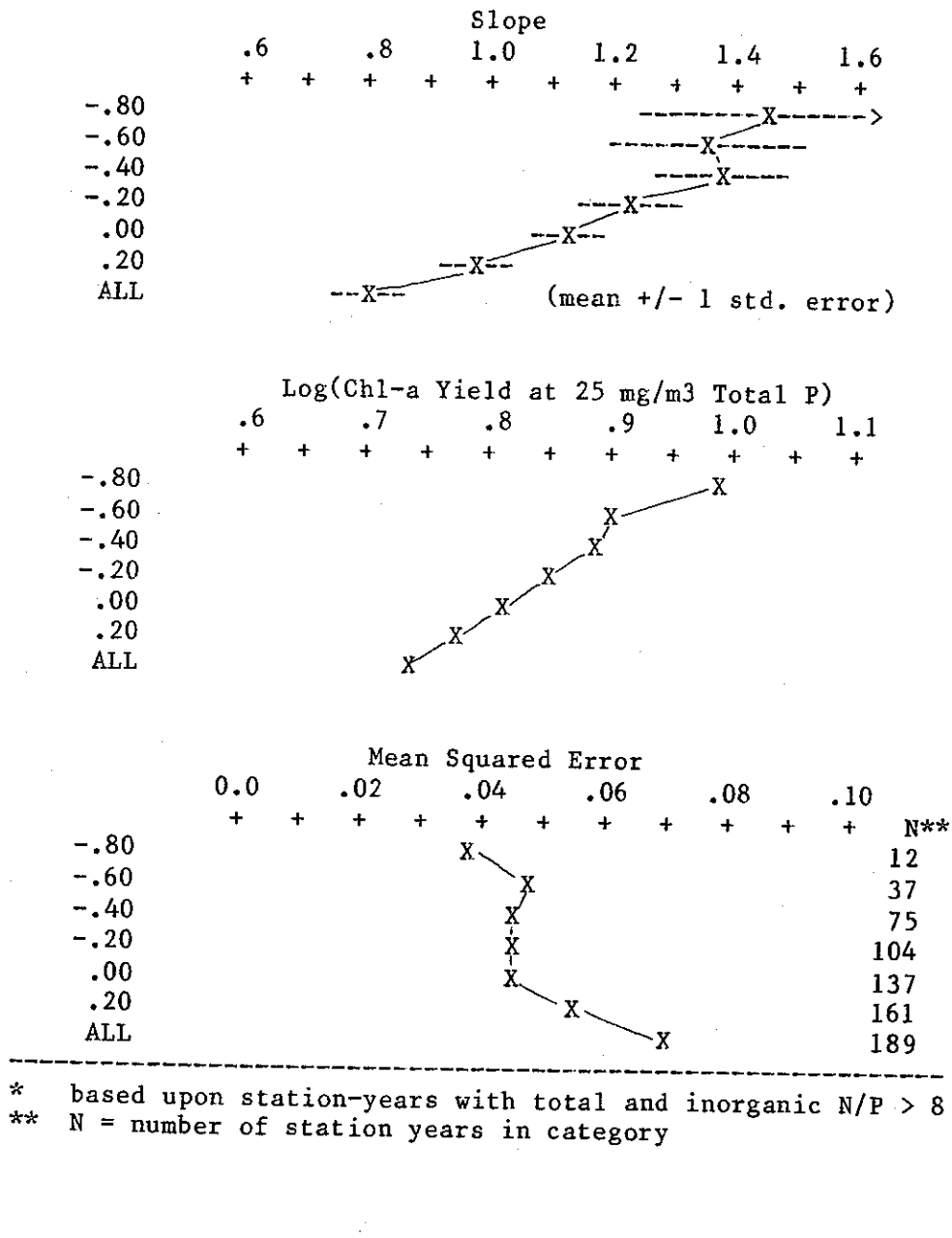
99. Additional analysis shows that nitrogen and turbidity are related to chlorophyll in ways which may account for at least some of the variability in the chlorophyll/phosphorus response. Possible effects of nitrogen and turbidity have been analyzed by plotting residuals and fitting the models to various data categories, defined by N/P ratio and turbidity. With these data, it is difficult to distinguish the performance of the log-linear model B01 from the linear model B02. Since for all data sets, residual variance was slightly lower for B01, this model is the focus of further analysis presented below.

100. To test for turbidity effects, chlorophyll/phosphorus regressions have been run for groups of stations defined by maximum turbidity values, ranging from -.8 to .6 on logarithmic scales. To eliminate possible nitrogen effects, 31 stations with inorganic N/P or total N/P ratios less than 8 have been excluded from the regressions, leaving a total of 187 station-years for the analysis. This cutpoint has been determined through residuals analysis and seems to be valid for most turbidity levels, although a cutpoint of 10 may be more appropriate at extremely low turbidities (< .37 1/m). Figure 7 plots the slope, yield, and mean squared error as functions of maximum turbidity. The "yield" is defined as the logarithm of the predicted chlorophyll-a concentration at an average total phosphorus concentration of 25 mg/m3. The yield tends to be more stable and statistically independent of slope than the intercept parameter (K1).

101. Figure 7 shows that both the regression slope and yield decrease with increasing turbidity limit. The slope varies from 1.44 to .80 and the yield, from .99 to .74 on log scales, or 10 to 5.5 mg/m3 on linear scales. The mean squared error is relatively stable at about .045 for maximum turbidities up to about 1.0 1/m (0. log units), but increases to about .07 at higher turbidities.

Figure 7

Parameter Stability of the Chlorophyll/Phosphorus Model
Versus Maximum Turbidity *



* based upon station-years with total and inorganic N/P > 8
** N = number of station years in category

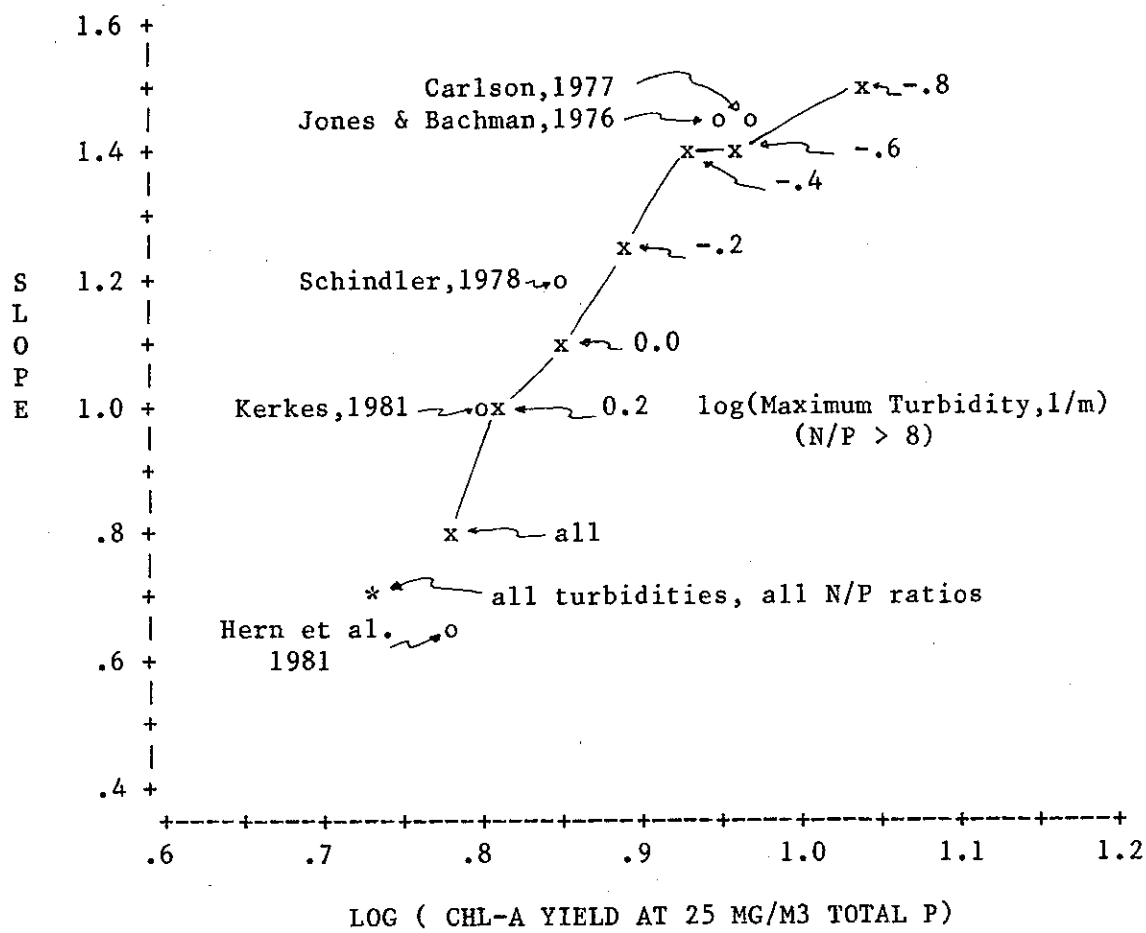
102. Figure 8 plots the path of the slope and yield parameters for increasing maximum turbidities. The path is shown in relation to the regression lines reported in other studies (see Figure 6). For a maximum turbidity of about .4 1/m, the regression is similar to the Jones and Bachman (1976) relationship. The regression calculated for a maximum turbidity value of 1.58 1/m (.2 log units) is similar to the O.E.C.D. summary relationship (Kerekes,1981). When the entire turbidity and N/P ranges are included, the parameters are similar to the regression calculated by Hern et al. (1981). These results suggest that variations in turbidity, as defined above, may explain some of the variations in the phosphorus/chlorophyll regression lines reported in the literature and some of the scatter in Figure 6.

103. Model B01 has been fit to five different data sets with various turbidity and N/P bounds (Table 19). Generally, as the maximum turbidity limit increases, the model becomes more general (i.e. more stations are included), but model error increases and phosphorus sensitivity decreases. Thus, information on likely turbidity levels is important to selecting appropriate model parameters for a given application. If no basis for turbidity estimation is available, then the most general model must be used, but at the expense of increased prediction error.

104. Both N/P and turbidity are positively correlated with total phosphorus. Analysis of the distributions of these variables indicates that out of 125 station-years with mean total phosphorus concentrations less than 40 mg/m3, only one had an N/P ratio less than 8 (inorganic) and none had a turbidity greater than 1.58 1/m (.2 log units). Thus, for practical purposes, model B01X03 in Table 19, in which chlorophyll is roughly porportional to total phosphorus, is applicable to all station-years in this low total phosphorus range. This relationship is nearly identical to the O.E.C.D. summary relationship (Kerekes, 1981). Similarly, all 80 station-years from reservoirs with mean depths in excess of 10 meters have turbidities less than 1.58 1/m. There is room for improvement in this model, however, since residuals are negatively correlated with turbidity and mean depth.

Figure 8

Slope and Yield Variations in the Chlorophyll/Phosphorus Model



105. Smith's (1980) model, B03, relates chlorophyll to total phosphorus and total nitrogen. This has been calibrated to two data sets: one containing all station-year averages and the other containing station-years with turbidities less than .37 1/m. The second group corresponds to the lowest turbidity group used in the chlorophyll/phosphorus model calibrations (model B01X05). This model does not explain appreciably more variance than model B01, even for N-limited, low-turbidity stations. The formulation of the model seems theoretically inadequate because it predicts finite chlorophyll-a concentrations at nitrogen or phosphorus concentrations approaching zero. At a given nitrogen concentration, for example, chlorophyll becomes less sensitive to phosphorus as phosphorus concentration decreases, which seems contra-intuitive. While it may be possible to formulate a model to include both phosphorus and nitrogen effects, this particular model does not appear useful for these reservoirs and is not analyzed further.

106. The Walker-Kuhner model (B04) is a multiple regression model with terms for total phosphorus, mean depth, turbidity, and surface overflow rate. This model was originally fit to EPA National Eutrophication Survey data from 23 reservoirs in Ohio, Indiana, and Illinois, none of which were nitrogen limited. Note that chlorophyll, total P, and mean depth are log-transformed, while turbidity and surface overflow rate are not. Thus, predicted chlorophyll-a is less sensitive to turbidity and surface overflow rate at low values than at high values.

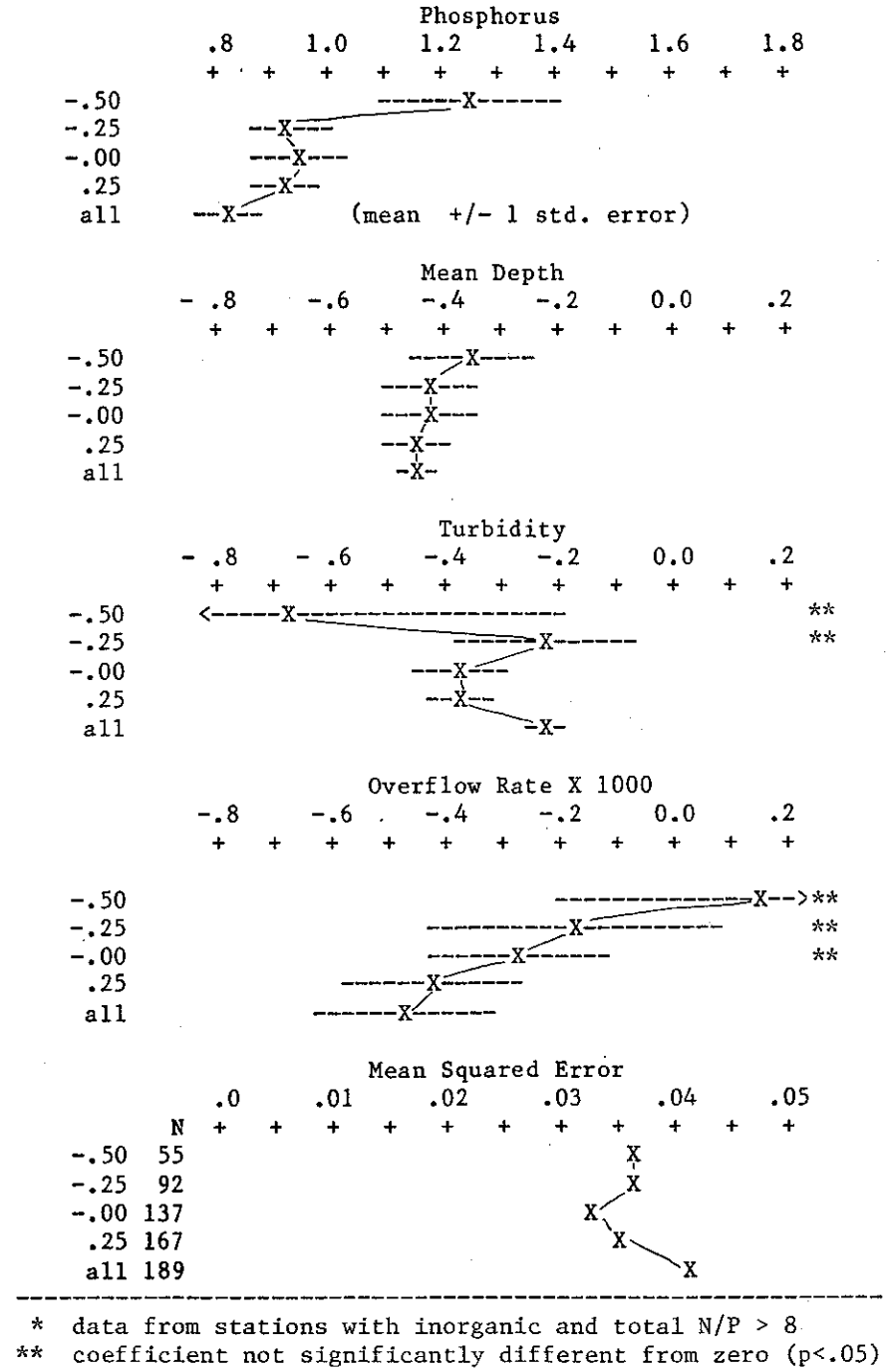
107. Because the model does not include a term for nitrogen, it has been fit to two data sets: one containing all the data, and the other containing 189 station years with inorganic and total N/P ratios greater than 8. Many of the reservoirs included in the Walker-Kuhner data set are also included here. To test for parameter stability, the model has been fit to an additional data set which includes 131 station-years with the above N/P constraints from reservoirs outside of the Ohio, Indiana, and Illinois region. The magnitudes and signs of the regression coefficients compare reasonably with the originally-reported values:

coefficient	original	optimal (B04X02) mean	optimal (B04X02) std. error	optimal* mean	optimal* std. error
intercept	.49	.22	.16	.12	.22
phosphorus	.88	.83	.075	.76	.104
mean depth	-.59	-.46	.071	-.32	.100
turbidity	-.23	-.23	.025	-.19	.034
overflow rate	-.00070	-.00047	.00020	-.00041	.0002

* excluding station-years from Ohio, Indiana, and Illinois

108. Figure 9 summarizes the results of a parameter stability analysis of this model. Following the scheme used in Figure 7, the model has been fit to different data sets of increasing maximum turbidity levels. Figure 9 tracks the coefficient and mean squared error values. Mean squared error is relatively stable up to turbidities of 1.58 1/m (.25 log units), but increases at higher values. As in the case of the log-linear model (B01), sensitivity to phosphorus tends to decrease with increasing maximum turbidity, although the range of coefficients is considerably lower for model B04. The decreasing trend suggests an interaction between turbidity and phosphorus effects which is not accounted for in the model formulation. Depth and turbidity coefficients are relatively stable. At low turbidities, the turbidity coefficient is not significant. This is consistent with the turbidity coefficient in B04X02, -.23, since at a maximum turbidity of .56 1/m (-.25 log units) the estimated turbidity effect would be -.13, which would be difficult to identify in relation to the model standard error when higher turbidity stations are excluded. The overflow rate coefficient shows a decreasing trend with increasing turbidity. This trend may result from an interaction between turbidity and overflow rate effects or from exclusion of stations with high overflow rates (where the effect is detectable) when low turbidity constraints are applied. The magnitude of the overflow rate coefficient (-.00047) indicates that

Figure 9
Parameter Stability of the Multivariate Chlorophyll Model (B04)
as a Function of Maximum Turbidity *



* data from stations with inorganic and total N/P > 8
** coefficient not significantly different from zero (p<.05)

its impact on predicted chlorophyll-a is appreciable (greater than or equal to .1 log units) only in reservoirs with overflow rates greater than 212 m/yr.

109. Stepwise regression (Appendix D) explains 18% of the variance in residuals from the multivariate model (B04X02), with significant positive terms for mean depth and significant negative terms for station total depth, surface area, drainage area/surface area. The depth term suggests that substitution of a station total depth term for the reservoir mean depth term may reduce model error, although the effects are probably small, based upon the low percentage of residual variance explained. The regional analysis of variance (Appendix D) explains only 7% of residual variation and is not statistically significant.

110. The fifth chlorophyll model (B05), developed by Meta Systems (1979) includes terms for the effects of algal growth limitation by phosphorus, nitrogen, and light. Theoretical expressions for the maximum algal biomass in a batch culture limited by each of these factors separately (Bp, Bn, and Bl) are based upon algal growth kinetics and stoichiometry (see Table 19). To provide for the effects of simultaneous limitation by more than one factor, the inverses of the limiting biomass levels are used as independent variables in the regression equation for chlorophyll. Using an electrical circuit analogue, the inverses of the potential biomass levels are represented as resistances to algal growth, which are summed, with empirical weighting factors to calculate the total growth "resistance". Calculated light-limited chlorophyll levels are negative for several station-years. Following the original model, a minimum Bl value of 20 mg/m3 has been assumed. Theoretical shortcomings of this model include failure to account for possible effects of (1) flushing on the limiting biomass levels, or (2) turbidity on the bio-availablity of total phosphorus or total nitrogen.

111. With its original parameter values (K1=1.89, K2=0, K3=1.36), this model explains more chlorophyll variance (R^2=.51, SE^2=.072) than any of the other models investigated with their respective original parameter values. Optimization of the parameters (K1=2.28, K2=1.91,

K3=1.24) has little influence on the fit (R^2=.57, SE^2=.063). For most station-years, the phosphorus term is of greatest importance in determining the predicted chlorophyll-a concentration. The parameter estimate for the nitrogen-limitation term, 1.91, is not statistically significant ($p<.05$). Compared with residuals from the multivariate model (B04), residuals from B05 show greater association with reservoir morphometric, hydrologic, and water quality characteristics (R^2=.40) and with region (R^2=.23).

112. Further comparisons of model performance in various data categories defined by turbidity limits are given in Table 20, which lists bias (mean error), mean squared error, and median absolute error by model and turbidity range for stations with inorganic and total N/P ratios exceeding 8. In the lowest turbidity category (< .18 1/m), model B01X05 (similar to the Jones and Bachman (1976) regression) has the lowest median and mean squared error. As turbidity is increased, the error from this model blows up and the multivariate model (B04X02) becomes the most accurate. Differences among the models are more pronounced at higher turbidities, particularly with respect to bias.

113. On the basis of minimum error likely to be encountered over the range of turbidity conditions, the multivariate model (B04) seems attractive. In order to apply this model, however, an independent estimate of turbidity is required. Since the error statistics for this model are based upon measured values, model error would be greater under conditions where turbidities must be estimated. The fact that values of turbidity used in calibration have been estimated from measured chlorophyll values (equation (42)) may also artificially reduce the error associated with this model. Thus, while the multivariate model seems attractive from a minimum error point of view, the practicality of the model depends upon the feasiblity of estimating turbidity, which has yet to be evaluated. The multivariate model also contains more terms than the others and alternative transformations or re-expressions of the individual terms may provide a fit which is of equal or superior quality.

114. Many of the above models suggest an approximate proportionality between total phosphorus and chlorophyll in the low- to

Table 20

Effect of Turbidity Range on Chlorophyll Model Error*

Group	Log Max. Turbidity (1/m)	N	Model B01X01	B01X02	B01X03	B01X04	B01X05	B04X02	B05X01
			Bias x 1000						
1	-.75	20	17	33	47	35	10	0	-28
2	-.50	35	73	75	65	34	-32	42	20
3	-.25	37	108	101	76	31	-62	57	52
4	.00	45	106	73	0	-84	-260	-10	71
5	.25	30	-70	-119	-221	-330	-556	-62	-20
6	.75	22	-203	-264	-389	-516	-779	7	-98
			Mean Squared Error x 1000						
1	-.75	20	61	56	50	43	38	39	49
2	-.50	35	73	66	53	44	40	39	49
3	-.25	37	76	69	57	50	58	35	50
4	.00	45	58	47	35	39	101	24	47
5	.25	30	74	79	108	165	362	47	75
6	.75	22	99	127	208	324	670	75	72
			Median Absolute Error x 100						
1	-.75	20	20	18	16	15	14	18	21
2	-.50	35	14	12	11	10	14	12	11
3	-.25	37	15	16	19	19	17	13	14
4	.00	45	16	12	14	15	26	10	15
5	.25	30	21	21	28	35	60	16	21
6	.75	22	22	25	37	50	79	13	16

* includes station-years with at least 3 sampling dates and inorganic and total N/P > 8

mid-turbidity ranges at P-limited stations. For stations with N/P ratios exceeding 8, the following model relates the "response ratio" (Hern et al., 1981) to depth and turbidity:

$$\log(B/P) = -.39 - .46 \log(Z) - .58 \log(A) \quad (45)$$
$$(R^2=.45,\ SE^2=.042)$$

The above model explains 75% of the variance in chlorophyll-a and suggests that the response ratio varies roughly inversely as the square root of the product of mean depth and turbidity. It is interesting that the depth alone is not significantly correlated with the response ratio (R^2=.01). Turbidity alone yields an R-Squared of .27, which increases to .45 when the depth term is added. This suggests that the product of depth and turbidity is of some significance, as predicted by the kinetic theory of algal growth under light-limited conditions, since it is directly related to the depth-averaged light intensity (Oskam,1973, Lorenzen and Mitchell,1973). Residuals plots indicate a negative bias (over-prediction) of about .2 log units in the above model for reservoirs with overflow rates exceeding 100 m/yr or residence times less than .03 years. This and alternative methods for representing phosphorus/turbidity/chlorophyll relationships (e.g., model B04, B05, equation (43)) should be more thoroughly investigated for their potential uses in reservoirs.

Regional Analysis

115. Regional distributions in transparency, chlorophyll, nutrients, and related factors provide additional insights into factors controlling transparency and chlorophyll. Table 21 summarizes the geometric mean concentrations of these variables on a regional basis. To provide the broadest possible data base for regional analysis, mean concentrations have been computed using data from 448 station-years with at least two sampling dates for corrected chlorophyll-a. Analysis based upon 218 station-years with at least 3 sampling dates excludes one region (South Pacific) but gives similar results. Analyses of variance

Table 21

Regional Variations in Chlorophyll, Transparency, and Nutrient Data from Station-Years with at Least Two Sampling Dates

Reg*	N	B	S	A	TP	TN	B×S	B/TP	TP×S	TN/TP	IN/DP**
					Variable						
					Regional Geometric Means						
All	448	7.9	1.14	.58	40	755	9.0	.20	45	19	22
02	7	6.5	2.28	.26	17	1195	14.7	.38	38	46	65
03	70	6.9	1.45	.47	24	585	10.1	.29	35	24	29
04A	19	8.4	1.29	.45	30	989	10.8	.28	39	33	56
04B	34	14.1	0.87	.64	51	1416	12.3	.28	44	28	59
04C	19	8.5	1.09	.68	38	943	9.2	.22	41	25	45
04D	34	6.5	1.28	.59	39	580	8.4	.17	50	15	15
05	25	17.7	1.31	.22	67	1679	23.2	.26	88	16	7
06	41	9.3	1.09	.58	43	838	10.2	.21	47	19	29
07A	41	4.8	2.29	.29	21	486	11.1	.23	48	23	33
07B	81	7.8	0.58	1.39	71	792	4.6	.11	41	11	12
08	59	10.0	0.89	.76	51	978	8.9	.20	45	19	27
09	11	2.5	2.92	.27	24	265	7.2	.10	70	11	4
10	7	1.0	4.88	.18	14	198	4.9	.07	69	13	3
					Analyses of Variance						
Mean Squares (base 10 logarithms)											
Within		1.412	1.503	2.124	1.430	.990	1.127	.991	.329	.807	3.504
Among		.101	.083	.127	.118	.047	.094	.093	.041	.066	.121
F†		13.98	18.20	16.66	12.11	21.15	11.93	10.66	8.04	12.28	29.04

* Regional Codes (C.E. Divisions)

02 = North Atlantic
03 = South Atlantic
04A = Ohio River (Pittsburg)
04B = Ohio River (Huntington)
04C = Ohio River (Louisville)
04D = Ohio River (Nashville)
05 = North Central
06 = Lower Mississippi
07A = Southwest (Little Rock)
07B = Southwest (other)
08 = Missouri River
09 = North Pacific
10 = South Pacific

** Inorganic nitrogen/dissolved phosphorus ratio
† All F statistics significant at $p < .001$; ANOVA's conducted on log scales

indicate significant regional variations for all variables and variable combinations investigated. Three variable combinations are particularly useful:

B*S = chlorophyll * transparency (mg/m2)
B/P = chlorophyll / total phosphorus -
P*S = total phosphorus * transparency (mg/m2)

The first statistic provides an indication of the percentage of light extinction attributed to chlorophyll and related substances. The second, termed the "response ratio" by Hern et al. (1981), is an indicator of the amount of chlorophyll produced per unit of total phosphorus. The third, derived from the phosphorus/transparency model calibrated above (S05X02), reflects the percentage of light extinction attributed to materials associated with phosphorus, whether organic or inorganic in form. Other important factors include the total N/P ratio and inorganic N/P ratio, as indicators of the potential nitrogen limitation.

116. Analyses of variance indicate that regional factors are strongest in the case of the inorganic N/P ratio (F=29.0) and weakest in the case of P*S (F=8.0). The relatively low variablity in P*S reflects the low mean squared error of the phosphorus/transparency model and covariance attributed to non-algal suspended solids.

117. Stem-and-leaf (Mosteller and Tukey, 1977) diagrams of these factors (Figure 10) facilitate analysis of regional variations. The chlorophyll*transparency distribution has two low outliers: region 7B (Southwest Division, exclusive of Little Rock District) and region 10 (South Pacific Division, although this average is derived from only 7 station-years of data, all from one reservoir, and may not be representative of the Division as a whole). In these regions, relatively low percentages of incident light are available for photosynthesis and relatively high percentages of nutrients may be tied up in inorganic forms. N/P ratios generally show a decreasing trend from east to west. There are three regions where the inorganic N/P ratio averages less than 8: region 5 (North Central Division), region 9

Figure 10

Stem-and-Leaf Diagrams of Eutrophication-Related Factors
by Region *

Station-Years with at Least Two Sampling Dates

```
Chl-a×Secchi          Chl-a/Total P          Total P×Secchi

1.3| 5                -.4|                 ** 2.1|
1.2|                   -.5|                    2.0|
1.1| 2                -.6| 2  3  4A 4B 5     1.9| 5
1.0| 3 4A 4B 6 7A     -.7| 4C 4D 6  7A 8     1.8| 9 10
 .9| 8 4C 4D          -.8|                    1.7| 4D
 .8| 9                -.9|                    1.6| 4B 4C 6 7A 8 7B
 .7|                 -1.0| 7B 9               1.5| 2  3 4A
 .6| 7B 10           -1.1|                    1.4|
 .5|                 -1.2| 10                 1.3|

Total N/P             Inorganic N/P          Turbidity

1.6| 2                2.0|                     .1| 7B
1.5| 4A               1.8| 2                   .0|
1.4| 4B               1.6| 4A 4B 4C           -.1|
1.3| 7A 3 4C          1.4| 3  6  8  7A        -.2| 4B 4C 8
1.2| 5  6  8          1.2|                    -.3| 4D 6
1.1| 4D 10            1.0| 4D 7B              -.4| 4A 3
1.0| 7B 9              .8| 5                  -.5|
 .9|                   .6| 9                  -.6| 2  7A 9
 .8|                   .4| 10                 -.7| 5
 .7|                   .2|                     -.8| 10

Mean Depth            Residence Time         Overflow Rate

1.6| 9                -.2| 8                  2.1| 10
1.5|                   -.3|                    2.0|
1.4|                   -.4| 5 7A 9             1.9| 4B 4D 9
1.3|                   -.5| 6 7B               1.8| 2
1.2| 10               -.6|                    1.7| 4A
1.1| 7A               -.7|                    1.6| 3  4C
1.0|                   -.8| 3 4C               1.5| 7A
 .9| 2  3  4D 8       -.9| 2 4A               1.4|
 .8| 4A 4C 6         -1.0| 10                 1.3|
 .7| 4B 7B           -1.1| 4D                 1.2| 6 7B
 .6| 5               -1.2| 4B                 1.1|
 .5|                 -1.3|                    1.0| 5 8
```

* regional codes defined in Table 21
** minimum of interval (log10 scales)

(North Pacific) and region 10 (South Pacific). In these regions, algal growth is more likely to be limited by nitrogen than by phosphorus, on the average. Regions 9 and 10 also lie at the upper ends of the mean depth and surface overflow rate distributions.

118. The above outlier groups can be used to explain some of the regional variations in chlorophyll and transparency responses to phosphorus. Region 10 has the lowest chlorophyll/phosphorus ratio (.07) and is also found in all of the above outlier groups. Region 9 has the next lowest B/P ratio (.10) and is in the low N/P and deep groups. Region 7B has the next lowest B/P value (.11), the lowest chlorophyll*transparency product, and the highest average turbidity. The remaining regions are clustered are higher B/P ratios. The phosphorus*transparency distribution shows three high outliers, regions 5, 9, and 10. These correspond to the regions with lowest inorganic N/P ratios and lowest turbidities. In N-limited situations, appreciable fractions of total phosphorus may be in dissolved form and have little impact on transparency. While the data base is relatively weak in some regions (especially New England, North Atlantic, North Pacific, South Pacific), variations in turbidity, N/P ratio, and depth, which show strong regional patterns, determine the average responses of transparency and chlorophyll to total phosphorus.

Conclusions

119. The following conclusions can be drawn from the internal model testing described above:

a. Predicting transparency as a function of chlorophyll is difficult in these reservoirs because of the influences of substances unrelated to chlorophyll on light extinction.

b. The following model can be used to partition light into two components:

$$1/S = A + .025\ B$$

where,

S = mean transparency (m)

B = mean chlorophyll-a (mg/m^3)

A = non-algal turbidity (1/m)

Variations in the intercept term ("A") are large and tend to obscure the chlorophyll/transparency relationship. Independent data indicate that "A" values calculated from the above equation are positively correlated with Hach turbidity, suspended solids, and true color.

c. At stations with inorganic and total N/P ratios exceeding 8, transparency can be related to total P using model S05X02:

$$1/S = .082 + .022\ P \qquad (R^2=.77, SE^2=.024)$$

where,

P = mean total phosphorus (mg/m^3)

The above model over-predicts transparency by an average of 35% at stations where chlorophyll accounts for less than about 12% of the total light extinction. Transparency is under-predicted in northern reservoirs, which tend to have lower N/P ratios and lower non-algal turbidity levels. Phosphorus associated with algae has a somewhat smaller influence on transparency than that associated with turbidity.

d. The following model represents the partitioning of phosphorus at stations with N/P ratios exceeding 8:

$$\log(P) = \log(2.0 + 1.76\ B + 26.2\ A) \qquad (R^2=.84, SE^2=.019)$$

This model has relatively low error, but cannot be used in reverse (to predict chlorophyll, for example), without a predictive basis for turbidity.

e. Effects of nitrogen, turbidity, depth, and overflow rate contribute

to variations in phosphorus/chlorophyll relationships.

f. Phosphorus/chlorophyll models fit to data sets with increasingly restrictive N/P and turbidity limits show increased phosphorus sensitivity and yield, reduced error, reduced association with reservoir morphometric, hydrologic, and water quality characteristics, and reduced association with region, but reduced generality and robustness.

g. The multivariate model (B04X02) which includes terms for the effects of phosphorus, depth, turbidity, and overflow rate on chlorophyll has fairly stable coefficients and applies to 87% of the station-years studied (exclusive of N-limited stations):

$$\log(B) = .22 + .83 \log(P) - .23\ A - .46 \log(Z) - .00046\ Qs \qquad (R^2 = .72, SE^2 = .041)$$

Parameter stability tests indicate an interaction between phosphorus and turbidity effects which is not accounted for in the model.

h. Model selection and, in the cases of models B04 and B05, model use depend upon estimates of turbidity and N/P ratio. Means for estimating these variables *a priori* are needed if these models are to be used in a reservoir planning context. Additional investigation of alternative means for representing the effects of turbidity and N/P ratio on phosphorus/chlorophyll relationships is needed.

i. In the absence of a basis for estimating turbidity or N/P ratio, model B01X03 may be applied to stations with mean total phosphorus concentrations less than 40 mg/m3:

$$\log(B) = -.60 + .98 \log(P) \qquad (R^2 = .64, SE^2 = .057)$$

This model also applies to all stations with N/P ratios > 8 and turbidities < 1.58 1/m, or 74% of the station-years studies. Errors are not independent of mean depth or turbidity, however.

j. Regional variations in average chlorophyll-transparency products, inorganic N/P ratios, and reservoir mean depths explain regional variations in the responses of transparency and chlorophyll to total phosphorus.

PART VI: LOADING MODELS

Introduction

120. Another class of models relates reservoir water quality characteristics to external phosphorus loading, morphometric characteristics, and hydrologic characteristics. These models can be classified according to predicted variable:

a. mean, annual, outflow phosphorus concentration
b. mean, growing-season, epilimnetic phosphorus concentration
c. mean, growing-season, epilimnetic chlorophyll-a concentration
d. mean, growing-season transparency
e. hypolimnetic oxygen depletion

The calibration and testing of models in the first four classes are described in the following sections. The fourth section discusses the potential effects of spatial gradients on these relationships. Hypolimnetic oxygen depletion is treated separately in Part VII.

Outflow Phosphorus

121. Prediction of outflow phosphorus concentration provides a basis for establishing a phosphorus mass balance around the reservoir, since the outflow concentration estimates are flow-weighted and averaged on an annual basis. Nutrient and water budgets for the EPA/NES tributary sampling years have been used to provide estimates of inflow phosphorus concentration, mean depth, and hydraulic residence time. After application of the screening criteria described in Part III, data from 62 "group A" reservoirs are available for model testing. The data set is listed and summarized in Appendix C.

122. A total of 16 different model formulations have been compiled from the literature. Formulations, parameters, and error statistics for the original and optimized models are listed in Table 22. Complete statistical summaries of model residuals, regional analyses, correlation

Table 22

Formulations, Parameter Estimates, and Error Statistics for Models Predicting Outflow Phosphorus Concentration

Model R01: first-order sedimentation
Equation: $\log(Po) = \log(Pi) - \log(1 + K1\ T)$

Code	Coefficients	K1	N	R2	MSE
R01A01	Vollenweider(1969)	.65	62	.135	.128
R01A02	Mueller(1980)	2.00	62	.499	.074
R01X01	Optimal	4.24	62	.633	.055
	standard error	.57			
R01X02	Optimal *	3.31	56	.724	.041
	standard error	.45			

Model R02: first-order settling
Equation: $\log(Po) = \log(Pi) - \log(1 + K1/Qs)$

Code	Coefficients	K1	N	R2	MSE
R02A01	Vollenweider(1969)	10.0	62	.287	.106
R02A02	Dillon(1975)	13.2	62	.368	.094
R02A03	Chapra (1976)	16.0	62	.420	.086
R02A04	Higgins et al(1980)	92.0	62	.104	.133
R02X01	Optimal	33.3	62	.534	.070
	standard error	5.1			
R02X02	Optimal *	25.1	56	.655	.051
	standard error	3.9			

Model R03: Vollenweider(1976) and others

Equation: $\log(Po) = \log(Pi) - \log(1 + K1\ T^{K2})$

Code	Coefficients	K1	K2	N	R2	MSE
R03A01	Vollenweider(1976)	1.00	.50	62	.426	.085
R03A02	Walker(1977)	.82	.45	62	.369	.094
R03A03	Larsen et al (1976)	.89	.51	62	.379	.092
R03A04	Mueller (1980)	2.09	.83	62	.564	.065
R03A05	Clasen (1980)	2.27	.59	62	.647	.052
R03A06	Clasen (1980)	2.00	.50	62	.638	.054
R03A07	Fricker (1980)	1.42	.049	62	.534	.069
R03X01	Optimal	2.98	.59	62	.671	.051
	standard errors	.59	.13			
R03X02	Optimal *	2.13	.50	56	.775	.033
	standard errors	.39	.12			

(continued)

Table 22 (continued)

Model R04
Equation: log(Po) = log(Pi) - log(K1 + K2 T)

Code	Coefficients	K1	K2	N	R2	MSE
R04A01	Jones&Bachman (1976)	1.18	.76	62	.377	.092
R04A02	Reckhow (1977)	1.13	.17	62	.058	.140
R04A03	Mueller (1980)	1.14	1.83	62	.547	.067
R04X01	Optimal	1.36	3.16	62	.660	.052
	standard errors	.17	.69			
R04X02	Optimal *	1.38	2.16	56	.760	.036
	standard errors	.14	.53			

Model R05: Reckhow (1978)
Equation: log(Po) = log(Pi) - log(K1 + K2/Qs)

Code	Coefficients	K1	K2	N	R2	MSE
R05A01	Reckhow(1978)	1.20	11.6	62	.461	.080
R05X01	Optimal	1.56	18.1	62	.581	.064
	standard errors	.20	5.4			
R05X02	Optimal *	1.56	10.7	56	.715	.043
	standard errors	.15	3.8			

Model R06: Kirchner & Dillon (1975)
Equation: log(Po) = log(Pi)-log(1-K1 EXP(-K2 Qs)-K3 EXP(-K4 Qs))

Code	Coefficients	K1	K2	K3	K4	N	R2	MSE
R06A01	Kirchner et al (1975)	.426	.271	.574	.00949	62	.508	.073
R06A02	Ostrofski (1978)	.201	.0425	.574	.00949	62	.593	.060
R06A03	Mueller (1980)	.29	.556	.71	.00483	62	.647	.052
R06X01	Optimal	**	**	.76	.0073	62	.663	.052
	standard errors			.050	.0022			
R06X02	Optimal *	**	**	.70	.0074	56	.783	.032
	standard errors			.050	.0021			

** term not significant

Model R07: Norvell, Frink, and Hill (1979)
Equation: log(Po) = log(Pi) + log((K1 + Qs)/(K2 + Qs))

Code	Coefficients	K1	K2	N	R2	MSE
R07A01	Norvell et al (1979)	1.2	12.0	62	.298	.104
R07X01	Optimal	23.1	103.4	62	.660	.052
	standard errors	14.4	40.0			
R07X02	Optimal *	28.3	99.3	56	.781	.032
	standard errors	16.5	38.9			

(continued)

Table 22 (continued)

Model R08: Higgins and Kim (1981)
Equation: $\log(Po) = \log(Pi) + \log(K1 + K2 \log(Qs))$

Code	Coefficients	K1	K2	N	R2	MSE
R08A01	Higgins et al. (1981)	.54	.51	62	.114	.130
R08X01	Optimal	.084	.237	62	.622	.056
	standard errors	.085	.059			
R08X02	Optimal *	.144	.232	56	.756	.037
	standard errors	.084	.056			

Model R09: plug flow settling
Equation: $\log(Po) = \log(Pi) - K1/Qs$

Code	Coefficients	K1	N	R2	MSE
R09A01	Higgins et al (1981)	26.5	62	-16.	2.500
R09X01	Optimal	3.74	62	.199	.121
	standard errors	.62			
R09X02	Optimal *	3.06	56	.427	.084
	standard errors	.55			

Model R10: Clasen (1980)
Equation: $\log(Po) = \log(Pi) - \log(1 + K1\ T^{K2}\ Z^{K3})$

Code	Coefficients	K1	K2	K3	N	R2	MSE
R10A01	Classen (1980)	7.24	.608	-.50	62	.635	.054
R10A02	Fricker (1980)	9.35	1.00	-.69	62	.486	.076
R10X01	Optimal	4.16	0.62	-.14	62	.675	.051
	standard errors	1.95	.14	.18			
R10X02	Optimal *	3.24	.54	-.17	56	.780	.034
	standard errors	1.41	.13	.17			

Model R11: Clasen (1980)
Equation: $\log(Po) = K1 \log(Pi) + K2$

Code	Coefficients	K1	K2	N	R2	MSE
R11A01	Classen (1980)	.85	-.11	62	.554	.066
R11A02	Fricker (1980)	1.01	-.35	62	.494	.075
R11A03	Fricker (1980)	.88	-.18	62	.533	.069
R11X01	Optimal	.70	.28	62	.622	.058
	standard errors	.07	.15			
R11X02	Optimal *	.81	.088	56	.711	.043
	standard errors	.07	.14			

(continued)

Table 22 (continued)

Model R12: Clasen (1980)

Equation: $\log(Po) = \log(Pi)\ (1 - K1\ T^{K2})$

Code	Coefficients	K1	K2	N	R2	MSE
R12A01	Clasen (1980)	.25	.32	62	.747	.038
R12X01	Optimal	.29	.34	62	.763	.036
	standard errors	.024	.064			
R12X02	Optimal *	.25	.32	56	.813	.028
	standard errors	.024	.068			

Model R13: Fricker (1980)

Equation: $\log(Po) = K2 + K1 \log(Pi/(1+T^{.5}))$

Code	Coefficients	K1	K2	N	R2	MSE
R13A01	Fricker (1980)	.906	.104	62	.613	.057
R13A02	Fricker (1980)	.754	.254	62	.709	.043
R13A03	Ryding (1980)	.96	-.02	62	.613	.058
R13X01	Optimal	.74	.32	62	.718	.043
	standard errors	.060	.12			
R13X02	Optimal *	.83	.19	56	.794	.031
	standard errors	.057	.11			

Model R14: multivariate, Walker (1977)

Equation: $\log(Po) = K1 + K2 \log(Pi) + K3 \log(Z) + K4 \log(T)$

Code	Coefficients	K1	K2	K3	K4	N	R2	MSE
R14A01	Walker (1977a)	-.02	.88	-.15	-.17	62	.672	.049
R14X01	Optimal	.48	.61	-.22	-.23	62	.810	.030
	standard errors	.20	.061	.093	.048			
R14X02	Optimal *	.18	.73	-.11	-.22	60	.837	.025
	standard errors	.21	.067	.091	.045			

Model R15

Equation: $\log(Po) = \log(Pi) - \log(1 + 10^{K1}\ Pi^{K2}\ Z^{K3}\ T^{K4})$

Code	Coefficients	K1	K2	K3	K4	N	R2	MSE
R15A01	Canfield & Bachman(1981)	-.89	.55	0.	.45	62	.749	.037
R15A02	Canfield & Bachman(1981)	-.79	.46	0.	.54	62	.653	.051
R15A03	Canfield & Bachman(1981)	-.94	.59	0.	.41	62	.768	.034
R15X01	Optimal	-1.50	.70	.46	.43	62	.813	.030
	standard errors	.40	.11	.18	.11			
R15X02	Optimal *	-.93	.51	.23	.44	56	.828	.027
	standard errors	.68	.14	.20	.11			
R15X03	Optimal *	-.68	.50	.00	.50	56	.828	.027
	standard errors	.045	**	**	**			

** parameters constrained to above values

(continued)

Table 22 (continued)

Model R16: Walker and Kuhner (1978)
Equation $\log(Po) = \log(Pi) - \log(1 + (K1 + K2\ Sr)/Qs)$
Sr = sedimentation rate (kg/m2-yr)

Code	Coefficients	K1	K2	N	R2	MSE
R16A01	Walker & Kuhner (1978)	-4.0	1.0	17	.099	.056
R16X01	Optimal **	-5.5	.92	17	.110	.055
	standard errors	6.2	.38			

** cases with sedimentation rate data conform to restricted data set described below (i.e., R16X02=R16X01).

* restricted data set includes reservoirs with:
inflow (Ortho-P/Total P) > .12
inflow Total P < 500 mg/m3

matrices, and results of stepwise regressions are given in Appendix D. Models R01-R10 can be described as first-order models in which the retention coefficient:

$$R = 1 - Po/Pi \tag{46}$$

where,

R = total phosphorus retention coefficient
Pi = average inflow concentration (mg/m3)
Po = average outflow concentration (mg/m3)

is estimated exclusively as a function of morphometric/hydrologic characteristics. As discussed in Part III, inflow concentrations have been corrected for evaporation effects according to equation (35) and correspond to the total loading divided by the reservoir discharge. For models R01-R10, outflow phosphorus concentration is assumed to be proportional to the inflow concentration, with the proportionality constant estimated from mean depth, hydraulic residence time, and/or surface overflow rate. This amounts to assuming that the removal of phosphorus from the water column is a first-order reaction. For models R11-R15, proportionality between inflow and outflow concentration is not assumed, i.e., the retention coefficient may depend upon phosphorus concentration, as well as upon morphometric/hydrologic variables. For model R16, the sedimentation rate is an important independent variable; however, sediment survey data are available for only 17 "group A" reservoirs for calibration and testing of this model (see Part III).

123. The relationship between inflow and outflow total P concentrations is depicted in Figure 11. The regression model R11 relates Po directly to Pi without accounting for morphometric/hydrologic effects on the retention coefficient and explains 62% of the variance in the outflow concentration values with a mean squared error of .058. For most models, residuals plots have revealed significant negative deviations (model over-predictions by .2 to .5 log units) for reservoirs with extremely high concentrations of inflow total phosphorus (> 500 mg/m3) or with low percentages of orthophosphorus loading (< 12 %). To eliminate the influences of these reservoirs on the model parameter

Figure 11

Outflow Total P vs. Inflow Total P

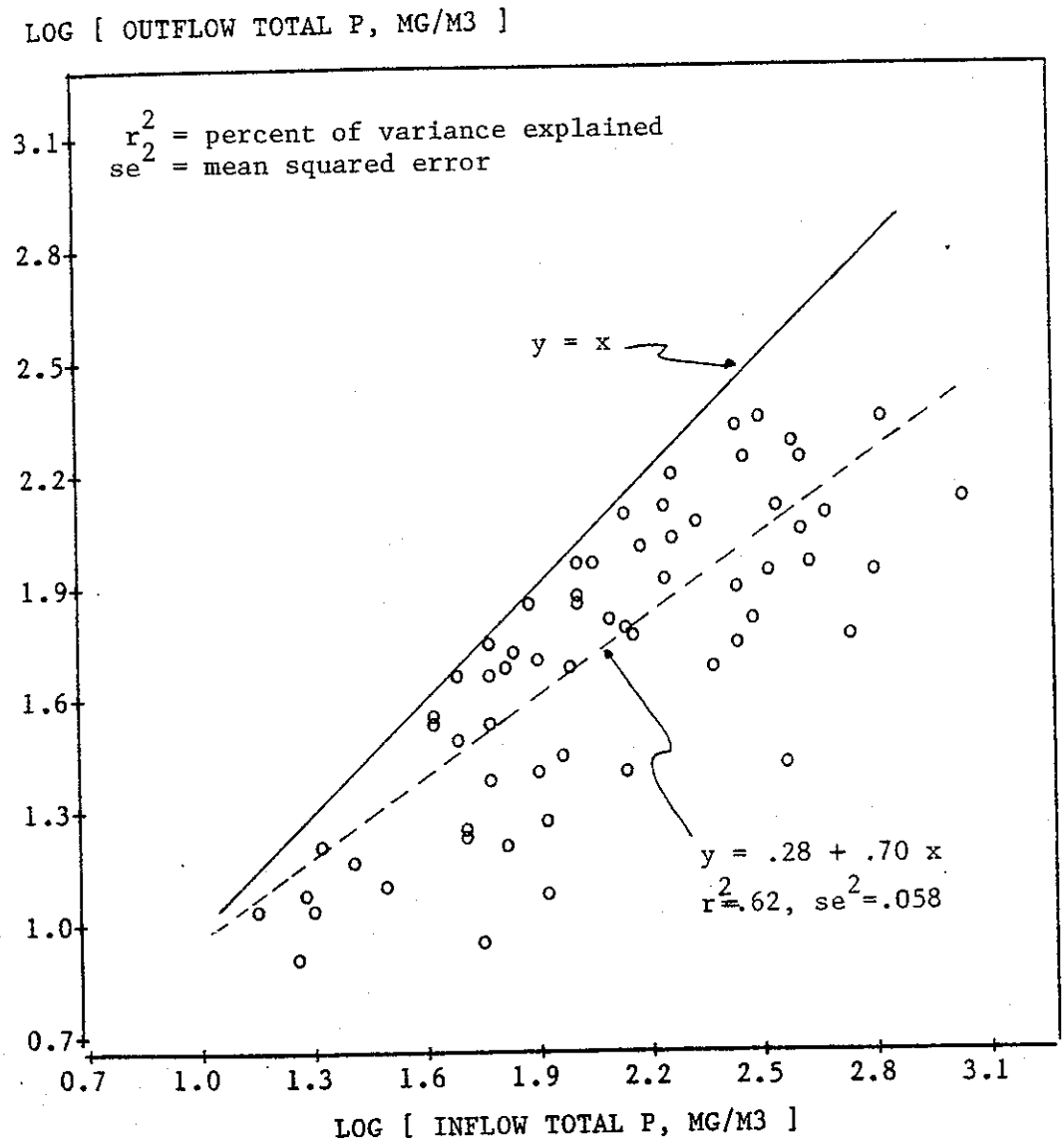
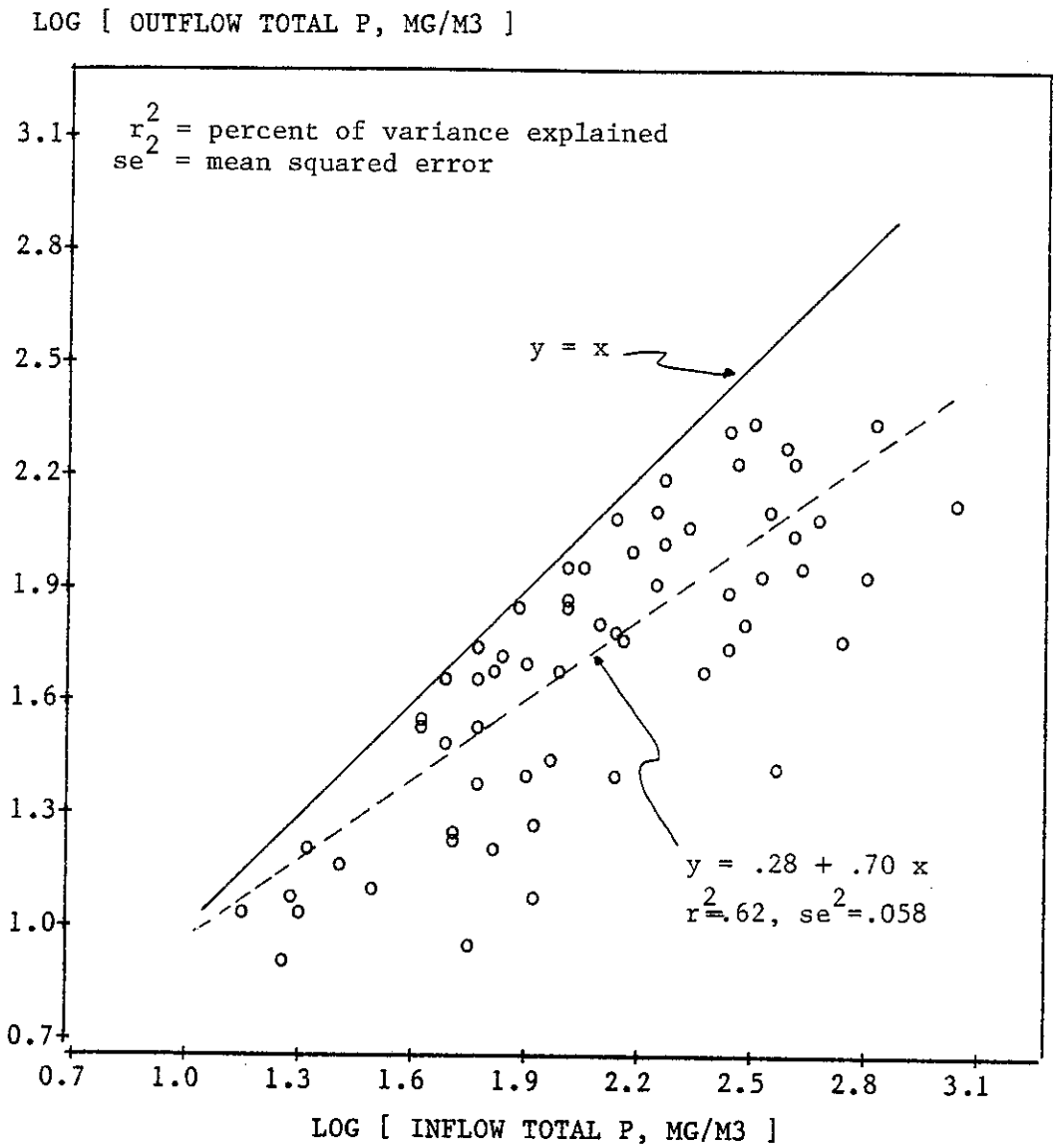


Figure 11

Outflow Total P vs. Inflow Total P



estimates, all models have been fit to an additional data set which excludes six reservoirs in the above categories. For most models, errors are significantly lower for the restricted data set. Observed and predicted outflow phosphorus concentrations are plotted in Figure 12 for models R03, R12, and R15.

124. Model R01 is the first-order sedimentation model proposed by Vollenweider (1969). This represents the reservoir as a completely mixed reactor at steady-state. For the restricted data set, the optimal decay rate parameter is 3.3 1/yr, as compared with the originally proposed value of .65 1/yr. Similarly, the optimal coefficient for the settling velocity model (R02) is 25 m/yr, as compared with lake values in the range of 10 - 16m/yr and with a value of 92 m/yr found by Higgins and Kim (1981) for TVA reservoirs with total P concentrations greater than 25 mg/m3 (Appendix E).

125. Model R03 permits the sedimentation coefficient to vary as a power function of residence time. The optimal exponent is -.50, identical to the original value found by Vollenweider (1976), Larsen and Mercier (1976), and others. The optimal coefficient, however, is 2.1 (standard error .39), compared with original values ranging from .82 to 1.0 for lake data sets and 2 to 2.3 for other reservoir data sets (Mueller,1980, Clasen,1980). Thus, calibration of models R01-R03 indicates that, for a given residence time and mean depth, these reservoirs tend to be more effective at removing phosphorus from the water column than are the natural lakes used in empirical model development. Some the difference may be attributed to plug-flow behavior (i.e., significant spatial gradients) and some to higher sedimentation rates in reservoirs.

126. The potential effects of plug flow can be calculated by assuming that the reservoir consists of a series of n linked segments of equal volume and applying Vollenweider's model (R03A01) to each segment. The resulting expression for the outflow/inflow concentration ratio is:

$$Po/Pi = [\ 1 + (T/n)^{.5}\ ]^{-n} = [\ 1 + KE\ T^{.5}\ ]^{-1} \qquad (47)$$

where,

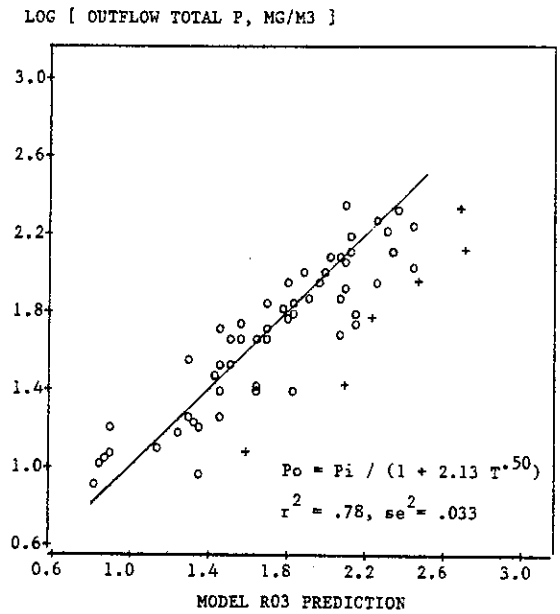
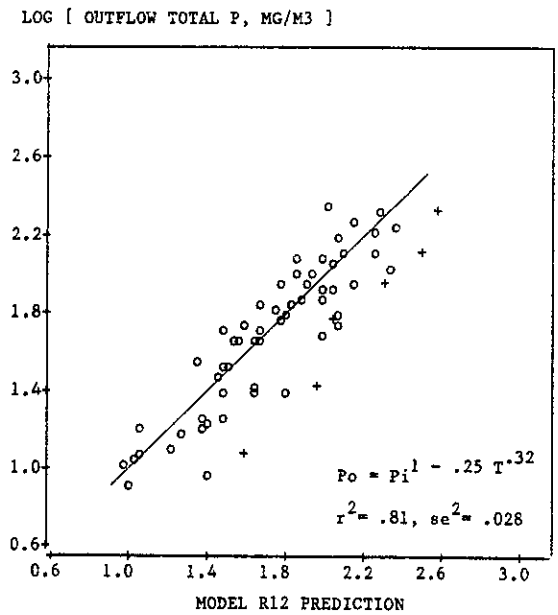
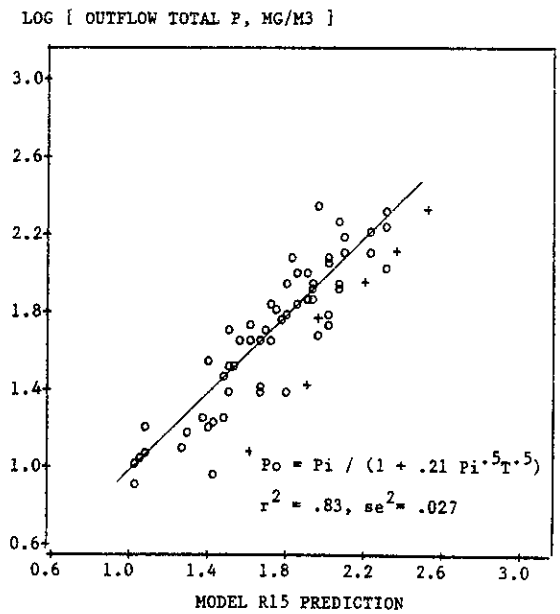


Figure 12

Observed and Predicted Outflow P Concentrations

o = points included in regression
+ = points excluded from regression
Pi > 500 mg/m3, or
Inflow Ortho-P/Total P < .12





T = total residence time (yr)

n = number segments of equal residence time in series

KE = effective rate constant for mixed model (R03)

The effective rate constant, KE, corresponds to the parameter estimate which would result from optimization of the model, assuming mixed conditions (or one segment). Table 23 presents calculated ratios and effective rate constants for values of T ranging from .1 to .9 years and values of n ranging from 1 to 5 cells. For a given residence time, plug flow effects could clearly result in lower outflow concentrations and higher effective rate constants, especially as residence time and number of cells increase. For three cells at a residence time of .5 year, for example, an effective rate constant of about 2.5 is calculated, where each of the three segments has a rate constant of 1.0 (i.e., obeys the original Vollenweider/Larsen-Mercier model).

127. Thus, it seems likely that plug flow effects could partially account for the higher rate coefficients estimated for models R01 - R03, although residuals analyses described below suggest that higher sediment accumulation rates may also be involved. The above analysis is theoretical and may over-estimate the plug-flow effects, since it has not been demonstrated that Vollenweider's model can be successfully applied to separate reservoir segments, especially in series. It seems unlikely that the same rate coefficients could apply to each reservoir segment, since, in many cases, upper pool segments would tend to have higher percentages of allochthonous particulate phosphorus and have different removal mechanisms, compared with near-dam segments (Thornton et al, 1980). More detailed modelling of spatial gradients within reservoirs, similar to the work done by Higgins and Kim (1981) on Cherokee Reservoir, is needed in order to sort out these factors. Calibration of the plug-flow, settling model proposed by Higgins and Kim (model R09) is largely unsuccessful (R^2=.31, SE^2=.084) because the model requires a much higher sensitivity to overflow rate than the data support. It is possible that their approach could be applied successfully to reservoirs in certain morphometric and inflow concentration ranges. The current study is limited, however, to a

Table 23

Potential Effects of Plug Flow Behavior on
Phosphorus Removal and Effective Rate Coefficients

n = Effective Number of Cells

T(yr)	1	2	3	4	5
	Po/Pi				
.10	.760	.668	.605	.556	.516
.20	.691	.577	.502	.446	.402
.30	.646	.520	.439	.380	.334
.40	.613	.477	.393	.333	.288
.50	.586	.444	.358	.298	.253
.60	.564	.417	.330	.270	.226
.70	.544	.395	.307	.247	.204
.80	.528	.375	.287	.228	.186
.90	.513	.358	.270	.212	.171
T (yr)	KE				
.10	1.00	1.57	2.06	2.52	2.96
.20	1.00	1.63	2.21	2.77	3.32
.30	1.00	1.68	2.33	2.98	3.63
.40	1.00	1.73	2.44	3.16	3.91
.50	1.00	1.76	2.53	3.33	4.17
.60	1.00	1.80	2.62	3.49	4.42
.70	1.00	1.83	2.70	3.64	4.66
.80	1.00	1.81	2.70	3.76	4.85
.90	1.00	1.88	2.85	3.92	5.12

* Po/Pi = outflow/inflow concentration
KE = effective rate parameter for completely mixed model
n = number of segments of equal T connected in series

"black-box" input/output analysis.

128. Of the models requiring that the retention coefficient be independent of concentration (R01-R10), model R03X02 (see Figure 12) has the best fit:

$$Po = Pi/(1 + 2.1\ T^{.5}) \qquad (R^2=.78,\ SE^2=.033) \qquad (48)$$

Modification of the model to include a depth term (model R10) does not improve the fit, since the optimal depth exponent is not significantly different from zero. Parameter estimates are identical to those found by Clasen (1980) for the OECD Reservoir and Shallow Lakes data base (model R03A06). As demonstrated below (Table 24), errors from this and other retention models are not independent of morphometric complexity. The optimal residence time coefficient (2.1 in equation 48) is 1.8 (standard error = .25) for 36 reservoirs with one major tributary and 2.8 (standard error = .51) for 20 reservoirs with more than one tributary arm. As demonstrated in Figure 13, residuals from this model are also negatively correlated with inflow phosphorus concentration (r =-.49. This result, coupled with the lower errors generally observed for models R11-R15, suggests that the retention coefficient should not be considered independent of concentration.

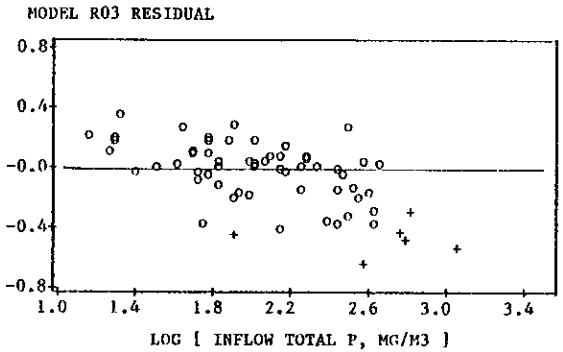
129. Of the models not requiring first-order concentration response, the multiple regression model (R14) has the lowest mean squared error (.025). This model, however, along with R11 and R13, is somewhat deficient theoretically, since it does not require the outflow concentration to approach the inflow concentration as the residence time approaches zero. Model R15 is an extension of the original phosphorus sedimentation models (R01, R02, R03, R10) which permits the sedimentation coefficient to vary as a function of residence time, mean depth, and inflow phosphorus concentration:

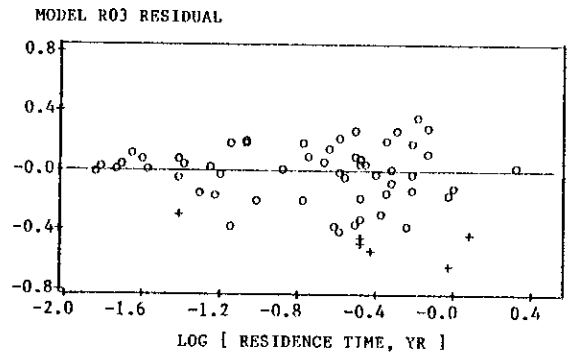
$$Po = Pi/(1 + .12\ Pi^{.70} Z^{.23}\ T^{.44}) \qquad (R^2=.83, SE^2=.026) \qquad (49)$$

Considering the variances of the above parameter estimates, this can be simplified to R15X03:

Figure 13

Residuals Plots of Outflow P Concentration Models

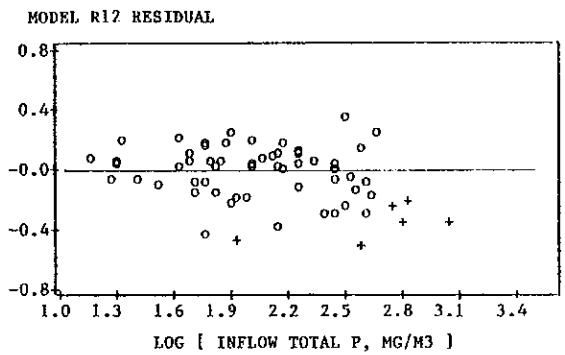


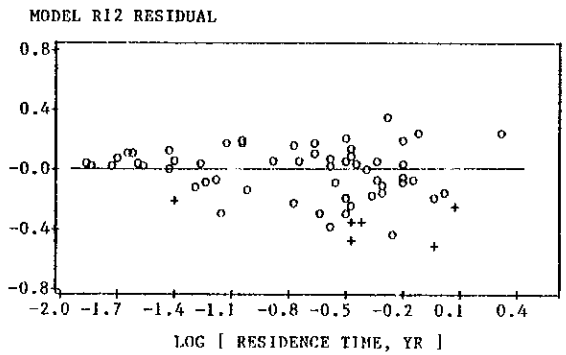


Model R03X02 :

$Po = Pi / (1 + 2.13\ T^{.50})$

$r^2 = .78,\ se^2 = .033$

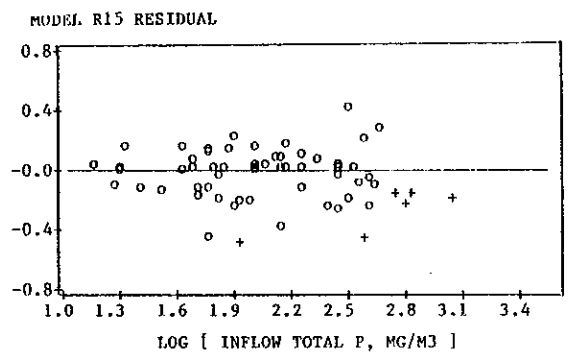


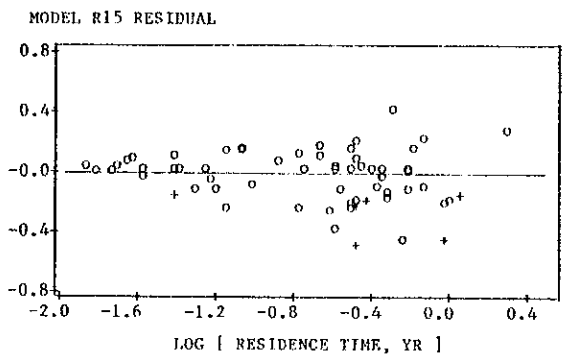


Model R12X02 :

$Po = Pi^{1} - .25\ T^{.32}$

$r^2 = .81,\ se^2 = .028$





Model R15X02 :

$Po = Pi / (1 + .21\ Pi^{.5} T^{.5})$

$r^2 = .83,\ se^2 = .027$

o = points included in regression
+ = points excluded from regression
Pi > 500 mg/m3, or
Inflow Ortho-P/Total P < .12

$$Po = Pi/(1 + .21\ Pi^{.5}\ T^{.5}) \qquad (R^2=.83, SE^2=.026) \tag{50}$$

Observations and predictions are plotted in Figure 12. The above model is equivalent to the following formulation for the first-order sedimentation coefficient:

$$K = .21\ T^{-.5}\ Pi^{.5} \tag{51}$$

where,

K = effective first-order sedimentation coefficient (yr^{-1})

The parameter K represents the rate of removal of phosphorus from the water column per unit of phosphorus concentration. The significant dependence on Pi suggests a nonlinear response to concentration. Since Pi/T is equal to volumetric phosphorus loading, equation (51) is similar to relationships found by Canfield and Bachman (1981), as discussed in detail in the next section.

130. Model R12 is another non-linear formulation with relatively low error. This model, developed by Clasen (1980), is of the following form:

$$Po = Pi^{(1 - .25\ T^{.32})} \qquad (R^2=.81, SE^2=.027) \tag{52}$$

The above coefficients, based upon the restricted data set, are identical to the original values found by Clasen. Compared with model R03 (equation 48), model error is somewhat lower for both this data set (SE^2=.027 vs. .034) and for the OECD/RSL data set (SE^2=.050 vs. .070, see Appendix E). The stability of the parameters and model comparisons derived from both data sets suggest model generality. The lower mean squared errors for this data set may reflect the greater flexibility for data screening which has been possible for the CE data base. The formulation of the model suggests that the sensitivity (exponent) of outflow concentration with respect to inflow concentration decreases with increasing residence time. In the limit of low residence times, the outflow concentration approaches the inflow value, i.e., the

exponent approaches 1.0.

131. Residuals plots (Figure 13) for all of the retention models show a tendancy for error variance to increase as a function of residence time. Thus, the notion of decreasing inflow concentration sensitivity with increasing residence time may have some validity. It seems reasonable that as residence time increases, the potential for changes in water quality induced by the reservoir environment increases and the inflow/outflow sensitivity decreases. In analyzing EPA/NES data from over 100 lakes and reservoirs in the northeastern and northcentral U.S., Walker (1977a) also found that model errors (R03A02) increased with residence time. This can be explained by assuming that estimation errors for the effective sedimentation coefficient are stable and by demonstrating that the sensitivity of the predicted outflow concentration to the sedimentation coefficient increases with residence time, according to the following error analysis scheme for model R01:

$$\log(Po) = \log(Pi) - \log(1 + KT) \tag{53}$$

$$Var(\log(Po)) = DK^2\ Var(\log(K)) + DI^2\ Var(\log(Pi)) \tag{54}$$

$$= [KT/(1+KT)]^2 Var(\log(K)) + Var(\log(Pi)) \tag{55}$$

where,

DK = derivative of log(Po) with respect to log(K)

DI = derivative of log(Po) with respect to log(Pi)

As T approaches zero, the first term in equation (55) approaches zero and errors in estimated Po values are attributed exclusively to errors in the inflow estimates (Var(log(Pi)). As T increases, the first term becomes more significant and approaches the variance in the estimated sedimentation rates, since the term in brackets approaches one. Error analysis results are qualitatively similar for other phosphorus retention models and are consistent with the variance patterns evident in Figure 13.

132. As discussed above, data from only 17 reservoirs are available to permit testing for the effects of sediment accumulation rate (as estimated from sediment surveys) on phosphorus retention.

Model P17 (Walker and Kuhner, 1978) relates the effective settling velocity to the sedimentation rate:

$$Po = Pi/(1 + U/Qs) \qquad (R^2=.11, SE^2=.055) \qquad (56)$$

$$U = -5.5 + .92\ Sr \qquad (57)$$

where,

U = effective settling velocity for total P (m/yr)

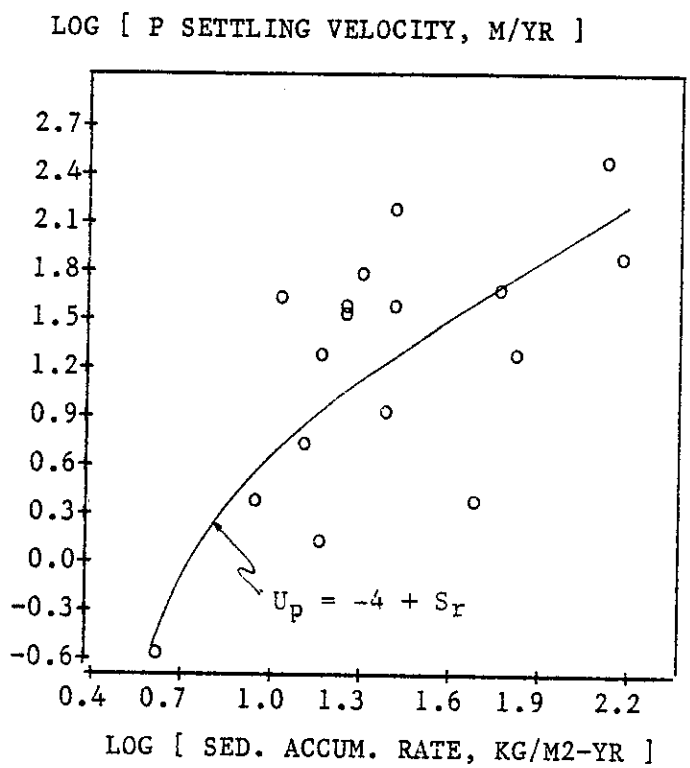
Sr = sedimentation rate (kg/m2-yr)

Optimal parameter values for this model (-5.5 and .92) are not significantly different from the original model formulation (-4 and 1.0). Five out of the 17 reservoirs included in this data set were also included in the data set used for model development (Walker and Kuhner, 1978) and may partially account for the stability of the parameter estimates. Figure 14 plots the relationship between settling velocity and sedimentation rate on log scales. While there is a positive correlation between these two variables, model error for predicting outflow phosphorus concentrations is higher than many of the other formulations tested. The low R-squared of this model is related to the low variance of the observed outlet concentrations in this subset of data, compared with the complete data set (.062 vs. .156). Year-to-year variability in the hydrologic conditions may contribute to variability in this relationship, since the overflow rates refer to the year of EPA/NES sampling and the sedimentation rates reflect long-term averages. The availability and reliability of the sediment survey information also limit potential applications of this model.

133. Appendix D (Table D12) presents a correlation matrix of the residuals from five of the retention models discussed above against various reservoir characteristics. Significant negative correlations are apparent for shoreline development ratio, surface area, and sedimentation rate. While the data base on sedimentation rates is limited, residual correlations are generally strongest with this variable, a result which supports the correlation of phosphorus setting velocity with sedimentation rate shown in Figure 14. Negative

Figure 14

Effective Phosphorus Settling Velocity
vs. Sediment Accumulation Rate



correlations with shoreline development and surface area may reflect the influences of spatial variations on the retention model performance, since reservoirs with greater shoreline development and surface area would have greater potential for spatial heterogeneity in water quality. Significant positive correlations are apparent for the inflow dissolved P/total P ratio, which may reflect greater trapping efficiency for particulate vs. dissolved phosphorus.

134. To investigate the effects of morphometric complexity on model performance, the data set has been divided into two groups according to whether the reservoirs contain one or more than one major tributary arm. Table 24 summarizes model errors by group and uses t-tests to identify significant differences in the mean errors. Differences are significant at between p=.04 and p=.07 for the models tested. The group with simpler morphometry (one tributary) has higher mean residuals than the group with more complex morphometry by about .1 log units. This difference is not large in relation to the model standard errors. While residual variances tend to be higher in the second group, the differences in variance are not statistically significant, based upon F ratio tests.

Table 24

Effect of Number of Major Tributary Arms on Retention Model Error and Parameter Estimates

Model	Number of Major Tributaries	N	Mean	Std.Dev.	t*	Pr(>t)
R03X02	1	36	.036	.164	1.97	.054
	>1	20	-.062	.200		
R12X02	1	36	.042	.149	2.10	.041
	>1	20	-.052	.180		
R13X02	1	36	.03	.153	2.04	.046
	>1	20	-.067	.194		
R14X02	1	36	.017	.145	1.81	.076
	>1	20	-.060	.164		
R15X02	1	36	.036	.146	1.92	.060
	>1	20	-.047	.171		

* t statistic for Ho: mean(1)=mean(2), variances equal in all cases, based upon F test (SAS Institute,1979)

Reservoir Water Quality

135. Models in this category predict reservoir phosphorus, chlorophyll, and transparency as functions of external phosphorus loading, morphometry, and hydrology. Calibration for predicting growing-season, reservoir-average values is described below. Formulations and parameter estimates are given in Tables 25, 26, and 27, for phosphorus, chlorophyll-a, and transparency models, respectively. The data reduction and screening procedures described in Part III have provided a total of 43 reservoir-years for testing these relationships. The data set is listed in Appendix C, Table C2. Potential effects of spatial variance within reservoirs on these relationships are discussed in a subsequent section.

136. The models listed in Table 25 predict average, growing-season, surface-layer concentrations of total phosphorus. They correspond to those described previously for predicting outflow phosphorus concentration (Table 22), but in many cases the optimal parameter estimates are significantly different. Figure 15 depicts the relationship between pool and outflow phosphorus concentrations. The regression equation is:

$$\log(P) = .26 + .85 \log(Po) \qquad (R^2 = .78, SE^2 = .033) \tag{58}$$

where,

P = growing-season, surface-layer, total phosphorus (mg/m3)

Po =annual-mean, outflow total phosphorus (mg/m3)

This relationship is not significantly different from a simple equality (P=Po), also shown in Figure 15. Differences between P and Po reflect the combined influences of (1) spatial variations within the pool, (2) epilimnetic vs. hypolimnetic withdrawals, (3) seasonal variations, and (4) flow-weighting of the outflow concentrations. One would expect the first mechanism to result in P/Po ratios greater than 1.0 because of negative concentration gradients moving downstream in the reservoirs. Stratified impoundments with bottom outlets would probably tend to have lower P/Po ratios, owing to accumulation of phosphorus in the

Table 25

Formulations, Parameter Estimates, and Error Statistics for Loading Models Predicting Average Phosphorus Concentrations

Model P01: first-order sedimentation
Equation: $\log(P) = \log(Pi) - \log(1 + K1\ T)$

Code	Coefficients	K1	N	R2	MSE
P01A01	Vollenweider(1969)	.65	43	.133	.126
P01A02	Mueller(1980)	2.00	43	.373	.091
P01X01	Optimal	3.21	43	.415	.087
	standard error	.73			
P01X02	Optimal *	2.55	39	.639	.054
	standard error	.54			

Model P02: first-order settling velocity
Equation: $\log(P) = \log(Pi) - \log(1 + K1/Qs)$

Code	Coefficients	K1	N	R2	MSE
P02A01	Vollenweider(1969)	10.0	43	.270	.106
P02A02	Dillon(1976)	13.2	43	.329	.097
P02A03	Chapra (1976)	16.0	43	.365	.092
P02A04	Higgins et al.(1980)	92.0	43	-.082	.157
P02X01	Optimal	28.1	43	.420	.086
	standard error	6.4			
P02X02	Optimal *	20.5	39	.651	.052
	standard error	4.4			

Model P03: Vollenweider (1976) and others
Equation: $\log(P) = \log(Pi) - \log(1 + K1\ T^{K2})$

Code	Coefficients	K1	K2	N	R2	MSE
P03A01	Vollenweider(1976)	1.00	.50	43	.406	.086
P03A02	Walker(1977a)	.82	.45	43	.367	.092
P03A03	Larsen et al.(1976)	.89	.51	43	.367	.092
P03A04	Mueller (1980)	2.09	.83	43	.443	.081
P03A05	Clasen (1980)	2.27	.59	43	.547	.066
P03A06	Clasen (1980)	2.00	.50	43	.564	.063
P03A07	Fricker (1980)	1.42	.049	43	.570	.062
P03X01	Optimal	1.80	.26	43	.606	.060
	standard errors	.46	.13			
P03X02	Optimal *	1.43	.25	39	.776	.034
	standard errors	.32	.12			

(continued)

Table 25 (continued)

Model P04: Jones and Bachman (1976)
Equation: log(P) = log(Pi) - log(K1 + K2 T)

Code	Coefficients	K1	K2	N	R2	MSE
P04A01	Jones et al. (1976)	1.18	.76	43	.370	.091
P04A02	Reckhow (1977)	1.13	.17	43	.119	.128
P04A03	Mueller (1980)	1.14	1.83	43	.449	.080
P04X01	Optimal	1.86	.93	43	.582	.064
	standard errors	.24	.66			
P04X02	Optimal *	1.66	.87	39	.767	.036
	standard errors	.17	.49			

Model P05: Reckhow (1978)
Equation: log(P) = log(Pi) - log(K1 + K2/Qs)

Code	Coefficients	K1	K2	N	R2	MSE
P05A01	Reckhow(1978)	1.20	11.6	43	.448	.080
P05X01	Optimal	1.87	7.2	43	.585	.063
	standard errors	.24	5.2			
P05X02	Optimal *	1.65	7.1	39	.777	.034
	standard errors	.16	3.6			

Model P06: Kirchner & Dillon (1975)
Equation: log(P) = log(Pi)-log(1-K1 EXP(-K2 Qs)-K3 EXP(-K4 Qs))

Code	Coefficients	K1	K2	K3	K4	N	R2	MSE
P06A01	Kirchner et al.(1975)	.426	.271	.574	.00949	43	.448	.080
P06A02	Ostrofski (1978)	.201	.043	.574	.00949	43	.476	.076
P06A03	Mueller (1980)	.29	.556	.710	.00483	43	.492	.074
P06X01	Optimal	.387	.353	.613	.0023	43	.605	.062
	standard errors	.074	.394	.074	.0017			
P06X02	Optimal *	.502	.216	.498	.0012	39	.779	.035
	standard errors	.066	.112	.066	.0013			

Model P07: Norvell, Frink, and Hill (1978)
Equation: log(P) = log(Pi) + log((K1 + Qs)/(K2 + Qs))

Code	Coefficients	K1	K2	N	R2	MSE
P07A01	Norvell et al.(1978)	1.2	12.0	43	.276	.105
P07X01	Optimal	102.1	285.5	43	.603	.060
	standard errors	95.9	221.6			
P07X02	Optimal *	116.1	276.2	39	.767	.036
	standard errors	99.1	116.1			

(continued)

Table 25 (continued)

Model P08: Higgins and Kim (1980)
Equation: log(P) = log(Pi) + log(K1 + K2 log(Qs))

Code	Coefficients	K1	K2	N	R2	MSE
P08A01	Higgins et al. (1980)	.54	.51	43	-.905	.262
P08X01	Optimal	.214	.156	43	.598	.061
	standard errors	.127	.080			
P08X02	Optimal *	.252	.166	39	.776	.034
	standard errors	.109	.068			

Model P09: plug flow settling
Equation: log(P) = log(Pi) - K1/Qs

Code	Coefficients	K1	N	R2	MSE
P09A01	Higgins et al. (1980)	26.5	43	-12.0	1.890
P09X01	Optimal	4.03	43	.245	.112
	standard errors	.82			
P09X02	Optimal *	3.53	39	.558	.066
	standard errors	.65			

Model P10: Clasen (1980)
Equation: log(P) = log(Pi) - log(1 + K1 T^{K2} Z^{K3})

Code	Coefficients	K1	K2	K3	N	R2	MSE
P10A01	Clasen (1980)	7.24	.608	-.50	43	.560	.064
P10A02	Fricker (1980)	9.35	1.00	-.69	43	.396	.088
P10X01	Optimal	2.26	0.29	-.09	43	.607	.061
	standard errors	1.54	.15	.25			
P10X02	Optimal *	2.13	.30	-.16	39	.780	.035
	standard errors	1.21	.13	.22			

Model P11: Clasen (1980), Fricker (1980)
Equation: log(P) = K1 log(Pi) +K2

Code	Coefficients	K1	K2	N	R2	MSE
P11A01	Clasen (1980)	.85	-.11	43	.597	.059
P11A02	Fricker (1980)	1.01	-.35	43	.549	.065
P11A03	Fricker (1980)	.88	-.18	43	.574	.062
P11X01	Optimal	.70	.28	43	.682	.048
	standard errors	.075	.16			
P11X02	Optimal *	.67	.37	39	.793	.032
	standard errors	.074	.15			

(continued)

Table 25 (continued)

Model P12: Clasen (1980)

Equation: $\log(P) = \log(Pi)\ (1 - K1\ T^{K2})$

Code	Coefficients	K1	K2	N	R2	MSE
P12A01	Clasen (1980)	.25	.32	43	.678	.047
P12X01	Optimal	.23	.17	43	.711	.044
	standard errors	.029	.072			
P12X02	Optimal *	.20	.20	39	.834	.025
	standard errors	.025	.067			

Model P13: Fricker (1980)

Equation: $\log(P) = K1\ \log(Pi/(1+T^{.5})) + K2$

Code	Coefficients	K1	K2	N	R2	MSE
P13A01	Fricker (1980)	.906	.104	43	.608	.057
P13A02	Fricker (1980)	.754	.254	43	.707	.042
P13A03	Ryding (1980)	.96	-.02	43	.595	.059
P13X01	Optimal	.704	.396	43	.726	.042
	standard errors	.067	.131			
P13X02	Optimal *	.677	.463	39	.833	.026
	standard errors	.064	.125			

Model P14: multivariate, Walker (1977a)

Equation: $\log(P) = K1 + K2\ \log(Pi) + K3\ \log(Z) + K4\ \log(T)$

Code	Coefficients	K1	K2	K3	K4	N	R2	MSE
P14A01	Walker (1977a)	-.02	.88	-.15	-.17	43	.645	.051
P14X01	Optimal	.96	.53	-.41	-.053	43	.807	.031
	standard errors	.26	.075	.12	.057			
P14X02	Optimal *	.96	.51	-.39	-.078	39	.869	.021
	standard errors	.25	.073	.12	.051			

Model P15: generalized phosphorus sedimentation

Equation: $\log(P) = \log(Pi) - \log(1 + 10^{K1}\ Pi^{K2}\ Z^{K3}\ T^{K4})$

Code	Coefficients	K1	K2	K3	K4	N	R2	MSE
P15A01	Canfield & Bachman(1981)	-.89	.55	0.0	.45	43	.712	.042
P15A02	Canfield & Bachman(1981)	-.78	.46	0.0	.54	43	.610	.057
P15A03	Canfield & Bachman(1981)	-.94	.59	0.0	.41	43	.737	.038
P15X01	Optimal	-2.45	.89	.78	.06	43	.804	.031
	standard errors	.57	.16	.25	.12			
P15X02	Optimal	-2.95	1.0	1.0	.00	43	.800	.030
	standard errors	.05	-	-	-			
P15X03	Optimal *	-2.98	1.0	1.0	.00	39	.841	.023
	standard errors	.05	-	-	-			
P15X04	Optimal *	-1.75	.68	.52	.16	39	.859	.022
	standard errors	.60	.18	.25	.11			

(continued)

Table 25 (continued)

Model P16

Equation $\log(P) = \log(Pi) - \log(1 + (K1 + K2\ Sr)/Qs)$

Sr = sedimentation rate (kg/m2-yr)

Code	Coefficients	K1	K2	N	R2	MSE
P16A01	Walker & Kuhner (1978)	-4.0	1.00	13	.252	.035
P16X01	Optimal	-5.0	.95	13	.264	.035
	standard errors	7.1	.41			

* restricted data set includes reservoirs with:

Inflow Total P < 500 mg/m3

Inflow (Dissolved P/Total P) > .12

Table 26

Formulations, Parameter Estimates, and Error Statistics for Loading Models Predicting Chlorophyll-a

Model B10

Equation: $\log(B) = K1 + K2 \log[Pi/(1 + 12.4/Qs)]$

Code	Coefficients	K1	K2	N	R2	MSE
B10A01	Chapra (1976)	-1.08	1.45	43	-5.5	.733
B10X01	Optimal	.13	.46	43	.345	.077
	standard errors	.19	.10			
B10X02	Optimal *	.06	.51	39	.352	.081
	standard errors	.22	.11			

Model B11

Equation: $\log(B) = K1 + K2 \log[Pi/(1 + T^{.5})]$

Code	Coefficients	K1	K2	N	R2	MSE
B11A01	Vollenweider (1976)	-.44	.91	43	-.636	.184
B11A02	Rast & Lee (1978)	-.26	.76	43	-.006	.113
B11A03	Clasen (1980)	-.02	.58	43	.360	.072
B11A04	Fricker (1980)	-.22	.68	43	.328	.075
B11A05	Fricker (1980)	-.22	.71	43	.211	.089
B11A06	Ryding (1980)	-.31	.81	43	-.221	.137
B11A01	Ryding (1980)	-.82	1.01	43	-.182	.110
B11X01	Optimal	.10	.48	43	.432	.067
	standard errors	.17	.086			
B11X02	Optimal *	.04	.52	39	.439	.070
	standard errors	.19	.096			
B11X03	Optimal **	-.15	.66	29	.583	.062
	standard errors	.19	.107			

Model B12

Equation: $\log(B) = K1 + \log[1 - \exp(-K2\ Pi/(1 + 2\ T^{.5}))]$

Code	Coefficients	K1	K2	N	R2	MSE
B12A01	Clasen (1980)	1.70	.007	43	.020	.110
B12X01	Optimal	1.21	.022	43	.408	.069
	standard errors	.07	.0067			
B12X02	Optimal *	1.23	.025	39	.410	.077
	standard errors	.071	.0081			

(continued)

Table 26 (continued)

Model B13

Equation: $\log(B) = K1 + K2 \log(Pi/(1 + 2 T^{.5}))$

Code	Coefficients	K1	K2	N	R2	MSE
B13A01	Clasen (1980)	.06	.58	43	.320	.075
B13X01	Optimal	.17	.46	43	.431	.067
	standard errors	.15	.083			
B13X02	Optimal *	.13	.50	39	.432	.071
	standard errors	.17	.093			

Model B14

Equation: $\log(B) = K1 + K2 \log[Pi/(1 + 92/Qs)]$

Code	Coefficients	K1	K2	N	R2	MSE
B14A01	Walker (1980b)	.49	.34	43	.204	.089
B14X01	Optimal	.51	.32	43	.205	.089
	standard errors	.16	.10			
B14X02	Optimal *	.52	.32	39	.187	.099
	standard errors	.17	.11			

Model B15

Equation: $\log(B) = K1 + K2 \log[Pi/(1 + .001 Pi Z)]$

Code	Coefficients	K1	K2	N	R2	MSE
B15X01	Optimal	-.24	.71	43	.540	.054
	standard errors	.18	.10			
B15X02	Optimal *	-.23	.71	39	.520	.060
	standard errors	.20	.11			
B15X03	Optimal **	-.48	.89	29	.710	.042
	standard errors	.18	.10			

* data set excludes:
Inflow (ortho P/total P) < .12
Inflow total P > 500 mg/m3

** data set excludes:
Inflow (ortho P/total P) < .12
Inflow total P > 500 mg/m3
Inflow total (N/P) < 8
Nonalgal turbidity > 1.58 1/m (.2 log units)

Table 27

Formulations, Parameter Estimates, and Error Statistics for Loading Models Predicting Transparency

Model S10: Rast and Lee (1978)

Equation: $\log(S) = K1 + K2 \log[Pi/(1 + T^{.5})]$

Code	Coefficients	K1	K2	N	R2	MSE
S10A01	Rast & Lee (1978)	.93	-.36	43	.044	.101
S10A02	Ryding (1980)	1.12	-.51	43	.485	.054
S10A03	Clasen (1980)	.93	-.20	43	-2.41	.360
S10X01	Optimal	1.13	-.60	43	.717	.031
	standard errors	.11	.058			
S10X02	Optimal *	1.20	-.65	39	.807	.021
	standard errors	.10	.054			
S10X03	Optimal **	1.08	-.56	29	.828	.013
		.088	.049			

Model S11

Equation: $\log(S) = K1 + K2 \log[Pi/(1 + .001\ Pi\ Z)]$

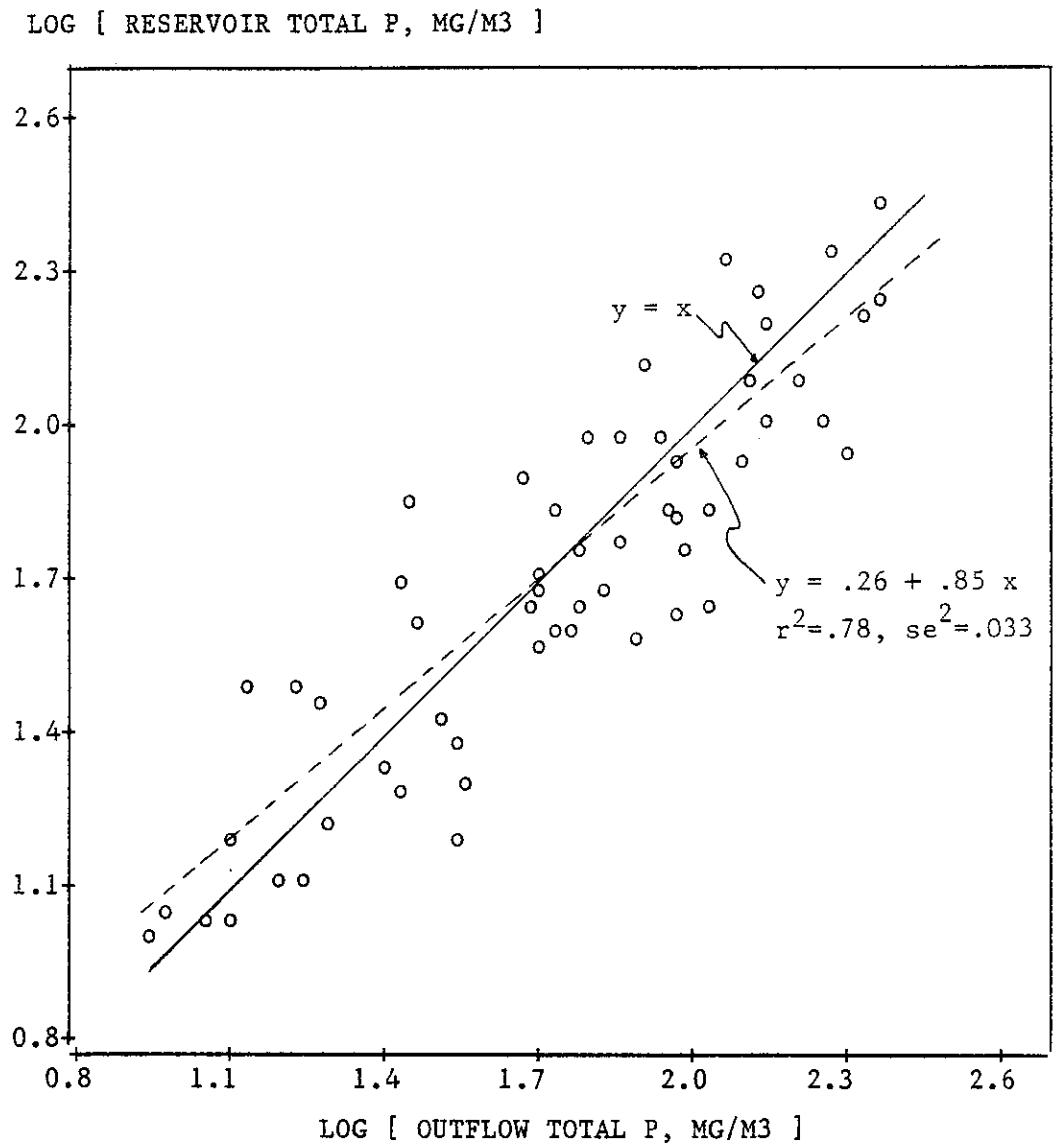
Code	Coefficients	K1	K2	N	R2	MSE
S11X01	Optimal	1.47	-.84	43	.795	.023
	standard errors	.12	.066			
S11X02	Optimal *	1.43	-.82	39	.800	.022
	standard errors	.12	.066			
S11X03	Optimal **	1.25	-.69	29	.845	.012
	standard errors	.10	.056			

* data set excludes:
- Inflow (ortho P/total P) < .12
- Inflow total P > 500 mg/m3

** data set excludes:
- Inflow (ortho P/total P) < .12
- Inflow total P > 500 mg/m3
- Inflow total (N/P) < 8
- Nonalgal turbidity > 1.58 1/m (.2 log units)

Figure 15

Reservoir Total P vs. Outflow Total P



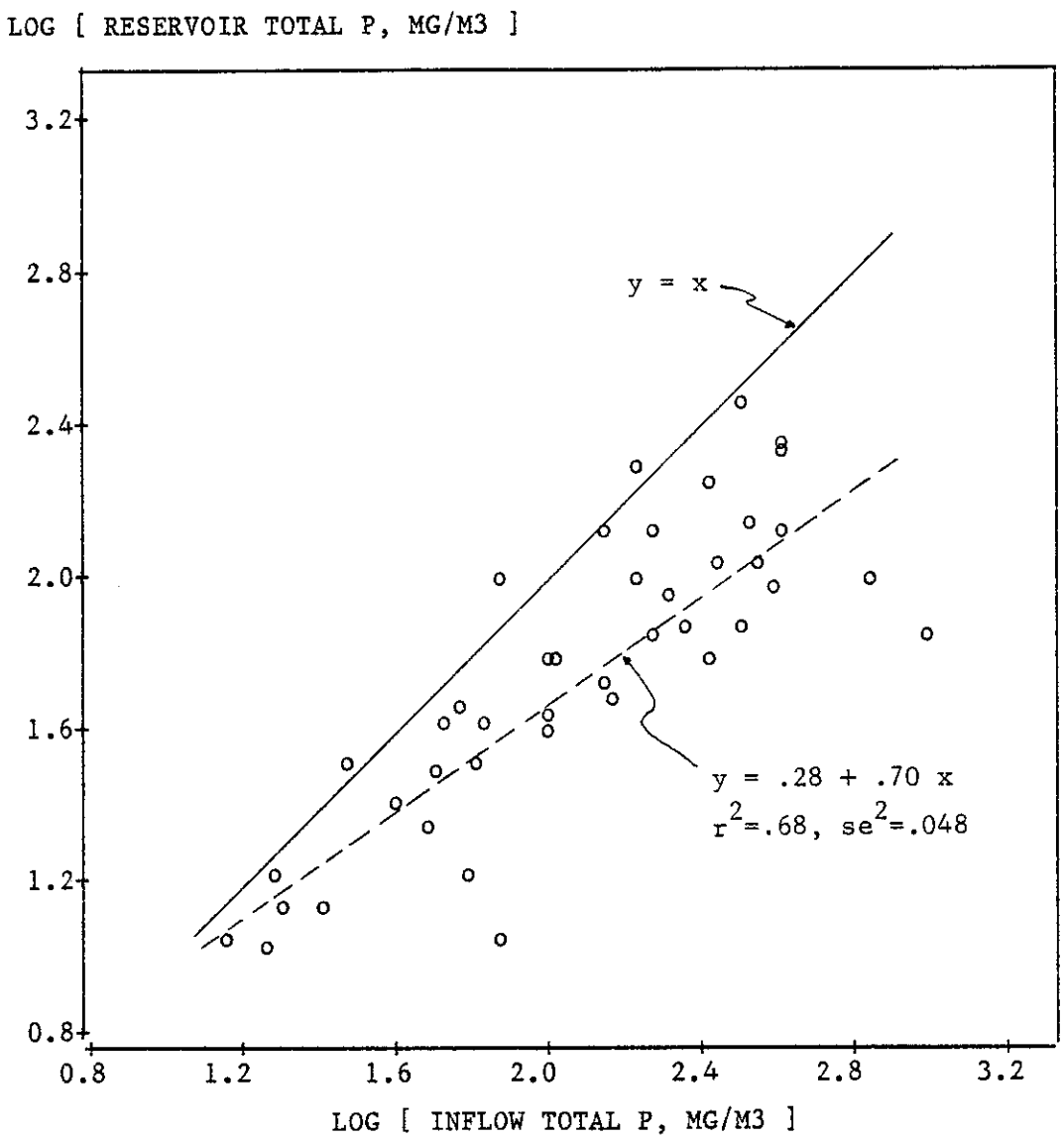
hypolimnion during the summer. (Compilation of data on principal outlet levels is currently underway to provide a means for testing effects of outlet level on reservoir nutrient balances.) Seasonal variations could increase or decrease the ratio, depending upon the significance of seasonal hydrologic variations, dilution effects on point-source discharges, internal phosphorus loadings, algal growth and sedimentation patterns, etc. Correlation studies indicate that the P/Po ratio is not significantly associated with hydraulic residence time, mean depth, or surface overflow rate.

137. The relationship between average pool phosphorus and average inflow phosphorus is shown in Figure 16. The regression line (model P11X01) explains 68% of the variance with a mean squared error of .048 log units. The slope of the line, .70, is significantly different from 1.0. The fact that a few reservoirs have pool phosphorus concentrations which exceed the inflow values may result from the combined influences of seasonal variations, internal or unaccounted-for loadings, and sampling variability.

138. Following the outflow phosphorus analysis, each model has been fit to an additional data set which excludes 4 reservoirs with inflow concentrations exceeding 500 mg/m3 or with inflow dissolved P/total P ratios less than .12. Residuals plots indicate negative biases for reservoirs in the above categories for most models. Results of the internal model evaluations (Part V) indicate that chlorophyll-a levels are roughly proportional to total phoshorus concentrations for non-algal turbidity concentrations less than 1.58 1/m (.2 log units). To reduce the effects of relatively turbid or N-limited reservoirs on model coefficients, a third data set which has the above constraints on inflow total P and inflow dissolved P/total P and which also excludes reservoirs with average turbidities greater than 1.58 1/m or inflow total N/P ratios less than 8 has also been used in fitting some models. The third data set includes 29 reservoirs. Residuals plots verify use of the above limits, particularly for chlorophyll models, although some turbidity effects remain within the restricted data set, as discussed below.

Figure 16

Reservoir Total P vs. Inflow Total P



139. Of the models which assume that the retention coefficient, in this case estimated from the pool and inflow P values, is independent of concentration (P01-P10), mean squared errors range from .034 to .066. An average sedimentation coefficient of 3.6 1/yr is estimated for model P01 and an average settling velocity of 21 m/yr, for model P02. These parameters are somewhat lower than those estimated for outflow phosphorus predictions, although they are still generally higher than values derived from lake data (Appendix E). The optimal parameters for model P03 suggest a lower sensitivity to residence time (.26) than predicted by the original Vollenweider/Larsen-Mercier model:

$$P = Pi/(1 + 1.8\ T^{.26}) \qquad (R^2=.61, SE^2=.06) \tag{59}$$

Models P11-P12 have a lower mean squared error range (.024-.036).

140. When the sedimentation coefficient is allowed to vary as a function of inflow concentration, mean depth, and residence time, the following model results (P15X01):

$$P = Pi/(1 + .0035\ Pi^{.89}\ Z^{.78}\ T^{.06}) \qquad (R^2=.80, SE^2=.031) \tag{60}$$

Considering the variabilities in the coefficients, this is equivalent to:

$$P = Pi/(1 + .001\ Pi\ Z) \qquad (R^2=.80, SE^2=.030) \tag{61}$$

The above statistics refer to the complete data set. Excluding reservoirs with inflow total P greater the 500 mg/m3 and inflow dissolved P/total P less than .12, the coefficients are stable but the mean squared error reduces to .024 (model P15X03 in Table 25). The above result is equivalent to the following expression for the total phosphorus sedimentation coefficient:

$$K = .001\ (Pi\ Z\ /\ T) = .001\ L \tag{62}$$

where,

K = effective first-order decay rate (yr^{-1})

L = total phosphorus loading (mg/m2-yr)

Thus, optimal coefficients suggest that the average decay rate is

proportional to areal phosphorus loading. This is consistent with results obtained by Canfield and Bachman (1981) in their analysis of data from 704 natural lakes and reservoirs, 626 of whose data were derived from the EPA National Eutrophication Survey. When lake and reservoir data were combined, Canfield and Bachman found that the phosphorus sedimentation coefficient was correlated with volumetric and areal loading (r = .78 and .76, respectively). Correlation coefficients for 433 reservoirs were .76 and .76, respectively. Their models (P15A01, P15A02, P15A03) were calibrated to all data combined, lake data alone, and reservoir data alone, respectively. Their reservoir model (P15A03) performs better on this data set than any of the other models tested (R2=.74,SE2=.038) with original coefficients.

141. Models P01, P02, P03, and P10 are special cases of model P15, with the inflow concentration sensitivity parameter equal to zero and different values for the residence time and depth exponents. Table 28 compares the average absolute errors and mean squared errors from these models with various forms of model P15. An approximate F-test (Bard,1974) is used to test for significant differences in the mean squared errors and parameter values between the original models and the optimal forms of P15, using each of the three data sets described above. Results indicate that two Canfield/Bachman models (P15A01 and P15A03) are not significantly different from the optimized forms for the restricted data sets (B and C). For these data sets, errors from the Canfield/Bachman reservoir model (P15A03) with Pi, Z, and T exponents of .59, 0., and .41, respectively, are not significantly lower than model P15X02, with corresponding exponents of 1.0, 1.0, and 0.0.

142. To better define the confidence ranges for model P15 parameters, residual mean squares are mapped for various values of the Pi, Z, and T exponents in Table 29. The model intercept (parameter K1 in Table 25) has been optimized for each set of exponents. Confidence regions are defined based upon the F-test given in Table 28 and a significance level of .05. Optimal exponent ranges for Pi, Z, and T are .4 to 1.2, 0. to 1.2, and 0. to .4, respectively. These ranges are conditional; i.e., the parameters are not independent of each other.

Table 28

Tests for Variations in Model P15 Parameters

	Parameters				Data Set A		Data Set B		Data Set C	
Model	bi	bt	bz	c	AE	MSE	AE	MSE	AE	MSE
P01A01	.00	1.00	.00	-.19	283	1322	240	831	220	735
P01A02	.00	1.00	.00	.30	248	961	211	572	199	517
P02A01	.00	1.00	-1.00	1.00	254	1103	209	633	193	561
P02A03	.00	1.00	-1.00	1.20	229	959	189	543	170	489
P02A04	.00	1.00	-1.00	1.96	298	1534	285	1474	296	1534
P03A01	.00	.50	.00	.00	228	909	189	515	169	442
P03A02	.00	.45	.00	-.09	236	972	195	559	173	480
P03A03	.00	.51	.00	-.05	236	968	196	557	175	480
P03A04	.00	.83	.00	.32	233	852	198	500	186	455
P03A05	.00	.59	.00	.36	205	691	174	405	165	384
P03A06	.00	.50	.00	.30	197	665	165	378	155	350
P03A07	.00	.05	.00	.15	196	646	170	428	166	378
P10A01	.00	.61	-.50	.86	194	661	163	382	154	352
P10A02	.00	1.00	-.69	.97	228	913	192	520	174	464
P15A01	.55	.45	.00	-.89	157	437	131	260*	121	233*
P15A02	.46	.54	.00	-.79	187	593	157	341	145	306
P15A03	.59	.41	.00	-.94	148	396	124	249*	114	220*
P15X02	1.00	.00	1.00	-2.95	138	309*	123	238*	108	189*
P15X04	.68	.16	.52	-1.75	140	330*	119	211*	105	175*

Model: $P/Pi = 1/(1 + 10^{c} Pi^{bi} Z^{bz} T^{bt})$

Data Sets:
- A = all data (n=43)
- B = Pi < 500 mg/m3, Inflow Ortho-P/Total P > .12 (n=39)
- C = B constraints + Turbidity < 1.58 1/m, Inflow N/P > 8 (n=29)

AE = average absolute error x 1000
MSE = mean squared error x 10000

* mean squared error and parameters not significantly different from optimal values ($p<.05$), based upon F-ratio test (Bard, 1974):

$$MSE/MSE^* = 1 + p F / (n-p)$$

where,
- MSE^* = minimum mean squared error
- p = number of model parameters = 4
- n = number of observations (29, 39, or 43)
- F = F Statistic with p and n-p degrees of freedom

Table 29

Confidence Regions for Model P15 Parameters

	bt						bt					
	-.4	-.2	0.	.2	.4	.6	-.4	-.2	0.	.2	.4	.6
			bi=.4						bi=1.0			
bz												
.0	63	45	34	27*	26*	30	72	50	36	31	32	41
.2	56	41	31	26*	26*	32	62	43	31	27*	30	39
.4	52	38	30	27*	28	35	54	37	28	25*	28	38
.6	49	37	31	29	31	40	48	33	25*	23*	28	38
.8	47	38	33	32	37	49	43	30	24*	23*	29	40
1.0	48	40	37	39	46	60	40	29	24*	25*	31	45
1.2	51	45	44	48	58	75	38	29	26*	28	36	52
1.4	56	52	53	60	73	93	38	31	29	33	44	62
			bi=.6						bi=1.2			
bz												
.0	64	45	32	26*	25*	30	81	57	43	38	41	51
.2	56	39	29	24*	24*	30	69	48	37	33	37	48
.4	50	36	27	23*	25*	32	59	42	32	30	35	46
.6	46	34	26*	24*	27*	35	52	37	29	28	33	46
.8	44	33	27	26*	31	41	46	33	27*	27*	33	46
1.0	43	34	30	31	37	50	42	31	26*	27*	35	49
1.2	44	37	34	37	46	62	39	30	26*	29	38	54
1.4	47	42	41	47	58	77	38	30	28	33	43	62
			bi=.8						bi=1.4			
bz												
.0	67	46	33	27*	27*	34	92	67	53	48	53	66
.2	58	40	29	24*	25*	33	79	57	45	43	48	62
.4	51	35	26*	23*	25*	33	68	49	40	39	45	59
.6	46	32	25*	22*	25*	35	59	43	36	36	43	57
.8	42	30	24*	23*	28	39	52	39	33	34	42	56
1.0	40	30	25*	26*	32	45	47	35	31	33	42	58
1.2	40	31	28	31	39	54	43	34	30	34	44	61
1.4	41	35	33	38	49	67	41	33	31	36	47	66

Model : $P/Pi = (1 + c\ Pi^{bi}\ Z^{bz}\ T^{bt})$

parameter c values optimized for each set of bi,bz, and bt values

table entries are values of residual mean square x 1000 for estimating base-10 logarithm of P, using restricted data set (Pi< 500 mg/m3, Inflow Ortho-P/Total P > .12 n = 39)

* parameters not significantly different from optimal values (p<.05)

This parameter variability is also reflected in the coefficient standard errors in Table 25. This suggests that, while model P15 performs somehat better than the other formulations, the optimal coefficients are not well-defined, i.e., the coefficients can vary over fairly wide ranges without significant changes in error because of correlations among the independent variables (Pi, Z and T).

143. The most curious aspect of equation (61) is that the predicted total phosphorus concentration is independent of hydrologic factors (residence time or overflow rate). The low hydrologic sensitivity may reflect the fact that the completely mixed, "bathtub" assumption inherent in the calculation of mean hydraulic residence time is inadequate as a representation of reservoir hydrodynamics. The significance of mean depth may be related to internal loading or phosphorus exchange with the bottom sediments. The fact that reservoir phosphorus and other response variables can be predicted independently of hydrologic factors considerably reduces the data requirements for model implementation. The original concept of a first-order sedimentation reaction in a mixed vessel as a model for predicting average phosphorus concentrations does not appear to be valid, since the "constant" (K) depends so strongly upon the key system variables (Pi, Z, and T). Equations (60)-(62) are purely empirical results, i.e., they have no theoretical basis.

144. For each response variable, it is difficult to select the "best" formulation for normalized loading based upon residual error alone, because the error ranges are generally small and the independent variables are correlated with each other. The normalized loading expressions are most sensitive to inflow phosphorus concentration and differ primarily with respect to morphometric or hydrologic coefficients. Because variations in inflow concentration account for most of the variations in the normalized loading statistics, it is difficult to distinguish among the model formulations. Table 30 presents correlation coefficients for each response variable (total P, chlorophyll-a, and transparency) against seven alternative expressions of normalized phosphorus loading, derived from the model calibrations in

Table 30

Correlation of Response Variables with Normalized Phosphorus Loadings**

Expression	Total P	Chl-a	Transparency
Data Set 1*			
1 Pi	.826	.643	-.794
2 $Pi/(1+T^{.5})$	.852	.657	-.847
3 $Pi/(1+2T^{.5})$	.857	.657	-.863
4 $Pi/(1+1.43T^{.25})$	.853	.655	-.841
5 $Pi^{(1-.2T^{.2})}$	.856	.654	-.855
6 $Pi/\left(1+.114\ Pi^{.59T^{.41}}\right)$	.863	.651	-.879
7 $Pi/(1+.001\ Pi\ Z)$	.895	.732	-.892
Data Set 2*			
1 Pi	.891	.656	-.849
2 $Pi/(1+T^{.5})$	.912	.662	-.888
3 $Pi/(1+2T^{.5})$	.914	.657	-.897
4 $Pi/(1+1.43T^{.25})$	.914	.662	-.885
5 $Pi^{(1-.2T^{.2})}$	.916	.658	-.896
6 $Pi/\left(1+.114\ Pi^{.59T^{.41}}\right)$	.910	.645	-.899
7 $Pi/(1+.001\ Pi\ Z)$	.918	.723	-.894
Data Set 3*			
1 Pi	.904	.758	-.876
2 $Pi/(1+T^{.5})$	.915	.763	-.910
3 $Pi/(1+2T^{.5})$	.910	.756	-.916
4 $Pi/(1+1.43T^{.25})$	.917	.763	-.908
5 $Pi^{(1-.2T^{.2})}$	.918	.762	-.911
6 $Pi/\left(1+.114\ Pi^{.59T^{.41}}\right)$	.906	.745	-.914
7 $Pi/(1+.001\ Pi\ Z)$	.929	.842	-.920

* data set restrictions:	1	2	3
Inflow Total P (mg/m3)	-	< 500	< 500
Inflow (Diss P/Total P)	-	> .13	> .13
Inflow (Total N/Total P)	-	-	> 8
Turbidity (1/m)	-	-	< 1.58
Number of Reservoirs	43	39	29

** all variables log-transformed

Table 25. Coefficients are listed for each of the three data sets described above. For most data set/response variable combinations, correlation coefficients are somewhat higher for normalized loadings calculated according to equation (61). Coefficient differences are greatest in the case of chlorophyll, which has a range of .745 to .842 for the third data set. In no cases, however, do the correlations coefficients differ by more than .1 among the expressions tested for a given data set and response variable.

145. Figures 17 and 18 illustrate response variable correlations with two normalized loading statistics: Pv (the Vollenweider/Larsen-Mercier expression, model B11A01) and Pn (equation (61)), respectively. Plots for other normalized loading statistics listed in Table 30 are not substantially different. Regression lines and data in these figures correspond to the third (most restricted) data set in Table 30. Figure 17 indicates that the regression model for predicting mean chlorophyll-a as a function of the Vollenweider/Larsen-Mercier normalized loading is not significantly different from that derived by Rast and Lee (1978) using the OECD North American data set. Chlorophyll models developed by Clasen (1980) and Vollenweider and Kerekes (1980) are also similar. The Rast and Lee model for transparency has a significant positive bias which might be attributed to regional factors, since most of the OECD North American impoundments are north of the impoundments in this data set (see Part VIII, paragraphs 189-192).

146. When the Vollenweider/Larsen-Mercier expression (Pv) is used for normalized phosphorus loading, stepwise regressions (Appendix D, Table D16) explain 20%, 74%, and 50% of the residual variance in phosphorus, chlorophyll, and transparency, respectively. When equation (61) (Pn) is used for normalized loading, regressions explain 0%, 70%, and 18% of the residual variance, respectively. High percentages for chlorophyll models are primarily attributed to residual correlations with the product of mean depth and turbidity. The effects of depth and turbidity are consistent with the results of internal model evaluations (Part V); for example, equation (45) suggests that the chlorophyll/total

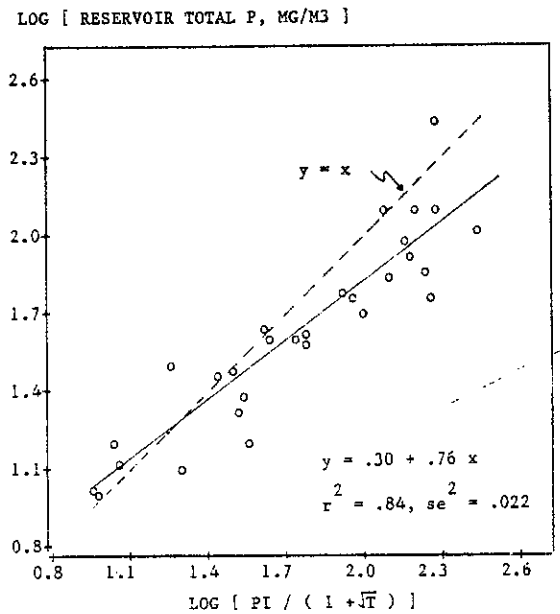
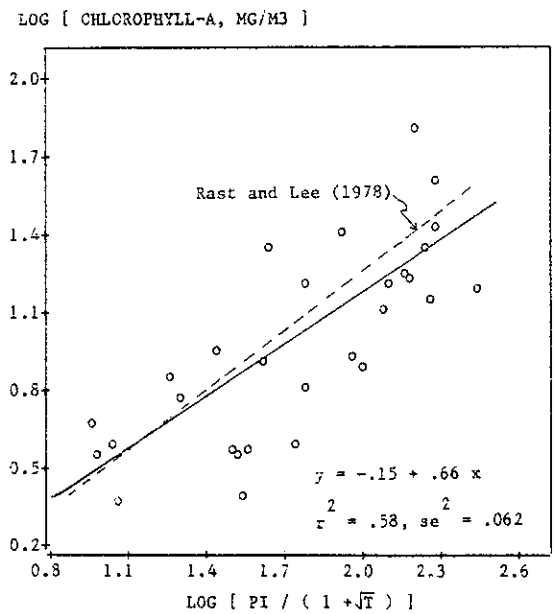
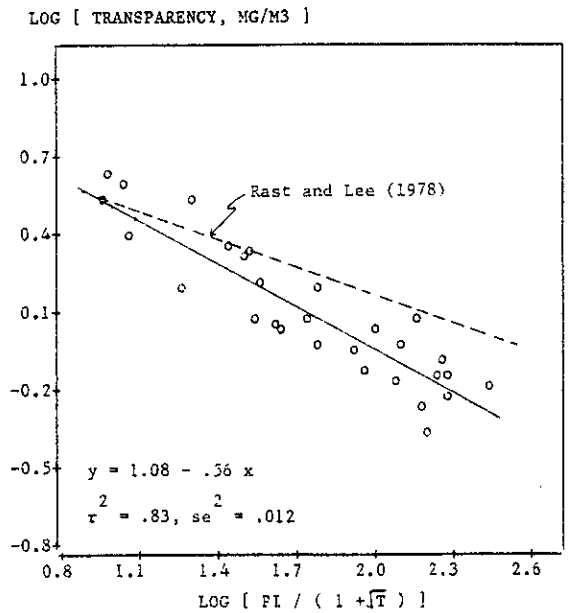


Figure 17

Observed and Predicted Water Quality Using Pv for Normalized Phosphorus Loading





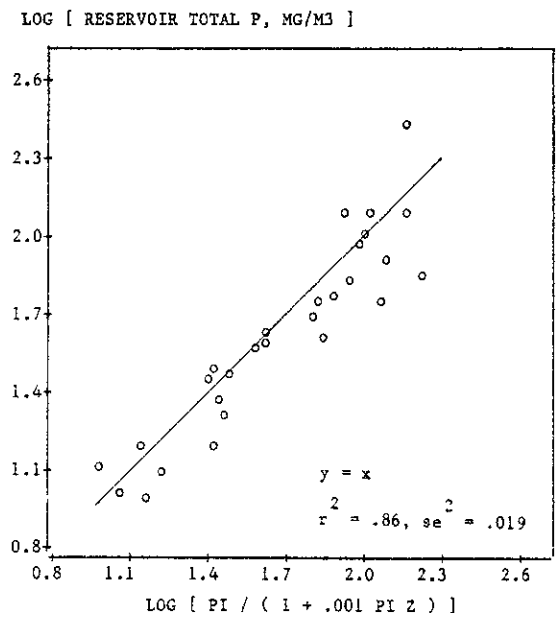
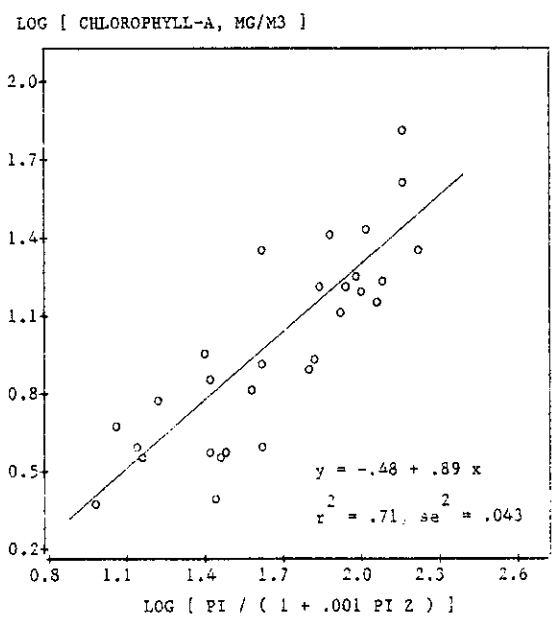
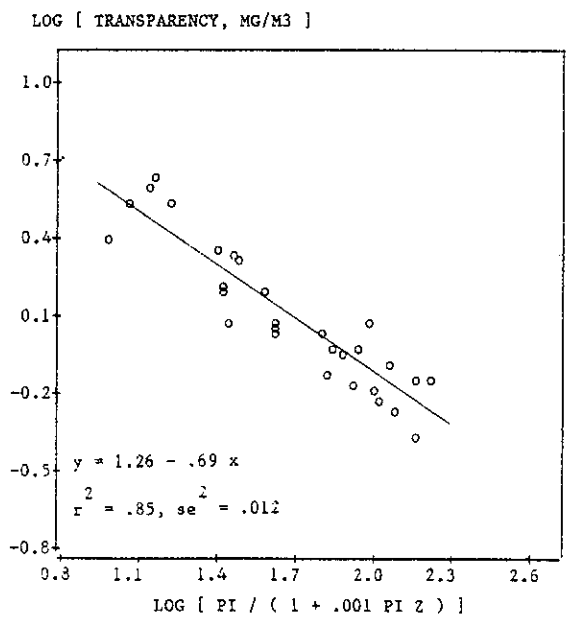


Figure 18

Observed and Predicted Water Quality Using Pn for Normalized Phosphorus Loading





P ratio at P-limited stations is inversely related to the square root of the product of mean depth and turbidity, possibly owing to effects of light-limitation and/or nutrient availablility.

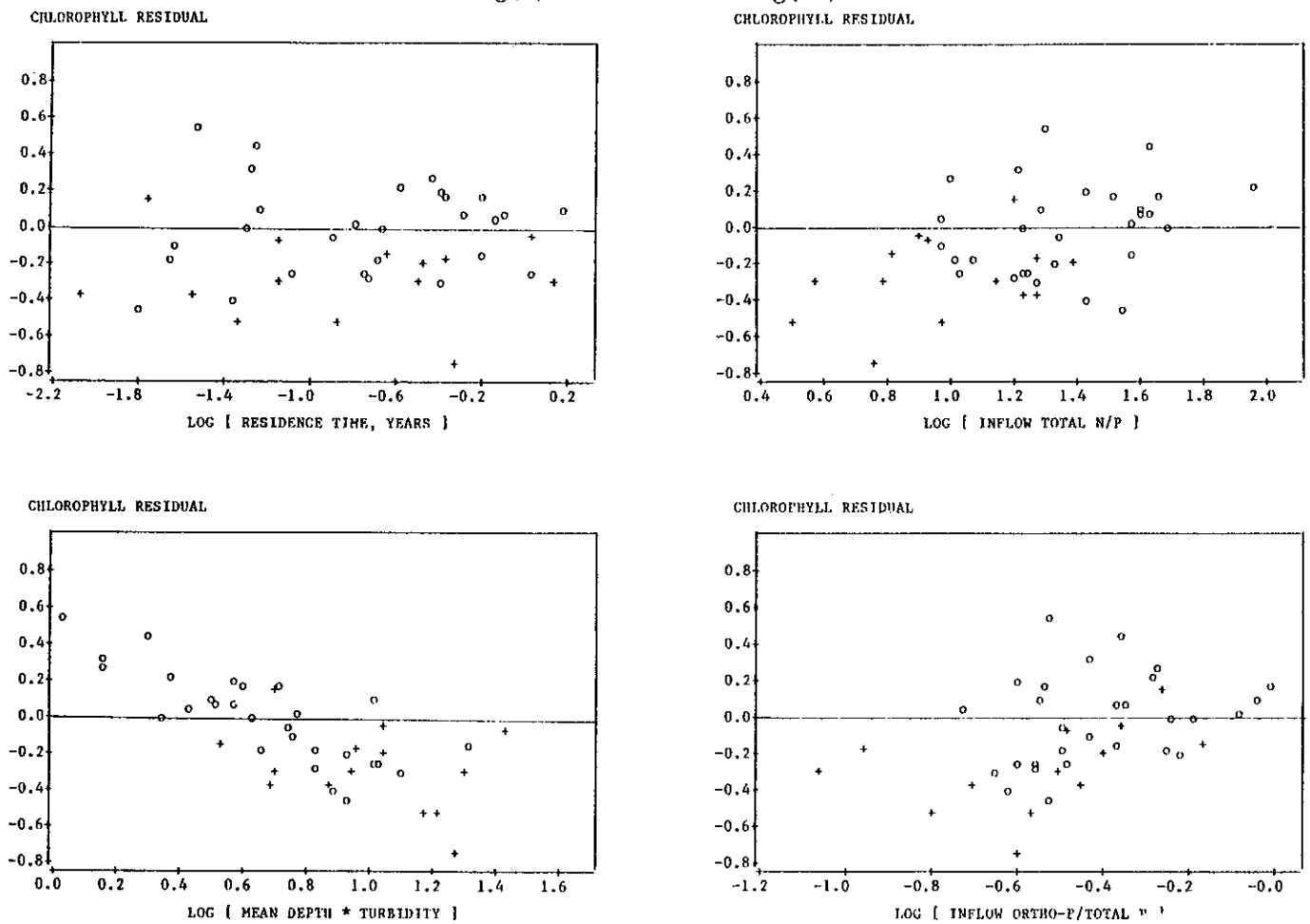
147. Plots of chlorophyll-a residuals against residence time, the product of turbidity and mean depth, inflow total N/P ratio, and inflow ortho-P/total P ratio are shown in Figures 19 and 20. For both models, residuals are unrelated to residence time, except for negative biases (model over-predictions) for two reservoirs with residence times less than about .02 years. These biases may be related to kinetic control of algal growth by flushing rate. Residual correlations are much stronger with the other three factors. The models tend to over-predict chlorophyll in reservoirs with turbidity-depth products exceeding about 6, inflow total N/P ratios less than about 8, or inflow ortho-P/total P ratios less than about .2. Chlorophyll is under-predicted in reservoirs with turbidity-depth products less than about 2.5 or inflow total N/P ratios greater than about 40. Because of correlations among these factors, it is difficult to establish which is the most important. Stepwise regressions indicate, however, that the product of turbidity and mean depth explains most of the residual variance. These residual associations suggest possibilities for chlorophyll model improvement over the simple relationships depicted in Figures 17 and 18.

148. Residual mean squared errors for transparency models (Table 25) range from .012 to .018 and are considerably lower than the phosphorus (.019-.025) and chlorophyll (.043-.063) model error ranges. The relatively low errors characteristic of these models are also apparent in Figures 17 and 18. Figure 21 indicates that transparency residuals tend to be positively correlated with residence time and mean depth, possibly because concentrations of allochthonous particulates would tend to be greater in reservoirs which are shallower and/or more rapidly flushed. In contrast with chlorophyll residuals, transparency residuals are not correlated with inflow dissolved P/inflow total P. This may result from two partially offsetting mechanisms in reservoirs with lower inflow dissolved P/total P ratios: (1) higher turbidities associated with allochthonous particulate phosphorus (tending to

Figure 19

Residuals Plots of Chlorophyll-a vs. Pv

Model: log(B) = -.15 + .66 log(Pv)

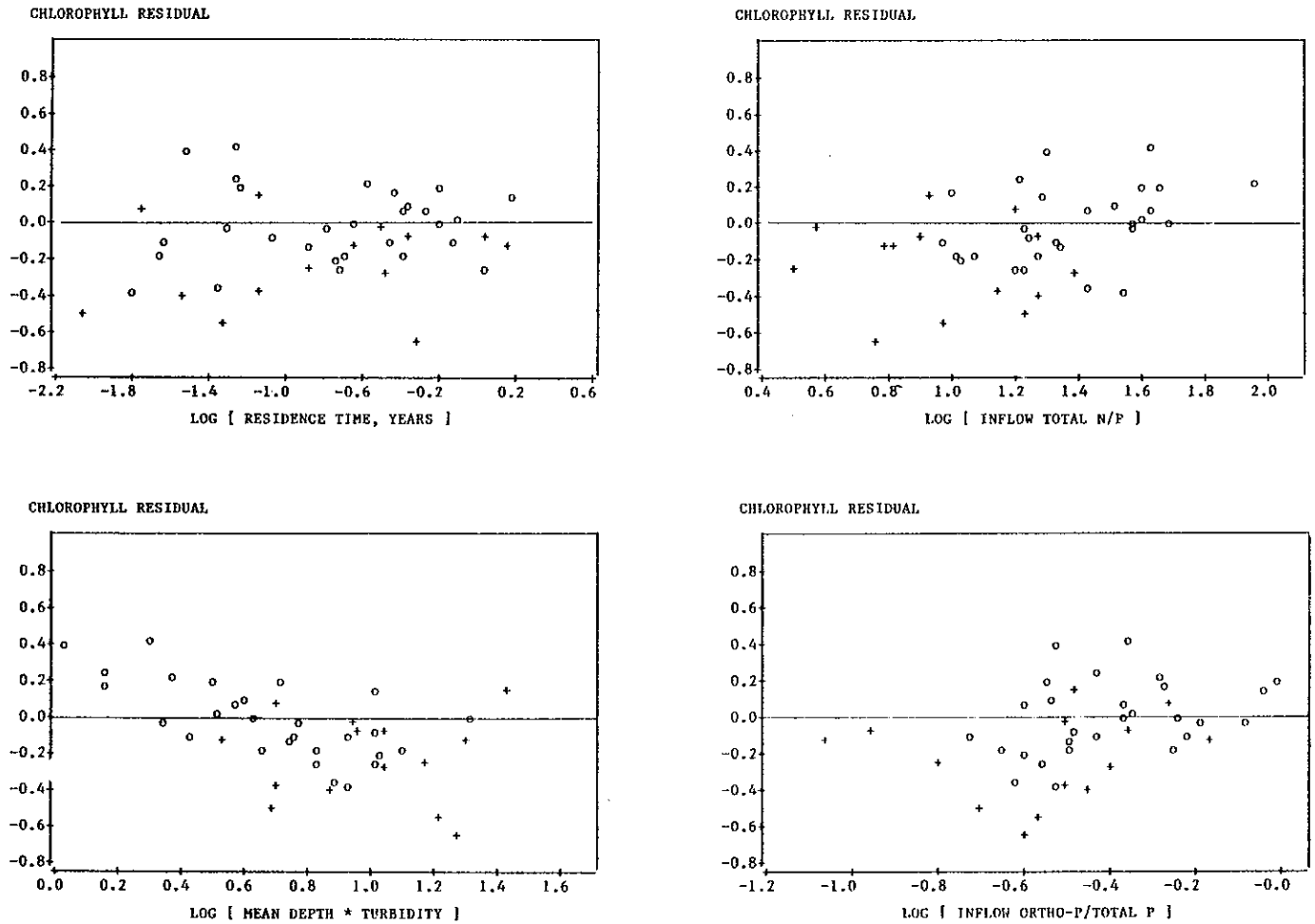


(+ points excluded from regression)

Figure 20

Residuals Plots of Chlorophyll-a vs. Pn

Model: log(B) = -.48 + .89 log(Pn)

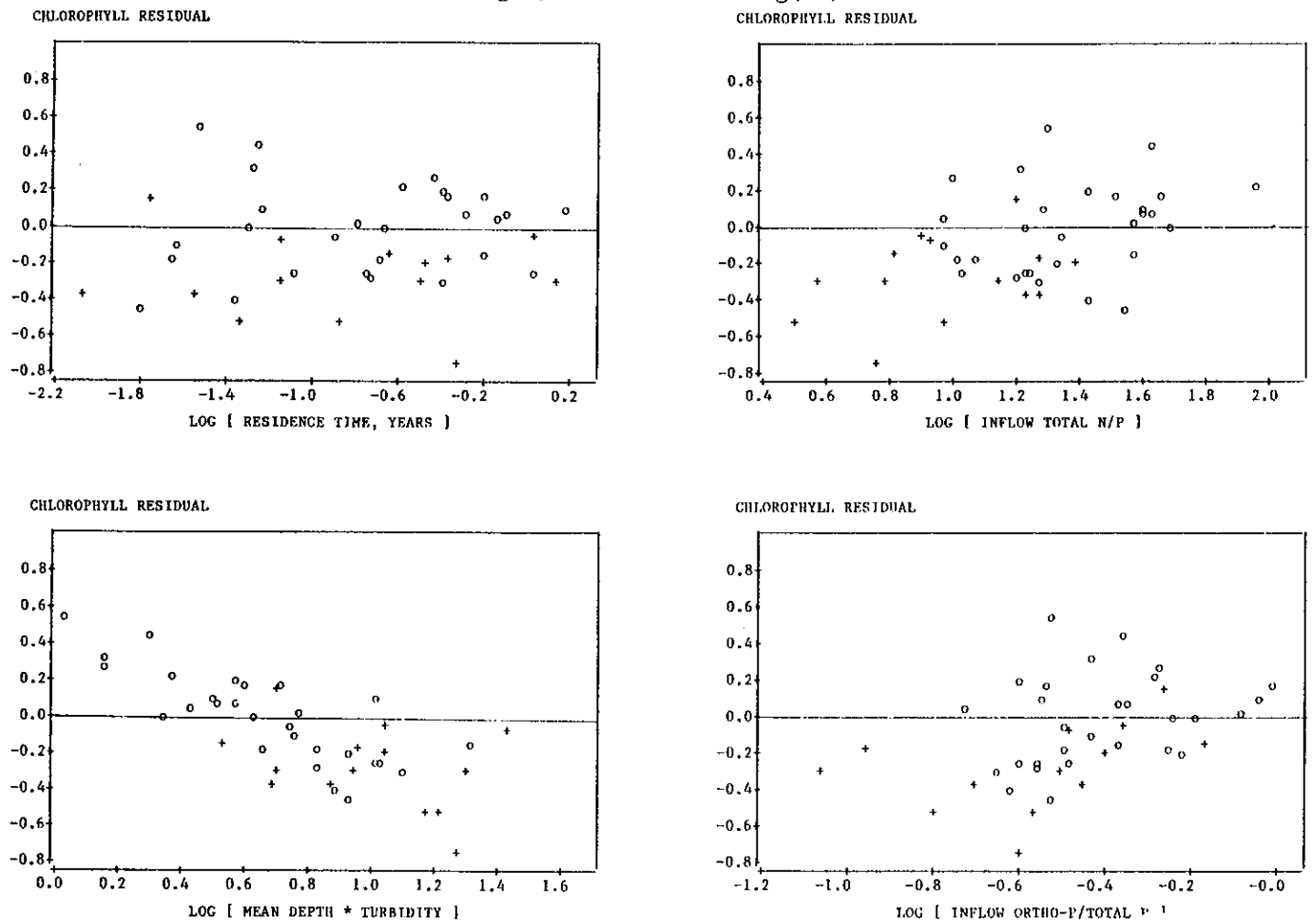


(+ points excluded from regression)

Figure 19

Residuals Plots of Chlorophyll-a vs. Pv

Model: log(B) = -.15 + .66 log(Pv)

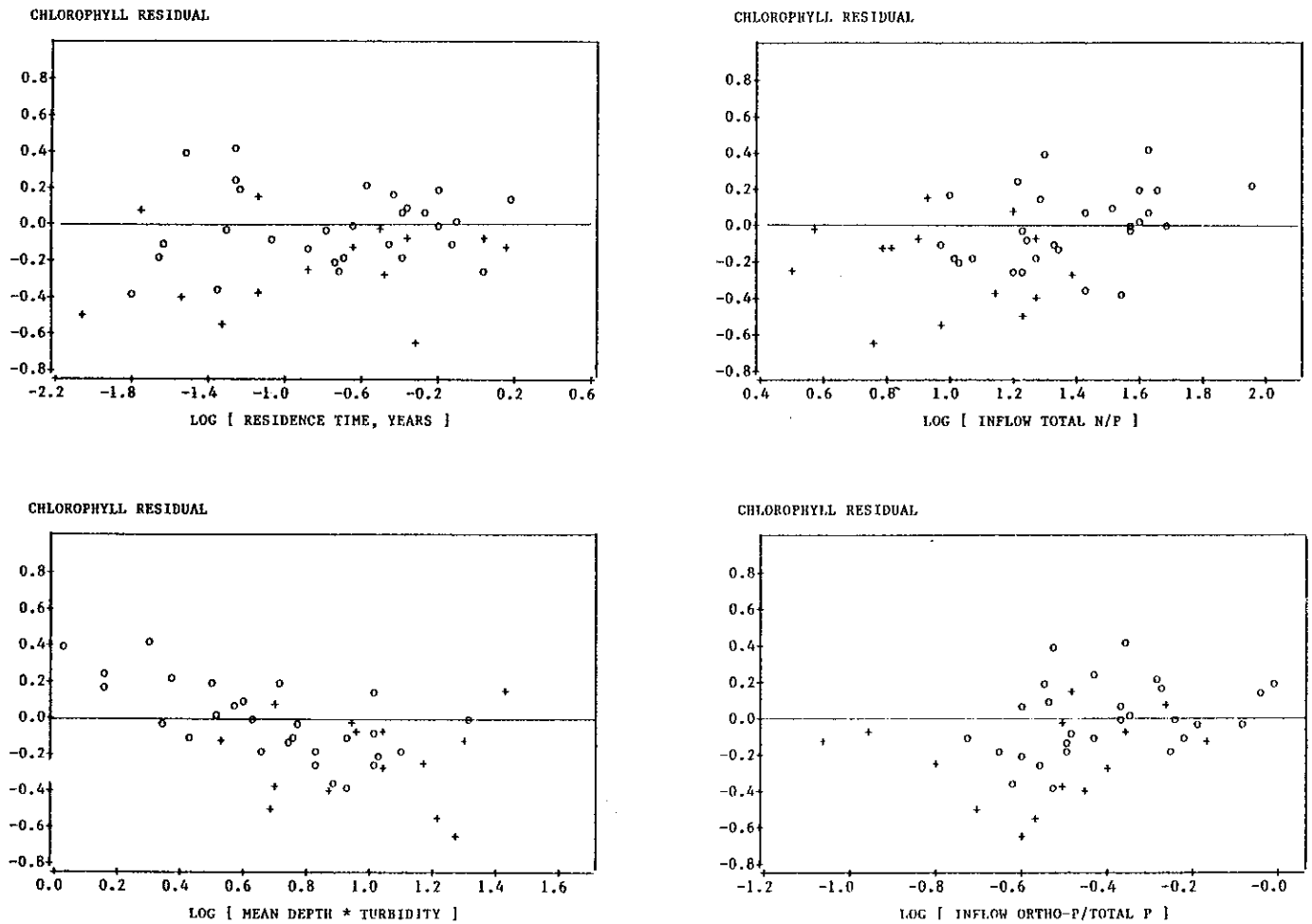


(+ points excluded from regression)

Figure 20

Residuals Plots of Chlorophyll-a vs. Pn

Model: log(B) = -.48 + .89 log(Pn)

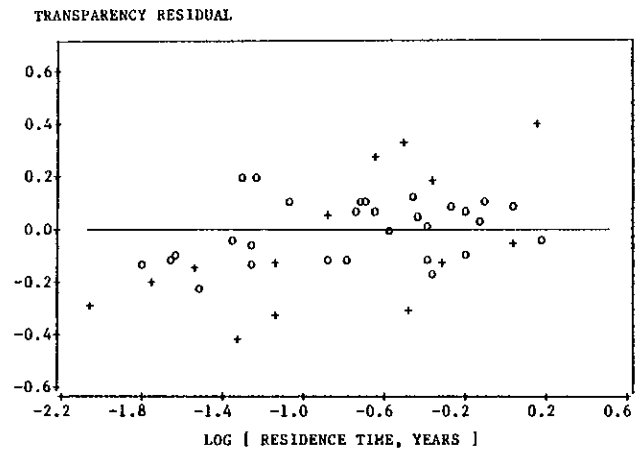


(+ points excluded from regression)

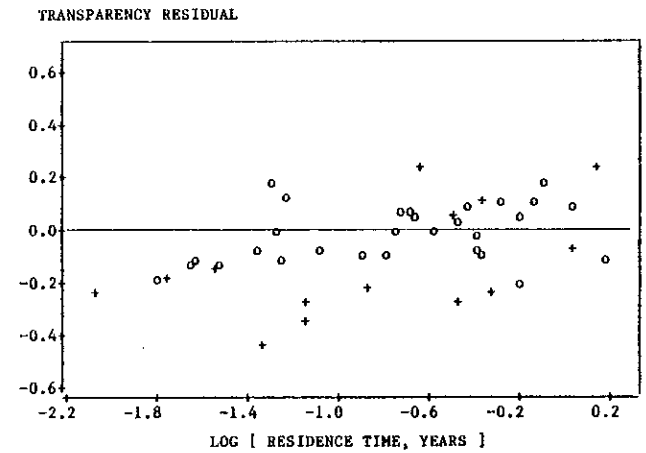
Figure 21

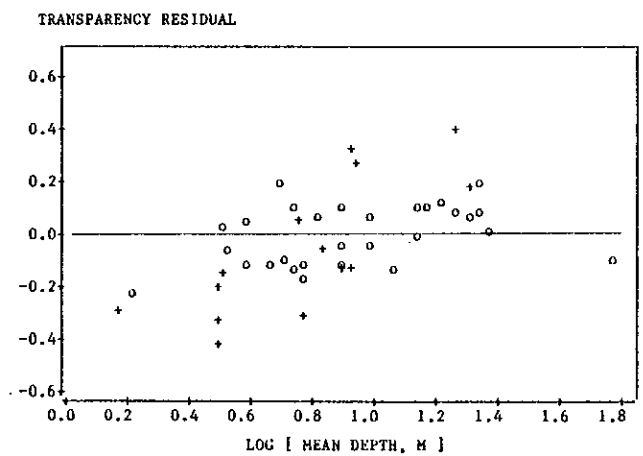
Residuals Plots of Transparency Models

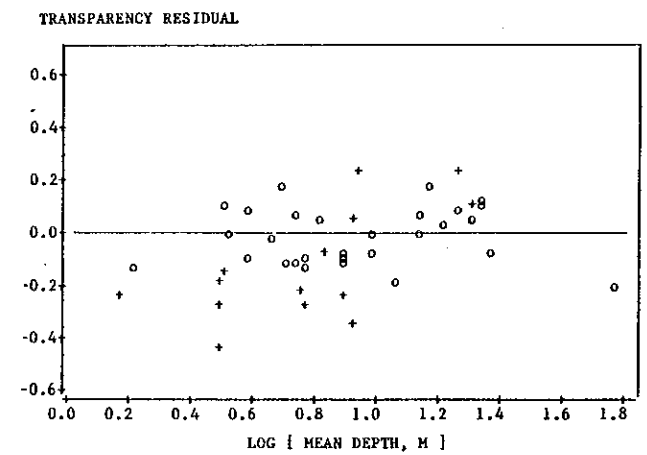
Model: log(S) = 1.08 - .56 log(Pv)



Model: log(S) = 1.26 - .69 log(Pn)







(+ points excluded from regression)

decrease transparency) and (2) greater phosphorus trapping efficiency (tending to increase transparency). The apparent insensitivity of the transparency models to the dissolved fraction of the total phosphorus loading partially accounts for the lower prediction errors of these models.

149. Regional analyses suggest that both sets of loading models tend to under-predict transparency in northern impoundments (approximately above 42 degrees latitude), which tend to have lower non-algal turbidities owing to climatologic and/or geologic factors (glacial soils vs. sedimentary soils). Additional data from northern impoundments are needed to define these effects quantitatively.

150. Phosphorus, chlorophyll, and transparency residuals have also been tested for effects of morphometric complexity by comparing means and standard deviations from reservoirs with one tributary arm with those from reservoirs with more than one arm. Effects are not significant, however, except for transparency predicted according to model S11X03 (Table 27), for which mean residuals are higher by about .1 log units in reservoirs with more than arm. The effect is small in relation to the error correlations discussed above.

Effects of Spatial Variations

151. The loading model evaluations described in the previous section are based upon predictions of reservoir-average phosphorus, transparency, and chlorophyll concentrations. As discussed in Part III, the accuracies of these averages depend upon reasonable distribution of sampling stations among representative reservoir areas, since it has not been possible within the scope of this project to estimate or apply areal weighting factors to the individual station averages.

152. To provide a basis for a preliminary assessment of spatial variance effects, the ranges of station-average phosphorus, transparency, and chlorophyll values have been calculated for each reservoir during the year sampled by the EPA/NES. Figure 22 displays the ranges in the average phosphorus concentrations against annual-average

outflow phosphorus concentration. Figures 23-25 display the ranges in the phosphorus, chlorophyll, and transparency averages against the average inflow phosphorus concentration.

153. Some of the within-reservoir variability depicted in Figures 22-25 is statistical, i.e., results from the limited accuracies of the station-mean estimates. The average coefficient of variation of the station-mean chlorophyll estimates is .28 (Table 12), or about .12 on a base-10 logarithmic scale. For sample sizes less than 10, the expected value of the range is given approximately by the standard deviation multiplied by the square root of the sample size (Snedecor and Cochran,1972). For an average of four stations per reservoir, then, the expected range of the station-average chlorophyll is about .24 log units. Corresponding calculations for phosphorus and transparency yield expected ranges of .13 and .15 log units, respectively. These calculations would tend to over-estimate the ranges because the errors in the station-mean estimates are not independent, owing to temporal variance effects (Walker, 1981).

154. Variance component analyses of station-average chlorophyll, transparency, and phosphorus values indicate that within-reservoir variability accounts for 36%, 24% , and 21% of the total variance, respectively. It is apparent that the ranges for many reservoirs in Figures 22-25 considerably exceed the expected values calculated above and thus represent real spatial variance. The reservoir with the most spatial variance is Sakakawea (30-235), on the Missouri River in North Dakota, in which station-average chlorophyll, phosphorus, and transparency values differ by factors of 23, 36, and 21, respectively from one end of the reservoir to the other.

155. While the models calibrated in the previous section are valid for predicting reservoir-average conditions, calculated as the simple arithmetic means across reasonably well-distributed stations, it is difficult to distinguish among alternative model formulations on the basis of minimum error. It seems possible that the model comparisons could be sensitive to the spatial averaging scheme employed, since within-reservoir variability seems to be appreciable in many cases.

Figure 22
Ranges of Station-Mean Phosphorus Concentrations vs.
Outflow Total Phosphorus

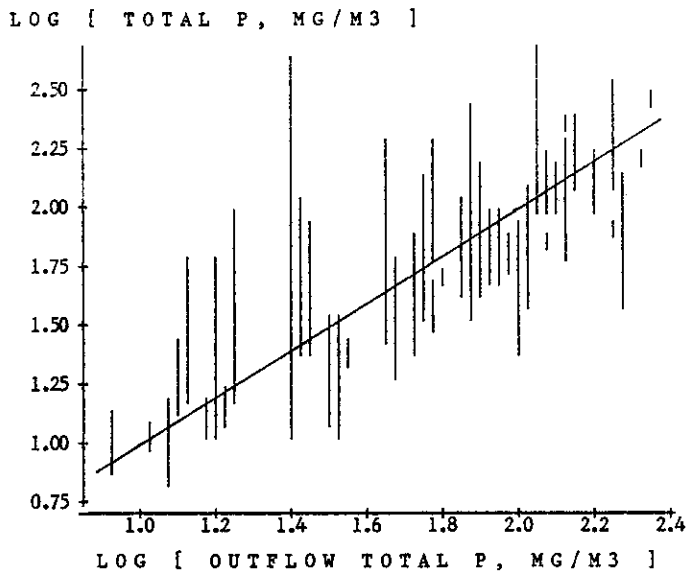


Figure 23
Ranges of Station-Mean Phosphorus Concentrations vs.
Inflow Total Phosphorus

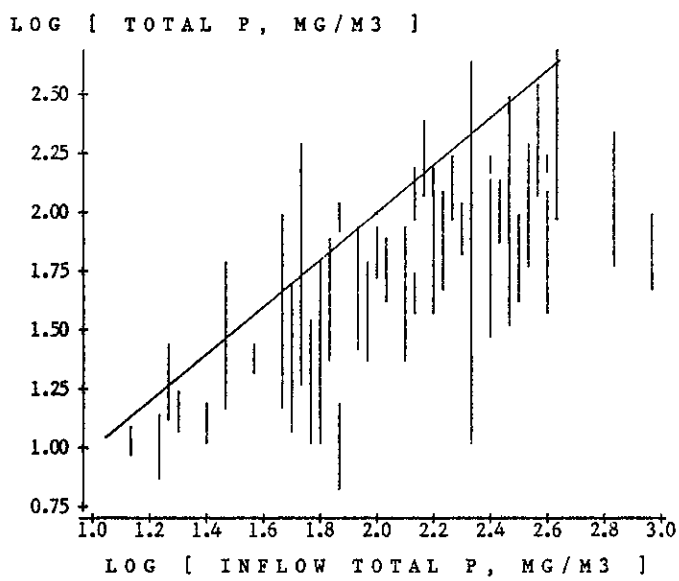


Figure 24
Ranges of Station-Mean Chlorophyll Concentrations vs.
Inflow Total Phosphorus

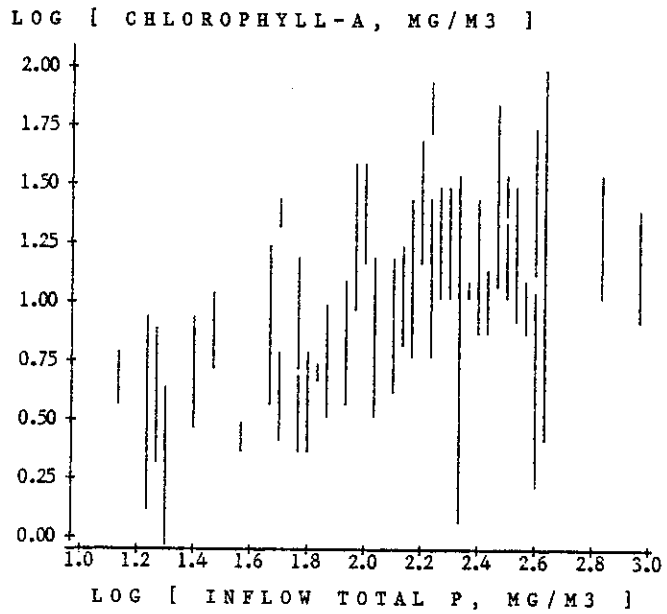
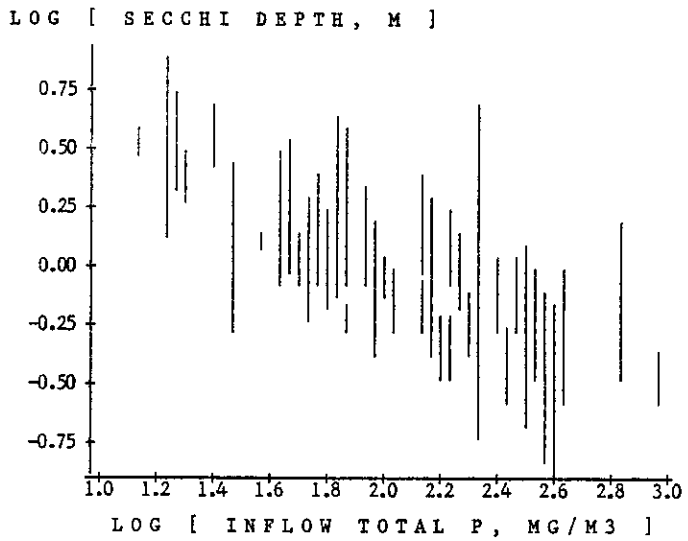


Figure 25
Ranges of Station-Mean Secchi Depths vs.
Inflow Total Phosphorus



Firm conclusions regarding appropriate nutrient loading models for reservoirs cannot be drawn without a more detailed analysis of spatial variance effects. This would involve, minimally, estimation of areal and/or volumetric weighting factors for each station and reservoir. A single reservoir-average value is misleading in many cases and adaptation of the empirical modelling approach to permit spatial gradient prediction seems appropriate. This would require a somewhat more theoretical modelling framework which disaggregates each reservoir into its major tributary arms and treats the nutrient balances and water quality responses separately within each arm, while considering the potential for longitudinal variations. The CE data base seems well-suited for this type of analysis, since the stations have already been classified and sorted in downstream order within each reservoir arm, although additional map work would be required to compile more detailed morphometric information.

Conclusions

156. Results of the loading model evaluations conducted in the previous sections can be summarized by the following:

a. Coefficients and error statistics for models predicting annual-average outflow phosphorus and growing-season, reservoir-average, surface-layer, phosphorus concentrations indicate that the retention coefficient cannot be considered to be independent of concentration. For a given residence time and mean depth, a reservoir with a higher inflow phosphorus concentration will tend to have a higher retention coefficient. The concentration-dependence may be related to the influence of internal loading terms which are neglected in the nutrient balance formulation.

b. Retention model coefficients for predicting outflow phosphorus concentrations agree well with values found by Clasen (1980) in the

OECD Reservoir and Shallow Lakes Project. At a given mean depth and residence time, results suggest higher phosphorus removal rates in reservoirs, as compared with the lakes used in original model development. Some of this difference can be attributed to the effects of spatial variance or plug flow in reservoirs, although higher sediment accumulation rates are probably also involved, since residuals from all phosphorus models are negatively correlated with sediment accumulation rate.

c. Alternative formulations for predicting outflow phosphorus include:

$$Po = Pi/(1 + 2.1\ T^{.5}) \qquad (R^2 = .70,\ SE^2 = .034)$$

$$Po = Pi/(1 + .21\ Pi^{.5}\ T^{.5}) \qquad (R^2 = .83,\ SE^2 = .026)$$

$$Po = Pi^{(1 - .25\ T^{.32})} \qquad (R^2 = .81,\ SE^2 = .027)$$

where,

Po = outflow total P (mg/m^3)
Pi = inflow total P (mg/m^3)
T = hydraulic residence time (years)

The first expression is a calibration of the Vollenweider/Larsen-Mercier model which requires linear concentration response; errors from this model are negatively correlated with inflow concentration. The other formulations do not require a linear response and have somewhat lower mean squared errors. The above models tend to over-predict outflow concentration in reservoirs with low percentages of orthophosphorus loading (< 12%). Residuals are correlated with sediment accumulation rate, shoreline development ratio, surface area, and inflow ortho-P/total P.

d. Residual variance from the above models increases strongly with residence time. The variance pattern can be explained by the increased sensitivity of the predicted phosphorus concentration to

the estimated phosphorus sedimentation coefficient at higher residence times.

e. Two alternative schemes for predicting surface phosphorus, chlorophyll, and transparency values, averaged by reservoir and growing season are:

$$Pv = Pi/(1 + T^{.5})$$

$$\log(P) = .30 + .76 \log(Pv) \qquad (R^2=.84, SE^2=.022)$$

$$\log(B) = -.15 + .66 \log(Pv) \qquad (R^2=.58, SE^2=.062)$$

$$\log(S) = 1.08 - .56 \log(Pv) \qquad (R^2=.83, SE^2=.013)$$

and,

$$Pn = Pi/(1 + .001\ Pi\ Z)$$

$$\log(P) = \log(Pn) \qquad (R^2=.86, SE^2=.019)$$

$$\log(B) = -.48 + .89 \log(Pn) \qquad (R^2=.71, SE^2=.043)$$

$$\log(S) = 1.26 - .69 \log(Pn) \qquad (R^2=.85, SE^2=.012)$$

where,

P = reservoir total P (mg/m^3)
B = reservoir chlorophyll-a (mg/m^3)
S = reservoir transparency (m)
Z = mean depth (m)

The first set of expressions are based upon normalized phosphorus loading calculated according to the Vollenweider/Larsen-Mercier model. The second form uses a normalized loading which is based upon the empirical finding that the effective sedimentation coefficient is approximately proportional to the areal phosphorus loading. This gives the curious result that all water quality predictions are independent of hydrologic factors (residence time or overflow rate).

f. Residual variance for the second set of models is slightly lower and shows less association with reservoir mean depth. Residuals for both chlorophyll models are negatively correlated with inflow dissolved P/total P and with the product of mean depth and turbidity. These correlations, which explain 76% and 60% of the residual variance from the respective chlorophyll equations, suggest effects of phosphorus availablility and light limitation on algal responses to phosphorus loading. These strong residual correlations also suggest that there is considerable room for model improvement.

g. Considering the error dependencies, the relatively low range of mean square error, and the potential effects of spatial variance discussed below, it is difficult to select a single "best" set of load/response model formulations, based upon the work completed thus far. While the second set of models performs somewhat better than the first on this data set, their lack of hydrologic dependence is a significant departure from previous models and analyses of other data sets are needed to assess generality (see Part VIII). If the response variables can be predicted independently of hydrologic variations (except as they may influence inflow phosphorus concentrations or reservoir depth), data requirements for model application are considerably reduced. The importance of depth, opposed to residence time, in the second set suggests the importance of exchange/equilibration with bottom sediments, as opposed to a kinetically limited sedimentation process, as the most important factor regulating reservoir phosphorus levels.

h. Spatial water quality variations within many reservoirs are substantial and need to be explicitly considered in order to refine the models tested above. This would minimally involve estimation of areal or volumetric weighting factors for application to

stations in computing reservoir-averages. More elaborate modelling approaches which disaggregate the reservoirs into relatively homogeneous segments would permit more refined calibration and testing of load/response relationships and provide a framework for predicting spatial variations in eutrophication-related water quality characteristics in reservoirs.

PART VII: OXYGEN DEPLETION MODELS

Introduction

157. This section evaluates models for predicting reservoir oxygen status based upon internal measurements of phosphorus, transparency, and chlorophyll-a, external phosphorus loadings, and reservoir morphometric characteristics. The data sources and reduction procedures used to develop model testing data sets containing the independent variables of these models are described in Part III. The models investigated are summarized in Appendix E, Part IV.

Data Set Development

158. Most of the models in this category are designed to predict areal or volumetric rates of hypolimnetic oxygen depletion during the stratified period. Estimation of depletion rates for these reservoirs would require detailed consideration of vertical, horizontal, and temporal variations in oxygen and temperature in relation to the morphometric characteristics of each reservoir and is beyond the scope of this work. During the stratified period and at a given location in the reservoir pool, anoxic conditions generally begin developing at the bottom of hypolimnion. As the season progresses, the depth of the anaerobic layer approaches the thermocline. In some reservoirs, metalimnetic demands may also be important, but these are not focused on here. If a prediction of hypolimnetic depletion rate is valid, then it should be useful as an indicator of oxygen status, as measured by the maximum fraction of the hypolimnion which is anoxic (< 2 mg/liter) over the course of the stratified period.

159. To transform estimates of areal depletion rate into estimates of concentration, the depth of the hypolimnion must be taken into consideration, or the depletion rate must be expressed on a volumetric basis. This has been done by computing the "days of oxygen supply" equivalent to a given depletion rate, hypolimnetic depth, and spring

oxygen concentration (Walker, 1979):

$$TDO = DOsp\ Zh\ /\ HODa \tag{63}$$

where,

TDO = days of oxygen supply at onset of stratification (days)
DOsp = oxygen concentration at onset of stratification (g/m3)
Zh = mean hypolimnetic depth = volume/area (m)
HODa = estimated areal oxygen depletion rate (g/m2-day)

In testing an empirical model for predicting depletion rates in northern lakes as a function of phosphorus levels and morphometry, Walker (1979) found that "oxic" lakes could be distinguished from "anoxic" lakes at a TDO value of about 200 days, which is comparable to the length of the stratified period in the northern temperature zone. In the absence of spring oxygen measurements for each lake, calculations assumed a constant value of 12 g/m3 at spring turnover (saturation at 6.2 degrees C). A review of oxygen and temperature plots indicates that 12 g/m3 is a reasonable approximation for spring DO values in about 90% of the CE reservoirs used in the tests described below; a few of the (southern) reservoirs have values between 8 and 10 g/m3. In the absence of precise estimates of spring DO values for each reservoir, a constant value of 12 g/m3 is assumed below.

160. At a constant DOsp value, the TDO statistic is inversely proportional to the volumetric depletion rate. Discrimination between oxic and anoxic reservoirs at a calculated TDO value of 200 days is equivalent to discrimination at a volumetric depletion rate of 0.06 g/m^3-day. In addition to model errors in estimating depletion rates, variations in the length of the stratified period, variations in oxygen concentrations at spring turnover, and nonlinearities in oxygen deficit development contribute to the potential errors involved in using TDO as an indicator of oxygen status. The potential influences of spring DO variations on model testing results are small, since variations in areal depletion rate and mean hypolimnetic depth are dominant. On the average, calculated TDO values differ by more than an order of magnitude between oxic and anoxic reservoirs; additional TDO variance attributed to spring

D.O. variations would have negligible influence on group separation statistics, although they may contribute to individual classification errors. Classification errors are evaluated for each model with error tolerances of accounting for variations of plus or minus 26% in spring D.O. or length of stratified period.

161. Contour diagrams (depth x month) of oxygen and temperature variations have been generated for each reservoir after averaging all measurements at 5-foot, 1-week intervals. While anoxic conditions may develop earlier at relatively shallow, upper-pool stations in some reservoirs, data from mid-pool or near-dam stations would be more representative of the total hypolimnetic volume and have been used exclusively in these tests. Plots have been reviewed and the following data extracted:

a. maximum profile depth
b. mid-summer, mid-thermocline depth
c. mid-summer, top-to-bottom temperature difference
d. maximum extent (minimum depth) of anaerobic zone (D.O. < 2 mg/l)
e. mean hypolimnetic temperature

Because of the scale factors used in the contour diagrams, estimates of top-to-bottom temperature difference have an error margin of 0-6 degrees C. Each reservoir has been classified into one of three groups, based upon the fraction of the total hypolimnetic depth which is anaerobic:

Group	Maximum Anaerobic Fraction	Number of Reservoirs
Oxic	< .2	5
Intermediate	.2 - .8	12
Anoxic	> .8	46

The data set includes 63 reservoirs with stable stratification and mid-summer, top-to-bottom temperature differences greater than 6 degrees C. This classification scheme provides an approximate basis for testing the TDO statistic and other discriminant functions (Reckhow, 1978) as predictors of oxygen status in stratified reservoirs. All of the

reservoirs in the "Oxic" class had no observed anaerobic conditions. Contour plots indicate that metalimnetic oxygen demands are significant in about 10 of the above reservoirs.

162. Mean hypolimnetic depths have been estimated using mean pool elevations, mid-thermocline depths, and the morphometric polynomials described in Part III. Estimates of average water quality conditions needed for model testing have been derived by averaging mid-pool and near-dam stations within each reservoir. Phosphorus loading statistics refer to the year of pool sampling by the EPA/NES. Two sets of data have been used in model testing: one including all 63 reservoirs and another including 27 reservoirs which passed the screening criteria for water quality and nutrient loading data in Part III. Model comparisons are not significantly different, however, for the two data sets. Most of the misclassifications (model errors) cannot be explained on the basis of data screening codes. Thus, results from the larger data set are emphasized below. Appendix C, Table C3, lists the data set used for oxygen model testing.

Statistical Methods

163. Figure 26 summarizes the theory of a univariate discriminant function for groups of unequal variance. The F-statistic derived from a one-way analysis of variance of the discriminant function (estimated TDO) grouped by observed oxygen status provides one measure of discriminating power. The following statistic is another useful measure of normalized distance between groups which does not assume homogeneity of variance:

$$Z^* = (M1 - M2) / (S1 + S2) \tag{64}$$

where,

Z^* = normalized distance between groups 1 and 2

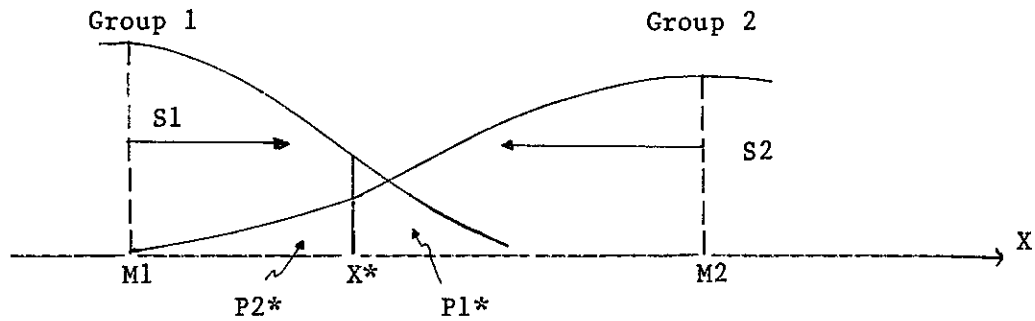
$M1$ = mean of group 1

$M2$ = mean of group 2

$S1$ = standard deviation of group 1

Figure 26

Theory of Univariate Discriminant Functions for Two Groups of Unequal Variance



Define error integral P* and critical value X* that:

$$P1^* = \int_{X^*}^{\infty} f1(X)\, dX \quad = \quad P2^* \quad = \int_{\infty}^{X^*} f2(X)\, dX$$

where,

f1(X) = normal frequency distribution function of group 1 (M1,S1)
f2(X) = normal frequency distribution function of group 2 (M1,S1)
P1* = fraction of population X1 above X*
P2* = fraction of population X2 below X*

Solution given by:

$$Z^* = (X^* - M1) / S1 = (M2 - X^*) / S2$$

$$X^* = (M1\ S2 + M2\ S1) / (S1 + S2)$$

$$Z^* = (M2 - M1) / (S1 + S2)$$

S2 = standard deviation of group 2

As demonstrated in Figure 26, Z* reflects the overlapping of the populations and can be used to calculate P*, the probable classification error. The critical value of the discriminating variable at which the classification error probabilities are equal for each group is given by:

$$X^* = (M1\ S2 + M2\ S1) / (S1 + S2) \tag{65}$$

Calculated values of X* for distinguishing between oxic and anoxic groups can be compared with the length of the stratified period in order to assess parameter stability.

164. Classification errors have been assessed by comparing predicted log(TDO) values with observed oxygen status, using a nominal estimate of 200 days (2.3 log units) as an average value for the length of the stratified period and as a rule for distinguishing anoxic reservoirs from the others. Misclassifications have also been computed allowing for an error margin of .1 log units in the discriminant function, to allow for potential variations in the length of the stratified period, spring oxygen concentration, and data variability. Reckhow's function (1978) has been evaluated using a discriminant value of 0 with an error margin of .5 units.

Model Testing

165. Models can be broadly categorized into those based upon internal water quality measurements and those based upon external phosphorus loadings. Table 31 lists the codes, formulations, and original parameter estimates for each model evaluated. Models have been evaluated based upon the following criteria:

a. normalized distance measures and ANOVA statistics
b. classification errors
c. review of bivariate classification plots
d. parameter stability

Table 31

Models for Predicting Reservoir Oxygen Status

Model D01: Lasenby, 1975

D01A01 $\log(HODa) = .35 - 1.35 \log(S)$

S = mean Secchi depth (m)
HODa = areal hypolimnetic oxygen depletion rate (g/m2-day)

Model D02: Walker, 1979

D02A01 $\log(HODa) = Fm + .0204 (-15.6 + 46.1 \log(P))$
D02A02 $\log(HODa) = Fm + .0204 (75.3 + 44.8 \log(1./S - .08))$
D02A03 $\log(HODa) = Fm + .0204 (20.0 + 33.2 \log(B))$
D02A04 $\log(HODa) = Fm + .0204 (-15.6 + 46.1 \log(Pv))$
D02A05 $\log(HODa) = Fm + .0204 (-15.6 + 46.1 \log(Pn))$

$$Fm = -3.58 + 4.55 \log(Z) - 2.04 \log(Z)^2 \quad , \text{for } Z < 20 \text{ m}$$
$$= -1.12 \quad , \text{for } Z > 20 \text{ m}$$

$$Pv = Pi / (1 + T^{.5})$$

$$Pn = Pi / (1 + .001 \, Pi \, Z)$$

Fm = morphometric factor
Z = mean depth (m)
P = mean total P (mg/m3)
B = mean chlorophyll-a (mg/m3)
Pi = average inflow total P concentration (mg/m3)
T = mean hydraulic residence time (yrs)
Pv = Vollenweider/Larsen-Mercier normalized phosphorus loading
Pn = normalized loading according to equation (61), Part VI

Model D03: Welch and Perkins, 1979

D03A01 $\log(HODa) = -1.49 + .39 \log (Pi \, Z)$

(continued)

Table 31 (continued)

Model D04: Cornett and Rigler, 1979

D04A01 $HODa = -.277 + .0005\ Ap + .005\ Th^{1.74} + .150\ \ln(Zh)$

$Ap = Qs\ (Pi - Po)$

Ap = total phosphorus accumulation (trapping) rate (mg/m2-yr)
Po = average outflow total P (mg/m3)
Qs = surface overflow rate (m/yr)
Th = mean hypolimnetic temperature (deg C)
Zh = mean hypolimnion depth (m)

Model D05: Rast and Lee, 1978 (D05A01)
Vollenweider and Kerekes, 1980 (D05A02)
Ryding, 1980 (D05A03)

D05A01 $\log(HODa) = -1.07 + .467 \log(Pv)$
D05A02 $\log(HODa) = -1.07 + .585 \log(Pv)$
D05A03 $\log(HODa) = -2.42 + .67 \log(Pv) + \log(Zh)$

Model D06: Reckhow, 1978

D06A01 $D = 2.33 - 4.61 \log(Pi) + 5.73 \log(Z) - 0.51 \log(Qs)$

D = discriminant score (Oxic for D > 0)

e. interpretation of outliers (misclassified reservoirs)

Table 32 summarizes the ANOVA statistics and distributions of calculated discriminant functions for each reservoir group and model. For comparative purposes, the distributions of reservoir morphometric, hydrologic, and water quality characteristics within each group are also described. With the exception of Lake Sakakawea, described in detail below, none of the completely oxic reservoirs are misclassified by any of the models. The sample size for this group, however, is limited to 4. Table 33 presents group separation statistics for reservoirs classified into two categories, "anoxic" and "other", where the latter refers to the "oxic" and "intermediate" groups combined. Classification errors with and without tolerances are presented in Table 34 for the above categories. As discussed below, one oxic reservoir (Lake Sakakawea, 30-235) was misclassified by all of the models. The statistics in Tables 32-34 exclude this reservoir.

166. Graphical analysis is another important means of evaluating the models. Most of the models are separable into morphometric and water quality terms. Figures 27-35 plot these terms against each other for each model, using different symbols to distinguish reservoir groups. The solid line in each figure represents the solution of the model for a TDO value of 200 days (or a function value of 0. for model D06). Dashed lines reflect an error tolerance of .1 log units, as discussed above. The validity of each model is reflected by the separation of oxygen status groups by the TDO lines. The slopes of the lines reflect the relative sensitivities of oxygen status to water quality and morphometric factors.

167. Internal models (D01 and D02) relate oxygen status to surface measurements of chlorophyll, phosphorus, or transparency averaged over the growing season. F statistics range from 35.0 to 50.3 for the three-group classifications (Table 32) and from 70.0 to 96.0 for the two-group classifications (Table 33). Classification errors (Table 34) range from 4.8 to 14.0% without tolerance and 3.2 to 4.8% with tolerance. All of the models show reasonable group separation on bivariate plots (Figures 27-35), using a TDO value of 200 days to

Table 32

Distributions of Oxygen Discriminant Functions and other Reservoir Characteristics by Oxygen Status Group

	Oxygen Status Group									ANOVA	Results*
	Oxic			Intermediate			Anoxic				
Variable	n	mean	std	n	mean	std	n	mean	std	F	F
Internal Models **											
D01A01	4	2.85	0.20	12	2.60	0.18	46	1.41	0.58	35.0	17.3
D02A01	4	2.71	0.38	12	2.62	0.14	46	1.78	0.38	36.8	27.6
D02A02	4	2.68	0.18	12	2.40	0.18	46	1.55	0.35	50.3	25.1
D02A03	4	3.00	0.18	12	2.52	0.18	34	1.92	0.28	48.1	25.3
External Models **											
D02A04	3	2.94	0.30	11	2.50	0.21	31	1.61	0.48	28.1	20.9
D02A05	3	3.04	0.27	11	2.48	0.14	31	1.67	0.35	47.5	31.0
D03A01	3	2.95	0.15	11	2.68	0.10	31	2.06	0.33	28.6	21.1
D04A01	3	2.90	0.14	11	2.40	0.28	31	1.60	0.49	22.5	15.5
D05A01	3	3.15	0.22	11	2.75	0.12	31	1.91	0.45	29.4	21.8
D05A02	3	3.01	0.24	11	2.60	0.14	31	1.69	0.48	29.3	22.2
D05A03	3	2.70	0.13	11	2.69	0.17	31	2.30	0.26	13.3	10.8
D06A01	3	4.02	1.34	11	2.03	1.00	31	-2.75	2.38	31.0	20.4
Morphometry/Hydrology											
Hyp. Depth	4	1.46	0.24	12	1.16	0.10	46	0.60	0.31	33.3	15.3
Mean Depth	4	1.51	0.23	12	1.25	0.07	46	0.83	0.22	37.0	15.5
Max. Depth	4	1.92	0.25	12	1.73	0.10	46	1.32	0.25	25.9	13.9
Res. Time	4	-0.53	0.33	12	-0.38	0.50	45	-0.62	0.55	1.0	1.6
Overf. Rate	4	2.04	0.13	12	1.62	0.51	45	1.46	0.48	3.1	.3
Water Quality											
Total P	4	1.33	0.24	12	1.09	0.15	46	1.62	0.31	17.1	18.0
Chl-a	4	0.34	0.22	12	0.58	0.28	34	0.96	0.27	15.6	7.6
Secchi	4	0.49	0.21	12	0.52	0.14	46	0.06	0.24	25.1	15.1
Inflow P	3	1.42	0.16	11	1.44	0.26	31	1.99	0.35	14.5	8.8
Pv ***	3	1.20	0.19	11	1.21	0.25	31	1.80	0.39	13.3	10.8
Pn ***	3	1.10	0.13	11	1.24	0.15	31	1.73	0.23	29.4	17.7

* F statistics derived from one-way analyses of variance; (F using all data (n=62), F′ using only data from reservoirs passing nutrient bugdet and water quality data screens (n=26)); statistics exclude Sakakawea (30-235)

** oxygen depletion models (Table 31) formulated to predict days of oxygen supply (equation 63), except for model D06

*** $Pv = Pi/ (1 + \sqrt{T})$; $Pn = Pi/(1 + .001\ Pi\ Z)$

Table 33

Summary of Model Statistics for Distinguishing between Anoxic and Other Reservoirs

	Reservoir Group						ANOVA †			
	Other			Anoxic						
Model	n	mean	std	n	mean	std	F	F′	Z*††	X*††
Internal Models										
D01A01	16	2.66	0.21	46	1.41	0.58	70.0	35.0	1.58	2.33
D02A01	16	2.64	0.21	46	1.78	0.38	74.4	49.6	1.46	2.33
D02A02	16	2.47	0.22	46	1.55	0.35	96.2	48.1	1.62	2.12
D02A03	16	2.64	0.28	34	1.92	0.28	70.9	35.8	1.28	2.28
External Models										
D02A04	14	2.60	0.29	31	1.61	0.48	51.6	35.0	1.30	2.23
D02A05	14	2.60	0.29	31	1.67	0.35	75.0	43.9	1.45	2.18
D03A01	14	2.74	0.15	31	2.06	0.33	53.8	38.2	1.41	2.52
D04A01	14	2.50	0.33	31	1.60	0.49	39.9	27.1	1.11	2.14
D05A01	14	2.83	0.22	31	1.91	0.45	54.1	38.1	1.39	2.53
D05A02	14	2.69	0.23	31	1.69	0.48	54.6	39.2	1.41	2.37
D05A03	14	2.69	0.16	31	2.30	0.26	27.1	21.7	.94	2.54
D06A01	14	2.46	1.33	31	-2.75	2.38	58.4	36.1	1.41	.59

† F statistics derived from analyses of variance; F′ includes only reservoirs passing data nutrient balance and water quality data screens

†† see Figure 26; Z* = normalized distance between groups; X* = function value for distinguishing between groups

Table 34

Classification Error Summary for Oxygen Depletion Models

Observed :	Oxygen Status: Other*	Other	Anoxic	Anoxic	Total	Total	Percent
Estimated :	Anoxic	Other	Other	Anoxic	Proj.	Errors	Error
Internal Models							
D01A01	0 (0)**	16	3 (3)	43	62	3 (3)	4.8 (4.8)
D02A01	0 (0)	16	4 (3)	42	62	4 (3)	6.5 (4.8)
D02A02	3 (2)	13	1 (0)	45	62	4 (2)	6.5 (3.2)
D02A03	1 (1)	15	6 (1)	28	50	7 (2)	14.0 (4.0)
External Models							
D02A04	2 (0)	12	2 (2)	29	45	4 (2)	8.9 (4.4)
D02A05	1 (0)	14	1 (1)	30	45	2 (1)	4.4 (2.2)
D03A01	0 (0)	14	9 (5)	22	45	9 (5)	20.0 (11.1)
D04A01	4 (3)	10	3 (2)	28	45	7 (5)	15.6 (11.1)
D05A01	0 (0)	14	8 (5)	23	45	8 (5)	17.8 (11.1)
D05A02	0 (0)	14	3 (1)	28	45	3 (1)	6.7 (2.2)
D05A03	0 (0)	14	16 (12)	15	45	16 (12)	35.6 (26.7)
D06A01	0 (0)	14	4 (2)	27	45	4 (2)	8.9 (4.4)

* "Anoxic" group includes reservoirs with >80% anaerobic hypolimnia; "Other" group includes the rest of the reservoirs; none of the completely oxic reservoirs (0% anaerobic fraction) are misclassified by any of the the models; statistics exclude Sakakawea (reservoir 30-235)

** classification criterion: "Anoxic" if estimated log(TDO) < 2.3, 200 days for models D01 - D06; "Anoxic" if discriminant function < 0 for model D06; numbers in parentheses reflect classification errors with a tolerance of .1 (e.g. log(TDO) = 2.2 to 2.4) for models D01-D06 and with a tolerance of .5 for model D06 (discriminant function = -.5 to .5)

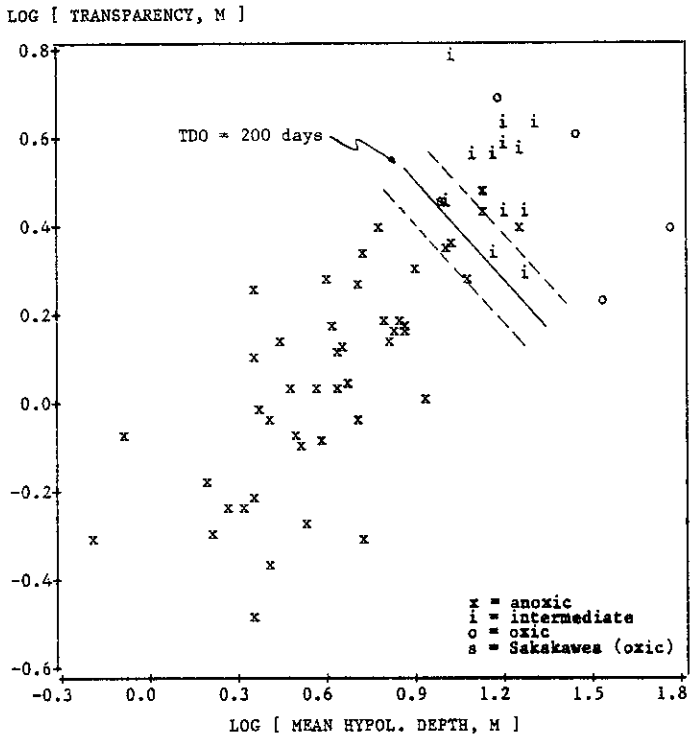


Figure 27

Oxygen Status Classification on Transparency vs. Hypolimnetic Depth Axes (Model D01A01)

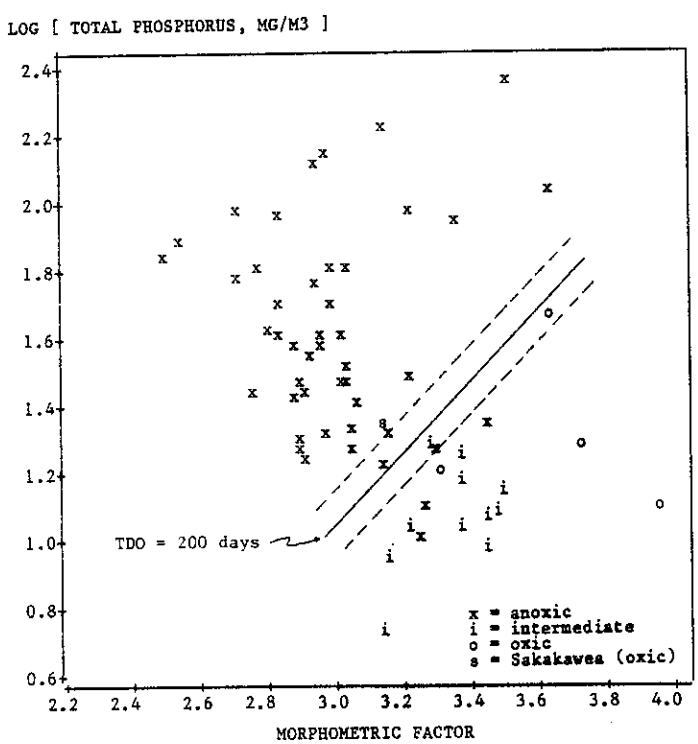


Figure 28

Oxygen Status Classification on Total P vs. Morphometric Factor* Axes (Model D02A01)

$$* \text{ Factor} = 4.66 - 4.55 \text{ LOG}(Z) + 2.04 (\text{LOG}(Z))^2 + \text{LOG}(ZH)$$

Z = mean depth (m)

ZH = mean hypolimnion depth (m)

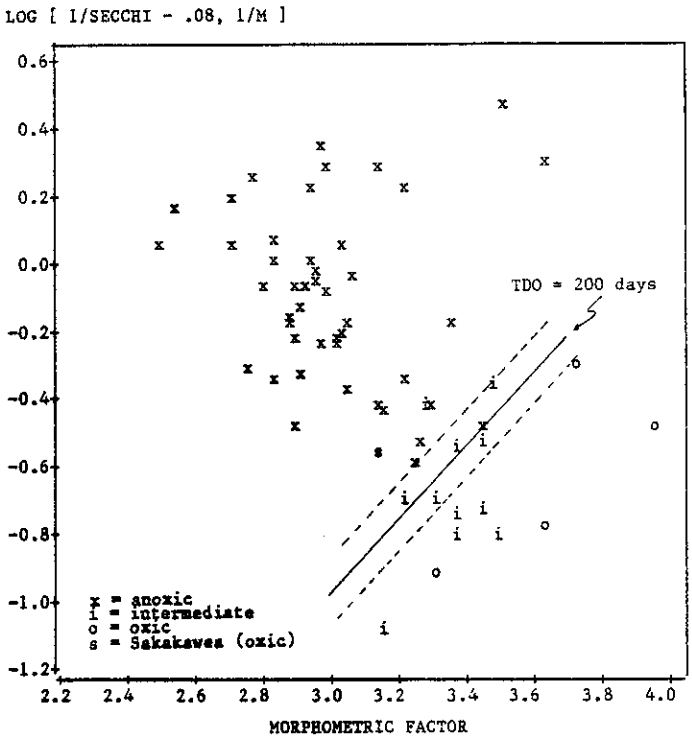


Figure 29

Oxygen Status Classification on Transparency vs. Morphometric Factor* Axes (Model D02A02)

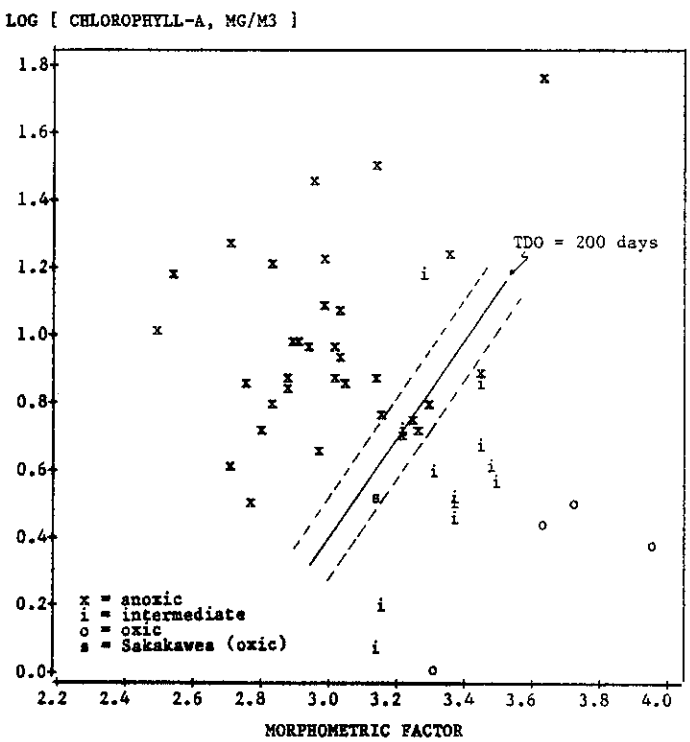


Figure 30

Oxygen Status Classification on Chlorophyll vs. Morphometric Factor* Axes (Model D02A03)

$$* \text{ Factor} = 4.66 - 4.55 \text{ LOG}(Z) + 2.04 (\text{LOG}(Z))^2 + \text{LOG}(ZH)$$

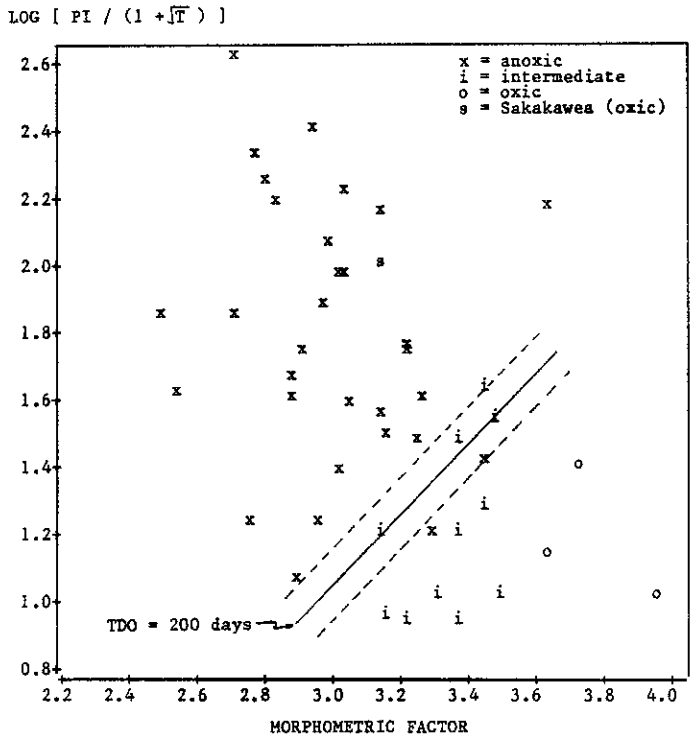


Figure 31

Oxygen Status Classification on Pv vs. Morphometric Factor* Axes (Model D02A04)

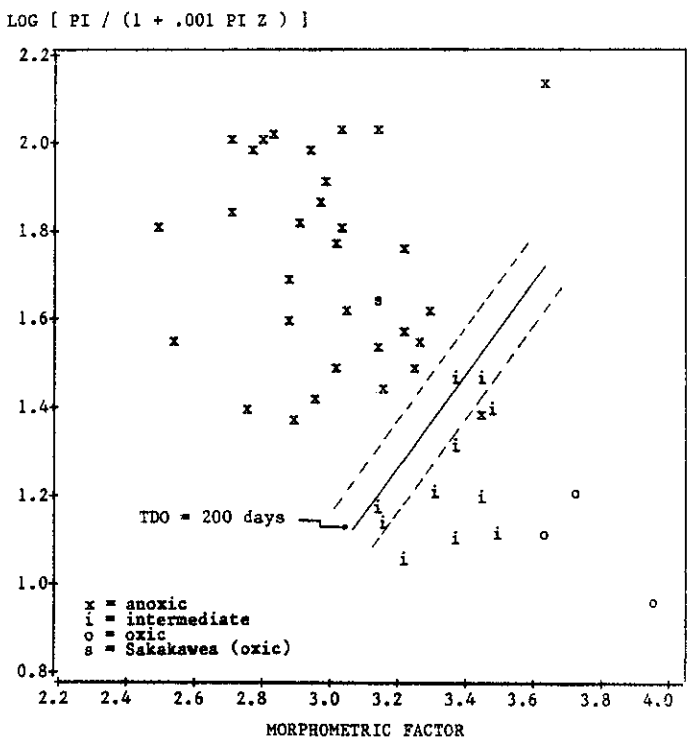


Figure 32

Oxygen Status Classification on Pn vs. Morphometric Factor* Axes (Model D02A05)

$$* \text{ Factor} = 4.66 - 4.55 \text{ LOG}(Z) + 2.04 (\text{LOG}(Z))^2 + \text{LOG}(ZH)$$

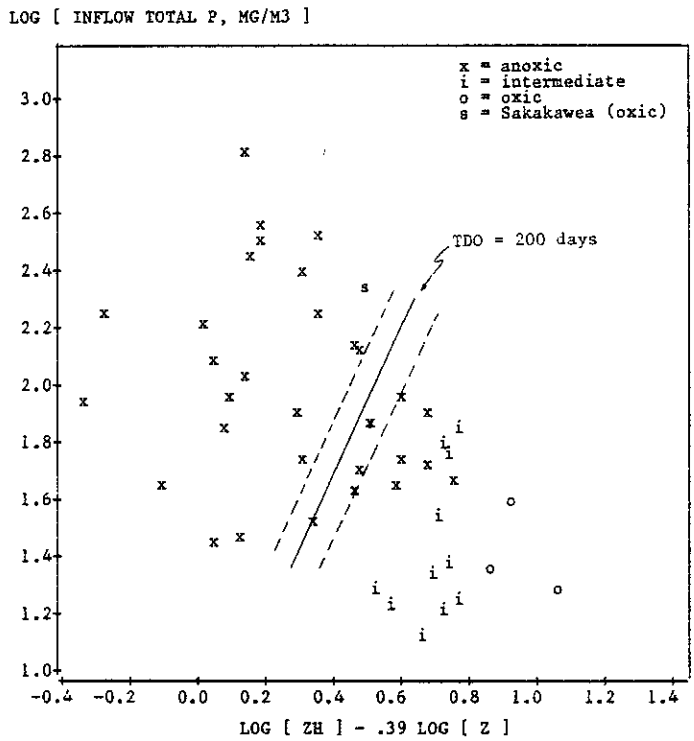


Figure 33

Oxygen Status Classification on Inflow P vs. Morphometric Factor Axes (Model D03A01)

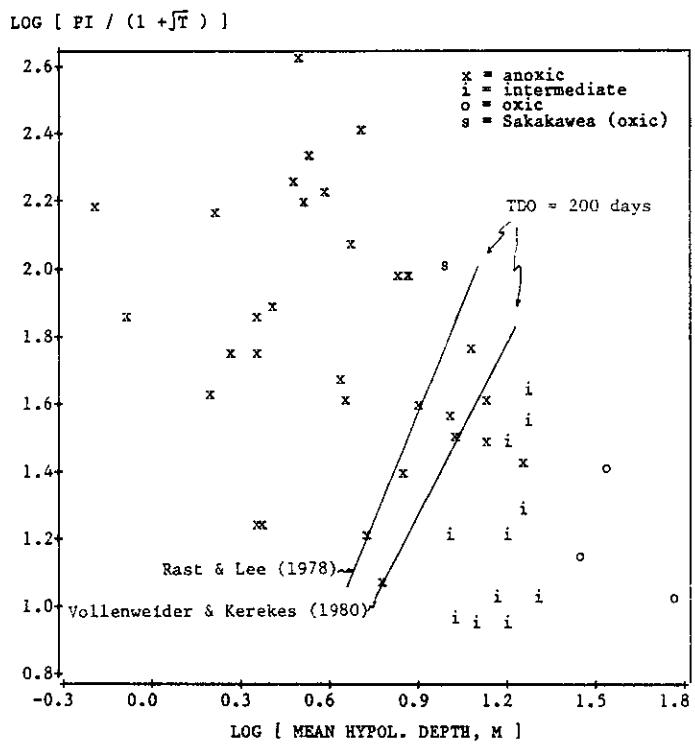


Figure 34

Oxygen Status Classification on Pv vs. Hypolimnetic Depth Axes (Models D05A01 and D05A02)

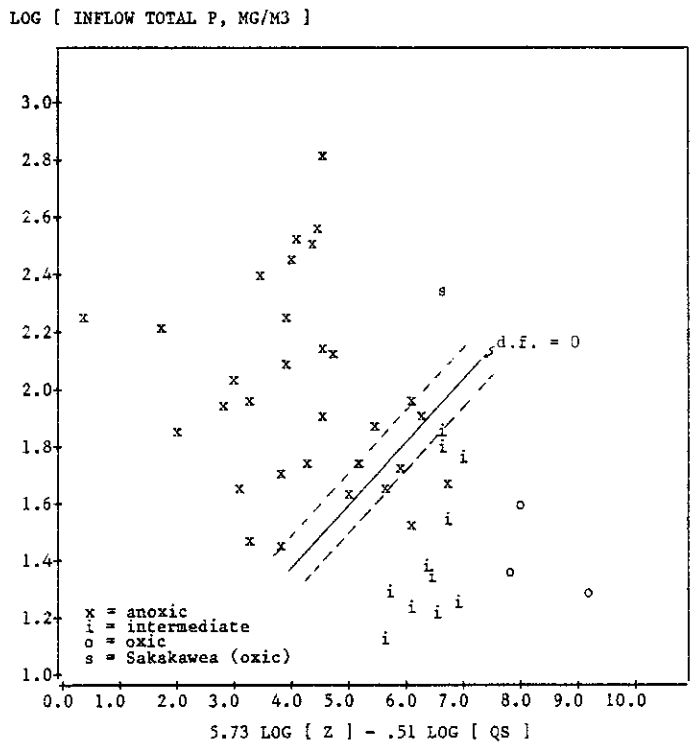


Figure 35

Oxygen Status Classification According to Reckhow (1978) Discriminant Function (Model D06A01)

distinguish the anoxic reservoirs from the others. The model based upon chlorophyll (D02A03, Figure 30) shows the best separation of the completely oxic group from the intermediate group. The discriminant line for this separation corresponds roughly to a discriminant function value of 2.6 or 400 days. With the exception of the two outliers described below, the data do not provide any basis for rejecting these models with their original coefficients.

168. External models (D03 - D06) relate oxygen status to phosphorus loading, hydrology, and morphometry. External forms of model D02 have also been tested, by substituting two alternative expressions for normalized phosphorus loading for the observed phosphorus concentration in model D02A01. The expressions (see Table 31) include the Vollenweider/Larsen-Mercier statistic (D02A04) and the expression derived from the loading model calibrations in Part VI (D02A05). The latter model (Figure 32) yields the best group separation and least classification error of any of the external models evaluated. F and Z* statistics for models D05A01 (Rast and Lee, 1978) and D05A02 (Vollenweider and Kerekes, 1980) are also relatively high. Figure 33 shows that recalibration of D05A01 (or use of a discriminant value higher than 200 days) would be required in order to reduce classification errors. The plots indicate that external loading models D02 and D05 do not differ greatly with respect to discriminating power, if allowances for recalibration are made. Classification errors or parameter biases may be attributed to phosphorus retention model errors, as well as variations in the internal phosphorus/oxygen depletion relationships.

169. The F statistics for morphometric factors in Table 32 are appreciable in relation to those for the water quality variables or for the models discussed above. This suggests that morphometric effects are extremely important in determining oxygen status and is consistent with previous studies of data from natural lakes (Reckhow, 1978, Cornett and Rigler, 1979, Walker, 1979). All stratified reservoirs with mean depths less than 13 meters or mean hypolimnetic depths less than 9 meters are classified as anoxic, for example, regardless of water quality. Thus,

sensitivity to water quality is only apparent in the deeper reservoirs. In the relatively shallow reservoirs, nutrient and chlorophyll concentrations generally exceed the values required to maintain oxic conditions throughout the stratified period, although the length of the anoxic period (and the severity of any secondary water quality impacts, such as mobilization of iron, manganese, and nutrients or production of hydrogen sulfide) may be sensitive to these concentrations. The importance of the morphometric factors, however, makes it difficult to evaluate and compare the water quality factors used in these models.

170. Line slopes in the bivariate plots (Figures 27-35) reflect relative sensitivities to morphometry and water quality. Vertical lines would reflect a dominance of morphometric effects; most are diagonal. Adjustments in the slopes and/or intercepts of some lines may reduce classification error for some models. Estimation and use of oxygen depletion rates, rather than oxygen status, would provide a better basis for identifying water quality sensitivity and for recalibrating the models.

171. As shown in Figures 27-35, one oxic reservoir (Lake Sakakawea, 30-235) is misclassified by most models. Distinctive features of this mainstem reservoir on the Missouri River include (1) its length (178 miles); (2) the presence of significant spatial gradients in chlorophyll, phosphorus, and transparency, as discussed in Part VI; and (3) an unusually low percentage of orthophosphorus loading (9%). Average chlorophyll concentrations range from 30 mg/m3 at the upper end of the reservoir to 1.4 mg/m3 near the dam. Station total depths range from 5 to 180 feet and generally increase moving down the pool. The highest concentrations of chlorophyll and nutrients are found at the shallow, upper-pool and mid-pool stations and the lowest concentrations are found at the deep, near-dam stations. For the internal models, use of area-weighted averaging schemes, possibly excluding data from unstratified stations, would probably eliminate the misclassification. Modifications of the external models to account for the effects of plug flow and the high percentage of particulate phoshorus loadings would be needed for correct classification of this reservoir. The presence of

Lake Sakakawea as an "outlier" in the oxygen depletion data set is consistent with the results of Parts V and VI.

172. Table Rock Reservoir (24-200) is classified as anoxic, but has calculated TDO values greater than 200 days for all of the models tested. This reservoir has a substantial metalimnetic oxygen demand and a relatively long stratified period (mid-April through late November, about 230 days). The oxygen contour plot shows anaerobic conditions developing from the metaliminion and from the bottom, both beginning in mid-July. By the end of September, the bottom and mid-depth anaerobic zones have merged and the entire hypolimnion is anoxic. Classification of this reservoir as anoxic can be explained by the effects of the metalimnetic demand and long stratified period. Spatial gradients may also be of significance in Table Rock, since most of the phosphorus loading enters about mid-way down the pool, as a result of a major point source. Thus, the entire volume of the reservoir is not available to assimilate the loading and the reservoir-average nutrient and chlorophyll levels may be lower than those found near the dam.

173. Other anoxic reservoirs which are frequently misclassified include Hartwell (08-330) and Sydney Lanier (10-076), both of which are fairly large and complex reservoirs which were sampled only twice by the EPA/NES during the growing season for chlorophyll, transparency, and nutrients. Spring oxygen concentration below 12 g/m3 may also contribute to misclassification of these (southern) reservoirs.

174. None of the misclassifications from the internal or external models can be explained by nitrogen-limitation effects, although the separation between the oxic and anoxic groups would increase if N-limitation effects were taken into account, since three out of the five oxic reservoirs had average inorganic N/P ratios less than 8. If nitrogen were limiting, estimated TDO values based upon phosphorus loading (or phosphorus concentration) would tend to be biased on the low side. Nitrogen limitation effects may explain the somewhat less distinct group separations for models based upon phosphorus concentration or loading, as compared with models based upon transparency or chlorophyll.

Conclusions

175. Results of the oxygen depletion model testing described above can be summarized as follows:

a. When formulated to predict days of oxygen supply or volumetric depletion rate, several of the existing hypolimnetic oxygen depletion models can be used to discriminate between anoxic reservoirs (those in which more than 80% of the hypolimnion falls below 2 g/m3 at some point during the stratified period) and other, stratified reservoirs, using a TDO value of 200 days or a HODv value of .06 g/m3-day.

b. Reservoir classifications do not provide any bases for rejecting or distinguishing between internal models D01 (Lasenby,1975) or D02 (Walker, 1979) in their original forms. The form of model D02 based upon chlorophyll-a provides the best separation between the completely oxic and partially anoxic reservoirs.

c. Among the models which employ normalized phosphorus loading as the water quality factor, model D02A05, based upon the phosphorus loading expression derived in Part VI (equation (61)), has the strongest discriminating power and least classification error. Thus, this expression seems to work best for predicting all response variables (chlorophyll, phosphorus, transparency, and oxygen depletion), despite its hydrologic independence. If allowances for recalibration are made, classification errors for model D05 (Rast and Lee, 1978, Vollenweider and Kerekes, 1980) and D06 (Reckhow, 1978) are equal to model D02A05, but group separation is less distinct, based upon analysis of variance statistics.

d. Two outliers (consistently misclassified reservoirs) can be explained by the effects of significant spatial gradients and

metalimnetic oxygen demand.

e. The strong influence of morphometric factors on oxygen depletion makes it difficult to distinguish among alternative expressions for water quality or nutrient loading sensitivity. Estimation of areal depletion rates would provide a better basis for model comparisons. Potentials for metalimnetic demands and spatial variations in hypolimnetic deficits should also be considered in future development of empirical methods for predicting reservoir oxygen status.

PART VIII: MODEL NETWORK

176. Previous chapters have identified, calibrated, and tested empirical models which seem to work best for CE reservoirs. This chapter presents a model "network" which summarizes relationships among external phosphorus loadings and reservoir-average water quality conditions. Presentation in the form of a network emphasizes the fact that these models, like the reservoir ecosystems which they partially represent, are not a series of unrelated equations or relationships, but a multivariate "system" with multiple controls and interactions.

177. The network is calibrated to data from 29 phosphorus-limited, low-turbidity impoundments, which are defined as reservoirs with inflow total N/P ratios greater than 8 and non-algal turbidities (1/Secchi - .025 Chl-a) less than 1.58 1/m (.2 log units). The above "operational" criteria are based upon the testing completed in previous sections and additional residuals analyses. The first criterion approximately distinguishes between N-limited and P-limited impoundments; it is not completely adequate, however, since the inflow total N/P ratio does not necessarily equal total N/P or inorganic N/P ratios measured within the reservoirs. Based upon the second criterion, all reservoirs with mean Secchi depths greater than .63 meters are included in the "low-turbidity" group, regardless of chlorophyll-a values.

178. As demonstrated in previous sections, some systematic effects of N/P ratios, inflow ortho-P/total P ratio, turbidity, mean depth, and residence time remain within the restricted data set. More complex empirical models are needed to account for the remaining effects, to include reservoirs not conforming to the above criteria, and to consider spatial variations within reservoirs. These will be addressed in future research.

179. The network is tested below using independent reservoir data sets compiled from the literature. The feasibility of using organic nitrogen as a fifth indicator of eutrophication (in addition to chlorophyll, phosphorus, transparency, and oxygen depletion) is demonstrated. Using multivariate statistical techniques, composite

measures of impoundment response are constructed and related to external phosphorus loadings. Error analyses are conducted to permit estimation of prediction confidence limits, as influenced by model errors and errors in the estimates of phosphorus loadings and reservoir-average water quality conditions.

180. All models in the network are one-variable, linear regressions with the dependent and independent variables transformed to base-10 logarithms. Two alternative expressions for normalized phosphorus loading are considered:

$$Pv = Pi \; / \; (1 + \sqrt{T}\;) \tag{66}$$

$$Pn = Pi \; / \; (1 + .001 \; Pi \; Z\;) \tag{61 bis}$$

where,

Pv = Vollenweider/Larsen-Mercier expression (mg/m3)
Pn = normalized loading developed in Part VI (mg/m3)
Pi = average inflow total P concentration (mg/m3)
T = mean hydraulic residence time (years)
Z = mean depth (m)

A unique feature of the second formulation is that it is independent of hydrologic factors (residence time or overflow rate). Based upon analyses in Parts VI and VII, Pn seems to work somewhat better than Pv as a predictor of all impoundment response variables. Tests using the independent data sets provide further discrimination between these formulations.

Independent Testing

181. Table 35 summarizes the characteristics and sources of three independent data sets which have been compiled for use in model testing. These include:

(1) EPA National Eutrophication Survey Compendium (94 CE Reservoirs)
(2) Tennessee Valley Authority Reservoirs (19 Reservoirs)

Table 35
Additional Data Sets Used in Testing Models for Predicting Reservoir-Average Conditions

---

1. EPA National Eutrophication Survey Compendium
   - 106 CE Reservoirs
   - Error Screening Criterion*:
     - Rp > -.1, based upon inflow/outflow data (n = 94)
   - Data Reduction:
     - Chlorophyll, Secchi: mean, spring-fall
     - Total P: median, spring-fall
   - Reference: USEPA (1978)

2. TVA Reservoirs:
   - 10 Tributary
   - 9 Mainstem Tennessee River
   - Error Screening Criteria*: none
   - Data Reduction:
     - Chlorophyll, Secchi: mean summer
     - Total P (EPA/NES): median spring-fall
   - References:
     - Higgins et al.(1980), Higgins and Kim (1981)
     - Walker (1980b) (Normandy)
     - USEPA (1978) (impoundment phosphorus data)

3. OECD Reservoir and Shallow Lakes Project
   - 43 Impoundments from Europe, Australia, Japan, U.S.
     - 8 (shallow) natural lakes
     - 8 artificial (pumped storage) reservoirs
     - 27 "semi-artificial" reservoirs (impounded natural valleys)
     - several sampled more than one year (reservoir-years = 83)
     - many impoundments sampled near dam only
   - Screening Criteria*:
     - include only data from "semi-artificial" reservoirs
     - exclude Mount Bold (heavy silt load (Clasen, 1980))
     - exclude Grafham Water (outlier, inflow P = 4900 mg/m3)
   - Data Reduction:
     - chlorophyll, total P: mean, annual, euphotic zone
     - transparency: median, annual
   - Reference: Clasen (1980)

---

* additional screening criteria applied in computing error statistics for all models:

Criterion	EPA	TVA	OECD
Inflow Total N/P > 8	x	na	x
Turbidity < 1.58 1/m	x	na	na

na = no impoundments with data violated criterion

(3) OECD Reservoir and Shallow Lakes Progam (43 Impoundments)

Detailed screening similar to that conducted in Part IV has not been feasible for these data sets, though some impoundments have been excluded from error statistic calculations based upon the inflow N/P and turbidity criteria discussed above and upon other, limited criteria presented in Table 35. Data sets are listed in Appendix F, along with plots of observed and predicted conditions for each model and data set. Different symbols are used to identify impoundments in various categories. Factor-of-two accuracy limits are indicated in order to provide perspective on error magnitudes; they do not necessarily reflect prediction confidence limits.

182. Figures 36-38 illustrate the relationships for all data sets combined, using different symbols to differentiate data sources. Table 36 summarizes the formulations and error statistics for each model and data set. Mean squared errors and percents of variance explained are calculated for each of three sets of parameter estimates:

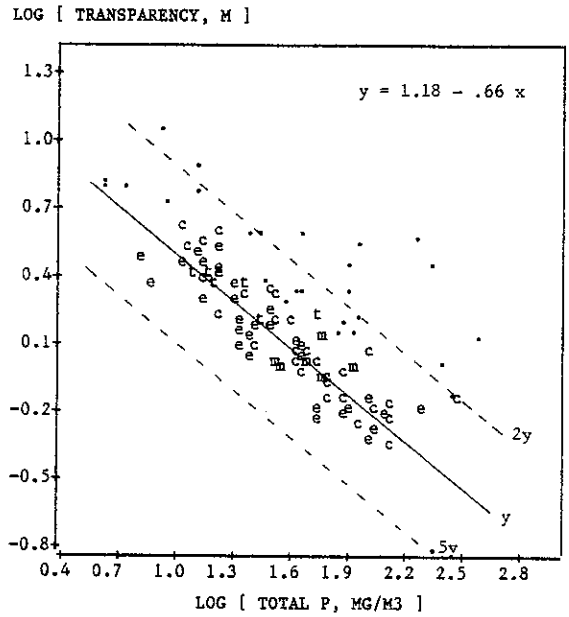
	Parameter Set		
	a	b	c
slope	original	original	optimized
intercept	original	optimized	optimized

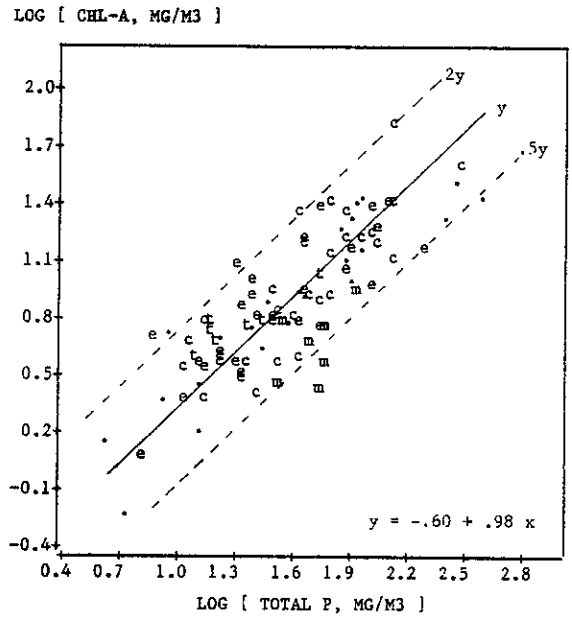
"Original" refers to coefficients estimated for the CE reservoir data set. "Optimized" refers to coefficients estimated for the independent data. Variance ratio statistics (see Table 28) are used to test for significant differences in mean squared errors among the parameter sets. Significant differences reflect instability in the optimal coefficients from data set to data set.

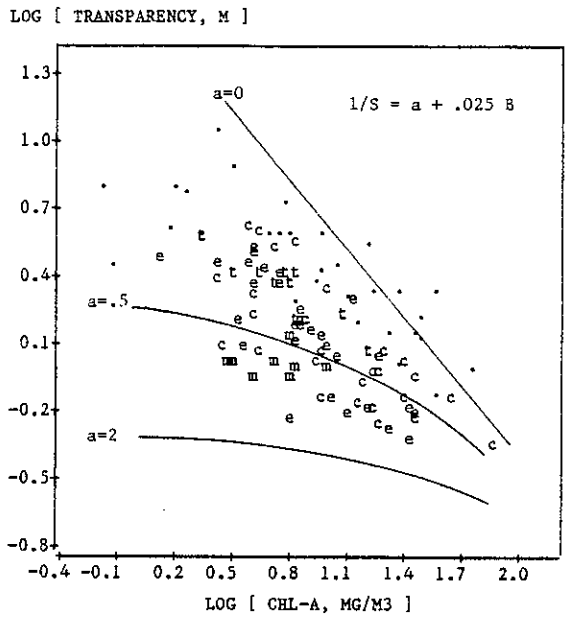
183. Differences in optimal intercept are indicated by differences in mean squared error between cases a and b. In some cases, instability in the intercept may be attributed to variations in data-reduction procedures. For example, median phosphorus concentrations are reported in the EPA/NES data set, as compared with arithmetic mean concentrations used in model calibration. Since within-reservoir variations tend to be

Figure 36

Internal Model Evaluations Using the Combined Data Set







Symbol	Meaning
c	CE Reservoir, CE Data Set
e	CE Reservoir, EPA/NES Data Set
t	TVA Tributary Reservoir
m	TVA Mainstem Reservoir
.	OECD Reservoir

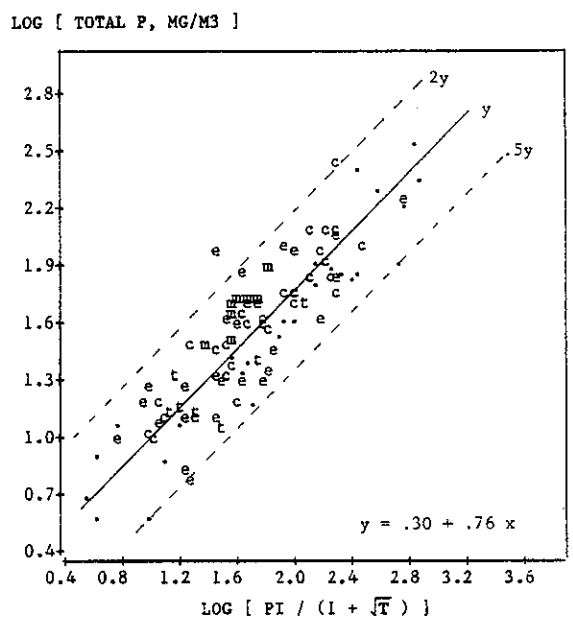
inflow N/P > 8, turbidity < 1.58 1/m

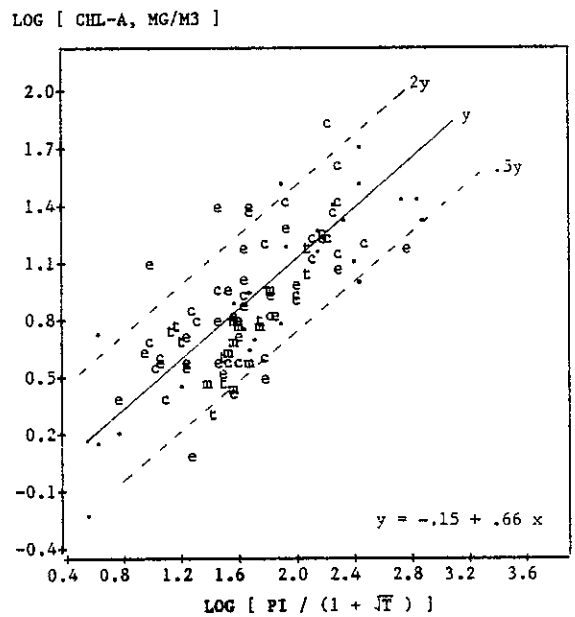
line = regression for CE reservoirs and CE data set

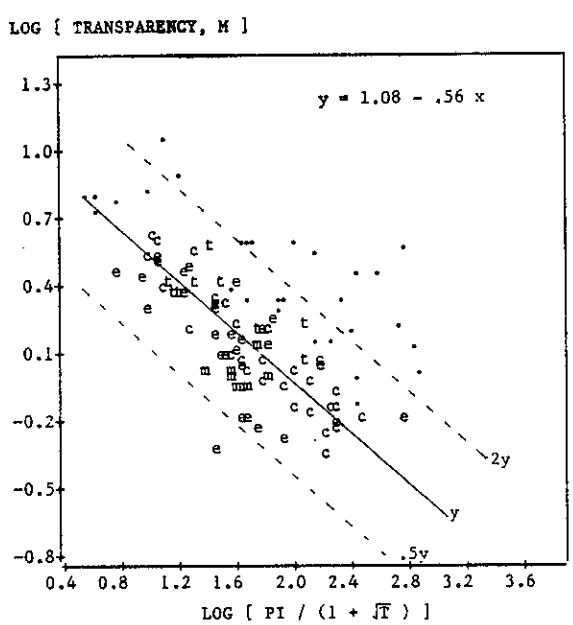
dashed line = 2-fold accuracy limits

Figure 37

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the Combined Data Set







Symbol	Meaning
c	CE Reservoir, CE Data Set
e	CE Reservoir, EPA/NES Data Set
t	TVA Tributary Reservoir
m	TVA Mainstem Reservoir
.	OECD Reservoir

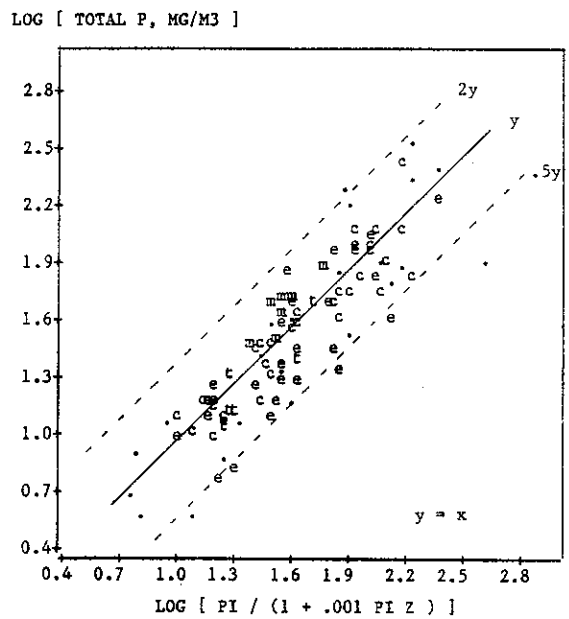
inflow N/P > 8, turbidity < 1.58 1/m

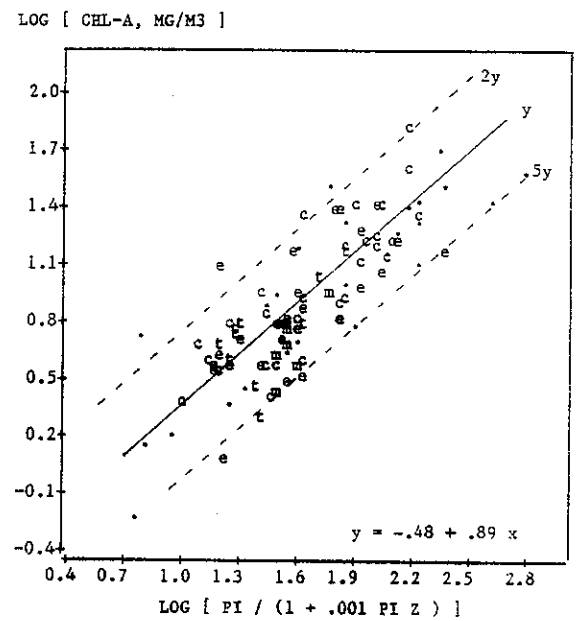
line = regression for CE reservoirs and CE data set

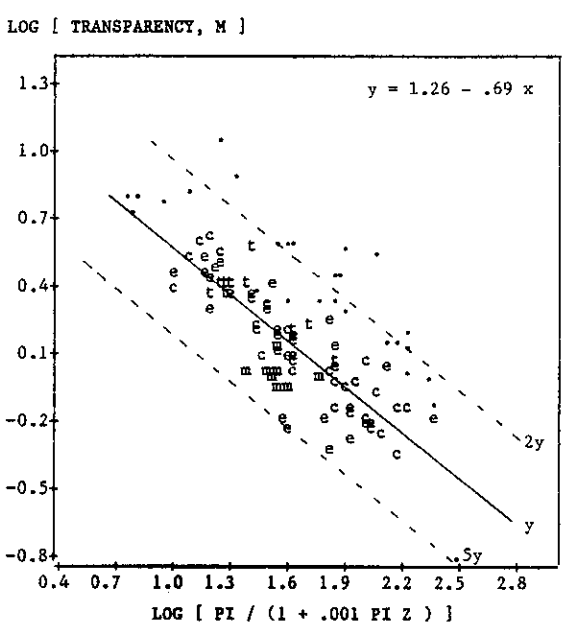
dashed line = 2-fold accuracy limits

Figure 38

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the Combined Data Set







Symbol	Meaning
c	CE Reservoir, CE Data Set
e	CE Reservoir, EPA/NES Data Set
t	TVA Tributary Reservoir
m	TVA Mainstem Reservoir
.	OECD Reservoir

inflow N/P > 8, turbidity < 1.58 1/m

line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits

Table 36
Summary of Model Equations and Errors by Data Set

Data	n	Vy	R-Squared a	R-Squared b	R-Squared c	Mean Sqd Error a	Mean Sqd Error b	Mean Sqd Error c	Mean	Med	Q3-Q1
model: log(P) = log(Pn)											
CE	29	133	857	859	857	19	19	19	-29	-21	178
EPA	51	131	563	704	705	57	39*	39*	-138#	-130	310
TVA	15	75	701	719	753	22	21	18	53	75	273
OECD	27	316	774	778	769	71	70	73	-60	-24	411
model: log(B) = -.48 + .89 log(Pn)											
CE	29	143	717	707	696	41	42	44	0	-13	342
EPA	51	102	567	611	624	44	40*	38*	-73#	-88	193
TVA	19	44	78	267	272	40	32	32	-100#	-103	297
OECD	26	234	749	750	747	59	59	59	-48	-95	332
model: log(S) = 1.26 - .69 log(Pn)											
CE	29	73	850	846	840	11	11	12	0	0	177
EPA	51	67	709	709	706	20	20	20	-21	0	163
TVA	18	42	407	435	400	25	24	25	-50	-42	260
OECD	29	86	-856	580	694	160	36*	26*	354#	352	239
model: log(P) = .30 + .76 log(Pv)											
CE	29	133	843	839	833	21	22	22	0	-12	173
EPA	51	131	616	638	641	50	47	47	-62	-110	330
TVA	19	75	528	533	497	35	35	38	52	132	322
OECD	27	316	875	899	896	40	32*	33*	-94#	-113	195
model: log(B) = -.15 + .66 log(Pv)											
CE	29	143	595	581	561	58	60	63	0	0	396
EPA	51	102	436	441	469	58	57	54	-41	-43	248
TVA	15	44	-162	235	265	51	33*	32*	-138#	-170	262
OECD	26	234	734	749	744	62	59	60	-76	-107	316
model: log(S) = 1.08 - .56 log(Pv)											
CE	29	73	836	829	823	12	13	13	0	18	207
EPA	51	67	568	587	602	29	28	27	-43	-24	209
TVA	18	42	275	244	239	30	32	32	-20	-36	331
OECD	29	86	-1631	280	590	227	62*	35*	409#	414	391

(continued)

Table 36 (continued)

Data	n	Vy	R-Squared a	R-Squared b	R-Squared c	Mean Sqd Error a	Mean Sqd Error b	Mean Sqd Error c	Mean	Med	Q3-Q1
model: log(B) = -.60 + .98 log(P)											
CE	29	143	691	680	681	44	46	46	0	-16	328
EPA	51	102	581	586	664	43	42	34	-41	-43	248
TVA	15	25	-2835	-2349	-52	96	83	26*	-130	-82	476
OECD	24	212	790	784	819	44	46	38	-24	-5	320
model: log(S) = 1.18 - .66 log(P)											
CE	29	73	801	793	786	15	15	16	0	-21	175
EPA	51	67	719	822	817	19	12*	12*	-84#	-82	178
TVA	15	34	733	727	721	9	9	10	-21	-26	151
OECD	27	82	-994	434	646	165	47*	29*	346#	314	283

Note: all statistics x 1000 (except n), log10 scales
data = data set, screened according to criteria in Table 35
n = number of impoundment-years
Vy = variance of dependent variable
R-squared = fraction of variance explained

parameters	D.F.
a - original	n
b - intercept optimized	n-1
c - slope and intercept optimized	n-2

D.F.= error degrees of freedom used in computing mean squared error and R-squared

error statistics for original parameters:

Mean = mean error (bias)
Med = median error
Q3-Q1 = interquartile range (75th - 25th percentile)

*mean squared error for case b or c significantly lower than mean squared error for case a ($p<.05$)

mean error significantly different from zero at $p<.05$

log-normally distributed (Walker, 1981), the median would tend to be lower than the arithmetic mean for a given collection of measurements. This would cause a lower intercept for the EPA/NES data set and models which predict reservoir phosphorus. Differences between the mean April-October chlorophyll concentrations in the CE data set and the mean annual chlorophyll concentrations used in the OECD/RSL data set may also introduce some instability in model intercepts. Significant variations in model slope have been found only in the cases of models predicting transparency using the OECD/RSL data set. These variations are discussed below.

184. For each set of residuals calculated for data set a, Table 36 also lists the mean value, median value, and the inter-quartile range. Mean residuals are tested for significance (vs. 0) using a standard t-test. This test is equivalent to one for significant variations in the model intercept. The median and inter-quartile range are presented as robust measures of error bias and scale, respectively (Mosteller and Tukey, 1977).

185. Data from 94 CE reservoirs have been extracted from the EPA National Eutrophication Survey Compendium tape and used as one independent data set. Since this data set includes the reservoirs used in model calibration and is based, ultimately, upon the same set of tributary and impoundment measurements, it is not truly "independent". It has been included to permit model testing on a larger number of CE reservoirs (51 vs. 29 passing screening criteria). Since the EPA/NES employed a completely different set of data-reduction procedures (loading estimates, reservoir water quality summaries, screening), this data set also provides an indication of the sensitivity of model errors to these factors. To eliminate impoundments with possible errors in the nutrient balance estimates, twelve with reported phosphorus retention coefficients less than -.1 have been excluded from plots and error calculations; this value (vs. 0) allows for some statistical variability in the phosphorus loading and outflow estimates.

186. For the EPA/NES data set, significant adjustments in intercept are indicated for two models involving reservoir phosphorus.

With these adjustments, the loading models employing Pn as an independent variable explain between 61 and 71 percent of the variance in impoundment response variables. Explained variance is somewhat lower (44 - 64 percent) for models using Pv as an independent variable. The bias of -.073 log units for prediction of chlorophyll as a function of Pn might be related to seasonal factors, since the mean chlorophyll values computed by the EPA/NES include early spring (March) and late fall (November) sampling dates for many impoundments.

187. The TVA data set includes 10 tributary (storage) impoundments and 9 mainstem impoundments located on the Tennessee River and is derived primarily from work by Higgins and Kim (1981). Impoundment types are identified using different symbols on the plots in Appendix F. Compared with the tributary reservoirs, the mainstem impoundments tend to have higher non-algal turbidities and lower hydraulic residence times (.013 to .038 years vs. .12 to .69 years). Based upon the results of Parts V and VII, both of these factors would tend to inhibit the chlorophyll/phosphorus response. This is consistent with the over-prediction of chlorophyll in all mainstem impoundments by all models. Modifications of the model structures to account for turbidity and flushing controls (see Part V) would be needed to eliminate these biases. R-Squared values tend to be lower for this data set than for the others. This is attributed primarily to the relatively low variance in the observed data; mean squared errors are similar to and, in many cases, lower than errors determined for other data sets.

188. The OECD Reservoir and Shallow Lakes Project (Clasen, 1980) includes data from 8 shallow, natural lakes, 8 pumped-storage reservoirs, and 27 "semi-artificial" reservoirs from Europe, Japan, Australia, and North America. These are identified using different symbols on the plots in Appendix F. The pumped storage impoundments are formed by berms constructed on flat plains and, as such, are completely artificial; many have extremely high total phosphorus levels (exceeding 100 mg/m3). Error statistics are computed using data from the 27 "semi-artificial" reservoirs (impounded natural valleys), which are more typical of CE reservoirs than the other impoundment types included in

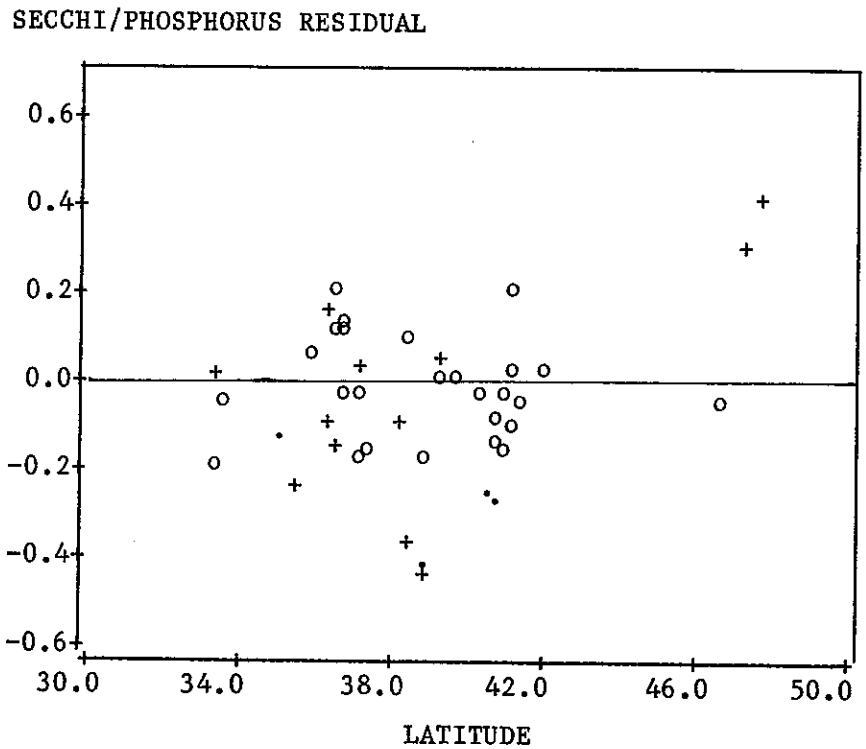
the OECD/RSL study.

189. The OECD reservoirs generally have lower non-algal turbidities than reservoirs in the other data sets; this may result primarily from the fact that most are located in northern, glaciated areas. All of the OECD/RSL impoundments in North America and Europe are above 42 degrees latitude, with the exception of Kerr Reservoir, a CE project in Virginia. CE reservoir models tend to under-predict transparency substantially (by roughly a factor of 2) in many of the OECD impoundments. Figure 39 plots the residuals from the phosphorus/transparency model as a function of latitude, using the CE data set. The tendency for positive residuals in northern latitudes is evident, although there are only three impoundments at latitudes higher than 42 degrees and two of these are potentially nitrogen-limited. Results of model testing in Part V indicate that phosphorus associated with non-algal turbidity tends to have somewhat greater effect on transparency than phosphorus associated with chlorophyll. The positive bias in the transparency models is consistent with the northern locations of most of the OECD reservoirs and latitude effects observed within the CE data set. Since the transparency (and other) models in Table 36 are based primarily upon data from projects below 42 degrees latitude, they cannot be reliably used in areas further north. Compilation of additional data from northern impoundments and modification of the models to account explicitly for effects of non-algal turbidity would be needed in order develop a single set of models which can be used in all CE Districts.

190. The OECD data set also includes many impoundments which are more highly enriched than those included in the CE data set. The OECD phosphorus/transparency plot suggests that the relationship flattens at total P concentrations exceeding about 100 mg/m3. Some of the bias in the transparency predictions may be attributed to impoundments above this value. The chlorophyll/transparency plot indicates that some of the OECD impoundments have non-algal turbidities which are less than zero. This suggests a possible bias in the chlorophyll light attenuation factor (.025 m2/mg) for these impoundments. Differences in

Figure 39

Phosphorus/Transparency Model Residuals vs. Latitude for CE Data Set



Model : log(S) = 1.18 - .66 log (P)

symbol	meaning
o	CE Reservoir
.	turbidity > 1.58 1/m
+	inflow N/P < 10

data-reduction procedures may also contribute to variations in the chlorophyll/transparency relationship, since the OECD data set includes mean, annual chlorophyll and median, annual Secchi depths.

191. Despite the transparency model biases, the CE loading models explain 77-88% of the variance in OECD total phosphorus data and 73-75% of the variance in OECD chlorophyll data, without significant adjustments in slope or intercept. Error variances for the OECD data set are similar to or higher than error variances for the other data sets, despite the fact that the OECD sampling programs were more intensive temporally than the EPA/NES sampling programs used in development of the CE data set.

192. Comparisons of error variance for the two alternative expressions for normalized phosphorus loading, each data set, and each response variable indicate that, with the exception of phosphorus predictions in the OECD/RSL data set, Pn is equal to or better than Pv as a predictor of impoundment response, despite its hydrologic independence. While use of spatial weighting factors for averaging within-pool measurements may shed additional light on the differences between these two loading expressions, independent tests do not provide any basis for rejecting the notion that average reservoir conditions can be predicted with knowledge of inflow phosphorus concentration and mean depth alone; except that observed chlorophyll levels will tend to be lower than predicted in reservoirs with residence times less than about .03 years.

Organic Nitrogen

193. Organic nitrogen has been suggested as a eutrophication indicator which is less sensitive to variations in nonalgal particulate materials than is total phosphorus; it has been included as a component in many of the various trophic state indices which have been proposed (Shannon and Brezonik, 1972; Boland, 1976; Taylor et al. ,1979; Witzig and Whitehurst, 1981). Primary productivity results in the conversion of inorganic to organic nitrogen in reservoirs, although a

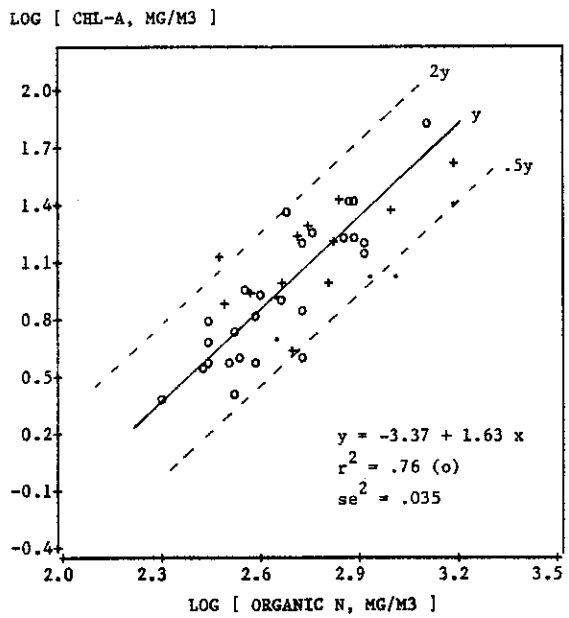
significant portion of the organic nitrogen may be allochthonous in some cases, especially those with significant point-source organic nitrogen loadings and low hydraulic residence times. The conversion of organic nitrogen to ammonia has been represented in various ecological models as a first-order process with a rate constant on the order of 0.1 day^{-1} at 20 degrees C (Zison et al., 1980). At this rate, over 90% would be expected to be converted in a period of 25 days. Since this is much longer than mean-annual or mean growing-season hydraulic residence times of most CE reservoirs and primary production is essentially the only other important source of reduced nitrogen, there would seem to be a potential for relating pool organic N measurements to indicators of eutrophication, including chlorophyll, transparency, and phosphorus. This potential is investigated below; relationships between organic N and other eutrophication measures are developed and incorporated into the model network.

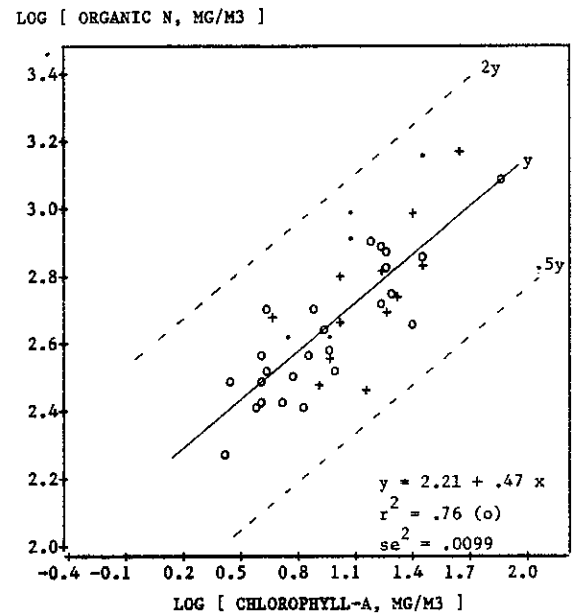
194. Models relating organic N to chlorophyll-a and total phosphorus are depicted in Figure 40. Residuals analyses indicate that the organic N models are somewhat more sensitive to inflow N/P or impoundment N/P ratio than are the other internal models. An inflow total N/P cutoff point of 10 seems to be more appropriate for distinguishing between N and P limitation than the cutoff point of 8 used for the other relationships. Accordingly, models involving organic N have been fit using data from 26 impoundments with inflow N/P ratios greater than 10 and non-algal turbidities less than 1.58 1/m.

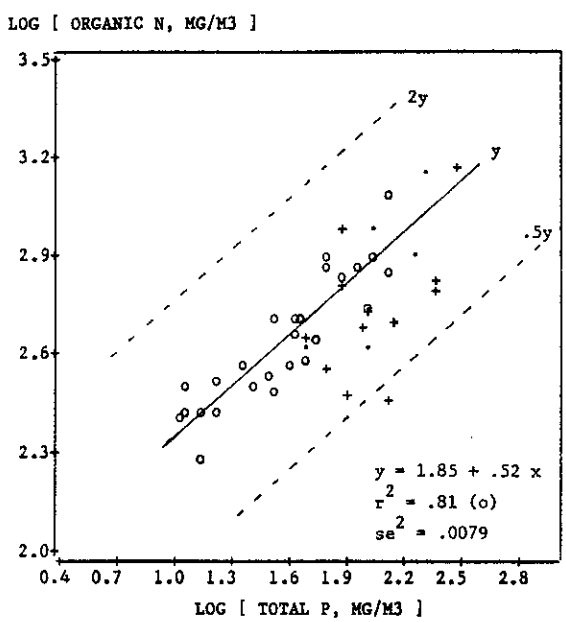
195. The regressions presented in Figure 40 indicate that chlorophyll and total phosphorus explain 76% and 81% of the variance in organic N, respectively. In contrast, for the same impoundments, total nitrogen explains only 60% of the organic N variance. This is consistent with phosphorus limitation of primary production, which results in conversion of inorganic N to organic N. Residuals plots indicate higher levels of organic N than those predicted by chlorophyll in three impoundments with hydraulic residence times less than .02 years; allochthonous organic N may be important in these reservoirs. Based upon the symbol distributions in Figure 40, the organic

Figure 40

Organic N/Phosphorus/Chlorophyll Relationships







symbol	meaning
o	CE reservoir
.	turbidity > 1.58 1/m
+	inflow N/P < 10

N/chlorophyll relationship seems to be relatively insensitive to N/P ratio; turbid reservoirs, however, tend to lie above the organic N/chlorophyll regression line, probably because a significant portion of the organic N in these impoundments is allochthonous and/or associated with non-algal particulates.

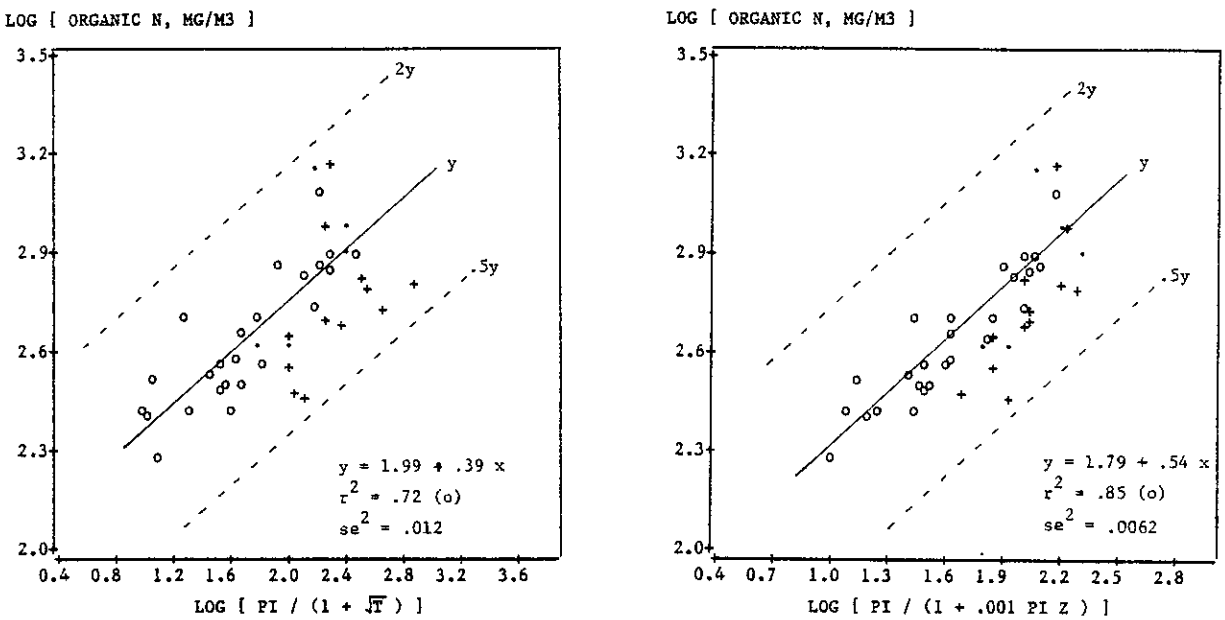
196. The reverse seems to be true for the organic N/total P relationship: turbid impoundments lie above and below the regression line, while most of the N-limited impoundments are below the line. The apparent lack of turbidity effect may be attributed to association of organic N and phosphorus with algal and non-algal particulates; this is analogous to the phosphorus/inverse transparency relationship in that variations in algal and non-algal particulates would tend to influence both measurements in the same direction (though not necessarily at the same rate). The potential for higher dissolved phosphorus levels would explain the locations of the N-limited impoundments in the organic N/total P plot.

197. Mean squared errors for predicting organic N as a function of chlorophyll-a and total phosphorus are .0099 and .0079, respectively, vs. errors in the range of .016 to .046 for other internal models in the network. The relatively high R-Squared values and low error variances suggest that organic nitrogen is a useful indicator of impoundment eutrophication. Because turbidity and N/P effects are apparently less strong, organic N is better than total phosphorus as a predictor of chlorophyll in the data set analyzed above (R2=.76 vs. R2=.66). This does not mean, however, that chlorophyll is nitrogen limited, since nitrogen supplies in these impoundments are in excess relative to algal physiologic requirements and the correlation of chlorophyll with total nitrogen is relatively weak (R2=.39). Essentially, organic N is a better "surrogate" variable for chlorophyll than is phosphorus or transparency, particularly when impoundments with short residence times are excluded.

198. Figure 41 shows the relationships between organic N and normalized phosphorus loadings. Regressions using Pv and Pn as independent variables explain 72% and 85% of the organic N variance with

Figure 41

Organic N/Normalized P Loading Relationships



symbol	meaning
o	CE reservoir
.	turbidity > 1.58 1/m
+	inflow N/P < 10

mean squared errors of .012 and .0062, respectively. Most of the N-limited and/or turbid impoundments tend to lie below the regression lines; allochthonous organic N may be important in one turbid reservoir with a strong positive residual and a residence time of .017 years.

199. The potential use of organic N (vs. chlorophyll) in eutrophication assessment opens up larger data sets for analysis, since chlorophyll-a measurements are limiting in many cases and organic N is much more commonly measured. Total Kjeldahl nitrogen (TKN) would also be expected to perform well as an indicator, since the bulk of the inorganic nitrogen entering reservoirs not subject to large point-source loadings is generally in nitrate form and its conversion to reduced nitrogen forms (ammonia and organic) is directly related to primary production. Additional investigations of TKN and organic carbon as indices of eutrophication are warranted, particularly considering their significance in relation to trihalomethane problems in drinking water (Dorin, 1980). Means for predicting the significance of allochthonous organic N, particularly in impoundments with short residence times, should also be researched.

Multivariate Analysis

200. Variations in total phosphorus, organic nitrogen, chlorophyll-a, and transparency from reservoir to reservoir partially reflect variations in algal densities and degree of eutrophication. As discussed previously, however, some of these measurements are influenced by factors unrelated to eutrophication, such as inorganic suspended solids loadings, organic nitrogen loadings, or color. Of these variables, chlorophyll is the most direct measure of algal standing crop, although it is not necessarily proportional to algal biomass and does not reflect other organic materials (detritus, zooplankton) which may result directly or indirectly from algal growth and which may have important water quality impacts, particularly on oxygen levels in the hypolimnion and near the sediment-water interface. The reliability of chlorophyll measurements is also limited by sampling error related to

high spatial and temporal variability and by variations in analytical procedures.

201. The method of partial correlation (Snedecor and Cochran,1972) can provide some useful insights into relationships among these measures of trophic state. Partial correlation coefficients among the four reservoir response measurements are given Table 37. The partial correlation coefficient "XY.Z" reflects the covariance between X and Y controlled for variations in Z. For example, if X and Y were regressed separately against Z, "XY.Z" would be the simple correlation coefficient between the residuals (observed minus predicted) from these regressions. Another way of interpreting "XY.Z" is as the correlation between X and Y for cases (reservoirs) having a fixed value of Z. When the network is controlled for variations in chlorophyll, correlations among the other three response measurements (phosphorus, transparency, and organic N) are at reduced but still significant levels. When the network is controlled for organic N, however, the phosphorus/chlorophyll and chlorophyll/transparency correlations become insignificant; this may reflect the relative strength of organic N as a trophic state indicator. The phosphorus/transparency correlation remains strong, even after controlling for both organic N and chlorophyll-a (r=-.71); this most likely reflects covariance attributed to non-algal suspended solids.

202. Given the relative strengths and weaknesses of these types of measurements as indicators of eutrophication, it is useful to summarize them in the form of one composite variable using a principle component analysis (Harris, 1975). This is the approach taken by Shannon and Brezonik (1972) and by Boland (1976) in developing regional, multivariate, trophic state indices for lakes. One advantage of a composite variable is that it helps to reduce the effects of <u>random</u> variations in the individual measurements. This pertains chiefly to analytical errors; it would not reduce biases attributed to unrepresentative sampling.

203. Results of a principle component analysis of the CE reservoir response measurements are summarized in Table 38. The first component explains 89% of the total variance in the individual measurements:

Table 37
Partial Correlation Coefficients Among Reservoir Response Measurements

Coefficient	--- Data Set --- All	Restricted
PB.	.717	.814
SB.	-.567	-.769
NB.	.799	.870
NP.	.764	.898
SP.	-.851	-.908
SN.	-.698	-.875
NP.B	.455	.663
SP.B	-.775	-.760
SN.B	-.494	-.654
PB.N	.275	.152
SP.N	-.688	-.573
SB.N	-.021	-.032
SP.NB	-.710	-.576

P = Total P
S = Secchi Depth
B = Chlorophyll-a
N = Organic N

XY.Z = correlation between X and Y controlled for variations in Z

All = 43 CE reservoirs
Restricted = 26 CE reservoirs with Turbidity < 1.58 1/m Inflow N/P > 10

All correlations on log scales

Table 38
Principal Components Analysis of Reservoir Response Measurements *

Correlation Matrix:

	Total P	Chl-a	Secchi	Org-N
Total P	1.000			
Chl-a	.814	1.000		
Secchi	-.908	-.769	1.000	
Org-N	.898	.870	-.875	1.000
Mean	1.540	.937	.155	2.650
Std. Dev.	.343	.370	.269	.198

Principal Components of Covariance Matrix:

Eigenvalue	.325	.029	.008	.004
R-Squared	.887	.079	.022	.012
Coefficients				
Total P	.577	.458	.658	-.156
Chl-a	.607	-.768	-.044	-.198
Secchi	-.436	-.446	.747	.229
Org-N	.330	.023	-.082	.940

* restricted data set (Table 37);log10 scales

$$PC1 = .57 \log(P) + .61 \log(B) - .44 \log(S) + .33 \log(No) \quad (67)$$

where,

PC1 = first principal component

P = total phosphorus (mg/m3)

B = chlorophyll-a (mg/m3)

S = transparency (m)

No = organic nitrogen (mg/m3)

In a principal component analysis, the relative values of the coefficients are selected to maximize the variance of each successive composite variable. Harris (1975) suggests that this procedure is essentially an "internal discriminant analysis". The high percentage of variance explained by the first component indicates that it is a useful statistic for discriminating among (or ranking) reservoirs. The R-Squared value of 89% indicates that, if each of the response measurements were regressed separately against PC1, a total of 89% of the variance would be explained.

204. The magnitude and scale of PC1 are somewhat arbitrary; computed values for CE reservoirs range from 1.4 to 3.5. Table 39 lists the CE reservoirs in the data set, sorted according to increasing PC1 value. The statistical procedure does not guarantee that PC1 is a "trophic state index"; for example, some of the covariance of phosphorus, transparency, and organic nitrogen represented by PC1 may still be attributed to allochthonous suspended solids. The chlorophyll term has the highest coefficient, however, so that a significant portion of the variance in PC1 should be attributed to variance in chlorophyll and algal standing crop. Since the analysis has been done using data from phosphorus-limited, low-turbidity reservoirs only, the significance of the phosphorus and transparency terms may be inflated in N-limited and/or turbid impoundments, as identified in Table 39.

205. Table 39 indicates that PC1 does a reasonable job of discriminating among reservoir "trophic states" assessed by the EPA/NES. The oligo/mesotrophic and meso/eutrophic boundaries lie at PC1

Table 39
CE Reservoirs Ranked Based upon PC1 Values

Code	Reservoir	*	PC1	P	B	S	No	Pn	Pv	TS
19343	Dale Hollow		1.44	1.01	0.56	0.64	2.41	1.15	0.97	OM
31077	Dworshak		1.45	1.11	0.38	0.40	2.28	0.96	1.04	O
03307	Beltzville		1.58	1.03	0.69	0.54	2.43	1.05	0.95	M
24013	Bull Shoals		1.63	1.20	0.60	0.60	2.52	1.12	1.03	M
17391	Summersville		1.68	1.11	0.79	0.55	2.42	1.21	1.29	M
17373	J.W. Flannagan		1.72	1.03	0.75	0.35	2.51	1.48	1.64	M
19122	Cumberland		1.74	1.19	0.58	0.23	2.43	1.40	1.55	M
16328	Allegheny		1.81	1.32	0.57	0.34	2.57	1.45	1.50	M
10003	Holt		1.83	1.38	0.41	0.09	2.50	1.43	1.53	E
24011	Beaver		1.89	1.49	0.59	0.33	2.49	1.47	1.49	M
24200	Table Rock		2.11	1.47	0.96	0.36	2.53	1.39	1.43	E
10411	Bankhead		2.15	1.60	0.60	0.08	2.70	1.60	1.73	E
25278	Tenkiller Ferry		2.17	1.58	0.82	0.21	2.57	1.57	1.77	E
18093	Monroe		2.19	1.49	0.86	0.21	2.71	1.40	1.25	E
30235	Sakakawea	n	2.26	1.86	0.87	0.36	2.48	1.65	2.01	O-E
19340	J. Percy Priest	n	2.33	1.65	1.00	0.25	2.65	1.81	1.98	E
18120	Barren River		2.34	1.65	0.93	0.07	2.59	1.60	1.61	E
06372	John H. Kerr		2.39	1.70	0.91	0.04	2.65	1.78	1.98	E
19342	Old Hickory	n	2.49	1.76	0.95	-0.12	2.55	1.81	1.95	E
29111	Pomona	t	2.53	1.66	0.93	-0.32	2.63	1.89	1.95	E
25267	Eufaula	nt	2.55	1.95	0.64	-0.35	2.67	1.99	2.33	E
25281	Wister	t	2.55	1.98	0.71	-0.23	2.64	1.77	1.75	E
17241	Atwood		2.58	1.62	1.22	-0.02	2.72	1.82	1.76	E
17256	Pleasant Hill		2.62	1.61	1.36	0.04	2.67	1.60	1.62	E
16243	Berlin		2.71	1.77	1.16	-0.07	2.90	2.04	2.24	E
20087	Shelbyville		2.75	1.84	1.23	-0.01	2.84	1.92	2.08	E
19119	Barkley	n	2.77	2.10	1.12	-0.16	2.46	1.91	2.06	E
04312	F.J. Sayers		2.78	1.98	1.26	0.08	2.75	1.97	2.14	E
29108	Milford	n	2.85	1.98	1.28	-0.07	2.73	2.01	2.63	E
16317	Shenango River		2.85	1.78	1.43	-0.03	2.87	1.87	1.90	E
29106	Kanopolis	nt	2.91	1.83	1.20	-0.46	2.81	2.18	2.84	E
18092	Mississinewa		2.92	2.02	1.20	-0.17	2.90	1.98	2.42	E
20081	Carlyle		2.92	1.93	1.24	-0.25	2.87	2.06	2.17	E
26355	Lewisville	nt	2.95	2.12	1.24	-0.20	2.70	2.02	2.20	E
17248	Delaware	t	2.95	2.01	1.04	-0.39	2.99	2.17	2.36	E
20088	Rend	n	2.95	1.85	1.37	-0.14	2.99	2.20	2.23	E
29207	Harlan County		3.12	2.10	1.44	-0.22	2.86	2.00	2.26	HE
17242	Beach City	t	3.12	2.22	1.04	-0.55	2.92	2.28	2.38	E
25105	John Redmond	nt	3.19	2.34	0.98	-0.73	2.80	2.25	2.50	E
25273	Keystone	nt	3.33	2.33	1.43	-0.44	2.83	1.97	2.49	E
17249	Dillon	t	3.36	2.27	1.42	-0.33	3.17	2.04	2.16	E
15237	Ashtabula	n	3.49	2.44	1.62	-0.13	3.16	2.15	2.27	E
17245	Charles Mill		3.50	2.10	1.83	-0.35	3.10	2.14	2.18	E

* n = inflow total N/P < 10 , t = non-algal turbidity > 1.58 1/m
PC1 = first principal component of P, B, S, and No (Table 38)
All data in log10 units:
P = reservoir total P (mg/m3) B = chlorophyll-a (mg/m3)
S = transparency (m) No = organic N (mg/m3)
Pn = Pi / (1 + .001 Pi Z) Pv = Pi / (1 + $\sqrt{T}$)
TS = "trophic state" assessed by EPA National Eutrophication Survey
(O=Oligotrophic,M=Mesotrophic,E=Eutrophic,HE=Hypereutrophic)

values of approximately 1.5 and 2.0, respectively. As discussed in Parts VI and VII, Lake Sakakawea is eutrophic at one end and oligotrophic at the other. Its intermediate ranking (PC1=2.26) refers to "average" conditions and is somewhat deceptive; this further emphasizes the need for considering spatial variations in some reservoirs.

206. The second principal component of the reservoir response measurements is given by the following expression:

$$PC2 = .46 \log(P) - .77 \log(B) - .45 \log(S) + .02 \log(No) \quad (68)$$

While this component accounts for only 8 percent of the response variance from the low-turbidity, P-limited reservoirs, it may be of some physical significance. Table 40 presents correlations between the first two principal components and various reservoir characteristics, using data from all 43 reservoirs in the CE load/response data set. While PC1 as a possible measure of eutrophication is correlated best with total P, chlorophyll, transparency, organic N, normalized phosphorus, and mean depth, PC2 is correlated best with the chlorophyll/secchi product (r=-.90) and non-algal turbidity (r=.80), as shown in Figure 42. As demonstrated in Part V, the product of chlorophyll and transparency is proportional to the fraction of light extinction attributed to chlorophyll-related substances; it is also proportional to the daily-integral photosynthetic rate per unit area under light-limited conditions, since it is directly related to the total amount of light absorbed by chlorophyll (Vollenweider and Kerekes, 1980). Thus, PC2 may be an indicator of the partitioning of light extinction (and nutrients) between algal-related and other substances. Comparing the coefficients for phosphorus (.46) and organic N (.02) indicates that the former has a greater tendency for association with non-algal substances; this is also reflected by the stronger correlation between organic N and chlorophyll than between total P and chlorophyll and by the partial correlation coefficients listed in Table 37. Table 41 lists data from 43 CE reservoirs, sorted by increasing PC2 value.

Table 40

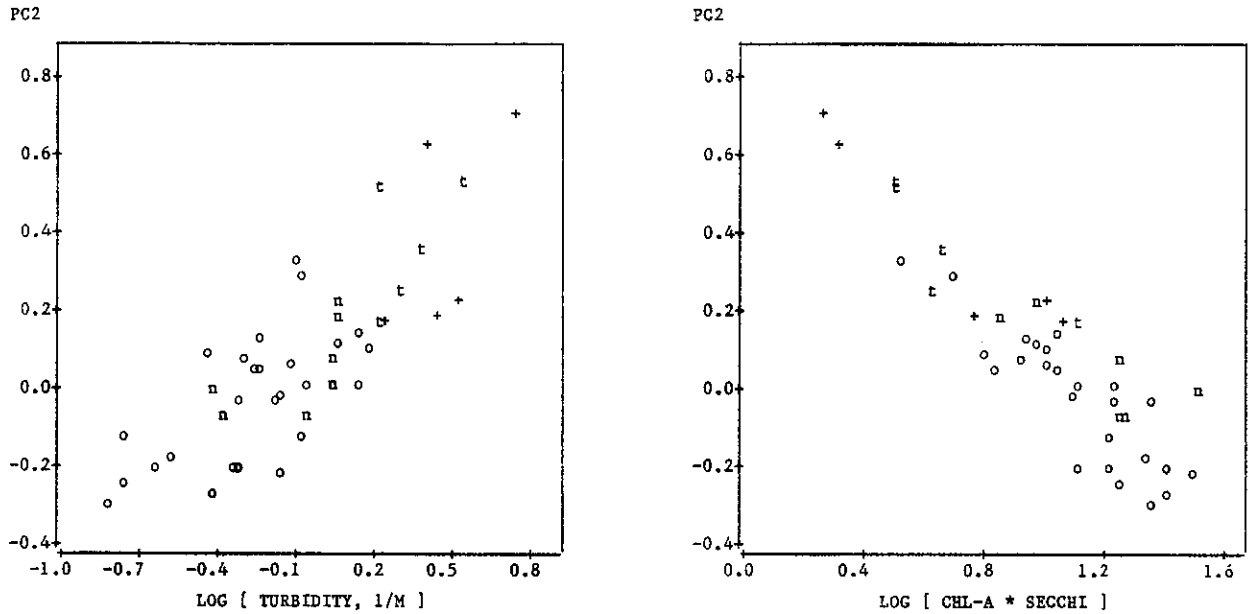
Correlations of Principal Components with Reservoir Characteristics

Measurement	Component PC1	PC2
Chlorophyll-a	.873	-.201
Transparency	-.865	-.645
Total P	.947	.499
Organic N	.876	.141
Chl-a × Transparency	.040	-.901
Non-Algal Turbidity	.655	.803
Mean Depth	-.827	-.304
Residence Time	-.349	-.329
Pi / (1 + .001 Pi Z)	.929	.431
Pi / (1 + $\sqrt{T}$)	.861	.453

PC1 and PC2 defined in Table 37;
all variables on log scales
based upon data from 43 reservoirs

Figure 42

Second Principal Component vs. Turbidity and Chlorophyll/Secchi Product



symbol	meaning
o	CE Reservoir
n	inflow N/P < 10
t	turbidity > 1.58 1/m
+	inflow N/P < 10, turbidity >.58 1/m

Table 41
CE Reservoirs Ranked Based upon PC2 values

Code	Reservoir	*	PC2	B*S	A	T
17391	Summersville		-0.29	1.34	-0.83	-1.25
17256	Pleasant Hill		-0.27	1.40	-0.44	-1.28
03307	Beltzville		-0.24	1.23	-0.78	-0.61
16317	Shenango River		-0.21	1.40	-0.36	-1.29
17245	Charles Mill		-0.21	1.48	-0.18	-1.54
17373	J.W. Flannagan		-0.20	1.10	-0.35	-0.38
19343	Dale Hollow		-0.20	1.20	-0.66	-0.12
24200	Table Rock		-0.17	1.32	-0.59	-0.23
17241	Atwood		-0.13	1.20	-0.09	-0.42
24013	Bull Shoals		-0.12	1.20	-0.78	-0.30
20088	Rend	n	-0.07	1.23	-0.07	-0.16
19340	J. Percy Priest	n	-0.06	1.25	-0.40	-0.66
04312	F.J. Sayers		-0.03	1.34	-0.34	-1.32
20087	Shelbyville		-0.03	1.22	-0.19	-0.68
18093	Monroe		-0.01	1.07	-0.17	-0.39
15237	Ashtabula	n	0.01	1.49	-0.43	-0.45
16243	Berlin		0.02	1.09	-0.07	-0.71
29108	Milford	n	0.02	1.21	0.02	-0.52
29207	Harlan County		0.02	1.22	0.13	0.16
19122	Cumberland		0.05	0.81	-0.27	-0.42
25278	Tenkiller Ferry		0.06	1.03	-0.28	-0.49
16328	Allegheny		0.07	0.91	-0.31	-0.75
18120	Barren River		0.07	1.00	-0.13	-0.82
30235	Sakakawea	n	0.08	1.23	0.03	0.12
31077	Dworshak		0.09	0.78	-0.46	-0.22
20081	Carlyle		0.11	0.99	0.16	-0.91
06372	John H. Kerr		0.12	0.95	0.05	-0.76
24011	Beaver		0.14	0.92	-0.25	0.01
18092	Mississinewa		0.14	1.03	0.13	-1.10
17249	Dillon	t	0.17	1.09	0.21	-1.77
26355	Lewisville	nt	0.17	1.04	0.22	0.02
29106	Kanopolis	nt	0.19	0.74	0.42	-0.90
19342	Old Hickory	n	0.19	0.83	0.05	-1.68
25273	Keystone	nt	0.23	0.99	0.51	-1.17
19119	Barkley	n	0.23	0.96	0.05	-1.66
29111	Pomona	t	0.25	0.61	0.28	-0.50
10411	Bankhead		0.30	0.68	-0.10	-1.38
10003	Holt		0.34	0.50	-0.12	-1.82
17248	Delaware	t	0.36	0.65	0.37	-1.57
17242	Beach City	t	0.53	0.49	0.52	-2.09
25281	Wister	t	0.53	0.48	0.20	-1.16
25267	Eufaula	nt	0.62	0.29	0.38	-0.35
25105	John Redmond	nt	0.71	0.25	0.72	-1.36

PC2 = second principal component (Table 38)
A = non-algal turbidity = 1/S - .025 B
B*S = secchi depth x chlorophyll-a (mg/m2)
T = mean hydraulic residence time (yrs)
* n = inflow N/P < 10 , t = turbidity > 1.58 1/m

207. Classification of reservoirs based upon PC1 and PC2 is shown in Figure 43, which plots PC2 against PC1 using different symbols to distinguish "N-limited" and "turbid" impoundments. The impoundments exceeding the non-algal turbidity limit of 1.58 1/m tend to lie in the upper right-hand region of the plot. The PC1 axis can be roughly considered as ranging from "oligotrophic" to "eutrophic", and the PC2 axis, from "algae-dominated" to "turbidity-dominated". Two impoundments (Holt and Bankhead) lie in the upper left-hand region of the plot, but are classified in the "low-turbidity" group. If the definition of "low-turbidity" were based upon chlorophyll/transparency product, rather than non-algal turbidity values, these reservoirs would be classified with the other impoundments with relatively high PC2 values (see Table 41). The models in Table 36 also tend to over-predict chlorophyll and transparency in these two impoundments. These results suggest that a classification system based upon PC2 or chlorophyll/Secchi product would be more appropriate than one based upon turbidity level. Future refinements in the model network should consider this revised classification system.

208. Regression analyses have been done to relate computed PC1 values to normalized phosphorus loading expressions, using data from 26 P-limited, low-turbidity impoundments:

$$PC1 = -.25 + 1.58\ Pn \qquad (R^2 = .89,\ SE^2 = .039) \tag{69}$$

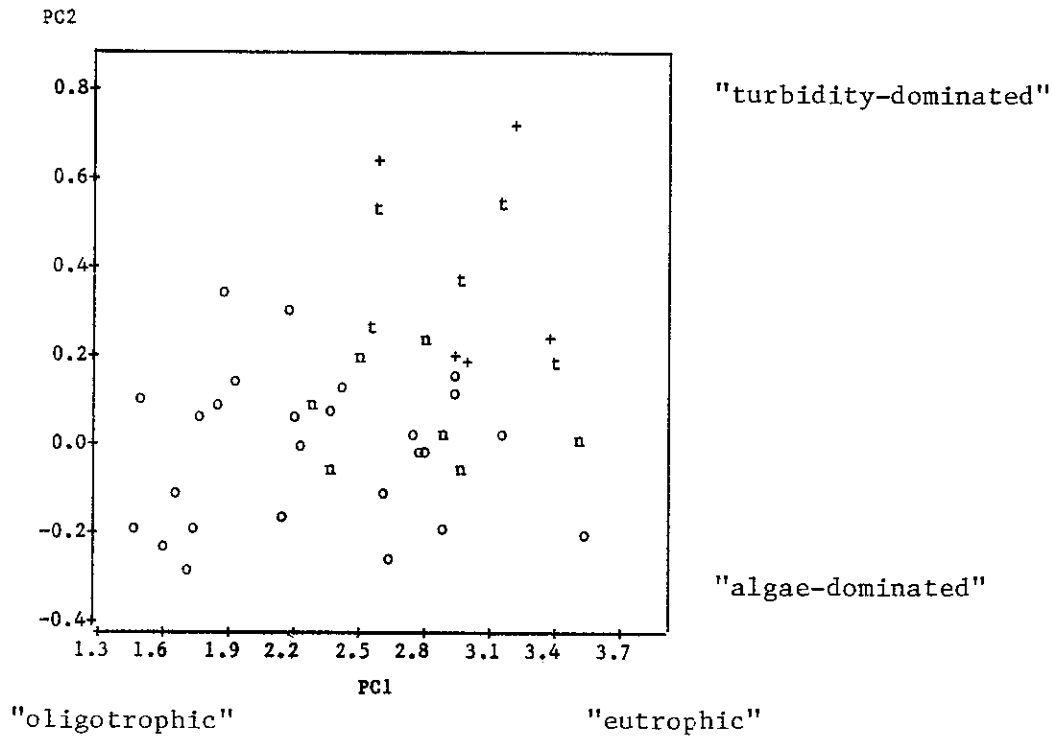
$$PC1 = .30 + 1.17\ Pv \qquad (R^2 = .78,\ SE^2 = .076) \tag{70}$$

The error variance for the Pn regression is about half that for the Pv regression. These relationships are depicted in Figure 44. The high percentages of variance explained by the normalized loading statistics indicate that impoundment rankings based upon Pn (or Pv) should be similar to those based upon PC1. Thus, both PC1 and the loading expressions are useful for predictive and ranking purposes.

209. The above equations relating PC1 to Pn and Pv are tested using the EPA/NES data set in Figure 45. Using data from P-limited, low-turbidity impoundments, R-Squared values are .77 and .59 for the Pn

Figure 43

Second Principal Component vs. First Principal Component

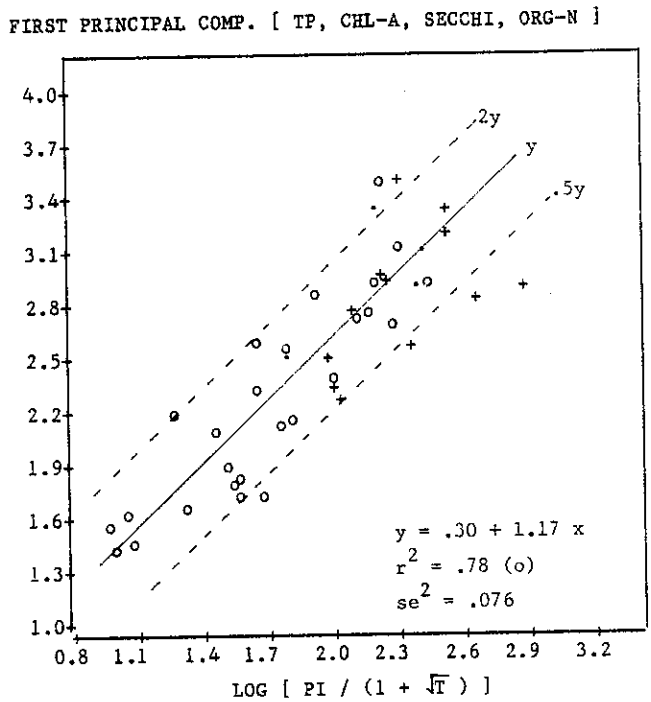


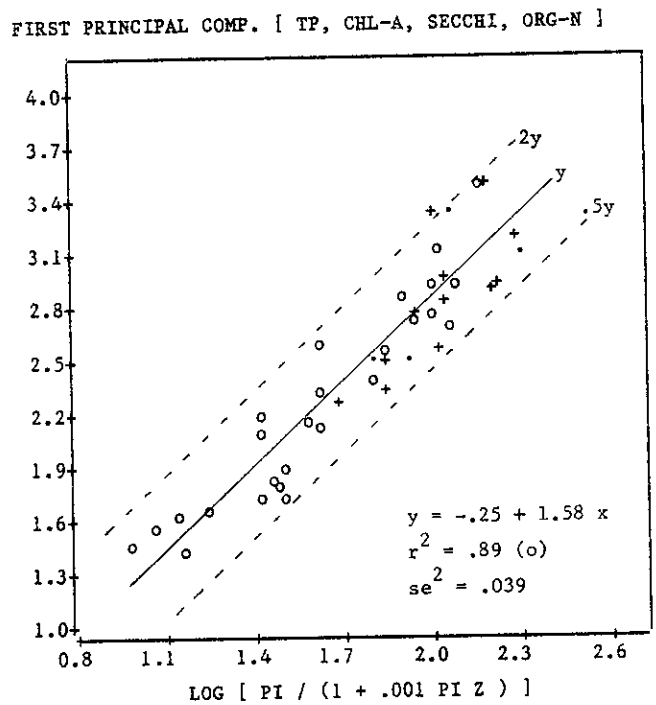
$$PC1 = .57 \log(P) + .61 \log(B) - .44 \log(S) + .33 \log(No)$$
$$PC2 = .46 \log(P) - .77 \log(B) - .45 \log(S) + .02 \log(No)$$

symbol	meaning
o	CE Reservoir
n	inflow N/P < 10
t	turbidity > 1.58 1/m
+	inflow N/P < 10, turbidity >1.58 1/m

Figure 44

First Principal Component vs. Normalized Phosphorus Loading Statistics: CE Data Set

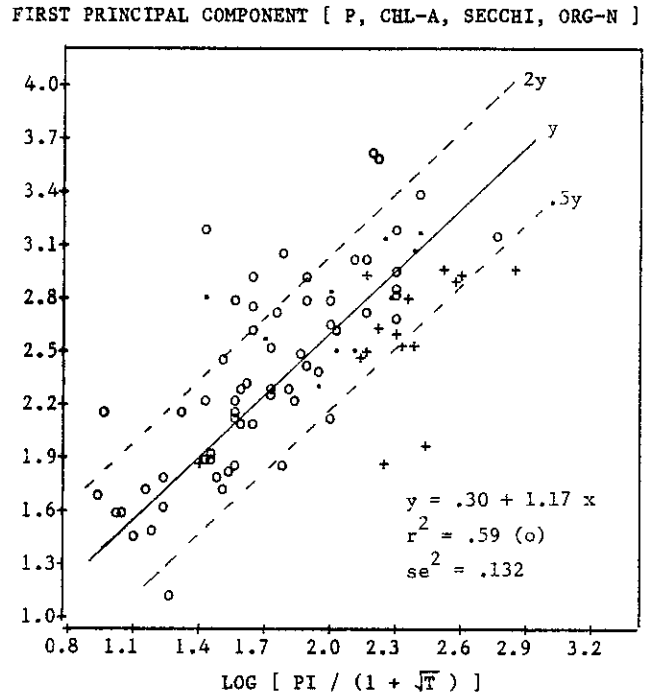


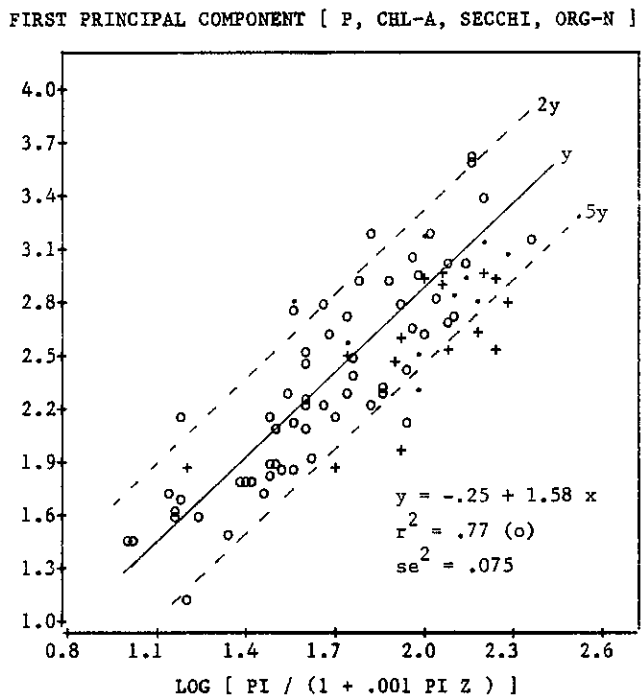


symbol	meaning
o	CE Reservoir
.	turbidity > 1.58 1/m
+	inflow N/P < 10

Figure 45

First Principal Component vs. Normalized Phosphorus Loading Statistics: EPA/NES Data Set





symbol	meaning
o	CE Reservoir
.	turbidity > 1.58 1/m
+	inflow N/P < 10

and Pv equations, respectively. Mean squared errors (.075 and .132, respectively) are higher than those in Figure 44; this may be related to differences in data reduction procedures and limited screening of the EPA/NES data.

210. Figures 44 and 45 show that the above equations work well for some N-limited and/or high-turbidity impoundments. In some cases, this may be attributed to offsetting biases in the calculation of PC1; for example, in a turbid impoundment, both chlorophyll and transparency would tend to be lower than predicted based upon the loading models, but the effects on PC1 would be partially cancelled out because these factors have opposite signs in the PC1 expression. Thus, the PC1/PC2 classification system does not completely separate eutrophication from turbidity effects. Using factor analysis techniques (Harris, 1975), it may be possible to expand upon the above results and to develop summary statistics which separate these factors and which consider nitrogen limitation. This is left for future work.

Error Analysis

211. In the data-reduction procedures described in Part IV, attempts were made to estimate the error variances associated with estimates of inflow nutrient concentrations and average water quality conditions for each impoundment. These error variances reflect spatial, temporal, sampling, and analytical variability in relation to the sampling program designs. Table 42 presents pooled estimates of total and error variance for impoundment response and inflow concentration variables. For the response measurements, between 4.8 and 10.3 percent of the total variance can be attributed to error variance; the remainder reflects true differences among reservoirs. Between 2.0 and 2.2 percent of variance in the normalized phosphorus loadings can be attributed to error. The 95% confidence factors for individual impoundment response values range from 1.36 to 1.75. The higher error in the case of chlorophyll reflects greater temporal, sampling, and/or analytical variability.

Table 42

Summary of Estimated Variance Components of Measurements Involved in Empirical Model Framework

Variable	Total(a) Variance	Error Variance	Percent Error	f95(d)
------ Reservoir-Average Conditions (b) ------				
Total P	.1332	.0071	5.3	1.47
Chl-a	.1429	.0147	10.3	1.75
Secchi	.0734	.0058	7.9	1.42
Organic N	.0630	.0030	4.8	1.36
----- Normalized Phosphorus Loadings (c) -----				
Pv	.1918	.0042	2.2	1.35
Pn	.1282	.0025	2.0	1.26

a Total variance reflects true differences among reservoirs and error variance, based upon data from 29 reservoirs with inflow N/P > 8 and non-algal turbidity < 1.58 1/m (.2 log units)

b Error variance reflects errors in estimating reservoir-average conditions based upon limited sampling (Part IV)

c Error variance reflects errors in estimating average inflow concentration based upon limited tributary sampling (Part IV)

$$Pv = Pi / (1 + \sqrt{T})$$
$$Pn = Pi / (1 + .001\ Pi\ Z)$$

d Approximate 95% confidence factor for impoundment mean value:

$$\hat{y} / f95 < y < \hat{y} * f95$$

212. The individual impoundment response statistics are generally less accurate than the inflow concentration statistics. This reflects an imbalance in the EPA/NES sampling program design: more than three or four sampling rounds per impoundment per year would have provided better estimates of average conditions. While the error variances are greater than desired for individual project assessments, their effects on model testing are minimal because they generally represent only a small fraction of the total variance across reservoirs.

213. Figure 46 summarizes all equations involved in the model network. Mean squared errors and 95% confidence factors are presented for total and model error components. The former is applicable for comparing predictions with observations based upon data similar to that used in model development (i.e., the EPA/NES sampling design). Model error variance is essentially the total error variance, corrected for the effects of data variance:

$$SE_m^2 = SE_t^2 - V_y - b^2 V_x \tag{71}$$

where,

SE_m^2 = model mean squared error

SE_t^2 = total mean squared error

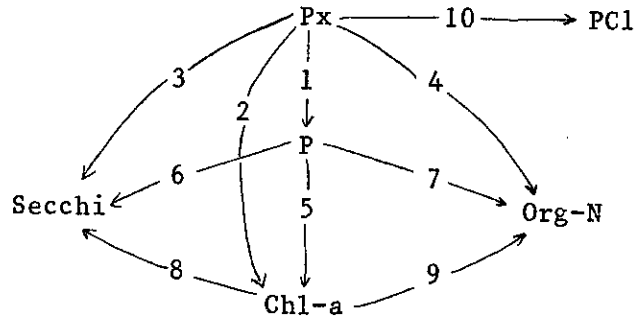
V_y = estimated data error variance of dependent variable

V_x = estimated data error variance of independent variable

b = regression slope

The above equation is approximate, because it assumes that the error variances in the dependent and independent variables are uncorrelated. Because covariance terms would be expected to be important in calculation of PC1, partitioning of model and data error is not feasible for models involving this statistic. Model error statistics would reflect expected error distributions derived from comparing predictions

Figure 46
Summary of Empirical Model Network Relating
Reservoir-Average Conditions



Model	y	x	a	b	R^2	SE^2	f95	SE^{*2}	f95*
1a	P	Pn	.00	1.00	.857	.0190	1.89	.0094	1.56
2a	Chl-a	Pn	-.48	.89	.717	.0435	2.63	.0268	2.13
3a	Secchi	Pn	1.26	-.69	.840	.0115	1.62	.0045	1.36
4a	Org-N	Pn	1.79	.54	.849	.0062	1.44	.0025	1.26
1b	P	Pv	.30	.76	.833	.0220	1.98	.0125	1.67
2b	Chl-a	Pv	-.15	.66	.561	.0630	3.18	.0465	2.70
3b	Secchi	Pv	1.08	-.56	.823	.0130	1.69	.0059	1.42
4b	Org-N	Pv	1.99	.39	.715	.0117	1.65	.0081	1.51
5	Chl-a	P	-.60	.98	.681	.0460	2.69	.0260	2.10
6	Secchi	P	1.18	-.66	.786	.0160	1.79	.0071	1.47
7	Org-n	P	1.84	.52	.807	.0079	1.51	.0030	1.29
8	Secchi	Chl-a	.65	-.59	.585	.0316	2.27	.0214	1.96
9	Org-N	Chl-a	2.21	.47	.756	.0099	1.58	.0037	1.32
10a	PC1	Pn	-.25	1.58	.886	.0386	2.47	-	-
10b	PC1	Pv	.30	1.17	.775	.0761	3.56	-	-

Equation: $\log(y) = a + b \log(x)$, units mg/m3, except Secchi (m)
All statistics are for non-algal turbidity < 1.58 1/m and inflow N/P > 8, except those involving org-N (inflow N/P > 10)
f95 = approx. 95% confidence factor: $\hat{y}/f95 < y < \hat{y}*f95$
Px = normalized Inflow P Concentration (Pv or Pn)
Pv = $Pi / (1 + \sqrt{T})$ Pn = $Pi / (1 + .001\ Pi\ Z)$
P = reservoir Total P Pi = Inflow Total P
PC1 = first principal component of P, Secchi, Chl-a, Org-N (R2=.887)
= .58 log(P) + .61 log(Chl-a) -.44 log(Secchi) + .33 log(org-N)
* estimated model mean squared error and f95, adjusted for data error component (see text and Table 41)

with error-free data (i.e., in the limit, data derived from highly intensive sampling programs).

214. All error statistics in Figure 46 refer to P-limited, low-turbidity impoundments. Chlorophyll values tend to be lower than predicted in N-limited and/or turbid impoundments. Based upon the results of residuals testing, the models also tend to over-predict transparency and chlorophyll in impoundments with residence times less than about .03 years. The framework is based largely upon data from reservoirs south of 42 degrees latitude. Tests described above indicate possible biases (particularly for transparency predictions) in reservoirs above this latitude. Augmentation of the data base would be required for development and testing of models applicable to northern impoundments.

215. Total and model errors for predicting transparency are generally lower than errors for predicting phosphorus or chlorophyll. This results from the relatively limited range of the Secchi measurement and from the phosphorus/transparency covariance attributed to non-algal suspended solids. The traditional approach to predicting transparency involves linkage of inflow P/pool P, pool P/chlorophyll, and chlorophyll/transparency models. This approach is clearly inferior to the direct inflow P/transparency model, based upon the error pathways depicted in Figure 46.

216. Predictions of chlorophyll are more uncertain than those of other response variables. Problems with the sampling and measurement of chlorophyll may be contribute to errors, along with variations of chlorophyll/biomass ratios as functions of algal species, growth stages, and environmental conditions. As demonstrated in Parts V and VI, errors can be reduced by incorporating the effects of turbidity, mean depth, and flushing rate on the chlorophyll/phosphorus response. This is a promising area for model improvement, although it is limited partially by the lack of a predictive basis for turbidity (or chlorophyll/transparency product).

217. As demonstrated in Part VI, spatial variance probably contributes to errors in all of the loading models and may influence

optimal model formulations and parameter estimates. These potential effects warrant additional investigation. Refinements to the network analysis should also consider parameter errors, more refined models, and possible application of path analysis techniques.

PART IX: GENERAL CONCLUSIONS

218. Specific recommendations regarding models in each category can be found at the ends of Parts V, VI, and VII. Some general conclusions are outlined below:

a. Empirical eutrophication models can be adapted for use for reservoirs, with expected errors which are similar in magnitude to those reported in "global" studies of natural lakes. Error variance for predicting chlorophyll is generally more than twice that for predicting phosphorus or transparency. This difference reflects temporal variability in the sizes and compositions of algal populations and variability in the chlorophyll measurement process, both of which tend to reduce the reliability of the station-mean or reservoir-mean chlorophyll estimates derived from limited numbers of sampling dates. Organic nitrogen is useful as a trophic state indicator in most reservoirs; it is highly correlated with chlorophyll and does not appear to be as strongly influenced by allochthonous suspended solids as are the total phosphorus or transparency measurements.

b. The following factors have been shown to be correlated with model residuals and to induce variability in the parameter estimates of phosphorus-based models in various categories:

    1. turbidity
    2. inflow and reservoir N/P ratios
    3. flushing
    4. mean depth
    5. inflow ortho-P/total P ratio
    6. sediment accumulation rate
    7. morphometric complexity

    Modifications of existing model structures to account for some or all of the above factors would result in significant reductions in error. In particular, about 70% of the residual variance from

models predicting chlorophyll as a function of normalized total phosphorus loading can be explained by effects of turbidity, mean depth, and/or inflow ortho-P/total P ratio. These effects are probably related to light-limitation and nutrient availability.

c. Since model applicability and potential biases, in many cases, depend upon turbidity and N/P ratio, predictive methods for these variables are needed if the models are to be used in a planning context.

d. Owing to data availability constraints, the regional distribution of the CE impoundments which have been used in model testing is heavily weighted in mid and southern latitudes of the U.S. (roughly, below 42 degrees). Because of regional geologic factors, the calibrated models may give biased predictions (particularly of transparency) in northern impoundments.

e. Since spatial gradients in phosphorus, chlorophyll, and transparency have been shown to be appreciable in many reservoirs, predictions of reservoir-average water quality conditions are potentially misleading. Modifications of these models to permit prediction of spatial variations would represent significant improvements.

f. Subsequent reports in this series will deal specifically with modifications of these models and recommendations concerning their use for evaluating and/or predicting water quality conditions in CE reservoirs.

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APPENDIX A

Morphometric Curve Parameters

This appendix contains a listing of estimated morphometric curve parameters* for 285 reservoirs, by reservoir.

Symbol	Meaning	
DIS	CE district code	
RES	CE reservoir code	
EMIN	minimum elevation with volume data	(ft,msl)
EMAX	maximum elevation with volume data	(ft,msl)
EZERO	base (zero-volume) elevation	(ft,msl)
C1-C5	morphometric curve parameters	

* Equations for using the parameters to estimate reservoir total depth, volume, and area at any elevation are given in Part III of the main text (equations 1-3); equations should not be used outside of EMIN - EMAX range.

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
01 NEW ENGLAND DIV	142 BUFFUMVILLE	493.0	524.0	477.8	2.15	1.88	0.000	0.000	0.0000
01 NEW ENGLAND DIV	144 EAST BRIMFIELD	619.0	653.0	619.0	0.20	3.10	-0.060	0.000	0.0000
01 NEW ENGLAND DIV	147 LITTLEVILLE	432.0	576.0	432.0	-15.08	10.64	-1.655	0.110	0.0000
01 NEW ENGLAND DIV	148 TULLY	625.0	668.0	625.0	1.58	-0.22	1.321	-0.177	0.0000
01 NEW ENGLAND DIV	150 WESTVILLE	515.0	572.0	515.0	-0.77	2.31	0.380	-0.244	0.0393
01 NEW ENGLAND DIV	151 BLACK ROCK	410.0	520.0	410.0	-16.16	21.50	-8.969	1.766	-0.1251
01 NEW ENGLAND DIV	152 COLEBROOK RIVER	567.0	761.0	567.0	8.07	-0.59	-0.536	0.283	-0.0260
01 NEW ENGLAND DIV	155 HANCOCK BROOK	454.0	484.0	454.0	1.65	1.09	0.491	-0.070	0.0000
01 NEW ENGLAND DIV	156 HOP BROOK	292.0	364.0	292.0	6.10	-15.70	10.661	-2.444	0.1975
01 NEW ENGLAND DIV	158 MANSFIELD HOLLO	195.0	257.0	195.0	-16.17	19.46	-5.998	0.891	-0.0474
01 NEW ENGLAND DIV	159 NORTHFIELD BROO	480.0	576.0	480.0	5.60	-2.78	0.840	0.012	-0.0085
01 NEW ENGLAND DIV	162 WEST THOMPSON	292.0	342.0	292.0	2.46	5.97	-3.916	1.204	-0.1187
01 NEW ENGLAND DIV	164 EDWARD MCDOWELL	904.0	946.0	904.0	-16.23	19.29	-5.366	0.547	0.0000
01 NEW ENGLAND DIV	165 EVERETT	325.0	418.0	325.0	-24.40	34.75	-15.027	2.953	-0.2083
01 NEW ENGLAND DIV	166 FRANKLIN FALLS	300.0	389.0	300.0	4.41	4.00	-1.939	0.526	-0.0466
01 NEW ENGLAND DIV	167 HOPKINTON	370.0	416.0	370.0	-11.36	13.03	-2.912	0.274	0.0000
01 NEW ENGLAND DIV	168 OTTER BROOK	670.0	781.0	670.0	65.96	-70.93	29.106	-5.025	0.3196
01 NEW ENGLAND DIV	169 SURRY MOUNTAIN	485.0	550.0	485.0	-12.64	13.63	-3.052	0.266	0.0000
01 NEW ENGLAND DIV	170 BALL MOUNTAIN	806.0	1017.0	806.0	1.63	-0.29	0.680	-0.085	0.0053
01 NEW ENGLAND DIV	172 NORTH HARTLAND	390.0	546.0	390.0	1.54	-1.23	1.892	-0.390	0.0275
01 NEW ENGLAND DIV	173 NORTH SPRINGFIE	450.0	546.0	450.0	-14.82	13.00	-2.499	0.194	0.0000
01 NEW ENGLAND DIV	174 TOWNSHEND	457.0	553.0	457.0	15.84	-17.04	8.366	-1.556	0.1060
02 NEW YORK	171 EAST BARRE	1165.0	1179.8	1138.2	4.38	1.52	0.000	0.000	0.0000
02 NEW YORK	176 WATERBURY	530.0	625.0	501.3	-37.39	29.99	-6.708	0.535	0.0000
02 NEW YORK	177 WRIGHTSVILLE	620.0	715.0	607.4	1.91	1.54	0.070	0.000	0.0000
03 PHILADELPHIA	307 BELTZVILLE	501.0	672.0	501.0	11.38	-13.13	6.658	-1.219	0.0820
03 PHILADELPHIA	313 FRANCIS E WALTE	1250.0	1474.0	1250.0	-16.13	18.69	-6.511	1.090	-0.0643
03 PHILADELPHIA	316 PROMPTON	1090.0	1205.0	1090.0	22.33	-29.31	14.793	-2.861	0.1976
04 BALTIMORE	227 ALMOND	1229.0	1300.0	1229.0	-5.44	4.45	-0.216	0.000	0.0000
04 BALTIMORE	229 WHITNEY POINT	950.0	1025.0	935.0	-23.36	-10.62	18.238	-5.175	0.4520
04 BALTIMORE	306 ALVIN R BUSH (K	810.0	937.0	806.7	-4.32	3.69	-0.102	0.000	0.0000
04 BALTIMORE	310 CURWENSVILLE	1126.0	1228.0	1126.0	-22.79	27.66	-10.379	1.909	-0.1317

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
04 BALTIMORE	312 F J SAYERS (BLA	580.0	657.0	580.0	-38.46	30.15	-6.019	0.239	0.0365
04 BALTIMORE	320 RAYSTOWN	600.0	826.0	600.0	16.06	-13.40	5.290	-0.743	0.0384
04 BALTIMORE	329 STILLWATER	1568.0	1621.0	1563.4	1.83	2.11	-0.143	0.020	0.0000
04 BALTIMORE	398 BLOOMINGTON	1240.0	1509.0	1240.0	-29.59	30.33	-9.685	1.431	-0.0772
04 BALTIMORE	401 SAVAGE	1313.0	1469.0	1313.0	-3.86	2.73	0.000	0.000	0.0000
06 WILMINGTON	233 B EVERETT JORDA	154.0	260.0	154.0	11.40	-9.30	3.684	-0.334	0.0000
06 WILMINGTON	372 JOHN H KERR	193.0	330.0	193.0	14.40	-16.88	9.166	-1.772	0.1244
06 WILMINGTON	375 PHILPOTT	805.0	1016.0	805.0	15.62	-18.17	8.553	-1.485	0.0938
07 CHARLESTON	232 W KERR SCOTT	970.0	1075.0	951.8	13.11	-16.07	7.752	-1.302	0.0779
08 SAVANNAH	074 CLARK HILL	190.0	346.0	190.0	189.25	-112.96	23.479	-1.571	0.0000
08 SAVANNAH	330 HARTWELL	475.0	674.0	475.0	-33.48	24.74	-4.945	0.379	0.0000
09 JACKSONVILLE	066 OCKLAWAHA(RODMA	0.0	23.0	-13.4	-18.10	11.36	-0.848	0.000	0.0000
10 MOBILE	001 CLAIBORNE	2.0	50.0	0.8	-0.77	3.43	1.317	-0.641	0.0768
10 MOBILE	003 HOLT	115.0	202.0	115.0	4.67	0.41	0.485	-0.047	0.0000
10 MOBILE	004 JONES BLUFF	64.0	140.0	61.6	-47.09	40.88	-10.228	0.923	0.0000
10 MOBILE	008 MILLERS FERRY	17.0	100.0	14.1	11.54	-27.39	20.691	-5.341	0.4725
10 MOBILE	069 ALLATOONA	700.0	860.0	700.0	-31.00	36.67	-13.061	2.039	-0.1083
10 MOBILE	070 GEORGE W ANDREW	62.0	108.0	62.0	67.60	-66.51	22.390	-2.333	0.0000
10 MOBILE	071 SEMINOLE (WOODR	44.0	79.0	44.0	3.32	2.01	0.221	-0.006	0.0000
10 MOBILE	072 WALTER F GEORGE	100.0	200.0	96.9	-6.29	10.79	-2.890	0.327	0.0000
10 MOBILE	073 WEST POINT	560.0	645.0	560.0	15.32	-7.81	2.551	-0.197	0.0000
10 MOBILE	075 CARTERS	660.0	1099.0	660.0	8.11	-8.25	4.250	-0.741	0.0471
10 MOBILE	076 SIDNEY LANIER	920.0	1086.0	920.0	1.89	1.68	0.236	-0.014	0.0000
10 MOBILE	411 BANKHEAD	200.0	270.0	175.0	29.48	-28.90	12.446	-2.101	0.1291
11 BUFFALO	228 MT MORRIS	584.2	760.0	578.1	1.21	4.01	-1.062	0.229	-0.0176
14 ROCK ISLAND	098 CORALVILLE	652.0	712.0	652.0	18.04	-12.66	4.514	-0.420	0.0000
14 ROCK ISLAND	099 RED ROCK	690.0	780.0	690.0	-0.33	3.11	0.037	0.000	0.0000
15 ST PAUL	178 GULL	1192.8	1194.8	1121.8	6.24	1.36	0.101	-0.009	0.0000
15 ST PAUL	179 LAC QUI PARLE	924.0	948.0	918.2	8.42	-1.44	1.214	-0.132	0.0000
15 ST PAUL	182 ORWELL	1038.0	1075.0	1034.8	5.73	-1.28	0.372	0.219	-0.0388
15 ST PAUL	184 POKEGAMA	1270.4	1276.4	1173.2	-2.10	2.71	0.196	-0.017	0.0000
15 ST PAUL	186 WINNIBIGOSHISH	1294.9	1303.1	1241.0	-39.37	34.25	-8.345	0.772	0.0000

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
15 ST PAUL	187 PINE RIVER	1227.3	1230.3	1157.1	2.08	2.52	0.000	0.000	0.0000
15 ST PAUL	236 HOMME	1048.0	1092.3	1018.0	54.72	-77.65	35.958	-6.616	0.4364
15 ST PAUL	237 ASHTABULA (BALD	1238.0	1275.0	1222.6	6.14	-10.63	7.807	-1.765	0.1419
15 ST PAUL	399 EAU GALLE	925.0	1010.0	925.0	12.44	-9.49	4.760	-0.885	0.0612
16 PITTSBURGH	243 BERLIN	949.0	1032.0	949.0	6.24	-6.59	3.649	-0.626	0.0446
16 PITTSBURGH	252 MICHAEL J KIRWA	930.0	993.0	930.0	-15.26	14.66	-3.074	0.261	0.0000
16 PITTSBURGH	254 MOSQUITO CREEK	869.0	907.0	869.0	-7.16	7.42	-0.569	-0.010	0.0000
16 PITTSBURGH	308 CONEMAUGH RIVER	848.0	986.0	848.0	-31.25	39.79	-16.277	3.045	-0.2056
16 PITTSBURGH	309 CROOKED CREEK	804.0	940.0	804.0	18.97	-19.68	8.941	-1.535	0.0959
16 PITTSBURGH	311 EAST BRANCH CLA	1523.0	1685.0	1523.0	2.90	-5.30	3.755	-0.707	0.0469
16 PITTSBURGH	314 LOYALHANNA	869.0	975.0	869.0	-17.83	18.20	-6.828	1.407	-0.1053
16 PITTSBURGH	315 MAHONING CREEK	1010.0	1162.0	1010.0	28.15	-28.67	12.689	-2.366	0.1677
16 PITTSBURGH	317 SHENANGO RIVER	881.2	919.0	873.5	-6.66	17.64	-7.989	1.754	-0.1396
16 PITTSBURGH	318 TIONESTA	1043.0	1180.0	1043.0	-11.09	9.92	-1.714	0.132	0.0000
16 PITTSBURGH	319 YOUGHIOGHENY RI	1313.0	1480.0	1313.0	-1.00	2.40	0.376	-0.104	0.0078
16 PITTSBURGH	322 WOODCOCK	1138.0	1210.0	1138.0	-6.51	5.90	-0.708	0.053	0.0000
16 PITTSBURGH	328 ALLEGHENY (KINZ	1195.0	1365.0	1195.0	-49.86	52.27	-18.169	2.912	-0.1723
16 PITTSBURGH	393 TYGART	960.0	1167.0	960.0	50.44	-45.10	16.530	-2.522	0.1423
17 HUNTINGTON	123 DEWEY	600.0	686.0	600.0	5.71	-4.55	2.271	-0.216	0.0000
17 HUNTINGTON	124 FISHTRAP	670.0	825.0	670.0	16.28	-12.03	3.788	-0.312	0.0000
17 HUNTINGTON	125 GRAYSON	585.0	681.0	585.0	20.72	-19.48	7.870	-1.159	0.0602
17 HUNTINGTON	239 PAINT CREEK	748.0	860.0	748.0	11.65	-13.14	7.075	-1.350	0.0948
17 HUNTINGTON	241 ATWOOD	890.0	941.0	887.2	-0.83	2.57	0.248	-0.040	0.0000
17 HUNTINGTON	242 BEACH CITY	948.4	977.0	936.3	-0.33	3.88	-0.461	0.068	0.0000
17 HUNTINGTON	245 CHARLES MILL	989.9	1020.0	985.0	4.31	0.64	0.628	-0.070	0.0000
17 HUNTINGTON	246 CLENDENING	862.0	911.0	857.2	0.24	0.75	0.969	-0.121	0.0000
17 HUNTINGTON	247 DEER CREEK	765.0	835.0	765.0	-46.44	37.66	-8.851	0.748	0.0000
17 HUNTINGTON	248 DELAWARE	880.0	947.0	880.0	-16.13	15.07	-3.341	0.317	0.0000
17 HUNTINGTON	249 DILLON	700.0	790.0	700.0	-9.47	7.00	-0.469	0.000	0.0000
17 HUNTINGTON	251 LEESVILLE	954.0	978.0	906.2	2.96	-1.56	1.322	-0.127	0.0000
17 HUNTINGTON	255 PIEDMONT	881.8	924.6	877.3	-1.27	3.93	-0.132	-0.015	0.0000
17 HUNTINGTON	256 PLEASANT HILL	972.0	1065.0	972.0	0.38	2.20	0.044	0.000	0.0000

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
17 HUNTINGTON	257 SENECAVILLE	812.5	843.0	804.3	5.82	-1.22	1.363	-0.168	0.0000
17 HUNTINGTON	258 TAPPAN	893.9	909.0	856.6	-2.70	4.16	-0.174	0.000	0.0000
17 HUNTINGTON	259 BURR OAK(TOM JE	689.0	740.0	689.9	0.08	3.41	-0.341	0.033	0.0000
17 HUNTINGTON	261 WILLS CREEK	733.0	779.0	716.8	37.62	-30.99	9.745	-0.904	0.0000
17 HUNTINGTON	373 JOHN W FLANNAGA	1210.0	1450.0	1210.0	-1.72	3.25	-0.441	0.055	0.0000
17 HUNTINGTON	374 NORTH FORK OF P	1550.0	1667.0	1550.0	10.78	-7.32	2.374	-0.183	0.0000
17 HUNTINGTON	389 BLUESTONE	1368.0	1520.0	1368.0	-9.77	13.99	-4.330	0.704	-0.0427
17 HUNTINGTON	390 EAST LYNN	653.9	701.0	613.8	0.91	0.17	0.945	-0.103	0.0000
17 HUNTINGTON	391 SUMMERSVILLE	1375.0	1711.7	1375.0	5.27	-1.28	0.446	0.000	0.0000
17 HUNTINGTON	392 SUTTON	810.0	1000.0	810.0	5.41	-6.32	3.879	-0.702	0.0460
17 HUNTINGTON	406 MOHICANVILLE	932.0	963.0	929.6	3.24	-2.03	2.237	-0.280	0.0000
18 LOUISVILLE	090 CAGLES MILL	631.9	704.0	588.6	0.89	2.41	0.000	0.000	0.0000
18 LOUISVILLE	091 HUNTINGTON	715.0	798.0	715.0	1.46	-4.46	5.500	-1.510	0.1391
18 LOUISVILLE	092 MISSISSINEWA	665.0	779.0	665.0	12.40	-12.36	6.817	-1.383	0.1054
18 LOUISVILLE	093 MONROE	490.0	556.0	490.0	62.57	-74.76	35.286	-6.930	0.4995
18 LOUISVILLE	094 SALAMONIE	684.0	793.0	680.0	-7.61	13.91	-6.429	1.465	-0.1136
18 LOUISVILLE	095 C M HARDEN (MAN	597.0	712.0	597.0	11.83	-12.57	6.691	-1.250	0.0850
18 LOUISVILLE	097 BROOKVILLE	628.0	775.0	628.0	19.40	-13.06	3.793	-0.289	0.0000
18 LOUISVILLE	120 BARREN RIVER	478.0	618.0	484.4	5.44	-2.05	1.945	-0.349	0.0230
18 LOUISVILLE	121 BUCKHORN	715.0	840.0	715.0	-25.32	35.99	-15.030	2.814	-0.1893
18 LOUISVILLE	126 GREEN RIVER	590.0	713.0	590.0	24.87	-34.35	17.247	-3.261	0.2199
18 LOUISVILLE	128 NOLIN RIVER	415.0	560.0	415.0	-2.10	6.11	-2.316	0.558	-0.0431
18 LOUISVILLE	129 ROUGH RIVER	430.0	524.0	420.7	25.73	-29.79	13.383	-2.278	0.1396
18 LOUISVILLE	134 CAVE RUN	656.0	765.0	656.0	-27.30	19.81	-3.435	0.226	0.0000
18 LOUISVILLE	260 WEST FORK OF MI	636.0	702.0	636.0	-14.53	7.85	-0.512	0.000	0.0000
18 LOUISVILLE	263 CLARENCE J BROW	965.0	1023.0	965.0	-4.90	5.22	-0.295	-0.005	0.0000
19 NASHVILLE	119 BARKLEY	280.0	375.0	280.0	-475.55	506.89	-197.200	33.812	-2.1433
19 NASHVILLE	122 CUMBERLAND (WOL	545.0	773.0	545.0	41.51	-35.57	13.033	-1.896	0.0998
19 NASHVILLE	337 CENTER HILL	525.0	685.0	477.7	11.50	-4.81	1.707	-0.131	0.0000
19 NASHVILLE	338 CHEATHAM	345.0	399.0	345.0	-26.45	30.02	-8.659	0.899	0.0000
19 NASHVILLE	340 J PERCY PRIEST	405.0	504.5	399.6	-25.64	21.84	-4.736	0.396	0.0000
19 NASHVILLE	342 OLD HICKORY	385.0	450.1	385.0	18.12	-16.50	9.331	-2.094	0.1769

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
19 NASHVILLE	343 DALE HOLLOW	508.0	663.0	508.0	25.48	-16.71	4.759	-0.373	0.0000
20 ST LOUIS	081 CARLYLE	406.0	465.0	406.0	-82.81	97.80	-39.983	7.462	-0.5176
20 ST LOUIS	087 SHELBYVILLE	546.0	626.0	546.0	4.71	0.92	0.243	0.000	0.0000
20 ST LOUIS	088 REND	379.0	411.4	379.0	39.95	-46.10	24.148	-5.265	0.4269
21 MEMPHIS	196 WAPPAPELLO	320.0	420.0	310.5	69.94	-77.44	31.480	-5.163	0.3050
22 VICKSBURG	014 DE GRAY	210.0	450.0	210.0	-6.22	7.52	-1.613	0.187	-0.0035
22 VICKSBURG	018 GREESON (NARROW	396.0	586.0	396.0	-6.03	5.06	-0.574	0.060	0.0000
22 VICKSBURG	019 OUACHITA (BLAKE	380.0	616.0	380.0	9.33	-9.07	4.029	-0.540	0.0261
22 VICKSBURG	188 ARKABUTLA	189.0	264.0	189.0	3.87	-6.15	6.251	-1.561	0.1331
22 VICKSBURG	189 ENID	194.0	293.0	194.0	-33.25	25.88	-5.197	0.395	0.0000
22 VICKSBURG	190 GRENADA	160.0	256.0	160.0	82.72	-93.62	40.957	-7.485	0.5027
22 VICKSBURG	192 SARDIS	204.0	311.0	204.0	20.38	-22.43	11.710	-2.275	0.1596
23 NEW ORLEANS	138 WALLACE	130.0	176.0	130.0	-16.65	22.08	-7.123	1.110	-0.0600
23 NEW ORLEANS	352 LAKE OF THE PIN	185.0	255.0	180.1	20.35	-30.95	16.637	-3.203	0.2153
23 NEW ORLEANS	353 TEXARKANA(WRIGH	180.0	265.0	180.0	-23.90	14.23	-1.232	0.000	0.0000
23 NEW ORLEANS	413 CADDO	160.0	184.0	160.0	7.80	1.97	-0.084	0.012	0.0000
24 LITTLE ROCK	011 BEAVER	914.0	1142.0	914.0	-11.71	9.47	-1.476	0.115	0.0000
24 LITTLE ROCK	012 BLUE MOUNTAIN	354.0	445.0	348.7	4.85	-4.55	2.677	-0.278	0.0000
24 LITTLE ROCK	013 BULL SHOALS	452.0	708.0	452.0	14.83	-11.66	5.246	-0.839	0.0499
24 LITTLE ROCK	016 GREERS FERRY	272.0	503.0	272.0	-16.46	23.62	-9.395	1.751	-0.1152
24 LITTLE ROCK	017 DARDANELLE	287.0	354.0	287.0	5.40	0.54	0.330	0.007	0.0000
24 LITTLE ROCK	021 NIMROD	300.0	400.0	300.0	41.73	-33.38	9.889	-0.859	0.0000
24 LITTLE ROCK	022 NORFOLK	380.0	590.0	363.3	0.08	-3.36	3.238	-0.602	0.0388
24 LITTLE ROCK	023 OZARK	365.4	382.0	323.0	149.66	-190.53	92.589	-19.431	1.5114
24 LITTLE ROCK	193 CLEARWATER	460.0	608.0	460.0	0.41	0.75	1.511	-0.380	0.0311
24 LITTLE ROCK	200 TABLE ROCK	695.0	947.0	695.0	-6.14	6.21	-0.780	0.065	0.0000
25 TULSA	020 MILLWOOD	213.0	287.0	213.0	129.96	-113.15	33.325	-3.084	0.0000
25 TULSA	102 COUNCIL GROVE	1224.0	1289.0	1224.0	14.00	-13.64	5.483	-0.563	0.0000
25 TULSA	103 ELK CITY	760.0	825.0	760.0	-4.02	14.76	-8.002	2.053	-0.1809
25 TULSA	104 FALL RIVER	917.0	988.0	917.0	51.63	-60.24	27.815	-5.282	0.3675
25 TULSA	105 JOHN REDMOND	1009.0	1076.0	1009.0	79.39	-107.30	54.219	-11.317	0.8581
25 TULSA	107 MARION	1308.0	1363.0	1308.0	37.05	-49.57	26.155	-5.541	0.4279

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
25 TULSA	112 TORONTO	862.0	942.0	862.0	15.30	-16.78	7.353	-1.039	0.0467
25 TULSA	264 BROKEN BOW	424.0	628.0	424.0	8.54	-8.79	4.606	-0.745	0.0426
25 TULSA	265 CANTON	1580.0	1638.0	1580.0	9.83	-9.14	6.436	-1.476	0.1208
25 TULSA	266 CHOUTEAU	480.0	530.0	480.0	6.53	-3.24	1.875	-0.185	0.0000
25 TULSA	267 EUFAULA	495.0	612.0	495.0	-11.20	10.35	-1.104	-0.094	0.0249
25 TULSA	268 FORT GIBSON	550.6	582.0	465.8	-8.76	4.99	-0.039	0.000	0.0000
25 TULSA	269 FORT SUPPLY	1988.0	2028.0	1988.0	2.74	3.49	-0.735	0.168	-0.0138
25 TULSA	270 GREAT SALT PLAI	1115.0	1138.5	1115.0	-5.05	12.53	-3.432	0.388	0.0000
25 TULSA	271 HEYBURN	730.0	792.0	730.0	-38.41	57.48	-28.794	6.473	-0.5239
25 TULSA	272 HULAH	696.0	765.0	696.0	26.60	-21.56	7.147	-0.670	0.0000
25 TULSA	273 KEYSTONE	648.0	760.0	654.0	7.47	-0.29	0.472	-0.017	0.0000
25 TULSA	274 NEWT GRAHAM	500.0	550.0	487.2	-2.21	4.03	-0.343	0.034	0.0000
25 TULSA	275 OOLOGAH	592.0	661.0	586.3	12.02	-4.06	1.611	-0.128	0.0000
25 TULSA	276 PINE CREEK	384.0	480.0	384.0	-36.97	48.65	-20.999	4.136	-0.2945
25 TULSA	277 ROBERT S KERR	412.0	472.0	412.0	19.21	-12.96	4.418	-0.382	0.0000
25 TULSA	278 TENKILLER FERRY	594.0	667.0	483.7	-2.11	4.04	-0.331	0.029	0.0000
25 TULSA	279 W D MAYO	390.0	414.0	390.0	4.32	-0.67	1.890	-0.540	0.0566
25 TULSA	280 WEBBERS FALLS	438.0	520.0	438.0	-13.79	15.19	-3.596	0.355	0.0000
25 TULSA	281 WISTER	436.0	510.0	436.0	56.89	-48.44	14.765	-1.362	0.0000
25 TULSA	282 CLAYTON	530.0	611.0	530.0	58.68	-72.41	33.744	-6.433	0.4477
25 TULSA	283 KAW	931.0	1070.0	931.0	4.86	-5.30	4.077	-0.807	0.0569
25 TULSA	284 COPAN	670.0	732.0	670.0	175.79	-206.25	89.505	-16.551	1.1262
25 TULSA	285 HUGO	360.0	438.0	360.0	11.68	-14.64	7.871	-1.343	0.0765
25 TULSA	286 OPTIMA	2703.0	2779.0	2703.0	-9.81	11.49	-2.368	0.207	0.0000
25 TULSA	287 WAURIKA	890.0	970.0	890.0	30.29	-41.85	22.048	-4.525	0.3350
25 TULSA	348 TEXOMA (DENNISO	520.0	643.2	520.0	31.13	-33.18	15.434	-2.817	0.1877
25 TULSA	357 PAT MAYSE	393.0	477.0	393.0	62.67	-78.96	37.845	-7.478	0.5385
25 TULSA	370 KEMP	1090.0	1160.0	1079.1	-24.30	29.44	-10.172	1.632	-0.0908
25 TULSA	402 GILLHAM	430.0	586.0	430.0	11.25	-11.96	5.980	-1.036	0.0657
26 FORT WORTH	344 BARDWELL	380.0	439.0	380.0	-5.60	6.43	-0.633	0.025	0.0000
26 FORT WORTH	345 BELTON(BELL)	480.0	631.0	480.0	-6.10	8.95	-3.185	0.723	-0.0569
26 FORT WORTH	346 BENBROOK	620.0	741.0	618.7	0.13	3.00	-1.478	0.571	-0.0580

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
26 FORT WORTH	347 CANYON	750.0	970.0	750.0	-41.33	37.04	-11.999	1.933	-0.1167
26 FORT WORTH	349 GRAPEVINE	470.0	581.0	470.0	9.67	-10.47	6.352	-1.259	0.0891
26 FORT WORTH	351 HORDS CREEK	1854.0	1920.0	1854.0	-1.40	4.23	-1.081	0.246	-0.0174
26 FORT WORTH	354 LAVON	443.0	503.5	440.1	-2.04	5.24	0.134	-0.256	0.0331
26 FORT WORTH	355 LEWISVILLE(GARZ	455.0	535.6	455.0	18.48	-22.74	13.047	-2.792	0.2155
26 FORT WORTH	356 NAVARRO MILLS	390.0	452.0	390.0	4.03	-2.71	2.956	-0.638	0.0497
26 FORT WORTH	358 PROCTOR	1120.0	1201.0	1120.0	-52.45	56.85	-20.814	3.572	-0.2293
26 FORT WORTH	359 SAM RAYBURN (MC	80.0	183.0	80.0	67.90	-75.96	32.968	-5.883	0.3842
26 FORT WORTH	360 O C FISHER (SAN	1840.0	1958.0	1837.0	-6.01	5.85	-0.395	-0.045	0.0104
26 FORT WORTH	361 SOMERVILLE	200.0	275.0	200.0	15.91	-22.26	13.915	-3.134	0.2501
26 FORT WORTH	362 STILLHOUSE HOLL	498.0	693.0	498.0	3.41	1.65	-0.936	0.353	-0.0311
26 FORT WORTH	363 WACO	400.0	470.9	322.9	-174.63	69.63	-6.436	0.000	0.0000
26 FORT WORTH	364 WHITNEY	429.0	571.0	429.0	-18.27	26.13	-10.429	1.946	-0.1285
26 FORT WORTH	371 B A STEINHAGEN	50.0	90.0	40.0	6.47	-3.51	1.285	0.000	0.0000
28 ALBUQUERQUE	065 JOHN MARTIN (HA	3765.0	3870.0	3765.0	36.93	-50.42	25.334	-4.985	0.3515
28 ALBUQUERQUE	218 ABIQUIU	6060.0	6362.0	6060.0	-9.49	1.10	1.944	-0.359	0.0197
28 ALBUQUERQUE	219 CONCHAS	4071.0	4235.0	4071.0	73.77	-101.18	45.649	-8.212	0.5289
28 ALBUQUERQUE	407 TRINIDAD	6081.0	6281.0	6081.0	1.64	-3.08	2.482	-0.450	0.0305
29 KANSAS CITY	100 RATHBUN	855.0	946.0	855.0	4.69	-1.77	2.307	-0.497	0.0384
29 KANSAS CITY	106 KANOPOLIS	1430.0	1537.0	1430.0	-2.31	12.46	-5.489	1.153	-0.0837
29 KANSAS CITY	108 MILFORD	1141.2	1176.2	1067.0	0.12	2.65	0.156	-0.028	0.0018
29 KANSAS CITY	109 MELVERN	958.0	1073.0	958.0	4.42	-2.86	1.637	-0.134	0.0000
29 KANSAS CITY	110 PERRY	820.0	922.0	820.0	79.06	-83.49	33.075	-5.389	0.3197
29 KANSAS CITY	111 POMONA	942.0	1006.0	928.7	2.19	2.03	0.121	-0.010	0.0000
29 KANSAS CITY	113 TUTTLE CREEK	1010.0	1140.0	973.0	131.64	-144.99	56.837	-9.231	0.5451
29 KANSAS CITY	114 WILSON	1430.0	1582.0	1425.0	-9.24	6.11	-0.291	0.000	0.0000
29 KANSAS CITY	194 POMME DE TERRE	750.0	874.0	750.0	9.51	-7.41	3.870	-0.639	0.0393
29 KANSAS CITY	195 STOCKTON	760.0	892.0	760.0	35.71	-48.01	22.723	-4.132	0.2679
29 KANSAS CITY	207 HARLAN COUNTY	1880.0	1982.0	1880.0	-10.97	11.34	-2.020	0.157	0.0000
30 OMAHA	064 CHERRY CREEK	5523.0	5640.0	5523.0	-4.99	12.21	-4.524	0.834	-0.0548
30 OMAHA	203 FORT PECK	2033.0	2251.6	2033.0	3.49	0.28	1.022	-0.162	0.0089
30 OMAHA	208 OLIVE CREEK	1310.0	1357.0	1310.0	4.67	-7.99	6.050	-1.405	0.1169

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
30 OMAHA	209 BLUESTEM	1276.0	1332.0	1276.0	52.84	-69.06	34.114	-7.009	0.5308
30 OMAHA	210 WAGON TRAIN	1256.0	1309.0	1256.0	-20.30	31.42	-16.223	3.911	-0.3376
30 OMAHA	211 STAGECOACH	1248.0	1291.0	1248.0	-14.23	22.27	-10.062	2.201	-0.1752
30 OMAHA	212 YANKEE HILL	1219.0	1267.0	1219.0	12.42	-16.99	10.203	-2.272	0.1848
30 OMAHA	213 CONESTOGA	1197.0	1258.0	1197.0	-17.31	21.34	-8.665	1.787	-0.1350
30 OMAHA	214 TWIN	1306.0	1361.0	1306.0	10.68	-11.47	5.619	-0.933	0.0559
30 OMAHA	215 PAWNEE	1206.0	1269.0	1206.0	31.11	-41.80	21.170	-4.245	0.3094
30 OMAHA	216 HOLMES PARK	1216.0	1269.0	1216.0	14.92	-14.48	5.776	-0.731	0.0250
30 OMAHA	217 BRANCHED OAK	1250.0	1317.0	1250.0	21.50	-21.49	10.626	-2.065	0.1477
30 OMAHA	234 BOWMAN HALEY	2715.0	2781.0	2715.0	-2.45	3.72	-0.181	0.023	0.0000
30 OMAHA	235 SAKAKAWEA(GARRI	1668.0	1860.0	1668.0	21.36	-24.75	12.162	-2.169	0.1373
30 OMAHA	331 SHARPE (BIG BEN	1340.0	1430.0	1340.0	-19.41	19.20	-4.085	0.334	0.0000
30 OMAHA	332 COLD BROOK	3578.0	3666.0	3544.6	-1.64	1.59	0.142	0.000	0.0000
30 OMAHA	334 FRANCIS CASE (F	1227.0	1390.0	1240.0	-12.50	14.45	-2.931	0.234	0.0000
30 OMAHA	335 LEWIS AND CLARK	1160.0	1230.0	1160.0	10.11	-5.34	2.527	-0.246	0.0000
30 OMAHA	336 OAHE	1420.0	1620.0	1420.0	0.10	5.82	-0.938	0.083	0.0000
30 OMAHA	415 CHATFIELD	5380.0	5530.0	5380.0	-14.10	11.50	-1.859	0.128	0.0000
31 WALLA WALLA	077 DWORSHAK	970.0	1640.0	970.0	-0.19	2.60	-0.184	0.023	0.0000
31 WALLA WALLA	078 LUCKY PEAK	2822.0	3080.0	2827.0	14.92	-17.44	8.272	-1.405	0.0845
31 WALLA WALLA	079 RIRIE	5023.0	5119.0	4922.0	-6.13	3.01	0.107	-0.008	0.0000
31 WALLA WALLA	379 ICE HARBOR	375.0	440.0	375.0	7.31	1.34	0.000	0.000	0.0000
32 SEATTLE	080 ALBENI FALLS (P	2048.1	2062.5	1951.7	7.08	1.81	0.000	0.000	0.0000
32 SEATTLE	204 KOOKANUSA(LIBBY	2110.0	2459.1	2110.0	9.85	-11.24	5.503	-0.863	0.0477
32 SEATTLE	377 RUFUS WOODS (CH	785.0	956.0	780.0	-1.29	7.80	-2.658	0.477	-0.0289
32 SEATTLE	384 MUD MOUNTAIN	910.0	1241.0	895.0	10.02	-6.23	1.801	-0.117	0.0000
32 SEATTLE	385 WYNOOCHEE	640.0	800.0	640.0	-18.04	20.53	-7.646	1.420	-0.0960
32 SEATTLE	386 HOWARD A HANSON	1035.0	1222.4	1035.0	-0.20	5.91	-2.667	0.605	-0.0434
33 PORTLAND	288 BLUE RIVER	1102.0	1357.0	1102.0	-3.12	4.19	-0.707	0.092	-0.0029
33 PORTLAND	290 COTTAGE GROVE	719.0	802.6	719.0	-7.36	5.85	-0.412	0.003	0.0000
33 PORTLAND	291 COUGAR	1274.0	1699.0	1274.0	-6.27	5.55	-1.159	0.199	-0.0125
33 PORTLAND	292 CELILO (DALLES)	155.0	160.0	103.6	5.26	1.85	0.000	0.000	0.0000
33 PORTLAND	293 DETROIT	1200.0	1569.0	1200.0	-2.38	0.99	0.528	-0.043	0.0000

MORPHOMETRIC CURVE PARAMETERS

DIS	RES	EMIN	EMAX	EZERO	C1	C2	C3	C4	C5
33 PORTLAND	294 DEXTER	690.0	695.0	654.1	4.69	1.49	0.000	0.000	0.0000
33 PORTLAND	295 DORENA	735.0	850.0	735.0	-13.94	13.07	-2.638	0.215	0.0000
33 PORTLAND	296 FALL CREEK	673.0	839.0	673.0	-2.33	5.69	-1.626	0.319	-0.0222
33 PORTLAND	297 FERN RIDGE	339.0	375.1	339.0	-4.96	9.05	-2.031	0.222	0.0000
33 PORTLAND	298 FOSTER	525.0	640.0	525.0	37.77	-26.40	7.094	-0.573	0.0000
33 PORTLAND	299 GREEN PETER	700.0	1015.0	700.0	-2.19	-0.39	1.052	-0.092	0.0000
33 PORTLAND	300 HILLS CREEK	1245.0	1544.0	1245.0	3.57	-0.86	1.144	-0.190	0.0116
33 PORTLAND	302 LOOKOUT POINT	688.0	934.0	688.0	-14.20	19.74	-6.603	1.017	-0.0554
33 PORTLAND	304 LOST CREEK	1550.0	1850.0	1550.0	16.94	-8.34	2.145	-0.141	0.0000
33 PORTLAND	305 BIG CLIFF	1193.0	1206.0	1121.0	0.01	1.97	0.000	0.000	0.0000
34 SACRAMENTO	024 BLACK BUTTE	381.0	490.0	381.0	0.36	5.43	-2.296	0.593	-0.0498
34 SACRAMENTO	026 ENGLEBRIGHT	295.0	550.0	295.0	5.16	-5.29	3.083	-0.538	0.0344
34 SACRAMENTO	028 ISABELLA	2455.0	2620.0	2455.0	28.92	-21.60	6.160	-0.494	0.0000
34 SACRAMENTO	030 MARTIS CREEK	5745.0	5853.0	5745.0	-7.14	4.30	-0.117	0.000	0.0000
34 SACRAMENTO	032 NEW HOGAN	535.0	720.0	535.0	4.15	0.97	-0.304	0.169	-0.0164
34 SACRAMENTO	033 PINE FLAT	565.5	960.0	565.5	-23.46	14.21	-2.002	0.112	0.0000
34 SACRAMENTO	036 SUCCESS	538.0	690.0	538.0	9.23	-10.63	5.915	-1.133	0.0797
34 SACRAMENTO	037 KAWEAH (TERMINU	507.0	720.0	507.0	-5.82	8.61	-2.888	0.565	-0.0389
34 SACRAMENTO	041 FOLSOM	240.0	466.0	240.0	-17.27	24.04	-8.395	1.329	-0.0744
34 SACRAMENTO	043 NEW BULLARDS BA	1600.0	1960.0	1344.7	-7.16	4.41	-0.426	0.052	-0.0021
34 SACRAMENTO	044 CAMANCHE	104.0	234.8	89.5	9.41	-10.12	5.594	-1.022	0.0674
34 SACRAMENTO	047 CHERRY VALLEY	4430.0	4700.0	4430.0	65.89	-68.46	25.686	-3.898	0.2125
34 SACRAMENTO	048 NEW DON PEDRO	550.0	830.0	355.6	0.78	-1.42	1.499	-0.214	0.0109
34 SACRAMENTO	051 MCCLURE (NEW EX	440.0	870.0	410.5	2.88	-4.33	2.631	-0.403	0.0223
34 SACRAMENTO	054 MILLERTON (FRIA	375.0	580.0	285.4	-0.12	-0.87	1.486	-0.241	0.0140
35 SAN FRANCISCO	029 MENDOCINO	637.0	800.0	640.0	1.26	3.85	-1.536	0.423	-0.0368
35 SAN FRANCISCO	039 SANTA MARGARITA	1190.0	1320.0	1190.0	-8.99	9.27	-2.815	0.520	-0.0335
36 LOS ANGELES	009 ALAMO	1040.0	1259.0	960.0	-71.20	37.94	-6.027	0.351	0.0000
36 LOS ANGELES	027 HANSEN	990.0	1087.0	990.0	19.61	-18.61	8.395	-1.469	0.0943

APPENDIX B

Data Listings

This appendix summarizes the mass balance terms by reservoir and nutrient for each of 108 reservoirs sampled by the U. S. Environmental Protection Agency's National Eutrophication Survey, and high- and low-priority water quality data by station-year and reservoir-year.

Table B1: Nutrient Budget Summaries

Table B2: Water Balances and Inflow Concentrations by Period

Table B3: Water Quality Data Summary by Station-Year

Table B4: Water Quality Data Summary by Reservoir-Year

Table B1

Nutrient Budget Summaries

Symbol	Meaning
DIS	CE District code
RES	CE reservoir code
PARAM	Total P, Ortho P, Total N, Inorg N in metric tons/yr; Flow in million m^3/yr)
LGAUG	gauged tributary loading
LUNGD	ungauged tributary loading
LPOINT	point-source loading
LOTHER	septic tank/wildfowl loading
LPREC	precipitation loading
LTOTAL	total loading
LEVAP	evaporation (FLOW only)
LOUT	outflow
LDSTOR	change in storage
LNET	net loading
CVI	coefficient of variation of total loading estimate
CVO	coefficient of variation of total outflow estimate

Note: Hydrologic conditions refer to year of tributary monitoring by EPA National Eutrophication Survey, as identified in Table 4, Part III of the main text.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
02	176	TOTAL P	4.67	2.20	0.00	0.00	0.10	6.97	.	5.30	0.20	1.48	0.18	0.21
02	176	ORTHO P	1.40	0.59	0.00	0.00	0.05	2.04	.	1.70	0.06	0.28	0.09	0.13
02	176	TOTAL N	202.32	70.40	0.00	0.00	3.25	275.97	.	177.71	6.56	91.69	0.21	0.06
02	176	INORG N	101.40	47.33	0.00	0.00	1.62	150.36	.	116.32	4.30	29.74	0.11	0.09
02	176	FLOW	181.92	115.01	.	.	3.84	300.76	2.07	294.73	10.81	-4.77	.	.
03	307	TOTAL P	2.41	0.27	0.00	0.00	0.11	2.79	.	2.26	-0.02	0.55	0.10	0.13
03	307	ORTHO P	1.15	0.18	0.00	0.00	0.06	1.39	.	1.40	-0.01	-0.00	0.06	0.11
03	307	TOTAL N	219.45	17.50	0.00	0.00	3.77	240.72	.	239.08	-2.14	3.78	0.08	0.13
03	307	INORG N	141.45	2.78	0.00	0.00	1.88	146.11	.	153.73	-1.37	-6.24	0.04	0.04
03	307	FLOW	180.25	24.76	.	.	5.44	210.45	3.07	211.01	-1.86	1.31	.	.
04	312	TOTAL P	79.29	0.46	0.00	0.00	0.14	79.90	.	38.19	-0.63	42.33	0.27	0.25
04	312	ORTHO P	50.44	0.19	0.00	0.00	0.07	50.70	.	19.17	-0.31	31.85	0.22	0.19
04	312	TOTAL N	1237.63	35.71	0.00	0.00	4.70	1278.05	.	936.66	-15.34	356.73	0.18	0.09
04	312	INORG N	829.73	24.61	0.00	0.00	2.35	856.69	.	569.79	-9.33	296.23	0.14	0.10
04	312	FLOW	457.91	16.12	.	.	4.38	478.41	3.47	464.17	-7.54	21.78	.	.
06	372	TOTAL P	911.22	16.07	21.70	0.13	5.78	954.91	.	188.35	-2.04	768.60	0.08	0.25
06	372	ORTHO P	234.25	4.67	21.70	0.13	2.89	263.65	.	97.00	-1.05	167.69	0.05	0.31
06	372	TOTAL N	9141.73	277.03	127.96	5.07	192.58	9744.38	.	8894.00	-96.10	946.47	0.12	0.19
06	372	INORG N	2349.56	43.30	127.96	5.07	96.29	2622.18	.	2194.51	-23.71	451.39	0.08	0.09
06	372	FLOW	6854.18	316.67	.	.	238.95	7409.80	196.10	7455.71	-78.44	32.52	.	.
08	074	TOTAL P	620.02	26.64	0.00	0.07	8.43	655.17	.	278.79	2.73	373.65	0.17	0.14
08	074	ORTHO P	174.29	8.75	0.00	0.07	4.22	187.33	.	100.13	0.98	86.22	0.14	0.13
08	074	TOTAL N	7369.71	544.22	0.00	2.90	281.11	8197.94	.	10244.91	100.42	-2147.39	0.14	0.30
08	074	INORG N	2983.32	98.25	0.00	2.90	140.55	3225.02	.	2582.20	25.31	617.51	0.10	0.07
08	074	FLOW	11126.09	516.23	.	.	417.81	12060.14	300.55	11779.20	112.52	168.42	.	.
08	330	TOTAL P	258.79	20.43	13.82	1.54	6.74	301.32	.	53.20	1.13	247.00	0.07	0.21
08	330	ORTHO P	90.85	8.21	13.82	1.54	3.37	117.78	.	33.30	0.71	83.78	0.05	0.13
08	330	TOTAL N	2899.53	663.37	30.75	54.44	224.67	3872.76	.	5824.66	123.40	-2075.29	0.05	0.48
08	330	INORG N	1041.33	198.33	30.75	54.44	112.33	1437.18	.	1206.58	25.56	205.04	0.17	0.16
08	330	FLOW	4231.70	1175.38	.	.	372.65	5779.73	228.77	6028.37	122.86	-371.51	.	.
10	003	TOTAL P	382.86	5.51	0.00	0.01	0.40	388.78	.	355.49	-0.01	33.30	0.13	0.12
10	003	ORTHO P	110.82	1.22	0.00	0.01	0.20	112.25	.	108.41	-0.00	3.84	0.13	0.16
10	003	TOTAL N	12607.88	197.19	0.00	0.10	13.30	12818.48	.	17388.39	-0.68	-4569.22	0.12	0.14
10	003	INORG N	6212.88	50.37	0.00	0.10	6.65	6270.02	.	8549.06	-0.33	-2278.71	0.05	0.08
10	003	FLOW	9834.54	216.67	.	.	22.77	10073.98	14.22	10382.79	-0.41	-308.41	.	.
10	069	TOTAL P	158.15	18.27	5.66	0.06	1.27	183.42	.	63.84	0.58	118.99	0.12	0.17
10	069	ORTHO P	31.26	2.92	5.66	0.06	0.64	40.53	.	21.38	0.20	18.95	0.08	0.10
10	069	TOTAL N	1525.93	194.12	8.75	2.20	42.38	1773.39	.	1393.04	12.74	367.61	0.07	0.17
10	069	INORG N	631.51	66.76	8.75	2.20	21.19	730.41	.	545.16	4.99	180.27	0.08	0.13
10	069	FLOW	2180.71	211.93	.	.	61.25	2453.90	42.08	2521.23	22.67	-90.00	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
10	071	TOTAL P	2422.25	56.78	6.57	0.00	4.61	2490.21	.	2032.16	0.51	457.54	0.05	0.23
10	071	ORTHO P	772.93	22.19	6.57	0.00	2.31	804.00	.	611.16	0.15	192.68	0.04	0.16
10	071	TOTAL N	36414.34	418.50	8.42	0.00	153.81	36995.08	.	35764.79	8.93	1221.36	0.12	0.22
10	071	INORG N	11565.10	57.74	8.42	0.00	76.91	11708.17	.	8426.54	2.10	3279.53	0.10	0.14
10	071	FLOW	25614.89	526.55	.	.	332.06	26473.50	180.12	26977.91	6.69	-511.09	.	.
10	072	TOTAL P	1179.01	8.64	7.26	0.04	5.26	1200.21	.	1129.43	-1.05	71.84	0.05	0.12
10	072	ORTHO P	404.78	2.85	7.26	0.04	2.63	417.56	.	417.34	-0.39	0.61	0.08	0.12
10	072	TOTAL N	12628.58	235.12	21.76	1.44	175.35	13062.25	.	14327.75	-13.38	-1252.11	0.09	0.16
10	072	INORG N	5276.80	48.59	21.76	1.44	87.68	5436.26	.	5782.92	-5.40	-341.25	0.10	0.08
10	072	FLOW	12201.20	305.57	.	.	331.45	12838.23	191.95	12705.19	-11.69	144.72	.	.
10	076	TOTAL P	190.37	37.24	21.05	0.41	4.64	253.71	.	49.14	1.49	203.08	0.16	0.45
10	076	ORTHO P	64.29	12.97	21.05	0.41	2.32	101.04	.	13.82	0.42	86.80	0.13	0.03
10	076	TOTAL N	2362.66	800.54	43.08	15.27	154.64	3376.19	.	2121.15	64.28	1190.76	0.09	0.17
10	076	INORG N	1009.50	380.17	43.08	15.27	77.32	1525.35	.	1090.56	33.05	401.74	0.05	0.09
10	076	FLOW	2531.34	611.42	.	.	290.13	3432.90	161.41	2806.88	80.17	545.85	.	.
10	411	TOTAL P	583.76	6.53	0.00	0.02	1.16	591.48	.	500.67	0.31	90.50	0.14	0.26
10	411	ORTHO P	135.59	2.63	0.00	0.02	0.58	138.82	.	109.48	0.07	29.27	0.10	0.16
10	411	TOTAL N	15083.55	377.60	0.00	0.80	38.74	15500.70	.	14823.99	9.21	667.50	0.08	0.17
10	411	INORG N	8201.82	226.61	0.00	0.80	19.37	8448.60	.	6934.16	4.31	1510.13	0.09	0.06
10	411	FLOW	8935.34	268.25	.	.	65.18	9268.77	41.42	9560.48	5.91	-297.63	.	.
14	099	TOTAL P	2968.73	34.79	4.93	0.00	1.54	3009.99	.	1081.88	-44.01	1972.12	0.17	0.09
14	099	ORTHO P	878.24	6.19	4.93	0.00	0.77	890.13	.	599.07	-24.37	315.43	0.07	0.14
14	099	TOTAL N	46139.88	333.60	14.79	0.00	51.48	46539.76	.	36354.27	-1478.85	11664.33	0.10	0.06
14	099	INORG N	34912.38	89.80	14.79	0.00	25.74	35042.71	.	29650.63	-1206.15	6598.24	0.12	0.07
14	099	FLOW	4830.95	95.12	.	.	36.48	4962.55	48.49	5027.89	-202.56	137.22	.	.
15	178	TOTAL P	3.15	0.10	0.00	0.15	1.57	4.97	.	2.81	0.03	2.13	0.14	0.05
15	178	ORTHO P	0.74	0.04	0.00	0.15	0.79	1.72	.	1.13	0.01	0.57	0.19	0.19
15	178	TOTAL N	102.05	5.22	0.00	5.71	52.47	165.46	.	96.31	1.15	68.00	0.14	0.11
15	178	INORG N	10.86	0.21	0.00	5.71	26.24	43.03	.	7.77	0.09	35.16	0.25	0.23
15	178	FLOW	125.45	7.04	.	.	43.70	176.20	37.40	186.19	1.77	-11.76	.	.
15	181	TOTAL P	8.25	1.26	1.75	0.00	13.59	24.87	.	8.19	-1.30	17.97	0.22	0.27
15	181	ORTHO P	3.15	0.45	1.75	0.00	6.80	12.16	.	3.24	-0.51	9.43	0.23	0.21
15	181	TOTAL N	636.76	82.23	5.27	0.18	453.09	1177.53	.	418.13	-66.13	825.53	0.16	0.30
15	181	INORG N	36.68	6.09	5.27	0.18	226.55	274.77	.	160.68	-25.41	139.50	0.33	0.75
15	181	FLOW	386.28	57.05	.	.	307.88	751.21	299.89	668.33	-58.27	141.15	.	.
15	237	TOTAL P	43.62	3.44	1.68	0.03	0.63	49.40	.	36.73	0.29	12.38	0.22	0.14
15	237	ORTHO P	22.61	1.43	1.68	0.03	0.31	26.07	.	28.45	0.23	-2.61	0.28	0.11
15	237	TOTAL N	418.09	38.22	5.05	1.06	20.98	483.39	.	361.21	2.88	119.30	0.20	0.07
15	237	INORG N	103.29	10.31	5.05	1.06	10.49	130.20	.	83.59	0.67	45.94	0.45	0.83
15	237	FLOW	159.44	13.01	.	.	11.50	183.95	16.02	179.35	1.30	3.30	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
16	243	TOTAL P	30.68	9.70	29.37	0.18	0.36	70.29	.	16.15	-0.53	54.66	0.09	0.21
16	243	ORTHO P	8.75	2.45	29.37	0.18	0.18	40.92	.	5.88	-0.19	35.24	0.08	0.23
16	243	TOTAL N	515.91	176.06	67.01	6.68	12.06	777.73	.	590.92	-19.28	206.09	0.05	0.11
16	243	INORG N	294.58	107.10	67.01	6.68	6.03	481.41	.	326.58	-10.66	165.49	0.07	0.12
16	243	FLOW	197.14	67.74	.	.	11.65	276.53	9.52	289.65	-9.14	-3.98	.	.
16	254	TOTAL P	5.42	7.28	3.62	0.00	0.89	17.22	.	5.58	-0.09	11.73	0.60	0.15
16	254	ORTHO P	1.16	2.16	3.62	0.00	0.45	7.39	.	1.38	-0.02	6.03	0.28	0.52
16	254	TOTAL N	73.11	105.88	7.71	0.00	29.76	216.47	.	165.69	-2.74	53.52	0.27	0.21
16	254	INORG N	32.85	51.70	7.71	0.00	14.88	107.14	.	35.10	-0.58	72.63	0.46	0.32
16	254	FLOW	37.18	51.07	.	.	27.98	116.23	22.73	117.52	-1.57	0.27	.	.
16	317	TOTAL P	62.11	0.98	0.00	0.07	0.40	63.57	.	56.84	-0.49	7.21	0.11	0.13
16	317	ORTHO P	22.50	0.39	0.00	0.07	0.20	23.16	.	10.81	-0.09	12.44	0.11	0.14
16	317	TOTAL N	950.67	31.55	0.00	0.22	13.29	995.74	.	1210.77	-10.36	-204.68	0.06	0.08
16	317	INORG N	442.12	15.44	0.00	0.22	6.64	464.44	.	532.98	-4.56	-63.98	0.08	0.15
16	317	FLOW	633.26	19.73	.	.	11.93	664.92	10.15	821.84	-6.94	-149.97	.	.
16	328	TOTAL P	169.88	5.40	0.00	0.13	1.37	176.78	.	113.83	-1.87	64.82	0.20	0.16
16	328	ORTHO P	44.71	1.97	0.00	0.13	0.69	47.50	.	32.79	-0.54	15.25	0.14	0.31
16	328	TOTAL N	2335.95	273.44	0.00	0.67	45.69	2655.75	.	4744.08	-78.01	-2010.32	0.15	0.15
16	328	INORG N	1300.15	121.70	0.00	0.67	22.85	1445.37	.	2335.05	-38.40	-851.28	0.17	0.20
16	328	FLOW	3526.38	316.33	.	.	49.64	3892.35	31.41	3677.86	-59.96	274.46	.	.
16	393	TOTAL P	51.12	7.50	0.00	0.01	0.18	58.81	.	93.13	0.02	-34.35	0.11	0.41
16	393	ORTHO P	15.31	3.08	0.00	0.01	0.09	18.50	.	25.25	0.01	-6.76	0.07	0.22
16	393	TOTAL N	1498.56	268.66	0.00	0.65	5.92	1773.79	.	1970.27	0.50	-196.98	0.06	0.13
16	393	INORG N	1142.17	180.22	0.00	0.65	2.96	1326.00	.	1448.27	0.37	-122.65	0.04	0.08
16	393	FLOW	2466.54	462.30	.	.	8.03	2936.87	4.52	2916.33	0.74	19.80	.	.
17	241	TOTAL P	7.63	1.18	0.00	0.05	0.19	9.05	.	2.46	-0.05	6.64	0.11	0.07
17	241	ORTHO P	1.65	0.36	0.00	0.05	0.09	2.17	.	0.85	-0.02	1.34	0.10	0.14
17	241	TOTAL N	155.71	79.47	0.00	6.25	6.24	247.67	.	84.80	-1.89	164.76	0.05	0.10
17	241	INORG N	86.03	63.71	0.00	6.25	3.12	159.11	.	32.38	-0.72	127.44	0.06	0.17
17	241	FLOW	58.64	43.62	.	.	6.03	108.29	4.92	94.37	-1.99	15.90	.	.
17	242	TOTAL P	64.44	11.93	2.29	0.56	0.07	79.30	.	60.61	-0.09	18.77	0.21	0.37
17	242	ORTHO P	11.86	1.45	2.29	0.56	0.04	16.20	.	10.25	-0.01	5.96	0.09	0.12
17	242	TOTAL N	1009.32	226.94	6.87	20.97	2.46	1266.56	.	1098.64	-1.55	169.47	0.08	0.12
17	242	INORG N	728.87	165.90	6.87	20.97	1.23	923.83	.	739.38	-1.04	185.49	0.16	0.33
17	242	FLOW	244.32	63.68	.	.	2.62	310.62	2.00	290.19	-0.41	20.83	.	.
17	245	TOTAL P	46.07	1.94	0.00	0.05	0.18	48.24	.	43.77	-0.34	4.81	0.19	0.21
17	245	ORTHO P	12.32	1.49	0.00	0.05	0.09	13.95	.	7.39	-0.06	6.62	0.10	0.16
17	245	TOTAL N	796.01	100.31	0.00	1.89	5.96	904.18	.	818.02	-6.39	92.55	0.09	0.03
17	245	INORG N	457.44	58.10	0.00	1.89	2.98	520.42	.	395.20	-3.09	128.31	0.11	0.31
17	245	FLOW	218.48	54.48	.	.	6.43	279.38	4.86	284.92	-2.19	-3.34	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
17	247	TOTAL P	33.27	0.92	0.14	0.00	0.14	34.47	.	47.00	-0.02	-12.51	0.14	0.10
17	247	ORTHO P	12.60	0.45	0.14	0.00	0.07	13.26	.	21.76	-0.01	-8.49	0.12	0.26
17	247	TOTAL N	1146.35	54.78	0.42	0.00	4.60	1206.15	.	1442.74	-0.69	-235.90	0.22	0.12
17	247	INORG N	844.11	41.56	0.42	0.00	2.30	888.39	.	1145.88	-0.55	-256.94	0.28	0.12
17	247	FLOW	353.54	20.50	.	.	5.11	379.15	3.86	371.78	-0.18	7.54	.	.
17	248	TOTAL P	96.56	15.52	0.08	0.12	0.14	112.43	.	74.55	-0.02	37.90	0.12	0.25
17	248	ORTHO P	32.36	7.32	0.08	0.12	0.07	39.96	.	30.61	-0.01	9.35	0.06	0.18
17	248	TOTAL N	1523.54	361.38	0.25	4.49	4.79	1894.46	.	1703.95	-0.38	190.90	0.03	0.08
17	248	INORG N	1066.77	291.21	0.25	4.49	2.40	1365.13	.	1221.34	-0.28	144.06	0.07	0.10
17	248	FLOW	347.26	71.87	.	.	5.41	424.54	4.03	429.75	-0.10	-5.11	.	.
17	249	TOTAL P	168.59	2.42	0.34	0.03	0.21	171.60	.	132.94	-0.22	38.89	0.17	0.08
17	249	ORTHO P	91.57	0.73	0.34	0.03	0.11	92.78	.	50.27	-0.08	42.60	0.28	0.13
17	249	TOTAL N	2469.49	143.09	1.01	1.10	7.16	2621.86	.	2641.65	-4.46	-15.34	0.04	0.04
17	249	INORG N	1589.38	104.39	1.01	1.10	3.58	1699.47	.	1786.40	-3.01	-83.92	0.05	0.04
17	249	FLOW	918.10	97.20	.	.	7.63	1022.93	5.84	1026.14	-1.72	-1.49	.	.
17	256	TOTAL P	10.31	0.59	1.19	0.00	0.09	12.18	.	11.41	-0.06	0.84	0.11	0.10
17	256	ORTHO P	3.90	0.21	1.19	0.00	0.04	5.35	.	5.67	-0.03	-0.29	0.08	0.23
17	256	TOTAL N	392.71	49.13	3.58	0.00	2.98	448.40	.	320.24	-1.67	129.83	0.05	0.09
17	256	INORG N	262.56	42.05	3.58	0.00	1.49	309.68	.	206.46	-1.08	104.30	0.05	0.11
17	256	FLOW	195.27	23.22	.	.	3.22	221.70	2.43	207.61	-1.07	15.16	.	.
17	258	TOTAL P	0.94	0.70	0.00	0.03	0.64	2.32	.	1.84	-0.20	0.68	0.13	0.29
17	258	ORTHO P	0.25	0.19	0.00	0.03	0.32	0.80	.	0.58	-0.06	0.28	0.17	0.19
17	258	TOTAL N	32.18	23.87	0.00	1.26	21.48	78.79	.	67.09	-7.27	18.98	0.13	0.18
17	258	INORG N	21.39	15.87	0.00	1.26	10.74	49.27	.	8.57	-0.93	41.63	0.14	0.35
17	258	FLOW	32.35	24.00	.	.	22.86	79.21	17.50	79.11	-6.68	6.78	.	.
17	373	TOTAL P	25.84	6.58	0.00	0.00	0.19	32.61	.	4.88	0.04	27.70	0.16	0.13
17	373	ORTHO P	2.50	0.48	0.00	0.00	0.10	3.08	.	2.10	0.02	0.97	0.06	0.03
17	373	TOTAL N	425.81	115.18	0.00	0.00	6.48	547.48	.	533.03	3.91	10.54	0.19	0.10
17	373	INORG N	141.45	37.90	0.00	0.00	3.24	182.59	.	151.69	1.11	29.78	0.08	0.03
17	373	FLOW	326.41	89.38	.	.	8.06	423.85	5.45	402.82	2.91	18.11	.	.
17	389	TOTAL P	310.12	5.60	4.22	0.02	0.43	320.39	.	302.07	6.05	12.27	0.07	0.09
17	389	ORTHO P	121.17	1.58	4.22	0.02	0.21	127.20	.	126.78	2.54	-2.12	0.06	0.10
17	389	TOTAL N	9483.46	186.37	12.67	0.69	14.31	9697.50	.	9376.22	187.90	133.38	0.04	0.07
17	389	INORG N	6940.29	118.87	12.67	0.69	7.15	7079.67	.	7018.70	140.66	-79.69	0.04	0.07
17	389	FLOW	6772.09	198.50	.	.	17.84	6988.42	12.02	6621.18	132.45	234.79	.	.
17	391	TOTAL P	52.47	2.77	0.00	0.00	0.21	55.46	.	35.60	-0.01	19.87	0.13	0.19
17	391	ORTHO P	14.89	0.64	0.00	0.00	0.11	15.63	.	15.95	-0.01	-0.31	0.06	0.13
17	391	TOTAL N	2012.51	92.88	0.00	0.00	7.11	2112.51	.	2018.55	-0.84	94.80	0.03	0.05
17	391	INORG N	1544.23	66.26	0.00	0.00	3.56	1614.05	.	1650.89	-0.69	-36.16	0.05	0.05
17	391	FLOW	2188.92	111.97	.	.	9.47	2310.35	5.43	2358.24	-0.98	-46.91	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
18	092	TOTAL P	326.28	12.41	0.59	0.02	0.39	339.69	.	136.09	0.00	203.60	0.25	0.40
18	092	ORTHO P	103.16	4.49	0.59	0.02	0.19	108.45	.	63.27	0.00	45.18	0.10	0.43
18	092	TOTAL N	5415.74	323.29	3.54	1.19	12.93	5756.70	.	4083.27	0.00	1673.43	0.08	0.14
18	092	INORG N	3233.72	223.21	3.54	1.19	6.47	3468.13	.	3002.94	0.00	465.18	0.12	0.16
18	092	FLOW	947.31	57.38	.	.	15.72	1020.42	10.54	1042.70	0.00	-22.28	.	.
18	093	TOTAL P	11.57	1.84	0.66	0.02	1.36	15.45	.	6.58	-0.20	9.06	0.09	0.31
18	093	ORTHO P	2.67	0.43	0.66	0.02	0.68	4.47	.	2.88	-0.09	1.67	0.07	0.09
18	093	TOTAL N	360.59	63.85	4.08	1.44	45.33	475.29	.	361.68	-10.74	124.36	0.06	0.06
18	093	INORG N	230.50	43.46	4.08	1.44	22.67	302.14	.	180.83	-5.37	126.68	0.05	0.07
18	093	FLOW	422.76	71.96	.	.	51.80	546.51	39.24	554.86	-15.32	6.96	.	.
18	120	TOTAL P	84.75	8.34	26.92	0.02	1.07	121.10	.	84.94	5.85	30.32	0.04	0.16
18	120	ORTHO P	64.41	6.60	26.92	0.02	0.54	98.49	.	32.83	2.26	63.40	0.28	0.28
18	120	TOTAL N	3708.05	774.35	67.29	0.69	35.75	4586.14	.	2226.41	153.23	2206.50	0.37	0.07
18	120	INORG N	1828.12	542.31	67.29	0.69	17.88	2456.29	.	1576.95	108.53	770.80	0.18	0.06
18	120	FLOW	1780.28	488.23	.	.	44.75	2313.26	33.67	1830.56	123.67	359.04	.	.
19	119	TOTAL P	6284.43	42.95	38.81	0.08	7.00	6373.28	.	6238.30	5.92	129.06	0.09	0.08
19	119	ORTHO P	2259.82	13.95	38.81	0.08	3.50	2316.16	.	2118.89	2.01	195.25	0.11	0.07
19	119	TOTAL N	55003.32	1463.83	110.08	3.19	233.36	56813.79	.	57970.25	55.05	-1211.51	0.14	0.13
19	119	INORG N	29346.48	916.60	110.08	3.19	116.68	30493.03	.	25722.30	24.43	4746.29	0.10	0.06
19	119	FLOW	46731.71	992.78	.	.	318.55	48043.04	219.81	51141.86	48.36	-3147.18	.	.
19	122	TOTAL P	744.28	96.92	0.00	0.02	5.92	847.14	.	512.91	-27.94	362.18	0.17	0.18
19	122	ORTHO P	163.86	15.23	0.00	0.02	2.96	182.07	.	120.05	-6.54	68.56	0.10	0.14
19	122	TOTAL N	13200.64	1724.12	0.00	0.78	197.49	15123.03	.	13734.33	-748.17	2136.87	0.25	0.38
19	122	INORG N	4819.21	580.68	0.00	0.78	98.74	5499.42	.	9233.74	-503.00	-3231.31	0.04	0.53
19	122	FLOW	12882.20	1561.41	.	.	296.89	14740.50	170.93	15339.80	-826.31	227.02	.	.
19	338	TOTAL P	5309.00	265.71	277.60	0.06	0.92	5853.29	.	9113.68	4.27	-3264.66	0.15	0.19
19	338	ORTHO P	1656.64	155.87	277.60	0.06	0.46	2090.63	.	2680.21	1.26	-590.84	0.14	0.18
19	338	TOTAL N	37145.91	1406.16	818.62	2.28	30.63	39403.59	.	34624.34	16.21	4763.04	0.15	0.19
19	338	INORG N	15187.02	715.03	818.62	2.28	15.31	16738.27	.	16047.63	7.51	683.12	0.10	0.06
19	338	FLOW	33382.59	877.95	.	.	42.08	34302.63	28.85	35741.58	16.72	-1455.68	.	.
19	340	TOTAL P	272.57	32.87	21.27	0.03	1.66	328.40	.	225.42	-8.12	111.11	0.10	0.15
19	340	ORTHO P	175.74	19.08	21.27	0.03	0.83	216.95	.	122.95	-4.43	98.43	0.11	0.20
19	340	TOTAL N	1720.06	251.20	50.22	1.17	55.33	2077.99	.	1941.35	-69.97	206.61	0.04	0.09
19	340	INORG N	1362.32	208.79	50.22	1.17	27.67	1650.17	.	1142.75	-41.19	548.60	0.04	0.14
19	340	FLOW	2001.06	346.37	.	.	78.97	2426.40	52.12	2242.00	-78.92	263.33	.	.
19	342	TOTAL P	2577.41	317.15	10.10	0.08	2.64	2907.38	.	2670.04	-1.02	238.35	0.17	0.13
19	342	ORTHO P	742.61	131.66	10.10	0.08	1.32	885.77	.	744.14	-0.28	141.92	0.15	0.13
19	342	TOTAL N	26559.03	1003.78	16.87	2.92	87.89	27670.50	.	26312.50	-10.01	1368.01	0.14	0.15
19	342	INORG N	11918.92	442.25	16.87	2.92	43.95	12424.91	.	11747.81	-4.47	681.57	0.11	0.05
19	342	FLOW	26631.64	736.29	.	.	125.44	27493.37	82.79	28446.82	-10.79	-942.67	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
19	343	TOTAL P	43.69	2.80	0.00	0.01	3.29	49.79	.	19.46	-0.56	30.90	0.05	0.13
19	343	ORTHO P	18.71	1.16	0.00	0.01	1.64	21.53	.	13.05	-0.38	8.85	0.04	0.08
19	343	TOTAL N	1668.11	117.83	0.00	0.31	109.63	1895.87	.	3486.76	-101.07	-1489.81	0.06	0.27
19	343	INORG N	952.18	72.69	0.00	0.31	54.81	1079.99	.	1920.84	-55.68	-785.17	0.04	0.43
19	343	FLOW	2607.19	171.60	.	.	206.78	2985.56	97.68	2445.19	-68.05	608.42	.	.
20	081	TOTAL P	696.43	34.30	0.36	0.02	3.94	735.04	.	478.02	-25.45	282.48	0.09	0.16
20	081	ORTHO P	218.16	8.93	0.36	0.02	1.97	229.43	.	223.83	-11.92	17.52	0.13	0.17
20	081	TOTAL N	14900.18	554.99	1.15	0.71	131.25	15588.27	.	14237.59	-758.05	2108.73	0.05	0.11
20	081	INORG N	10728.24	188.03	1.15	0.71	65.62	10983.76	.	8306.87	-442.28	3119.17	0.05	0.20
20	081	FLOW	3416.54	241.32	.	.	163.38	3821.24	116.94	4071.65	-210.56	-39.85	.	.
20	087	TOTAL P	256.78	28.40	0.86	0.01	1.59	287.65	.	167.82	13.60	106.22	0.12	0.33
20	087	ORTHO P	147.97	12.10	0.86	0.01	0.79	161.75	.	85.57	6.94	69.24	0.12	0.32
20	087	TOTAL N	11647.37	1865.89	2.63	0.64	52.96	13569.49	.	9847.29	798.28	2923.92	0.03	0.16
20	087	INORG N	10513.97	1868.40	2.63	0.64	26.48	12412.13	.	7612.13	617.08	4182.91	0.05	0.21
20	087	FLOW	1405.99	205.15	.	.	82.65	1693.79	47.19	1636.33	128.83	-71.37	.	.
20	088	TOTAL P	111.81	19.60	0.00	0.00	2.48	133.90	.	39.86	-4.40	98.45	0.18	0.17
20	088	ORTHO P	18.94	4.11	0.00	0.00	1.24	24.30	.	10.79	-1.19	14.70	0.22	0.14
20	088	TOTAL N	758.67	338.68	0.01	0.00	82.67	1180.03	.	656.36	-72.49	596.16	0.09	0.19
20	088	INORG N	223.12	139.78	0.01	0.00	41.33	404.25	.	171.80	-18.97	251.42	0.11	0.15
20	088	FLOW	292.84	132.54	.	.	92.21	517.59	75.76	538.47	-51.11	30.23	.	.
21	196	TOTAL P	142.72	10.27	0.00	0.07	0.78	153.84	.	96.47	-1.04	58.41	0.90	0.14
21	196	ORTHO P	25.18	3.45	0.00	0.07	0.39	29.09	.	20.50	-0.22	8.82	0.46	0.16
21	196	TOTAL N	2139.64	519.11	0.00	2.83	25.97	2687.55	.	2690.16	-29.01	26.40	0.27	0.12
21	196	INORG N	478.23	129.81	0.00	2.83	12.99	623.86	.	650.43	-7.01	-19.55	0.21	0.20
21	196	FLOW	1321.24	439.02	.	.	29.26	1789.52	25.12	2006.65	-21.37	-195.76	.	.
22	014	TOTAL P	14.81	4.97	0.00	0.03	1.58	21.39	.	27.38	-0.84	-5.15	0.06	0.19
22	014	ORTHO P	6.09	1.63	0.00	0.03	0.79	8.54	.	7.77	-0.24	1.02	0.07	0.10
22	014	TOTAL N	138.61	68.81	0.00	1.13	52.77	261.32	.	745.35	-22.86	-461.16	0.10	0.41
22	014	INORG N	47.64	24.92	0.00	1.13	26.38	100.07	.	116.00	-3.56	-12.37	0.12	0.15
22	014	FLOW	941.67	341.31	.	.	89.64	1372.61	60.45	1405.63	-41.25	8.23	.	.
22	019	TOTAL P	38.63	15.33	0.58	0.01	4.79	59.34	.	42.58	-0.82	17.59	0.09	0.33
22	019	ORTHO P	23.20	7.54	0.58	0.01	2.39	33.73	.	18.21	-0.35	15.87	0.22	0.19
22	019	TOTAL N	1416.40	359.22	2.53	0.43	159.57	1938.16	.	1232.35	-23.65	729.46	0.20	0.24
22	019	INORG N	339.54	46.61	2.53	0.43	79.79	468.90	.	454.00	-8.71	23.62	0.10	0.20
22	019	FLOW	1829.45	758.38	.	.	298.75	2886.58	170.61	2866.88	-51.75	71.46	.	.
22	188	TOTAL P	283.00	22.75	16.06	0.02	1.90	323.73	.	451.61	-7.28	-120.60	0.05	0.12
22	188	ORTHO P	108.91	8.76	16.06	0.02	0.95	134.70	.	123.09	-1.98	13.59	0.05	0.18
22	188	TOTAL N	2766.50	222.40	25.51	1.01	63.29	3078.71	.	2050.65	-33.04	1061.10	0.07	0.24
22	188	INORG N	2290.48	184.13	25.51	1.01	31.65	2532.77	.	786.39	-12.67	1759.06	0.10	0.24
22	188	FLOW	2883.02	231.76	.	.	93.25	3208.03	66.06	1683.34	-26.06	1550.75	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
22	189	TOTAL P	414.83	3.20	0.00	0.01	2.16	420.21	.	84.89	8.84	326.47	0.23	0.55
22	189	ORTHO P	119.43	0.65	0.00	0.01	1.08	121.18	.	30.39	3.17	87.63	0.30	0.65
22	189	TOTAL N	2311.74	46.41	0.00	0.62	72.07	2430.84	.	1145.09	119.30	1166.46	0.24	0.19
22	189	INORG N	658.87	8.82	0.00	0.62	36.03	704.35	.	486.30	50.66	167.38	0.26	0.34
22	189	FLOW	1365.12	34.26	.	.	148.07	1547.45	75.22	1382.86	136.23	28.36	.	.
22	190	TOTAL P	453.12	0.31	0.00	0.01	5.19	458.64	.	301.88	-15.97	172.72	0.04	0.23
22	190	ORTHO P	125.30	0.06	0.00	0.01	2.60	127.97	.	71.92	-3.80	59.86	0.05	0.13
22	190	TOTAL N	2682.18	1.91	0.00	0.28	173.09	2857.46	.	2680.29	-141.76	318.94	0.04	0.14
22	190	INORG N	713.47	0.45	0.00	0.28	86.54	800.76	.	595.97	-31.52	236.31	0.06	0.14
22	190	FLOW	3662.05	2.84	.	.	334.81	3999.70	180.66	3034.29	-150.93	1116.34	.	.
22	192	TOTAL P	263.57	11.76	0.00	0.00	5.32	280.66	.	66.99	-4.33	218.00	0.04	0.58
22	192	ORTHO P	49.11	2.06	0.00	0.00	2.66	53.84	.	35.31	-2.28	20.81	0.10	0.82
22	192	TOTAL N	2099.90	96.97	0.00	0.00	177.50	2374.37	.	2500.17	-161.64	35.83	0.04	0.89
22	192	INORG N	842.55	37.58	0.00	0.00	88.75	968.88	.	272.99	-17.65	713.53	0.07	0.49
22	192	FLOW	3181.15	159.44	.	.	354.54	3695.13	185.26	3820.75	-235.04	109.41	.	.
23	352	TOTAL P	110.94	38.14	6.13	0.09	2.61	157.91	.	42.31	-0.32	115.93	0.14	0.14
23	352	ORTHO P	59.58	16.29	6.13	0.09	1.30	83.40	.	12.13	-0.09	71.36	0.19	0.19
23	352	TOTAL N	1055.05	378.62	18.10	3.52	86.85	1542.14	.	1164.38	-8.79	386.55	0.09	0.14
23	352	INORG N	206.06	48.18	18.10	3.52	43.42	319.29	.	113.92	-0.86	206.23	0.09	0.21
23	352	FLOW	1048.64	500.42	.	.	128.91	1677.97	110.55	1704.84	-12.03	-14.84	.	.
23	353	TOTAL P	504.36	193.70	0.73	0.00	4.05	702.85	.	656.85	-1.17	47.17	0.16	0.13
23	353	ORTHO P	211.85	98.99	0.73	0.00	2.02	313.60	.	287.09	-0.51	27.01	0.28	0.18
23	353	TOTAL N	3573.53	1638.78	0.90	0.00	134.94	5348.16	.	4416.76	-7.88	939.28	0.09	0.08
23	353	INORG N	875.32	363.79	0.90	0.00	67.47	1307.49	.	1056.44	-1.89	252.93	0.24	0.17
23	353	FLOW	3814.09	2015.68	.	.	211.66	6041.42	171.76	5279.63	-9.12	770.91	.	.
23	413	TOTAL P	201.54	9.69	0.48	0.26	3.96	215.94	.	213.47	.	2.47	0.11	0.11
23	413	ORTHO P	73.42	3.01	0.48	0.26	1.98	79.16	.	71.07	.	8.09	0.11	0.23
23	413	TOTAL N	2716.96	128.98	1.50	9.79	132.04	2989.27	.	3872.48	.	-883.20	0.10	0.24
23	413	INORG N	270.44	10.65	1.50	9.79	66.02	358.41	.	204.74	.	153.67	0.15	0.11
23	413	FLOW	3941.94	202.75	.	.	206.58	4351.27	164.71	4800.36	.	-449.08	.	.
24	011	TOTAL P	114.18	18.37	0.00	0.01	3.56	136.11	.	36.11	-2.19	102.20	0.20	0.19
24	011	ORTHO P	27.36	7.60	0.00	0.01	1.78	36.76	.	13.32	-0.81	24.24	0.15	0.09
24	011	TOTAL N	1567.02	524.77	0.00	0.38	118.55	2210.73	.	1716.13	-104.14	598.74	0.06	0.27
24	011	INORG N	693.19	298.30	0.00	0.38	59.27	1051.16	.	619.48	-37.59	469.27	0.05	0.19
24	011	FLOW	1671.58	469.97	.	.	175.96	2317.51	129.76	2348.17	-134.63	103.96	.	.
24	012	TOTAL P	17.41	1.22	0.00	0.00	0.53	19.16	.	54.82	0.17	-35.83	0.17	0.28
24	012	ORTHO P	7.93	0.69	0.00	0.00	0.26	8.89	.	16.53	0.05	-7.69	0.12	0.45
24	012	TOTAL N	550.95	49.52	0.00	0.25	17.61	618.34	.	585.26	1.80	31.28	0.18	0.16
24	012	INORG N	55.01	4.81	0.00	0.25	8.81	68.88	.	136.16	0.42	-67.70	0.09	0.59
24	012	FLOW	666.64	80.19	.	.	20.28	767.11	19.73	761.98	2.28	2.85	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
24	013	TOTAL P	150.41	13.67	0.00	0.03	6.14	170.26	.	122.59	-7.56	55.22	0.14	0.18
24	013	ORTHO P	61.74	5.91	0.00	0.03	3.07	70.76	.	56.16	-3.46	18.05	0.08	0.10
24	013	TOTAL N	6235.18	726.60	0.00	1.22	204.53	7167.54	.	7673.72	-473.04	-33.15	0.11	0.21
24	013	INORG N	4017.78	311.89	0.00	1.22	102.27	4433.15	.	3651.39	-225.08	1006.85	0.17	0.27
24	013	FLOW	8249.41	1014.86	.	.	309.33	9573.60	213.47	10091.29	-608.90	91.22	.	.
24	016	TOTAL P	38.55	27.39	4.02	0.02	3.90	73.89	.	24.25	-0.34	49.98	0.42	0.07
24	016	ORTHO P	9.63	7.83	4.02	0.02	1.95	23.45	.	11.71	-0.16	11.90	0.11	0.05
24	016	TOTAL N	532.11	370.31	21.28	0.97	129.96	1054.63	.	2284.04	-31.72	-1197.69	0.18	0.35
24	016	INORG N	124.74	83.39	21.28	0.97	64.98	295.36	.	341.87	-4.75	-41.76	0.17	0.11
24	016	FLOW	1174.77	918.79	.	.	198.24	2291.79	138.95	2273.23	-29.64	48.21	.	.
24	021	TOTAL P	35.68	4.50	0.00	0.01	0.79	40.98	.	51.17	0.52	-10.71	0.11	0.18
24	021	ORTHO P	13.71	2.46	0.00	0.01	0.39	16.58	.	14.64	0.15	1.79	0.13	0.18
24	021	TOTAL N	1064.05	340.68	0.00	0.61	26.29	1431.63	.	836.92	8.58	586.12	0.24	0.20
24	021	INORG N	268.92	23.05	0.00	0.61	13.14	305.73	.	116.46	1.19	188.07	0.39	0.16
24	021	FLOW	1031.43	301.98	.	.	28.07	1361.47	16.31	1317.94	13.35	30.18	.	.
24	022	TOTAL P	29.26	3.80	0.00	0.03	2.84	35.93	.	49.35	-5.82	-7.60	0.10	0.25
24	022	ORTHO P	15.46	2.05	0.00	0.03	1.42	18.95	.	27.45	-3.24	-5.26	0.14	0.16
24	022	TOTAL N	1991.38	387.02	0.00	1.13	94.71	2474.24	.	2665.10	-314.19	123.32	0.06	0.16
24	022	INORG N	1360.78	195.69	0.00	1.13	47.35	1604.95	.	883.99	-104.21	825.18	0.08	0.20
24	022	FLOW	1957.03	329.77	.	.	143.22	2430.01	92.89	2649.23	-301.36	82.15	.	.
24	193	TOTAL P	11.66	1.70	0.38	0.01	0.26	14.02	.	36.68	-0.16	-22.51	0.13	0.39
24	193	ORTHO P	6.10	1.16	0.38	0.01	0.13	7.79	.	7.69	-0.03	0.13	0.05	0.14
24	193	TOTAL N	1223.94	215.26	1.14	0.56	8.75	1449.65	.	1455.92	-6.20	-0.07	0.27	0.24
24	193	INORG N	289.85	74.25	1.14	0.56	4.38	370.17	.	208.75	-0.89	162.30	0.08	0.20
24	193	FLOW	841.90	177.29	.	.	9.66	1028.84	6.38	1079.93	-4.57	-46.52	.	.
24	200	TOTAL P	233.62	13.80	1.15	0.03	5.19	253.79	.	103.17	-5.36	155.99	0.09	0.08
24	200	ORTHO P	227.39	10.65	1.15	0.03	2.59	241.82	.	73.22	-3.81	172.40	0.25	0.14
24	200	TOTAL N	9512.57	1247.01	3.55	1.28	172.86	10937.28	.	8087.13	-420.50	3270.66	0.09	0.10
24	200	INORG N	4112.74	639.88	3.55	1.28	86.43	4843.89	.	3170.74	-164.87	1838.02	0.08	0.12
24	200	FLOW	4466.98	687.35	.	.	223.32	5377.65	180.42	5881.34	-296.42	-207.27	.	.
25	020	TOTAL P	504.51	137.86	7.37	0.00	3.49	653.23	.	506.81	0.00	146.41	0.14	0.14
25	020	ORTHO P	113.94	56.90	7.37	0.00	1.74	179.95	.	129.14	0.00	50.81	0.19	0.10
25	020	TOTAL N	6153.79	1278.74	26.85	0.00	116.19	7575.59	.	4819.66	0.00	2755.92	0.13	0.08
25	020	INORG N	1521.62	489.82	26.85	0.00	58.10	2096.39	.	1240.51	0.00	855.87	0.14	0.16
25	020	FLOW	8614.15	1807.43	.	.	193.90	10615.47	141.98	10639.36	0.00	-23.89	.	.
25	102	TOTAL P	29.40	15.99	0.00	0.00	0.39	45.77	.	10.60	0.12	35.06	0.46	0.24
25	102	ORTHO P	5.03	4.78	0.00	0.00	0.19	10.00	.	4.39	0.05	5.56	1.70	0.31
25	102	TOTAL N	291.98	414.71	0.00	0.00	12.84	719.53	.	176.34	1.98	541.20	0.81	0.08
25	102	INORG N	110.36	224.87	0.00	0.00	6.42	341.65	.	57.55	0.65	283.45	1.26	0.22
25	102	FLOW	50.42	72.70	.	.	10.59	133.71	18.31	125.31	1.20	7.21	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
25	103	TOTAL P	56.40	19.08	0.54	0.00	0.48	76.51	.	118.32	-1.29	-40.52	0.05	0.17
25	103	ORTHO P	13.06	4.42	0.54	0.00	0.24	18.26	.	24.16	-0.26	-5.63	0.04	0.22
25	103	TOTAL N	1176.25	397.98	1.63	0.00	16.04	1591.91	.	1246.46	-13.60	359.04	0.03	0.16
25	103	INORG N	534.30	180.78	1.63	0.00	8.02	724.73	.	420.46	-4.59	308.86	0.03	0.13
25	103	FLOW	705.82	238.81	.	.	18.41	963.04	21.24	832.83	-8.85	139.06	.	.
25	104	TOTAL P	20.65	7.74	0.00	0.00	0.34	28.73	.	58.76	-0.29	-29.74	0.07	0.31
25	104	ORTHO P	7.75	2.02	0.00	0.00	0.17	9.94	.	10.93	-0.05	-0.93	0.08	0.15
25	104	TOTAL N	617.68	268.25	0.00	0.21	11.41	897.56	.	742.15	-3.68	159.08	0.08	0.06
25	104	INORG N	170.37	60.43	0.00	0.21	5.70	236.71	.	233.82	-1.16	4.05	0.08	0.11
25	104	FLOW	424.25	163.65	.	.	13.09	600.99	15.10	563.88	-2.72	39.83	.	.
25	105	TOTAL P	603.56	65.67	1.65	0.00	1.15	672.04	.	312.10	0.10	359.84	0.11	0.19
25	105	ORTHO P	172.28	14.23	1.65	0.00	0.57	188.74	.	125.09	0.04	63.61	0.06	0.15
25	105	TOTAL N	5444.34	680.75	4.96	0.00	38.32	6168.38	.	3463.53	1.14	2703.72	0.07	0.13
25	105	INORG N	2205.65	228.16	4.96	0.00	19.16	2457.93	.	1299.76	0.43	1157.75	0.07	0.14
25	105	FLOW	1590.60	202.19	.	.	43.97	1836.77	48.77	1801.11	0.58	35.08	.	.
25	107	TOTAL P	9.37	4.58	0.00	0.00	0.73	14.68	.	2.95	0.18	11.54	0.39	0.08
25	107	ORTHO P	3.05	1.12	0.00	0.00	0.37	4.54	.	0.88	0.05	3.60	0.38	0.13
25	107	TOTAL N	128.12	66.49	0.00	0.00	24.43	219.04	.	60.44	3.70	154.89	0.37	0.19
25	107	INORG N	31.84	23.99	0.00	0.00	12.22	68.05	.	7.94	0.49	59.62	0.32	0.17
25	107	FLOW	36.11	36.18	.	.	19.79	92.08	34.83	83.97	3.01	5.10	.	.
25	112	TOTAL P	22.16	7.04	0.52	0.01	0.34	30.08	.	63.10	-0.15	-32.87	0.06	0.17
25	112	ORTHO P	5.17	2.01	0.52	0.01	0.17	7.88	.	12.74	-0.03	-4.83	0.09	0.24
25	112	TOTAL N	529.80	171.60	1.56	0.56	11.49	715.02	.	1068.46	-2.53	-350.90	0.06	0.12
25	112	INORG N	153.07	40.94	1.56	0.56	5.75	201.88	.	290.68	-0.69	-88.11	0.08	0.08
25	112	FLOW	419.31	143.74	.	.	13.19	576.24	16.09	734.96	-1.70	-157.02	.	.
25	267	TOTAL P	2884.45	188.91	27.30	0.01	12.16	3112.82	.	1832.51	-144.67	1424.99	0.06	0.26
25	267	ORTHO P	641.84	42.65	27.30	0.01	6.08	717.87	.	568.00	-44.84	194.72	0.08	0.25
25	267	TOTAL N	14205.09	2032.84	80.39	0.27	405.25	16723.84	.	14148.17	-1116.95	3692.62	0.08	0.13
25	267	INORG N	1947.01	210.30	80.39	0.27	202.63	2440.60	.	4639.05	-366.24	-1832.22	0.31	0.24
25	267	FLOW	5564.10	3021.59	.	.	575.53	9161.23	536.46	10126.69	-757.12	-208.35	.	.
25	269	TOTAL P	1.10	0.04	0.00	0.00	0.22	1.36	.	1.23	-0.29	0.42	0.23	0.11
25	269	ORTHO P	0.25	0.01	0.00	0.00	0.11	0.38	.	0.36	-0.08	0.10	0.18	0.09
25	269	TOTAL N	19.43	0.77	0.00	0.10	7.41	27.71	.	21.35	-4.94	11.30	0.14	0.28
25	269	INORG N	4.37	0.20	0.00	0.10	3.70	8.38	.	1.85	-0.43	6.96	0.20	0.50
25	269	FLOW	25.95	0.45	.	.	4.36	30.76	12.07	36.00	-5.53	0.30	.	.
25	273	TOTAL P	4779.82	213.61	19.93	0.01	3.42	5016.78	.	1513.53	-47.73	3550.98	0.15	0.04
25	273	ORTHO P	1556.80	31.45	19.93	0.01	1.71	1609.90	.	1191.93	-37.59	455.55	0.07	0.10
25	273	TOTAL N	37469.40	2962.24	55.45	0.39	113.96	40601.45	.	20297.25	-640.04	20944.24	0.10	0.10
25	273	INORG N	10609.82	629.82	55.45	0.39	56.98	11352.47	.	10693.29	-337.20	996.38	0.21	0.33
25	273	FLOW	11395.79	1572.04	.	.	144.36	13112.19	153.75	14019.16	-437.23	-469.75	.	.

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DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
25	275	TOTAL P	935.19	21.53	8.33	0.01	3.88	968.94	.	413.56	-11.57	566.95	0.62	0.16
25	275	ORTHO P	168.58	20.56	8.33	0.01	1.94	199.42	.	157.17	-4.40	46.64	0.21	0.25
25	275	TOTAL N	7474.54	767.25	19.89	0.51	129.23	8391.43	.	8804.53	-246.29	-166.81	0.21	0.03
25	275	INORG N	1824.39	73.51	19.89	0.51	64.62	1982.93	.	2319.57	-64.88	-271.75	0.25	0.05
25	275	FLOW	3742.81	489.55	.	.	167.60	4399.96	174.36	4995.95	-134.87	-461.12	.	.
25	278	TOTAL P	195.85	14.37	15.83	0.02	1.60	227.68	.	120.19	-2.29	109.77	0.14	0.14
25	278	ORTHO P	109.22	8.01	15.83	0.02	0.80	133.88	.	76.76	-1.46	58.58	0.10	0.17
25	278	TOTAL N	4170.26	520.63	31.01	0.70	53.34	4775.94	.	4629.23	-88.14	234.85	0.09	0.16
25	278	INORG N	1751.25	94.22	31.01	0.70	26.67	1903.85	.	1583.81	-30.16	350.20	0.15	0.18
25	278	FLOW	1969.30	462.30	.	.	73.40	2504.99	66.53	2576.93	-47.80	-24.14	.	.
25	281	TOTAL P	100.92	11.25	0.00	0.00	1.08	113.25	.	112.90	-3.03	3.39	0.12	0.11
25	281	ORTHO P	31.82	2.32	0.00	0.00	0.54	34.68	.	42.19	-1.13	-6.37	0.12	0.32
25	281	TOTAL N	1358.55	124.81	0.00	0.14	35.85	1519.34	.	1440.40	-38.71	117.66	0.23	0.14
25	281	INORG N	169.11	24.16	0.00	0.14	17.92	211.33	.	264.49	-7.11	-46.05	0.20	0.24
25	281	FLOW	1352.13	238.35	.	.	43.97	1634.46	44.71	1638.48	-42.83	38.80	.	.
25	348	TOTAL P	2998.32	40.02	8.79	0.22	10.67	3058.02	.	780.87	-59.89	2337.03	0.31	0.33
25	348	ORTHO P	617.65	14.71	8.79	0.22	5.33	646.70	.	394.10	-30.22	282.82	0.20	0.44
25	348	TOTAL N	19356.74	806.31	23.16	8.44	355.51	20550.17	.	10090.86	-773.88	11233.18	0.14	0.29
25	348	INORG N	2825.92	387.80	23.16	8.44	177.76	3423.09	.	2077.64	-159.34	1504.79	0.15	0.18
25	348	FLOW	6863.75	856.10	.	.	416.88	8136.74	561.11	9048.39	-650.90	-260.75	.	.
25	370	TOTAL P	7.15	0.76	0.00	0.21	1.03	9.16	.	1.94	4.06	3.16	0.49	0.23
25	370	ORTHO P	1.90	0.20	0.00	0.21	0.52	2.83	.	0.38	0.79	1.66	0.11	0.15
25	370	TOTAL N	127.95	13.57	0.00	8.14	34.35	184.01	.	45.87	95.90	42.24	0.49	0.14
25	370	INORG N	72.80	7.72	0.00	8.14	17.18	105.84	.	5.16	10.78	89.91	0.21	0.37
25	370	FLOW	171.24	18.16	.	.	24.31	213.71	55.96	124.28	142.83	-53.40	.	.
26	345	TOTAL P	216.62	60.25	9.72	0.05	1.62	288.26	.	24.44	0.27	263.55	0.06	0.15
26	345	ORTHO P	168.07	54.93	9.72	0.05	0.81	233.58	.	9.06	0.10	224.41	0.06	0.16
26	345	TOTAL N	878.66	168.73	42.60	1.94	54.14	1146.07	.	905.21	9.94	230.91	0.05	0.06
26	345	INORG N	463.71	117.83	42.60	1.94	27.07	653.16	.	326.55	3.59	323.03	0.05	0.13
26	345	FLOW	599.87	87.49	.	.	48.35	735.71	77.18	1156.90	11.86	-433.04	.	.
26	347	TOTAL P	13.79	0.60	0.00	0.02	1.05	15.46	.	9.35	-0.43	6.53	0.19	0.06
26	347	ORTHO P	5.97	0.34	0.00	0.02	0.52	6.85	.	4.73	-0.22	2.34	0.14	0.10
26	347	TOTAL N	1110.66	22.92	0.00	0.83	34.91	1169.33	.	602.94	-27.66	594.04	0.04	0.05
26	347	INORG N	770.82	8.69	0.00	0.83	17.46	797.80	.	352.28	-16.16	461.68	0.04	0.11
26	347	FLOW	797.83	57.71	.	.	29.95	885.49	49.77	878.91	-38.04	44.62	.	.
26	354	TOTAL P	227.81	2.77	6.47	0.08	1.68	238.81	.	46.89	-1.40	193.32	0.32	0.24
26	354	ORTHO P	68.72	3.07	6.47	0.08	0.84	79.19	.	22.77	-0.68	57.10	0.68	0.35
26	354	TOTAL N	2014.64	185.81	11.51	3.10	55.96	2271.02	.	849.69	-25.34	1446.67	0.50	0.15
26	354	INORG N	576.77	92.23	11.51	3.10	27.98	711.60	.	193.94	-5.78	523.44	0.36	0.25
26	354	FLOW	991.64	97.23	.	.	65.67	1154.54	91.17	1047.74	-28.53	135.34	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
26	355	TOTAL P	288.41	37.89	30.72	0.00	2.89	359.91	.	112.36	0.02	247.54	0.30	0.09
26	355	ORTHO P	79.35	15.94	30.72	0.00	1.45	127.46	.	63.83	0.01	63.62	0.13	0.15
26	355	TOTAL N	1837.96	667.37	166.34	0.00	96.49	2768.15	.	1394.08	0.24	1373.84	0.19	0.09
26	355	INORG N	406.12	164.73	166.34	0.00	48.25	785.44	.	654.69	0.11	130.63	0.12	0.14
26	355	FLOW	914.06	516.83	.	.	106.57	1537.46	157.21	1615.24	0.25	-78.03	.	.
26	359	TOTAL P	253.23	107.33	1.06	0.03	13.29	374.95	.	98.03	4.11	272.81	0.06	0.20
26	359	ORTHO P	89.74	35.94	1.06	0.03	6.64	133.43	.	37.83	1.58	94.02	0.07	0.37
26	359	TOTAL N	2493.22	1125.15	3.12	1.30	442.94	4065.73	.	2754.41	115.39	1195.94	0.06	0.28
26	359	INORG N	452.48	215.87	3.12	1.30	221.47	894.25	.	618.93	25.93	249.39	0.13	0.17
26	359	FLOW	2745.81	1079.03	.	.	707.18	4532.03	586.35	4212.73	151.92	167.38	.	.
26	360	TOTAL P	3.71	0.70	0.00	0.00	0.30	4.71	.	1.17	5.49	-1.95	0.05	0.00
26	360	ORTHO P	1.49	0.28	0.00	0.00	0.15	1.92	.	0.23	1.06	0.64	0.06	0.00
26	360	TOTAL N	289.34	54.46	0.00	0.00	10.09	353.89	.	19.05	89.48	245.37	0.03	0.00
26	360	INORG N	757.26	142.54	0.00	0.00	5.04	904.84	.	0.23	1.10	903.51	0.05	0.00
26	360	FLOW	68.89	12.97	.	.	6.45	88.31	19.00	28.01	42.33	17.97	.	.
26	361	TOTAL P	65.71	11.81	2.17	0.00	1.51	81.21	.	49.08	0.00	32.12	0.09	0.15
26	361	ORTHO P	25.57	4.53	2.17	0.00	0.76	33.02	.	14.99	0.00	18.03	0.12	0.33
26	361	TOTAL N	977.67	194.18	6.49	0.21	50.34	1228.89	.	915.05	0.00	313.84	0.04	0.10
26	361	INORG N	125.19	26.06	6.49	0.21	25.17	183.12	.	67.20	0.00	115.92	0.13	0.25
26	361	FLOW	564.14	107.22	.	.	60.04	731.40	69.20	815.88	0.00	-84.48	.	.
26	362	TOTAL P	29.85	0.93	0.68	0.00	0.81	32.28	.	12.25	-0.45	20.48	0.34	0.12
26	362	ORTHO P	8.10	0.30	0.68	0.00	0.41	9.49	.	4.33	-0.16	5.32	0.19	0.11
26	362	TOTAL N	835.51	35.50	2.04	0.00	27.17	900.22	.	463.71	-16.93	453.43	0.25	0.08
26	362	INORG N	263.34	15.54	2.04	0.00	13.58	294.50	.	184.25	-6.73	116.98	0.13	0.09
26	362	FLOW	615.01	55.66	.	.	24.26	694.93	38.04	751.90	-26.06	-30.91	.	.
26	364	TOTAL P	608.55	1.02	1.53	0.25	2.60	613.95	.	28.54	2.78	582.62	1.32	0.30
26	364	ORTHO P	92.81	0.56	1.53	0.25	1.30	96.45	.	20.07	1.96	74.43	1.04	0.18
26	364	TOTAL N	3340.26	77.76	4.59	9.42	86.68	3518.71	.	2419.96	236.04	862.71	0.63	0.35
26	364	INORG N	688.10	37.80	4.59	9.42	43.34	783.26	.	1623.92	158.40	-999.06	0.41	0.73
26	364	FLOW	1989.82	84.17	.	.	79.41	2153.39	121.37	2105.59	193.54	-145.74	.	.
28	219	TOTAL P	0.89	0.11	0.00	0.04	0.52	1.56	.	1.98	-2.20	1.79	0.56	2.37
28	219	ORTHO P	0.23	0.02	0.00	0.04	0.26	0.55	.	0.33	-0.37	0.58	0.22	1.10
28	219	TOTAL N	10.38	1.34	0.00	1.52	17.30	30.54	.	81.70	-91.10	39.95	0.37	1.97
28	219	INORG N	1.51	0.12	0.00	1.52	8.65	11.80	.	3.14	-3.51	12.17	0.29	1.28
28	219	FLOW	11.87	1.53	.	.	4.82	18.22	28.18	81.37	-59.31	-3.85	.	.
29	100	TOTAL P	63.41	32.92	0.56	0.16	1.35	98.41	.	9.29	-0.20	89.31	0.06	0.13
29	100	ORTHO P	19.53	10.14	0.56	0.16	0.67	31.07	.	1.69	-0.04	29.41	0.14	0.14
29	100	TOTAL N	442.29	229.59	1.70	0.92	44.85	719.35	.	303.81	-6.43	421.97	0.16	0.07
29	100	INORG N	294.82	153.04	1.70	0.92	22.43	472.90	.	145.66	-3.08	330.32	0.12	0.06
29	100	FLOW	145.95	75.76	.	.	34.52	256.24	42.25	217.38	-3.71	42.56	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
29	106	TOTAL P	133.14	10.91	0.81	0.01	0.38	145.27	.	17.38	3.40	124.49	0.15	0.43
29	106	ORTHO P	29.90	3.37	0.81	0.01	0.19	34.29	.	5.64	1.10	27.55	0.07	0.17
29	106	TOTAL N	510.74	137.33	1.05	0.49	12.77	662.38	.	306.89	60.00	295.49	0.11	0.16
29	106	INORG N	75.97	68.31	1.05	0.49	6.39	152.21	.	84.53	16.53	51.16	0.15	0.19
29	106	FLOW	195.72	64.30	.	.	7.56	267.59	18.86	212.56	37.87	17.16	.	.
29	108	TOTAL P	235.91	18.88	0.83	0.00	1.94	257.57	.	27.22	1.81	228.54	0.08	0.24
29	108	ORTHO P	91.72	8.74	0.83	0.00	0.97	102.26	.	12.95	0.86	88.45	0.10	0.27
29	108	TOTAL N	1086.80	189.12	2.48	0.00	64.79	1343.20	.	681.05	45.34	616.81	0.19	0.41
29	108	INORG N	386.02	57.04	2.48	0.00	32.40	477.94	.	108.37	7.21	362.35	0.28	0.45
29	108	FLOW	476.06	54.98	.	.	42.92	573.96	89.07	545.60	30.39	-2.03	.	.
29	109	TOTAL P	27.77	23.46	0.31	0.00	0.83	52.37	.	7.54	1.14	43.69	0.26	0.15
29	109	ORTHO P	5.24	4.43	0.31	0.00	0.41	10.39	.	2.66	0.40	7.34	0.09	0.31
29	109	TOTAL N	502.52	424.40	0.93	0.00	27.66	955.51	.	364.64	55.00	535.88	0.11	0.17
29	109	INORG N	113.15	95.56	0.93	0.00	13.83	223.48	.	81.20	12.25	130.03	1.62	0.33
29	109	FLOW	129.85	109.67	.	.	23.04	262.55	36.61	246.86	31.71	-16.03	.	.
29	110	TOTAL P	145.87	6.62	1.78	0.00	1.48	155.74	.	23.11	-0.57	133.20	0.06	0.38
29	110	ORTHO P	40.37	1.62	1.78	0.00	0.74	44.51	.	7.28	-0.18	37.41	0.03	0.51
29	110	TOTAL N	921.12	103.15	5.33	0.00	49.30	1078.91	.	440.34	-10.77	649.34	0.06	0.19
29	110	INORG N	484.94	40.89	5.33	0.00	24.65	555.82	.	248.80	-6.09	313.11	0.10	0.33
29	110	FLOW	268.71	73.09	.	.	37.21	379.01	60.25	430.90	-9.07	-42.82	.	.
29	111	TOTAL P	22.10	4.54	0.68	0.00	0.49	27.81	.	14.48	-0.30	13.63	0.27	0.12
29	111	ORTHO P	7.25	2.65	0.68	0.00	0.24	10.82	.	3.60	-0.08	7.29	0.31	0.16
29	111	TOTAL N	479.61	149.96	2.04	0.00	16.30	647.92	.	555.03	-11.58	104.47	0.34	0.09
29	111	INORG N	163.08	40.21	2.04	0.00	8.15	213.47	.	175.78	-3.67	41.36	0.29	0.02
29	111	FLOW	126.28	77.12	.	.	13.58	216.98	20.75	264.13	-5.08	-42.07	.	.
29	113	TOTAL P	1464.46	34.08	7.49	0.00	2.06	1508.10	.	203.02	8.91	1296.17	0.07	0.23
29	113	ORTHO P	368.28	13.08	7.49	0.00	1.03	389.89	.	115.05	5.05	269.78	0.03	0.33
29	113	TOTAL N	6467.39	447.62	26.74	0.00	68.82	7010.57	.	3427.27	150.44	3432.86	0.11	0.07
29	113	INORG N	2409.53	201.52	26.74	0.00	34.41	2672.20	.	1785.62	78.38	808.20	0.19	0.24
29	113	FLOW	1267.33	202.40	.	.	52.01	1521.73	94.61	1585.73	65.45	-129.45	.	.
29	114	TOTAL P	18.32	0.12	0.27	0.00	1.12	19.84	.	3.14	-0.31	17.01	0.18	0.14
29	114	ORTHO P	2.99	0.02	0.27	0.00	0.56	3.84	.	0.98	-0.10	2.95	0.14	0.33
29	114	TOTAL N	121.04	14.65	0.81	0.00	37.47	173.97	.	90.41	-9.02	92.57	0.10	0.08
29	114	INORG N	21.53	7.94	0.81	0.00	18.73	49.02	.	19.77	-1.97	31.22	0.17	0.08
29	114	FLOW	74.06	7.46	.	.	15.28	96.80	53.41	136.84	-8.32	-31.71	.	.
29	194	TOTAL P	24.00	2.52	0.00	0.02	0.99	27.53	.	43.74	-0.24	-15.97	0.25	0.15
29	194	ORTHO P	26.64	1.44	0.00	0.02	0.50	28.60	.	20.66	-0.11	8.05	0.51	0.18
29	194	TOTAL N	803.31	355.91	0.00	0.99	33.03	1193.24	.	1202.33	-6.58	-2.50	0.26	0.06
29	194	INORG N	257.07	52.54	0.00	0.99	16.52	327.11	.	278.39	-1.52	50.24	1.09	0.22
29	194	FLOW	448.52	193.09	.	.	36.68	678.30	35.32	711.97	-0.71	-29.97	.	.

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DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
29	195	TOTAL P	56.11	36.51	0.38	0.00	3.14	96.14	.	27.72	0.30	68.12	0.22	0.05
29	195	ORTHO P	28.47	11.81	0.38	0.00	1.57	42.24	.	9.86	0.11	32.27	0.14	0.06
29	195	TOTAL N	2092.22	1229.91	0.97	0.21	104.56	3427.87	.	3790.59	40.83	-403.55	0.05	0.06
29	195	INORG N	1111.50	762.41	0.97	0.21	52.28	1927.37	.	800.56	8.62	1118.18	0.04	0.08
29	195	FLOW	741.51	508.81	.	.	116.11	1366.43	111.79	1487.64	14.82	-136.03	.	.
29	207	TOTAL P	72.19	1.14	1.92	0.04	1.43	76.72	.	21.05	-3.02	58.69	0.09	0.09
29	207	ORTHO P	62.50	0.45	1.92	0.04	0.71	65.63	.	11.42	-1.64	55.85	0.18	0.16
29	207	TOTAL N	1253.35	3.48	5.59	1.60	47.55	1311.57	.	213.28	-30.57	1128.86	0.13	0.08
29	207	INORG N	142.40	0.80	5.59	1.60	23.77	174.17	.	30.66	-4.39	147.90	1.79	0.27
29	207	FLOW	223.10	1.13	.	.	29.02	253.26	65.36	237.97	-24.74	40.03	.	.
30	064	TOTAL P	0.46	0.03	0.00	0.00	0.10	0.60	.	0.38	0.01	0.21	0.96	0.31
30	064	ORTHO P	0.19	0.01	0.00	0.00	0.05	0.26	.	0.20	0.00	0.06	0.50	0.56
30	064	TOTAL N	2.99	0.22	0.00	0.24	3.37	6.83	.	3.54	0.05	3.23	0.54	0.21
30	064	INORG N	1.26	0.09	0.00	0.24	1.69	3.28	.	0.87	0.01	2.39	0.66	0.37
30	064	FLOW	0.92	0.07	.	.	1.43	2.42	4.12	6.51	0.04	-4.13	.	.
30	215	TOTAL P	1.56	0.57	0.00	0.00	0.09	2.22	.	0.75	0.06	1.41	0.08	0.40
30	215	ORTHO P	0.92	0.34	0.00	0.00	0.04	1.30	.	0.23	0.02	1.06	0.13	0.69
30	215	TOTAL N	8.95	3.26	0.00	0.00	2.92	15.13	.	5.05	0.38	9.70	0.09	0.28
30	215	INORG N	2.81	1.02	0.00	0.00	1.46	5.30	.	2.05	0.15	3.09	0.13	0.57
30	215	FLOW	4.54	1.65	.	.	1.77	7.97	3.27	6.26	0.22	1.48	.	.
30	217	TOTAL P	3.89	2.12	0.00	0.00	0.22	6.23	.	2.40	0.26	3.56	0.11	0.29
30	217	ORTHO P	2.37	1.29	0.00	0.00	0.11	3.76	.	1.78	0.19	1.78	0.11	0.30
30	217	TOTAL N	36.71	19.97	0.00	0.00	7.18	63.85	.	13.87	1.50	48.49	0.08	0.21
30	217	INORG N	14.15	7.70	0.00	0.00	3.59	25.44	.	6.74	0.73	17.97	0.11	0.33
30	217	FLOW	11.05	6.01	.	.	4.34	21.41	8.04	17.47	1.02	2.92	.	.
30	235	TOTAL P	10887.86	314.25	17.65	0.01	42.72	11262.50	.	779.57	41.24	10441.69	0.24	0.38
30	235	ORTHO P	567.45	94.08	17.65	0.01	21.36	700.55	.	345.58	18.28	336.69	0.18	0.46
30	235	TOTAL N	41805.09	1889.53	52.94	0.45	1424.15	45172.17	.	15676.70	829.28	28666.19	0.12	0.21
30	235	INORG N	4683.45	167.10	52.94	0.45	712.08	5616.02	.	4792.39	253.51	570.12	0.29	0.20
30	235	FLOW	31337.46	1030.59	.	.	609.47	32977.53	1341.41	29981.41	1515.02	1481.10	.	.
31	077	TOTAL P	88.12	22.26	0.00	0.00	1.71	112.09	.	91.73	-3.19	23.55	0.21	0.19
31	077	ORTHO P	37.06	8.54	0.00	0.00	0.85	46.46	.	42.76	-1.49	5.19	0.30	0.17
31	077	TOTAL N	3093.39	876.93	0.00	0.00	56.99	4027.31	.	2135.39	-74.17	1966.10	0.18	0.23
31	077	INORG N	136.34	37.20	0.00	0.00	28.50	202.04	.	429.64	-14.92	-212.68	0.11	0.13
31	077	FLOW	4578.89	1229.44	.	.	37.07	5845.40	39.17	5550.58	-191.44	486.26	.	.
32	204	TOTAL P	24.04	84.67	0.00	0.00	3.86	112.57	.	233.29	-0.01	-120.70	0.07	0.10
32	204	ORTHO P	12.88	24.94	0.00	0.00	1.93	39.75	.	198.06	-0.01	-158.30	0.13	0.13
32	204	TOTAL N	144.41	979.56	0.00	0.00	128.77	1252.75	.	4194.20	-0.24	-2941.21	0.22	0.30
32	204	INORG N	18.09	97.27	0.00	0.00	64.39	179.75	.	828.34	-0.05	-648.54	0.21	0.11
32	204	FLOW	332.19	4569.96	.	.	58.72	4960.87	85.23	9751.90	-0.56	-4790.47	.	.

NUTRIENT BUDGET SUMMARIES

DIS	RES	PARAM	LGAUG	LUNGD	LPOINT	LOTHER	LPREC	LTOTAL	LEVAP	LOUT	LDSTOR	LNET	CVI	CVO
33	300	TOTAL P	36.50	8.80	0.00	0.00	0.27	45.57	.	40.32	-0.89	6.14	0.12	0.20
33	300	ORTHO P	28.26	6.81	0.00	0.00	0.13	35.21	.	27.05	-0.60	8.76	0.12	0.28
33	300	TOTAL N	166.59	40.15	0.00	0.03	8.88	215.65	.	276.91	-6.12	-55.13	0.18	0.36
33	300	INORG N	26.08	6.29	0.00	0.03	4.44	36.83	.	53.69	-1.19	-15.67	0.14	0.20
33	300	FLOW	908.65	219.00	.	.	10.98	1138.63	5.42	1132.75	-24.93	30.81	.	.
34	048	TOTAL P	26.75	31.77	10.62	0.00	1.21	70.36	.	32.98	2.63	34.76	0.23	0.19
34	048	ORTHO P	12.50	14.50	10.62	0.00	0.61	38.23	.	17.26	1.38	19.58	0.50	0.09
34	048	TOTAL N	873.95	752.11	23.56	0.19	40.37	1690.19	.	2183.03	174.29	-667.13	0.16	0.12
34	048	INORG N	49.88	88.09	23.56	0.19	20.18	181.91	.	250.08	19.97	-88.13	0.22	0.03
34	048	FLOW	1248.40	786.08	.	.	36.29	2070.77	61.68	2103.77	163.03	-196.03	.	.
35	029	TOTAL P	46.61	5.16	0.00	0.00	0.20	51.97	.	22.88	1.14	27.95	0.35	0.15
35	029	ORTHO P	9.50	1.05	0.00	0.00	0.10	10.66	.	9.26	0.46	0.93	0.15	0.11
35	029	TOTAL N	335.72	37.19	0.00	0.00	6.73	379.64	.	274.54	13.72	91.37	0.21	0.12
35	029	INORG N	51.52	5.71	0.00	0.00	3.36	60.59	.	43.15	2.16	15.28	0.22	0.15
35	029	FLOW	357.78	39.63	.	.	10.13	407.54	6.51	372.26	18.28	16.99	.	.
35	039	TOTAL P	0.43	0.17	0.00	0.00	0.08	0.69	.	0.13	-0.10	0.66	0.39	0.17
35	039	ORTHO P	0.20	0.08	0.00	0.00	0.04	0.32	.	0.04	-0.03	0.31	0.25	0.22
35	039	TOTAL N	1.24	0.48	0.00	0.21	2.74	4.67	.	2.28	-1.77	4.16	0.26	0.42
35	039	INORG N	0.88	0.34	0.00	0.21	1.37	2.81	.	0.15	-0.11	2.78	0.36	0.12
35	039	FLOW	5.57	2.17	.	.	2.31	10.05	3.77	8.69	-3.83	5.19	.	.

Table B2

Water Balances and Inflow Concentrations by Period

Symbol	Meaning
DIS	CE District code
RES	CE reservoir code
GP	data screening code (A = high accuracy, B = low accuracy)
PD	period (N = normal hydrologic year, P = year of pool monitoring by EPA/NES, T = period of tributary monitoring by EPA/NES)
QINC	corrected total inflow (hm3/yr) = (cubic hectometre/yr)
QOUT	total outflow (hm3/yr)
QEVAP	evaporation (hm3/yr)
QSTOR	change in storage (hm3/yr)
ELEV	mean elevation (ft,msl)
AREA	mean surface area (km2)
VOLUME	mean volume (hm3)
ZMAX	maximum depth (m)
ZMEAN	mean depth (m)
QS	surface overflow rate (m/yr)
THYD	hydraulic residence time (yr)
IPTL	inflow total P concentration (mg/m3)
IPDS	inflow ortho P concentration (mg/m3)
INTL	inflow total N concentration (mg/m3)
ININ	inflow inorganic N concentration (mg/m3)

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
02	176	B	N	210.1	208.1	2.1	0.0	580.0	3.4	33.1	24.0	9.6	60.5	0.159	22.8	7.2	906.5	462.7
02	176	B	P	.	.	2.1	-2.0	583.6	3.1	37.7	25.1	12.3	.	.	.	.	.	.
02	176	B	T	305.7	292.8	2.1	10.8	587.9	3.3	41.0	26.4	12.6	90.0	0.140	23.2	6.8	917.2	499.7
03	307	A	N	195.1	192.0	3.1	0.0	628.0	3.8	50.9	38.7	13.3	50.1	0.265	13.7	6.6	1137.2	693.6
03	307	A	P	212.5	207.5	3.1	1.9	628.2	3.8	51.3	38.8	13.5	54.5	0.247	13.2	6.6	1144.8	694.1
03	307	A	T	209.2	208.0	3.1	-1.9	627.6	3.8	50.6	38.6	13.4	55.1	0.243	13.3	6.6	1143.4	694.0
04	312	A	N	387.0	383.5	3.5	0.0	630.0	7.0	35.5	15.2	5.1	54.8	0.093	174.3	113.6	2695.6	1847.7
04	312	A	P	477.1	476.5	3.5	-2.9	621.6	4.8	22.7	12.7	4.7	99.1	0.048	165.1	104.0	2663.9	1775.2
04	312	A	T	456.8	460.9	3.5	-7.5	620.6	4.7	21.4	12.4	4.5	98.0	0.046	166.9	105.9	2670.4	1790.0
06	372	A	N	6825.6	6629.4	196.2	0.0	302.0	215.0	1888.6	33.2	8.8	30.8	0.285	128.1	36.2	1301.0	350.8
06	372	A	P	10868.3	10621.3	196.2	50.8	300.8	199.6	1865.8	32.9	9.3	53.2	0.176	133.0	33.0	1386.1	371.3
06	372	A	T	7380.1	7262.4	196.2	-78.5	299.6	192.8	1787.3	32.5	9.3	37.7	0.246	128.8	35.6	1314.6	353.8
08	074	A	N	7770.1	7469.4	300.7	0.0	330.0	287.9	3098.3	42.7	10.8	25.9	0.415	54.8	15.8	643.6	237.6
08	074	A	P	12520.8	11864.2	300.7	356.0	328.5	277.7	2967.8	42.2	10.7	42.7	0.250	54.2	15.5	684.0	271.1
08	074	A	T	11896.3	11483.1	300.7	112.6	329.2	281.4	3021.5	42.4	10.7	40.8	0.263	54.3	15.5	679.5	267.3
08	330	A	N	3950.5	3721.6	228.9	0.0	660.0	227.1	3147.2	56.4	13.9	16.4	0.846	51.4	22.2	673.9	239.4
08	330	A	P	5756.5	5317.1	228.9	210.5	659.4	223.1	3098.4	56.2	13.9	23.8	0.583	51.8	20.5	669.5	246.1
08	330	A	T	6153.6	5801.8	228.9	122.9	660.0	224.9	3138.2	56.4	14.0	25.8	0.541	52.0	20.2	668.9	247.7
10	003	A	N	6532.3	6518.1	14.2	0.0	187.0	13.3	145.6	21.9	10.9	488.2	0.022	35.3	10.5	1314.3	665.2
10	003	A	P	9539.8	9524.6	14.2	1.0	186.8	13.3	145.0	21.9	10.9	715.3	0.015	38.0	11.0	1279.6	629.8
10	003	A	T	10386.4	10372.6	14.2	-0.4	186.8	13.3	145.0	21.9	10.9	779.1	0.014	38.6	11.1	1271.9	622.2
10	069	A	N	1726.4	1684.3	42.1	0.0	848.0	57.7	582.1	45.1	10.1	29.2	0.346	61.8	16.7	661.5	283.1
10	069	A	P	2643.5	2539.1	42.1	62.3	835.5	42.3	380.0	41.3	9.0	60.0	0.150	76.1	16.4	728.5	298.9
10	069	A	T	2544.9	2480.1	42.1	22.7	836.3	42.4	388.8	41.5	9.2	58.5	0.157	74.6	16.4	722.2	297.4
10	071	A	N	20248.6	20068.4	180.2	0.0	77.0	151.8	453.4	10.1	3.0	132.2	0.023	85.3	29.6	1298.0	442.4
10	071	A	P	29270.6	29040.4	180.2	50.1	77.2	153.0	463.0	10.1	3.0	189.8	0.016	96.6	30.6	1426.1	442.0
10	071	A	T	26995.0	26808.1	180.2	6.7	77.3	154.0	465.9	10.1	3.0	174.1	0.017	94.0	30.4	1396.9	442.1
10	072	A	N	9990.5	9798.5	192.0	0.0	190.0	182.9	1153.4	28.4	6.3	53.6	0.118	93.2	33.7	1023.2	433.8
10	072	A	P	13087.5	12806.3	192.0	89.2	187.4	173.1	1017.9	27.6	5.9	74.0	0.079	93.5	32.4	1016.3	422.0
10	072	A	T	12698.4	12518.1	192.0	-11.7	187.7	175.5	1033.0	27.7	5.9	71.3	0.083	93.5	32.5	1017.1	423.3
10	076	A	N	2095.2	1933.7	161.5	0.0	1070.0	154.0	2366.3	45.7	15.4	12.6	1.224	72.9	34.0	840.2	399.1
10	076	A	P	3003.2	2443.9	161.5	397.8	1068.0	150.9	2278.6	45.1	15.1	16.2	0.932	75.4	30.2	1006.1	453.9
10	076	A	T	2888.2	2646.5	161.5	80.2	1069.9	154.8	2364.7	45.7	15.3	17.1	0.894	75.1	30.6	986.3	447.4
10	411	A	N	6079.5	6038.0	41.4	0.0	241.5	28.2	221.3	20.3	7.8	213.8	0.037	65.5	15.5	1682.4	903.3
10	411	A	P	8822.6	8782.4	41.4	-1.2	254.7	38.7	364.2	24.3	9.4	226.7	0.041	64.1	15.1	1673.6	909.7
10	411	A	T	9570.1	9522.7	41.4	5.9	254.7	38.8	364.7	24.3	9.4	245.6	0.038	63.8	15.0	1671.7	911.2
14	099	A	N	4128.0	4079.5	48.5	0.0	730.0	46.2	135.7	12.2	2.9	88.4	0.033	601.4	183.3	8960.8	6591.4
14	099	A	P	9330.1	9670.8	48.5	-389.2	736.8	64.4	320.8	14.3	5.0	150.3	0.033	627.8	163.7	11339.6	9421.6
14	099	A	T	4827.2	4981.3	48.5	-202.6	731.8	51.5	181.6	12.7	3.5	96.7	0.036	606.3	179.3	9374.7	7058.8
15	178	B	N	144.7	107.3	37.4	0.0	1193.8	52.8	671.0	21.9	12.7	2.0	6.254	28.1	10.4	927.3	248.0
15	178	B	P	242.0	204.0	37.4	0.6	1193.5	52.5	663.8	21.9	12.6	3.9	3.254	28.3	9.0	948.1	238.4
15	178	B	T	188.0	148.8	37.4	1.8	1193.5	52.5	663.3	21.9	12.6	2.8	4.457	28.2	9.7	936.7	242.1

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
15	181	B	N	691.6	391.6	300.0	0.0	1294.5	481.9	2170.1	45.6	4.5	0.8	5.542	33.7	16.6	1637.1	380.2
15	181	B	P	886.3	502.4	300.0	83.9	1294.5	482.0	2171.0	45.6	4.5	1.0	4.321	34.0	16.6	1782.7	407.7
15	181	B	T	610.3	368.6	300.0	-58.3	1294.1	482.0	2171.0	45.5	4.5	0.8	5.890	33.6	16.7	1568.6	367.3
15	237	A	N	119.7	103.7	16.0	0.0	1266.0	22.0	87.1	13.2	4.0	4.7	0.840	254.8	138.5	2496.9	614.5
15	237	A	P	228.5	211.4	16.0	1.1	1264.1	20.0	74.2	12.6	3.7	10.6	0.351	278.0	144.8	2708.5	773.7
15	237	A	T	180.7	163.4	16.0	1.3	1264.9	21.0	79.2	12.9	3.8	7.8	0.485	268.6	141.8	2627.4	708.1
16	243	A	N	214.2	204.7	9.5	0.0	1019.0	10.5	50.7	21.3	4.8	19.4	0.248	280.1	180.9	2832.2	1676.1
16	243	A	P	319.8	303.9	9.5	6.4	1020.7	11.4	59.6	21.9	5.2	26.6	0.196	242.2	132.6	2803.3	1778.2
16	243	A	T	280.6	280.2	9.5	-9.1	1021.7	12.1	62.3	22.2	5.2	23.2	0.222	252.6	146.4	2807.5	1736.4
16	254	B	N	99.7	77.0	22.7	0.0	901.4	31.8	101.7	9.9	3.2	2.4	1.321	152.2	68.8	1870.2	917.5
16	254	B	P	124.2	111.7	22.7	-10.2	900.3	30.0	91.8	9.6	3.1	3.7	0.822	146.6	61.5	1858.6	924.1
16	254	B	T	116.0	94.8	22.7	-1.6	900.1	29.8	89.9	9.5	3.0	3.2	0.948	148.2	63.6	1861.9	921.6
16	317	A	N	656.3	646.1	10.2	0.0	896.0	14.4	50.6	6.8	3.5	44.8	0.078	104.0	39.6	1424.8	624.4
16	317	A	P	819.8	807.2	10.2	2.4	893.6	13.0	41.2	6.1	3.2	62.1	0.051	95.3	34.7	1498.8	700.2
16	317	A	T	815.2	812.0	10.2	-6.9	893.6	13.3	41.6	6.1	3.1	61.0	0.051	95.5	34.8	1496.9	698.2
16	328	A	N	3446.5	3415.1	31.4	0.0	1328.0	48.9	706.8	40.6	14.5	69.8	0.207	46.1	12.4	694.4	379.3
16	328	A	P	3726.1	3629.9	31.4	64.8	1322.3	47.7	638.7	38.8	13.4	76.1	0.176	45.0	12.1	674.8	366.5
16	328	A	T	3619.3	3647.9	31.4	-60.0	1319.0	45.7	600.3	37.8	13.1	79.8	0.165	45.4	12.2	682.0	371.2
16	393	B	N	2074.1	2069.6	4.5	0.0	1088.0	6.8	122.8	39.0	18.1	304.4	0.059	19.6	6.6	591.0	422.5
16	393	B	P	2578.9	2548.8	4.5	25.6	1069.7	5.8	97.7	33.4	16.8	437.2	0.038	19.9	6.4	599.1	440.7
16	393	B	T	2918.2	2912.9	4.5	0.7	1069.7	5.9	95.3	33.4	16.1	491.5	0.033	20.0	6.3	603.7	451.3
17	241	A	N	69.6	64.6	4.9	0.0	928.0	6.2	29.1	12.4	4.7	10.4	0.451	93.0	23.2	2253.8	1413.4
17	241	A	P	81.3	76.4	4.9	-0.1	928.0	6.5	29.2	12.5	4.5	11.8	0.382	87.7	21.4	2276.0	1447.7
17	241	A	T	92.4	89.5	4.9	-2.0	926.9	6.2	27.2	12.1	4.4	14.3	0.304	83.6	20.1	2296.2	1478.7
17	242	A	N	238.0	236.0	2.0	0.0	948.0	1.7	2.1	3.6	1.3	138.8	0.009	255.1	55.6	3926.8	2811.4
17	242	A	P	382.1	380.6	2.0	-0.5	949.6	2.2	3.1	4.1	1.4	175.7	0.008	257.6	49.4	4320.5	3243.6
17	242	A	T	289.9	288.3	2.0	-0.4	950.4	2.5	3.8	4.3	1.5	117.1	0.013	255.8	52.8	4082.4	2979.5
17	245	A	N	176.7	171.8	4.9	0.0	997.0	5.5	7.4	3.7	1.4	31.4	0.043	166.7	48.9	2962.6	1574.3
17	245	A	P	316.9	314.3	4.9	-2.2	998.0	5.6	9.0	4.0	1.6	56.0	0.029	174.1	50.2	3305.0	1939.6
17	245	A	T	282.8	280.2	4.9	-2.2	998.5	6.0	9.9	4.1	1.7	47.0	0.035	172.6	49.9	3235.0	1861.9
17	247	B	N	230.0	226.2	3.9	0.0	805.0	4.5	18.6	12.2	4.1	49.8	0.082	103.7	40.1	2970.8	2114.4
17	247	B	P	398.1	394.9	3.9	-0.7	805.6	4.5	19.9	12.4	4.4	88.0	0.050	89.2	34.3	3211.0	2376.7
17	247	B	T	371.8	368.1	3.9	-0.2	805.9	4.6	21.0	12.5	4.6	79.9	0.057	90.9	35.0	3180.0	2342.2
17	248	A	N	306.1	302.1	4.0	0.0	915.0	5.3	15.9	10.7	3.0	57.0	0.053	263.4	98.6	4117.4	2800.8
17	248	A	P	532.2	532.5	4.0	-4.3	913.4	4.7	14.3	10.2	3.1	113.8	0.027	265.6	91.4	4692.1	3506.6
17	248	A	T	429.8	425.9	4.0	-0.1	913.9	4.8	15.0	10.3	3.1	88.8	0.035	264.7	94.1	4460.5	3214.2
17	249	A	N	706.7	700.9	5.8	0.0	737.0	6.1	19.9	11.3	3.3	115.5	0.028	195.9	115.9	2853.3	1785.7
17	249	A	P	1088.1	1083.5	5.8	-1.3	736.1	6.0	18.3	11.0	3.0	180.0	0.017	163.5	87.1	2518.0	1641.4
17	249	A	T	1024.8	1020.7	5.8	-1.7	739.0	7.2	24.9	11.9	3.5	142.3	0.024	167.7	90.7	2562.1	1660.7
17	256	A	N	174.1	171.7	2.4	0.0	1020.0	3.4	16.7	14.6	4.8	49.9	0.097	59.8	27.1	1948.3	1322.8
17	256	A	P	254.1	248.5	2.4	3.2	1014.4	2.5	13.2	12.9	5.3	99.5	0.053	50.5	21.8	2118.0	1494.6
17	256	A	T	206.6	205.3	2.4	-1.1	1019.8	3.0	17.1	14.6	5.7	68.8	0.083	55.3	24.5	2023.0	1397.5

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
17	258	B	N	73.9	65.9	8.0	0.0	899.0	9.5	42.6	12.9	4.5	6.9	0.647	28.5	9.8	989.4	635.1
17	258	B	P	90.5	78.5	8.0	4.1	897.3	8.7	37.8	12.4	4.3	9.0	0.482	27.5	9.4	981.4	651.4
17	258	B	T	61.8	61.6	8.0	0.0	899.0	9.5	42.6	12.9	4.5	6.5	0.691	29.3	10.1	995.9	623.3
17	373	A	N	252.2	246.7	5.4	0.0	1396.0	4.6	82.7	56.7	17.9	53.3	0.335	64.7	7.9	1276.9	413.5
17	373	A	P	326.0	299.7	5.4	20.9	1420.5	6.3	123.6	64.2	19.6	47.4	0.413	71.0	7.6	1284.6	422.6
17	373	A	T	405.9	397.5	5.4	2.9	1421.4	6.4	125.1	64.4	19.5	62.0	0.315	76.9	7.3	1291.2	430.6
17	389	A	N	4924.4	4912.3	12.0	0.0	1410.0	8.0	41.7	12.8	5.2	612.5	0.008	46.5	18.7	1412.1	1022.4
17	389	A	P	6588.6	6578.2	12.0	-1.6	1411.6	8.1	49.1	13.3	6.1	812.1	0.007	45.9	18.3	1389.1	1013.5
17	389	A	T	6756.2	6611.7	12.0	132.5	1437.5	14.5	142.6	21.2	9.8	455.2	0.022	45.8	18.2	1387.2	1012.7
17	391	A	N	1932.3	1926.8	5.4	0.0	1652.0	10.6	239.8	84.4	22.6	181.4	0.124	23.6	6.9	884.2	678.6
17	391	A	P	2582.4	2514.4	5.4	62.6	1599.8	6.7	140.4	68.5	21.0	376.3	0.056	24.2	6.7	927.9	707.5
17	391	A	T	2358.2	2353.7	5.4	-1.0	1604.2	7.1	142.8	69.9	20.1	330.6	0.061	24.0	6.8	914.0	698.3
18	092	A	N	625.7	615.2	10.5	0.0	737.0	12.9	92.8	22.0	7.2	47.8	0.151	314.4	102.9	5195.2	3105.4
18	092	A	P	1092.6	1073.3	10.5	8.7	731.5	11.4	84.6	20.3	7.4	93.9	0.079	334.5	106.5	5681.4	3425.2
18	092	A	T	1043.1	1032.6	10.5	0.0	736.2	12.9	95.0	21.7	7.3	79.8	0.092	332.8	106.2	5639.2	3397.3
18	093	A	N	459.4	420.2	39.3	0.0	538.0	43.5	225.0	14.6	5.2	9.7	0.535	29.0	8.6	869.9	525.6
18	093	A	P	686.8	649.4	39.3	-1.9	540.6	47.3	264.4	15.4	5.6	13.7	0.407	27.2	7.7	869.4	597.0
18	093	A	T	539.8	515.8	39.3	-15.3	538.8	45.4	236.8	14.9	5.2	11.4	0.459	28.3	8.2	869.5	552.8
18	120	A	N	1330.9	1297.2	33.7	0.0	552.0	40.5	316.4	20.6	7.8	32.0	0.244	64.0	50.9	1974.9	975.0
18	120	A	P	1858.5	1790.2	33.7	34.6	546.6	35.4	270.4	18.9	7.6	50.6	0.151	55.6	45.4	1985.2	1053.7
18	120	A	T	1955.0	1797.6	33.7	123.7	548.5	35.8	286.4	19.5	8.0	50.2	0.159	54.5	44.7	1987.2	1066.8
19	119	A	N	34871.2	34651.3	219.9	0.0	354.0	183.1	753.0	22.6	4.1	189.3	0.022	136.5	54.1	1149.8	641.9
19	119	A	P	50980.1	50716.0	219.9	44.2	358.3	230.2	1115.2	23.9	4.8	220.3	0.022	132.6	48.2	1181.6	634.4
19	119	A	T	51210.0	50941.7	219.9	48.4	358.9	233.6	1168.6	24.0	5.0	218.1	0.023	132.6	48.1	1182.0	634.3
19	122	A	N	8281.7	8110.7	171.0	0.0	690.0	166.0	3097.3	44.2	18.7	48.8	0.382	56.2	12.8	1061.6	354.6
19	122	A	P	12456.0	12008.6	171.0	276.5	716.0	201.8	4589.0	52.1	22.7	59.5	0.382	57.1	12.5	1035.3	367.8
19	122	A	T	14519.1	15174.7	171.0	-826.6	712.5	197.7	4385.7	51.1	22.2	76.8	0.289	57.4	12.3	1025.6	372.9
19	338	B	N	21076.5	21047.6	28.9	0.0	385.0	30.2	128.4	12.2	4.3	697.6	0.006	168.1	68.5	1080.1	475.9
19	338	B	P	32387.7	32354.7	28.9	4.1	385.2	30.8	133.1	12.3	4.3	1049.4	0.004	169.6	61.9	1133.6	484.0
19	338	B	T	35772.1	35726.5	28.9	16.7	385.2	30.7	132.6	12.2	4.3	1165.5	0.004	170.2	60.6	1147.3	486.8
19	340	A	N	1275.1	1223.0	52.1	0.0	480.0	42.8	330.8	24.5	7.7	28.6	0.271	164.0	111.3	1012.7	710.5
19	340	A	P	2155.6	2093.5	52.1	10.0	488.5	55.7	460.1	27.1	8.3	37.6	0.220	136.5	90.6	859.7	682.6
19	340	A	T	2163.9	2190.7	52.1	-79.0	488.3	55.4	456.4	27.0	8.2	39.6	0.208	136.4	90.4	858.7	682.4
19	342	A	N	16907.9	16825.0	82.8	0.0	445.0	91.1	518.4	18.3	5.7	184.7	0.031	93.6	29.3	1057.9	420.8
19	342	A	P	24640.1	24558.9	82.8	-1.6	444.6	87.5	508.2	18.2	5.8	280.6	0.021	102.2	31.4	1020.1	442.9
19	342	A	T	28447.0	28375.0	82.8	-10.8	444.7	88.0	511.4	18.2	5.8	322.5	0.018	105.7	32.2	1006.0	451.7
19	343	A	N	1477.1	1379.4	97.7	0.0	645.0	105.7	1492.5	41.8	14.1	13.0	1.082	17.2	7.8	686.2	364.7
19	343	A	P	2175.1	2053.0	97.7	24.3	647.9	109.2	1570.1	42.7	14.4	18.8	0.765	16.8	7.3	644.1	362.2
19	343	A	T	2378.1	2348.4	97.7	-68.1	648.4	109.7	1586.1	42.8	14.5	21.4	0.675	16.7	7.2	634.8	361.6
20	081	A	N	2207.4	2090.4	117.0	0.0	445.0	105.3	349.3	11.9	3.3	19.9	0.167	188.9	56.0	3527.4	2383.9
20	081	A	P	3899.7	3793.7	117.0	-10.9	448.3	124.5	462.2	12.9	3.7	30.5	0.122	192.3	60.1	4087.9	2882.5
20	081	A	T	3862.6	3956.2	117.0	-210.6	448.9	131.4	481.8	13.1	3.7	30.1	0.122	192.3	60.0	4077.8	2873.3

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
20	087	A	N	924.2	877.0	47.2	0.0	599.7	44.9	259.2	16.4	5.8	19.5	0.296	210.1	119.8	6790.8	5610.6
20	087	A	P	1725.4	1683.7	47.2	-5.5	605.7	55.8	351.9	18.2	6.3	30.2	0.209	171.0	96.2	7961.0	7255.5
20	087	A	T	1765.8	1589.8	47.2	128.9	603.7	53.0	320.0	17.6	6.0	30.0	0.201	169.7	95.4	8008.1	7325.1
20	088	A	N	436.4	360.6	75.8	0.0	405.0	76.9	222.8	7.9	2.9	4.7	0.618	258.1	47.1	2276.1	771.8
20	088	A	P	458.0	336.7	75.8	45.5	405.3	76.1	234.5	8.0	3.1	4.4	0.696	258.3	47.0	2277.3	775.7
20	088	A	T	487.6	462.9	75.8	-51.1	406.8	82.7	268.0	8.5	3.2	5.6	0.579	258.6	46.9	2279.0	780.7
21	196	B	N	1390.1	1365.0	25.1	0.0	355.0	21.0	47.6	13.6	2.3	64.8	0.035	77.6	15.5	1380.7	327.4
21	196	B	P	2283.7	2257.7	25.1	0.9	361.7	28.3	95.9	15.6	3.4	79.9	0.042	89.4	16.6	1551.1	356.9
21	196	B	T	1986.1	1982.3	25.1	-21.4	360.6	26.0	83.2	15.3	3.2	76.3	0.042	85.9	16.2	1501.1	348.3
22	014	B	N	775.9	715.5	60.5	0.0	408.0	54.3	808.2	60.4	14.9	13.2	1.130	16.6	7.0	210.8	72.0
22	014	B	P	490.4	280.4	60.5	149.5	403.6	50.1	729.1	59.0	14.5	5.6	2.600	17.5	7.7	229.3	71.6
22	014	B	T	1364.9	1345.7	60.5	-41.3	406.5	52.8	772.0	59.9	14.6	25.5	0.574	15.6	6.2	190.3	72.9
22	019	B	N	1492.0	1321.3	170.7	0.0	578.0	162.2	2654.4	60.4	16.4	8.1	2.009	20.5	11.5	575.7	134.5
22	019	B	P	2615.5	2341.0	170.7	103.8	576.2	158.7	2579.0	59.8	16.2	14.7	1.102	20.5	11.7	659.3	158.8
22	019	B	T	2816.2	2697.3	170.7	-51.8	576.6	159.7	2596.9	59.9	16.3	16.9	0.963	20.6	11.7	671.2	162.4
22	188	B	N	1225.6	1159.5	66.1	0.0	220.0	51.6	155.3	9.4	3.0	22.5	0.134	105.5	49.1	937.0	731.3
22	188	B	P	2364.5	2302.7	66.1	-4.3	229.8	91.4	399.0	12.5	4.4	25.2	0.173	106.9	45.0	1006.0	885.1
22	188	B	T	1657.9	1617.9	66.1	-26.1	221.9	63.3	207.7	10.0	3.3	25.5	0.128	105.6	46.7	967.0	796.9
22	189	A	N	918.3	843.0	75.2	0.0	257.0	81.2	490.3	19.2	6.0	10.4	0.582	271.4	78.3	1570.5	455.3
22	189	A	P	1633.0	1469.6	75.2	88.2	254.9	78.3	485.7	18.6	6.2	18.8	0.331	271.4	78.3	1570.2	455.0
22	189	A	T	1519.7	1308.1	75.2	136.3	252.2	72.1	405.7	17.8	5.6	18.1	0.310	271.4	78.3	1570.3	455.0
22	190	B	N	1911.5	1730.8	180.7	0.0	221.0	182.7	977.1	18.6	5.3	9.5	0.565	111.5	29.4	717.8	190.1
22	190	B	P	3034.3	2328.3	180.7	525.2	220.2	180.9	1064.0	18.4	5.9	12.9	0.457	115.0	32.3	713.7	201.4
22	190	B	T	2884.5	2854.7	180.7	-151.0	219.3	173.2	929.2	18.1	5.4	16.5	0.326	114.6	32.0	714.2	200.2
22	192	B	N	2299.6	2114.3	185.3	0.0	268.0	167.2	1138.1	19.5	6.8	12.6	0.538	74.8	14.2	678.0	249.0
22	192	B	P	4060.6	3261.6	185.3	613.6	271.5	185.9	1401.5	20.6	7.5	17.5	0.430	76.2	14.7	632.7	265.9
22	192	B	T	3587.1	3636.9	185.3	-235.1	269.8	177.7	1248.9	20.1	7.0	20.5	0.343	75.9	14.6	642.3	262.1
23	352	B	N	730.1	619.5	110.6	0.0	229.0	75.7	314.6	14.9	4.2	8.2	0.508	110.3	59.4	1035.0	263.9
23	352	B	P	.	.	110.6	52.2	229.9	84.9	342.6	15.2	4.0	.	.	.	.	.	.
23	352	B	T	1693.5	1594.9	110.6	-12.0	230.5	86.9	358.6	15.3	4.1	18.3	0.225	94.0	49.7	918.6	190.1
23	353	B	N	2724.9	2553.1	171.8	0.0	220.0	82.2	179.4	12.2	2.2	31.1	0.070	112.5	48.7	885.6	225.6
23	353	B	P	.	.	171.8	72.6	226.7	125.8	387.0	14.2	3.1	.	.	.	.	.	.
23	353	B	T	5272.5	5109.8	171.8	-9.1	227.9	135.1	431.1	14.6	3.2	37.8	0.084	116.3	51.9	884.9	216.4
23	413	B	N	2202.8	2038.0	164.8	0.0	170.0	121.5	209.8	3.0	1.7	16.8	0.103	51.3	16.5	694.4	73.6
23	413	B	P	.	3898.3	164.8	.	.	.	.	.	.	.	.	.	.	.	.
23	413	B	T	4802.2	4637.4	164.8	.	.	.	.	.	.	.	.	49.6	18.2	686.5	82.1
24	011	A	N	1372.5	1242.7	129.8	0.0	1120.0	114.3	2039.1	62.8	17.8	10.9	1.641	53.6	14.5	919.9	431.8
24	011	A	P	2246.1	2051.5	129.8	64.8	1122.0	118.6	2103.0	63.4	17.7	17.3	1.025	58.9	15.9	954.6	454.1
24	011	A	T	2214.4	2219.3	129.8	-134.7	1121.9	118.7	2100.1	63.4	17.7	18.7	0.946	58.7	15.9	953.6	453.4
24	012	B	N	472.9	453.2	19.7	0.0	387.0	13.8	42.1	11.7	3.1	32.9	0.093	25.8	11.8	786.7	86.3
24	012	B	P	574.3	557.2	19.7	-2.6	388.6	14.3	47.1	12.2	3.3	38.8	0.084	25.5	11.7	794.3	87.7
24	012	B	T	764.6	742.5	19.7	2.3	391.8	17.6	63.5	13.1	3.6	42.1	0.086	25.0	11.6	805.7	89.8

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
24	013	A	N	5633.8	5420.2	213.6	0.0	654.0	184.0	3762.4	61.6	20.4	29.5	0.694	16.7	7.4	698.4	440.2
24	013	A	P	9331.0	8702.7	213.6	414.7	663.7	205.1	4369.4	64.5	21.3	42.4	0.502	17.7	7.4	746.8	462.1
24	013	A	T	9486.0	9881.6	213.6	-609.1	663.8	204.7	4315.8	64.6	21.1	48.3	0.437	17.8	7.4	748.4	462.9
24	016	B	N	1713.3	1574.3	139.0	0.0	461.0	127.4	2356.9	57.6	18.5	12.4	1.497	32.6	10.8	459.3	127.3
24	016	B	P	2188.8	2114.3	139.0	-64.6	462.6	131.0	2447.6	58.1	18.7	16.1	1.158	32.3	10.3	460.1	128.8
24	016	B	T	2244.4	2135.1	139.0	-29.7	461.8	130.1	2414.6	57.9	18.6	16.4	1.131	32.3	10.3	460.2	129.0
24	021	B	N	770.0	753.7	16.3	0.0	345.0	18.6	51.1	13.7	2.8	40.6	0.068	28.5	11.6	898.2	190.0
24	021	B	P	999.1	1027.1	16.3	-44.4	348.9	23.5	82.5	14.9	3.5	43.7	0.080	29.2	11.9	967.9	205.7
24	021	B	T	1331.8	1302.1	16.3	13.4	350.9	26.3	97.7	15.5	3.7	49.5	0.075	30.1	12.2	1051.1	224.5
24	022	B	N	1750.4	1657.5	92.9	0.0	552.0	89.0	1544.5	57.5	17.3	18.6	0.932	13.4	7.1	982.6	567.3
24	022	B	P	2891.2	2790.4	92.9	7.8	559.5	97.6	1751.9	59.8	18.0	28.6	0.628	15.8	8.3	1043.5	735.0
24	022	B	T	2348.8	2557.3	92.9	-301.5	556.9	94.8	1676.3	59.0	17.7	27.0	0.655	14.8	7.8	1017.8	660.2
24	193	B	N	800.8	794.4	6.4	0.0	498.0	7.6	35.6	11.6	4.7	104.9	0.045	13.2	7.4	1246.7	329.4
24	193	B	P	1431.9	1430.3	6.4	-4.8	505.6	10.8	64.5	13.9	5.9	131.8	0.045	14.1	7.7	1585.3	391.7
24	193	B	T	1075.8	1074.0	6.4	-4.6	500.3	8.8	42.5	12.3	4.8	122.5	0.040	13.6	7.5	1408.4	359.6
24	200	A	N	3351.5	3171.0	180.5	0.0	915.0	174.4	3334.3	67.1	19.1	18.2	1.051	52.6	47.3	1975.4	903.5
24	200	A	P	6103.4	5879.9	180.5	43.0	917.2	175.8	3456.2	67.7	19.7	33.4	0.588	46.3	44.6	2043.2	899.9
24	200	A	T	5587.1	5703.1	180.5	-296.5	915.7	173.0	3377.9	67.3	19.5	33.0	0.592	47.2	44.9	2033.0	900.4
25	020	A	N	6035.3	5893.2	142.0	0.0	258.0	108.1	212.3	13.7	2.0	54.5	0.036	61.4	18.7	695.6	189.4
25	020	A	P	8952.3	8787.1	142.0	23.1	260.4	121.4	280.9	14.5	2.3	72.4	0.032	61.4	17.4	707.8	194.8
25	020	A	T	10643.5	10501.4	142.0	0.0	259.9	116.3	264.7	14.3	2.3	90.3	0.025	61.5	16.9	713.4	197.4
25	102	B	N	126.5	108.2	18.3	0.0	1274.0	13.1	59.9	15.2	4.6	8.3	0.553	342.1	74.7	5378.4	2553.8
25	102	B	P	228.8	250.6	18.3	-40.1	1271.9	12.8	54.4	14.6	4.2	19.5	0.217	411.5	81.9	6720.7	3240.5
25	102	B	T	126.6	107.0	18.3	1.2	1272.1	12.9	54.8	14.7	4.3	8.3	0.512	342.2	74.7	5379.0	2554.1
25	103	B	N	411.0	389.8	21.2	0.0	790.0	12.1	32.1	9.1	2.6	32.1	0.082	78.7	18.3	1505.8	589.6
25	103	B	P	799.8	780.7	21.2	-2.2	796.1	17.5	61.3	11.0	3.5	44.5	0.079	79.5	19.0	1646.0	744.6
25	103	B	T	824.3	811.9	21.2	-8.9	794.4	16.1	57.5	10.5	3.6	50.6	0.071	79.5	19.1	1652.6	752.5
25	104	B	N	319.1	304.0	15.1	0.0	948.0	9.5	27.0	9.4	2.8	31.9	0.089	53.9	18.5	1474.9	408.6
25	104	B	P	610.0	620.8	15.1	-25.9	951.0	11.7	37.1	10.4	3.2	52.9	0.060	47.0	16.3	1495.6	391.6
25	104	B	T	561.4	549.0	15.1	-2.7	950.4	11.4	35.6	10.2	3.1	48.1	0.065	47.8	16.5	1492.9	393.7
25	105	A	N	1446.1	1397.3	48.8	0.0	1036.0	31.5	66.7	8.2	2.1	44.4	0.048	360.4	104.9	3315.5	1275.1
25	105	A	P	2581.2	2968.2	48.8	-435.8	1041.0	42.9	130.6	9.8	3.0	69.1	0.044	374.7	99.4	3426.2	1447.0
25	105	A	T	1802.4	1753.0	48.8	0.6	1039.1	38.4	95.4	9.2	2.5	45.7	0.054	365.8	102.7	3357.0	1337.7
25	107	B	N	109.0	74.2	34.8	0.0	1351.0	24.9	106.2	13.1	4.3	3.0	1.431	162.5	50.3	2426.7	752.1
25	107	B	P	175.8	188.0	34.8	-47.1	1351.0	25.3	108.4	13.1	4.3	7.4	0.577	169.3	52.6	2533.5	781.3
25	107	B	T	87.0	49.2	34.8	3.0	1350.4	24.5	103.4	12.9	4.2	2.0	2.104	159.3	49.2	2377.8	738.7
25	112	B	N	453.8	437.7	16.1	0.0	902.0	11.0	27.0	12.2	2.5	39.8	0.062	52.7	13.9	1208.0	323.4
25	112	B	P	904.2	944.2	16.1	-56.2	905.2	12.0	37.3	13.2	3.1	78.8	0.040	51.8	13.4	1253.8	361.7
25	112	B	T	733.5	719.1	16.1	-1.7	904.3	11.5	35.2	12.9	3.1	62.5	0.049	52.0	13.5	1239.6	349.4
25	267	A	N	5694.5	5157.9	536.7	0.0	565.0	189.9	1067.5	21.4	5.6	27.2	0.207	326.8	85.6	1809.3	261.9
25	267	A	P	7161.8	6637.2	536.7	-12.0	586.5	404.2	2992.7	27.9	7.4	16.4	0.451	332.5	82.0	1815.9	263.5
25	267	A	T	9373.2	9593.9	536.7	-757.4	586.7	405.6	3019.7	28.0	7.4	23.7	0.315	339.6	78.3	1824.6	266.1

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
25	269	A	N	64.1	52.0	12.1	0.0	2004.0	7.4	17.1	4.9	2.3	7.1	0.330	42.7	10.1	757.4	207.4
25	269	A	P	33.3	18.6	12.1	2.6	2003.9	7.4	17.0	4.9	2.3	2.5	0.913	44.1	12.0	882.1	263.7
25	269	A	T	30.5	23.9	12.1	-5.5	2003.8	7.4	16.8	4.8	2.3	3.2	0.704	44.3	12.2	900.5	272.4
25	273	A	N	6529.8	6376.0	153.8	0.0	714.0	81.6	560.7	18.3	6.9	78.1	0.088	358.9	127.7	2575.0	455.1
25	273	A	P	13546.6	14059.2	153.8	-666.5	727.6	118.4	957.8	22.4	8.1	118.7	0.068	382.3	122.7	3092.8	863.0
25	273	A	T	13587.2	13870.8	153.8	-437.4	726.4	114.1	920.9	22.1	8.1	121.6	0.066	382.4	122.7	3095.1	865.3
25	275	B	N	2804.6	2630.1	174.4	0.0	638.0	121.5	683.1	15.8	5.6	21.7	0.260	186.4	42.0	1817.1	462.7
25	275	B	P	5180.4	5289.4	174.4	-283.5	641.7	132.5	840.2	16.9	6.3	39.9	0.159	224.2	45.6	1916.6	448.7
25	275	B	T	4862.9	4823.4	174.4	-134.9	641.1	129.3	818.2	16.7	6.3	37.3	0.170	220.0	45.1	1906.0	450.1
25	278	A	N	1437.7	1371.2	66.6	0.0	595.0	29.8	357.1	33.9	12.0	46.0	0.260	90.1	54.7	1804.0	714.5
25	278	A	P	2712.4	2649.9	66.6	-4.1	634.8	53.7	857.8	46.1	16.0	49.3	0.324	91.1	53.4	1919.0	765.8
25	278	A	T	2530.1	2511.4	66.6	-47.8	634.6	53.4	855.0	46.0	16.0	47.0	0.340	90.8	53.4	1905.7	759.6
25	281	A	N	987.0	942.3	44.7	0.0	472.0	16.2	33.4	11.0	2.1	58.2	0.035	67.2	19.6	888.1	116.8
25	281	A	P	1479.4	1401.9	44.7	32.8	479.5	32.6	98.0	13.3	3.0	43.0	0.070	68.9	21.0	922.6	127.2
25	281	A	T	1596.3	1594.4	44.7	-42.8	481.0	35.9	111.4	13.7	3.1	44.4	0.070	69.3	21.2	929.2	129.3
25	348	A	N	4485.9	3924.5	561.3	0.0	590.0	178.6	1295.1	21.3	7.3	22.0	0.330	364.3	88.2	2242.9	387.0
25	348	A	P	5107.2	4578.9	561.3	-33.0	616.6	351.1	3394.3	29.4	9.7	13.0	0.741	366.6	86.3	2298.1	393.5
25	348	A	T	8400.7	8490.5	561.3	-651.1	617.2	355.8	3458.1	29.6	9.7	23.9	0.407	375.6	79.4	2524.5	420.4
25	370	B	N	191.9	135.9	56.0	0.0	1144.0	57.3	330.8	19.8	5.8	2.4	2.435	41.4	13.2	792.8	440.6
25	370	B	P	143.8	118.5	56.0	-30.7	1132.0	33.1	171.0	16.1	5.2	3.6	1.443	40.4	13.4	749.3	409.8
25	370	B	T	267.2	68.3	56.0	142.9	1133.1	34.4	183.5	16.5	5.3	2.0	2.685	42.6	13.0	853.1	487.5
26	345	B	N	592.3	515.1	77.2	0.0	569.0	28.3	242.7	27.1	8.6	18.2	0.471	392.9	324.9	1551.4	873.0
26	345	B	P	289.3	150.9	77.2	61.1	593.2	51.6	546.3	34.5	10.6	2.9	3.620	408.2	346.9	1609.0	922.2
26	345	B	T	1169.2	1080.1	77.2	11.9	596.7	54.2	604.4	35.6	11.2	19.9	0.560	386.7	312.4	1534.7	865.0
26	347	A	N	376.1	326.3	49.8	0.0	906.0	32.0	441.7	47.6	13.8	10.2	1.354	15.6	7.0	1522.8	979.9
26	347	A	P	484.8	461.3	49.8	-26.3	908.3	34.5	461.9	48.3	13.4	13.4	1.001	16.1	7.2	1455.6	954.1
26	347	A	T	841.2	829.5	49.8	-38.1	909.5	34.9	473.7	48.6	13.6	23.7	0.571	17.5	7.7	1320.1	900.7
26	354	A	N	418.0	326.8	91.2	0.0	492.0	86.5	563.5	15.8	6.5	3.8	1.724	190.8	67.3	1866.1	589.2
26	354	A	P	611.0	480.8	91.2	39.0	474.7	48.4	209.7	10.6	4.3	9.9	0.436	196.4	66.9	1906.2	598.6
26	354	A	T	1019.6	956.9	91.2	-28.5	478.8	56.0	278.7	11.8	5.0	17.1	0.291	207.5	69.3	1967.9	617.8
26	355	A	N	688.6	531.3	157.3	0.0	515.0	94.0	564.9	18.3	6.0	5.7	1.063	243.3	102.5	1837.2	623.8
26	355	A	P	672.0	554.0	157.3	-39.3	515.7	90.4	581.1	18.5	6.4	6.1	1.049	243.9	103.4	1840.5	629.2
26	355	A	T	1616.1	1458.6	157.3	0.2	517.5	96.6	641.0	19.1	6.6	15.1	0.439	233.0	81.9	1794.6	505.4
26	359	B	N	1910.7	1324.1	586.6	0.0	164.0	459.2	3521.3	25.6	7.7	2.9	2.659	89.4	31.8	942.7	271.2
26	359	B	P	.	.	586.6	-604.8	163.8	459.2	3512.7	25.6	7.7	.	.	.	.	.	.
26	359	B	T	4366.3	3627.8	586.6	152.0	163.0	443.3	3379.0	25.3	7.6	8.2	0.931	82.7	29.4	896.8	197.3
26	360	B	N	33.8	14.8	19.0	0.0	1908.0	22.0	142.9	21.7	6.5	0.7	9.634	54.4	21.5	3426.9	6102.5
26	360	B	P	70.9	7.6	19.0	44.3	1866.4	3.2	9.3	9.0	2.9	2.4	1.222	53.3	21.8	4012.5	10298.5
26	360	B	T	70.4	9.0	19.0	42.3	1888.6	10.1	53.7	15.7	5.3	0.9	5.952	53.3	21.8	4005.9	10242.3
26	361	A	N	360.1	290.9	69.2	0.0	238.0	46.4	197.6	11.6	4.3	6.3	0.679	110.0	44.8	1554.4	255.2
26	361	A	P	456.4	356.8	69.2	30.4	238.7	48.2	210.8	11.8	4.4	7.4	0.591	109.9	44.5	1588.3	252.6
26	361	A	T	816.2	747.0	69.2	0.0	240.1	50.4	232.5	12.2	4.6	14.8	0.311	110.7	44.8	1678.6	249.3

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
26	362	A	N	294.8	256.8	38.1	0.0	622.0	26.0	290.9	37.8	11.2	9.9	1.133	44.0	11.9	1073.8	343.9
26	362	A	P	262.3	192.8	38.1	31.5	622.1	25.7	293.1	37.8	11.4	7.5	1.520	43.8	11.9	1048.5	335.2
26	362	A	T	726.1	714.1	38.1	-26.1	625.7	27.2	323.8	38.9	11.9	26.3	0.453	46.4	13.6	1294.8	423.5
26	364	B	N	1534.6	1413.2	121.4	0.0	533.0	95.4	774.1	31.7	8.1	14.8	0.548	261.2	43.0	1570.7	343.7
26	364	B	P	516.0	558.4	121.4	-163.8	528.7	80.4	659.2	30.4	8.2	6.9	1.181	208.2	40.0	1425.6	308.0
26	364	B	T	2300.0	1985.0	121.4	193.6	532.2	86.8	747.6	31.5	8.6	22.9	0.377	284.9	44.7	1633.0	363.2
28	219	B	N	270.2	242.0	28.2	0.0	4201.0	39.2	407.5	39.6	10.4	6.2	1.684	88.6	31.6	1600.8	605.1
28	219	B	P	139.2	160.4	28.2	-49.4	4168.7	17.9	149.3	29.8	8.3	9.0	0.931	87.3	30.7	1605.4	600.8
28	219	B	T	22.1	53.2	28.2	-59.3	4166.8	17.3	139.6	29.2	8.1	3.1	2.624	85.2	29.6	1661.5	633.2
29	100	B	N	198.7	156.4	42.3	0.0	904.0	44.6	253.5	14.9	5.7	3.5	1.620	382.4	121.2	2785.7	1803.0
29	100	B	P	479.1	557.5	42.3	-120.7	906.1	48.2	284.4	15.6	5.9	11.6	0.510	409.3	129.5	3075.5	2415.9
29	100	B	T	213.8	175.2	42.3	-3.7	903.7	44.9	250.1	14.9	5.6	3.9	1.427	384.5	121.8	2808.3	1846.9
29	106	A	N	323.7	304.9	18.9	0.0	1463.0	14.2	68.2	10.1	4.8	21.5	0.224	628.7	131.7	2570.4	488.8
29	106	A	P	612.2	789.6	18.9	-196.3	1467.9	18.0	99.5	11.6	5.5	44.0	0.126	907.9	141.5	2826.1	335.2
29	106	A	T	250.5	193.8	18.9	37.9	1460.5	12.8	61.3	9.3	4.8	15.2	0.316	542.9	128.3	2474.8	569.0
29	108	A	N	838.9	749.8	89.1	0.0	1144.0	64.8	504.6	23.5	7.8	11.6	0.673	511.5	180.4	2305.5	977.3
29	108	A	P	1421.6	1883.9	89.1	-551.5	1147.0	70.4	574.9	24.4	8.2	26.8	0.305	615.7	183.9	2259.5	1226.2
29	108	A	T	576.2	456.7	89.1	30.4	1144.1	64.9	506.5	23.5	7.8	7.0	1.109	448.6	178.1	2339.3	832.4
29	109	B	N	210.9	174.2	36.6	0.0	1036.0	28.0	190.5	23.8	6.8	6.2	1.094	196.9	38.3	3462.9	751.6
29	109	B	P	.	.	36.6	2.4	1027.9	22.3	125.8	21.3	5.6	.	.	.	.	.	.
29	109	B	T	278.7	210.3	36.6	31.7	1033.9	27.7	171.6	23.1	6.2	7.6	0.816	199.3	39.5	3637.7	850.7
29	110	B	N	664.6	604.3	60.3	0.0	892.0	50.1	307.8	21.9	6.1	12.1	0.509	442.7	120.4	3195.9	1745.7
29	110	B	P	866.8	1229.2	60.3	-422.7	893.8	54.3	335.4	22.5	6.2	22.6	0.273	463.2	122.8	3422.9	1936.4
29	110	B	T	422.0	370.8	60.3	-9.1	890.8	49.3	281.7	21.6	5.7	7.5	0.760	410.3	116.9	2844.1	1464.5
29	111	A	N	176.3	155.6	20.8	0.0	974.0	16.2	87.1	13.8	5.4	9.6	0.560	124.2	46.3	2875.5	931.5
29	111	A	P	269.2	305.3	20.8	-56.8	975.6	17.0	96.0	14.3	5.7	18.0	0.314	128.0	49.7	2994.3	987.1
29	111	A	T	259.2	243.5	20.8	-5.1	974.5	16.3	90.0	14.0	5.5	14.9	0.370	127.6	49.3	2983.4	981.9
29	113	A	N	1818.8	1724.2	94.6	0.0	1075.0	64.1	525.0	31.1	8.2	26.9	0.304	1027.1	257.5	4726.7	1822.1
29	113	A	P	2654.2	3968.4	94.6	-1408.8	1080.9	80.6	708.4	32.9	8.8	49.3	0.179	1186.3	265.2	5243.6	2118.9
29	113	A	T	1651.8	1491.7	94.6	65.5	1075.0	68.9	531.5	31.1	7.7	21.7	0.356	990.3	255.7	4603.8	1754.0
29	114	B	N	99.0	45.6	53.4	0.0	1516.0	36.6	305.9	27.8	8.4	1.2	6.710	182.5	35.8	1745.9	513.3
29	114	B	P	225.2	235.0	53.4	-63.3	1517.8	39.6	323.0	28.3	8.1	5.9	1.374	261.0	47.7	1904.6	485.9
29	114	B	T	128.6	83.5	53.4	-8.3	1515.6	37.5	296.9	27.6	7.9	2.2	3.557	204.2	38.9	1794.3	504.1
29	194	B	N	440.3	405.0	35.3	0.0	839.0	31.9	298.2	27.1	9.3	12.7	0.736	44.7	41.0	1698.0	407.3
29	194	B	P	651.9	610.6	35.3	6.0	840.5	33.4	314.2	27.6	9.4	18.3	0.515	41.3	41.9	1747.7	467.9
29	194	B	T	708.5	676.9	35.3	-3.7	840.2	33.1	311.1	27.5	9.4	20.5	0.460	40.6	42.2	1758.4	482.0
29	195	B	N	982.6	870.8	111.8	0.0	867.0	100.3	1095.0	32.6	10.9	8.7	1.258	71.4	32.5	2437.2	1404.4
29	195	B	P	1618.7	1450.1	111.8	56.8	868.0	106.7	1148.2	32.9	10.8	13.6	0.792	70.1	30.6	2520.1	1410.9
29	195	B	T	1503.0	1376.4	111.8	14.8	867.2	104.6	1121.5	32.7	10.7	13.2	0.815	70.3	30.9	2507.6	1409.9
29	207	A	N	322.7	257.3	65.4	0.0	1946.0	54.0	394.7	20.1	7.3	4.8	1.534	306.0	280.3	5969.1	811.3
29	207	A	P	272.3	281.6	65.4	-74.7	1946.4	53.8	403.3	20.3	7.5	5.2	1.432	305.1	271.8	5631.4	759.2
29	207	A	T	213.3	172.7	65.4	-24.7	1941.4	47.6	325.7	18.7	6.8	3.6	1.886	304.3	260.5	5182.1	692.8

WATER BALANCES AND INFLOW CONCENTRATIONS BY PERIOD

DIS	RES	GP	PD	QINC	QOUT	QEVAP	QSTOR	ELEV	AREA	VOLUME	ZMAX	ZMEAN	QS	THYD	IPTL	IPDS	INTL	ININ
30	064	B	N	7.9	3.8	4.1	0.0	5550.0	3.4	16.3	8.2	4.7	1.1	4.329	263.6	108.3	2815.6	1280.2
30	064	B	P	6.5	2.4	4.1	0.0	5549.9	3.4	16.2	8.2	4.8	0.7	6.786	245.3	107.7	2755.9	1291.9
30	064	B	T	6.6	2.4	4.1	0.0	5549.9	3.4	16.2	8.2	4.8	0.7	6.777	245.9	107.8	2757.8	1291.5
30	215	B	N	7.4	4.1	3.3	0.0	1244.0	2.9	10.2	11.6	3.5	1.4	2.479	279.4	159.8	1909.4	634.8
30	215	B	P	15.8	13.6	3.3	-1.1	1244.5	3.0	10.7	11.7	3.6	4.6	0.788	285.7	142.8	1973.2	487.8
30	215	B	T	6.5	3.0	3.3	0.2	1244.2	2.9	10.4	11.6	3.6	1.0	3.497	278.3	163.0	1898.4	664.9
30	217	B	N	23.2	15.2	8.0	0.0	1284.0	7.2	32.1	10.4	4.5	2.1	2.113	310.8	185.9	3274.9	1244.4
30	217	B	P	51.0	48.0	8.0	-5.0	1284.4	7.4	33.0	10.5	4.5	6.5	0.687	391.5	226.5	4530.4	1462.2
30	217	B	T	18.5	9.4	8.0	1.0	1283.7	7.2	31.4	10.3	4.4	1.3	3.328	290.7	175.6	2981.3	1187.6
30	235	A	N	25238.4	23896.5	1341.9	0.0	1850.0	1490.6	27941.0	55.5	18.7	16.0	1.169	257.9	19.2	1282.7	147.1
30	235	A	P	21222.8	18961.9	1341.9	919.0	1843.5	1389.6	24966.7	53.5	18.0	13.6	1.317	207.2	17.8	1219.1	131.3
30	235	A	T	31508.6	28651.0	1341.9	1515.6	1845.1	1425.4	25674.9	54.0	18.0	20.1	0.896	341.4	21.3	1369.3	170.3
31	077	A	N	5130.5	5091.3	39.2	0.0	1545.0	55.1	3320.5	175.3	60.3	92.5	0.652	19.1	7.9	676.8	34.6
31	077	A	P	5414.1	5505.3	39.2	-130.4	1545.2	56.7	3285.2	175.4	58.0	97.2	0.597	19.2	8.0	691.4	34.5
31	077	A	T	5361.2	5513.5	39.2	-191.5	1543.2	57.0	3285.2	174.8	57.6	96.7	0.596	19.2	7.9	688.7	34.5
32	204	B	N	10768.5	10683.3	85.3	0.0	2405.0	139.4	4513.4	89.9	32.4	76.6	0.422	23.0	8.0	251.6	35.6
32	204	B	P	10433.7	9655.9	85.3	692.6	2380.0	124.0	3974.5	82.3	32.1	77.9	0.412	22.9	8.0	251.9	35.8
32	204	B	T	9755.1	9670.4	85.3	-0.6	2380.0	128.9	3974.5	82.3	30.8	75.0	0.411	22.7	8.0	252.4	36.2
33	300	A	N	1023.9	1018.5	5.4	0.0	1541.0	10.4	431.6	90.3	41.3	97.5	0.424	40.4	31.1	189.4	32.0
33	300	A	P	1141.8	1126.1	5.4	10.3	1503.5	8.8	327.8	78.8	37.1	127.5	0.291	39.8	30.8	189.3	32.5
33	300	A	T	1108.2	1127.8	5.4	-24.9	1503.5	8.9	327.8	78.8	36.9	126.9	0.291	40.0	30.9	189.3	32.3
34	048	B	N	1368.0	1306.3	61.7	0.0	650.0	20.3	638.7	89.8	31.5	64.4	0.489	39.2	15.0	846.9	86.1
34	048	B	P	2238.5	1969.8	61.7	207.0	784.7	40.3	1869.6	130.8	46.4	48.8	0.949	33.6	18.0	815.7	86.8
34	048	B	T	2267.7	2042.9	61.7	163.1	785.8	40.4	1883.4	131.2	46.6	50.6	0.922	33.5	18.0	814.9	86.8
35	029	A	N	312.3	305.7	6.5	0.0	737.5	7.0	86.4	29.7	12.3	43.6	0.283	111.6	24.1	916.6	145.9
35	029	A	P	393.8	369.8	6.5	17.5	738.1	6.8	89.4	29.9	13.2	54.7	0.242	128.1	26.2	931.7	148.7
35	029	A	T	390.7	365.9	6.5	18.3	738.8	6.7	90.7	30.1	13.5	54.3	0.248	127.5	26.1	931.2	148.6
35	039	B	N	21.2	17.4	3.8	0.0	1300.7	2.9	28.9	33.8	9.8	5.9	1.657	62.8	27.8	260.7	419.5
35	039	B	P	7.0	3.8	3.8	-0.5	1298.2	2.8	27.2	33.0	9.8	1.4	7.220	67.3	31.2	414.3	319.9
35	039	B	T	4.9	4.9	3.8	-3.8	1297.8	2.7	26.9	32.9	9.8	1.8	5.454	69.0	32.5	486.6	301.6

Table B3

Water Quality Data Summary by Station-Year

Symbol	Meaning
DIS	CE District code
RES	CE reservoir code
STA	CE water quality station code
TYPE	station type code (D=near-dam, M=mid-pool, U=upper-pool)
YEAR	year of sample

Note: Data listed by screen code (A or B) and in 2 parameter groups; screen codes reflect data reliability(see Part III of the main text); District and reservoir codes are defined in Appendix A.

WATER QUALITY SUMMARY BY STATION-YEAR
POOL DATA SCREEN CODE=A

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CDEP	STATION DEPTH (M)	227	21.25	27.38	1.22	175.38
CPHF	PH (STANDARD UNITS)	258	7.85	0.47	6.27	8.70
CCNF	CONDUCTIVITY (UMHOS/CM)	258	493.30	548.24	22.50	4948.16
CALK	ALKALINITY (MG/L)	255	96.61	57.36	10.00	309.28
CTMP	TEMPERATURE (DEG-C)	258	20.69	2.96	13.18	27.89
CTRJ	TURDIBITY (JTU)	3	17.89	2.59	16.37	20.88
CTRH	HACH TURBIDITY (NTU)	46	10.16	11.31	1.60	40.00
CTRN	-LOG(% TRANS./100)	209	0.35	0.43	0.02	2.48
CTCO	TRUE COLOR (PT-CO UNITS)	17	56.49	37.62	15.00	105.00
CALPH	NON-ALGAL TURBIDITY (1/M)	258	0.87	0.79	0.08	6.02
CRTL	TOTAL SOLIDS (MG/L)	24	159.25	78.42	5.00	389.58
CRFL	DISSOLVED SOLIDS (MG/L)	33	115.46	51.34	44.80	208.50
CRNF	SUSPENDED SOLIDS (MG/L)	41	11.60	10.18	1.00	39.33
CALG	ALGAL COUNT (NO/LITER)	2	178350.00	157614.10	66900.00	289800.00
CBIO	ALGAL VOLUME (ML/LITER)	2	0.04	0.01	0.04	0.05
---------- POOL DATA SCREEN CODE=B ----------						
CDEP	STATION DEPTH (M)	205	15.82	12.72	1.32	82.32
CPHF	PH (STANDARD UNITS)	264	7.70	0.56	6.26	8.74
CCNF	CONDUCTIVITY (UMHOS/CM)	260	455.93	524.79	34.33	3999.11
CALK	ALKALINITY (MG/L)	250	85.67	71.31	10.00	324.33
CTMP	TEMPERATURE (DEG-C)	265	22.19	4.46	10.00	29.74
CTRJ	TURDIBITY (JTU)	9	63.83	83.87	2.50	280.00
CTRH	HACH TURBIDITY (NTU)	30	3.29	2.84	0.67	13.77
CTRN	-LOG(% TRANS./100)	207	0.49	0.72	0.04	4.61
CTCO	TRUE COLOR (PT-CO UNITS)	6	67.96	114.06	10.00	300.00
CALPH	NON-ALGAL TURBIDITY (1/M)	267	1.01	1.14	0.08	6.40
CRTL	TOTAL SOLIDS (MG/L)	22	184.14	117.59	10.00	465.93
CRFL	DISSOLVED SOLIDS (MG/L)	21	119.96	133.06	8.80	500.00
CRNF	SUSPENDED SOLIDS (MG/L)	40	25.21	88.73	0.00	566.67
CALG	ALGAL COUNT (NO/LITER)	13	192065.38	197137.09	61500.00	738500.00
CBIO	ALGAL VOLUME (ML/LITER)	12	0.08	0.11	0.01	0.30

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
03	307	305	D	73	37.0	7.15	46	12	17.5	.	.	0.10	.	0.15	.	.	.	.	.
03	307	306	M	73	22.7	7.06	47	11	18.2	.	.	0.11	.	0.15	.	.	.	.	.
03	307	307	U	73	11.9	7.13	131	10	18.8	.	.	0.16	.	0.20	.	.	.	.	.
04	312	311	D	73	9.0	7.92	273	106	17.6	.	.	0.16	.	0.49	.	.	.	.	.
06	372	322	D	73	30.5	7.60	504	29	22.5	.	.	0.11	.	0.36	.	.	.	.	.
06	372	323	M	73	15.5	7.57	550	29	22.3	.	.	0.12	.	0.39	.	.	.	.	.
06	372	324	M	73	24.3	7.66	513	31	22.8	.	.	0.15	.	0.57	.	.	.	.	.
06	372	326	U	73	4.9	7.30	466	32	21.9	.	.	0.48	.	2.07	.	.	.	.	.
06	372	327	U	73	4.8	7.28	482	43	20.0	.	.	0.75	.	2.16	.	.	.	.	.
10	001	011	U	77	.	7.12	156	52	21.0	.	34.0	.	101	1.22	.	87	.	.	.
10	001	015	M	77	.	7.30	145	44	17.0	.	36.7	.	102	1.02	.	81	.	.	.
10	001	016	D	77	.	7.20	145	43	21.0	.	33.8	.	90	1.09	.	78	.	.	.
10	003	311	D	73	22.7	6.74	784	19	25.0	.	.	0.16	.	0.75	.	.	.	.	.
10	004	018	M	77	.	7.12	123	42	23.8	.	24.0	.	64	1.06	.	72	.	.	.
10	008	007	D	77	.	7.07	135	39	22.5	.	23.8	.	100	0.94	.	76	.	.	.
10	008	016	D	77	.	7.17	153	42	23.3	.	26.0	.	91	0.96	.	88	.	.	.
10	008	017	D	77	.	7.20	155	43	23.6	.	40.0	.	98	1.18	.	85	.	.	.
10	008	018	D	77	.	7.20	149	42	23.3	.	35.0	.	105	1.16	.	88	.	.	.
10	072	005	D	78	.	6.87	62	17	26.4	.	7.4	.	21	0.66	.	65	4	.	.
10	072	006	D	78	.	7.90	57	16	26.5	.	6.6	.	19	0.60	.	52	5	.	.
10	072	007	M	78	.	7.52	63	17	27.2	.	7.6	.	22	1.27	.	55	5	.	.
10	072	009	M	78	.	7.12	62	16	27.0	.	8.0	.	21	0.70	.	55	6	.	.
10	072	010	M	78	.	7.37	72	17	26.2	.	12.6	.	20	0.91	.	49	10	.	.
10	073	118	M	75	.	6.68	58	18	22.3	16.4	.	.	30	1.77	56	45	11	.	.
10	073	121	M	75	.	6.72	53	16	21.3	20.9	.	.	34	1.76	67	55	13	.	.
10	073	124	M	75	.	6.85	58	16	22.5	16.4	.	.	26	1.90	60	45	15	.	.
10	411	314	M	73	17.3	6.80	938	30	25.2	.	.	0.17	.	0.62	.	.	.	.	.
10	411	316	U	73	10.4	6.46	621	18	26.5	.	.	0.32	.	1.24	.	.	.	.	.
15	178	005	M	77	19.2	8.00	223	113	18.5	.	2.1	.	15	0.23	.	.	3	.	.
15	237	305	D	74	8.3	8.26	625	277	14.8	.	.	0.13	.	0.72	.	.	.	.	.
15	237	306	M	74	4.6	8.44	595	265	17.0	.	.	0.16	.	0.56	.	.	.	.	.
15	237	307	M	74	6.6	8.48	690	309	16.9	.	.	0.15	.	0.08	.	.	.	.	.
16	243	309	D	73	7.2	7.80	398	73	19.1	.	.	0.15	.	0.75	.	.	.	.	.
16	243	310	M	73	12.0	7.89	401	71	19.0	.	.	0.16	.	0.85	.	.	.	.	.
16	243	313	U	73	5.2	7.86	465	85	19.5	.	.	0.35	.	0.64	.	.	.	.	.
16	254	305	M	73	3.9	7.70	211	43	18.4	.	.	0.42	.	0.11	.	.	.	.	.
16	254	306	D	73	6.9	7.73	228	44	17.9	.	.	0.23	.	0.35	.	.	.	.	.
16	317	319	M	73	5.3	8.08	199	50	19.0	.	.	0.24	.	0.44	.	.	.	.	.
16	317	320	D	73	8.8	7.48	215	52	17.9	.	.	0.16	.	0.61	.	.	.	.	.
16	317	321	M	73	4.4	8.45	210	57	18.5	.	.	0.19	.	0.25	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
16	328	337	D	73	30.3	7.67	118	25	15.5	.	.	0.08	.	0.30	.	.	.	.	.
16	328	338	M	73	26.8	7.62	120	23	16.1	.	.	0.09	.	0.31	.	.	.	.	.
16	328	339	U	73	2.4	7.31	181	19	16.3	.	.	0.42	.	1.08	.	.	.	.	.
16	328	340	M	73	20.5	7.65	133	27	17.4	.	.	0.09	.	0.26	.	.	.	.	.
16	393	312	D	73	35.8	6.61	487	13	22.4	.	.	0.17	.	0.32	.	.	.	.	.
16	393	313	M	73	27.7	6.60	510	10	22.0	.	.	0.13	.	0.31	.	.	.	.	.
16	393	314	U	73	22.9	6.33	565	10	22.6	.	.	0.04	.	0.26	.	.	.	.	.
17	241	306	M	73	8.5	7.88	262	46	18.8	.	.	0.25	.	0.50	.	.	.	.	.
17	241	307	M	73	5.5	8.11	265	46	19.1	.	.	0.34	.	0.61	.	.	.	.	.
17	241	308	U	73	3.2	8.30	371	50	19.2	.	.	0.60	.	0.87	.	.	.	.	.
17	241	309	U	73	1.4	8.70	279	52	19.9	.	.	0.53	.	1.29	.	.	.	.	.
17	242	312	D	73	2.3	7.56	559	72	19.1	.	.	2.15	.	3.31	.	.	.	.	.
17	245	306	U	73	1.5	8.23	444	151	19.4	.	.	2.48	.	0.73	.	.	.	.	.
17	245	307	M	73	6.3	8.07	373	126	19.1	.	.	1.03	.	0.38	.	.	.	.	.
17	245	308	D	73	2.0	8.45	374	126	19.4	.	.	1.63	.	0.89	.	.	.	.	.
17	247	306	D	73	10.6	8.17	466	188	20.1	.	.	0.62	.	0.91	.	.	.	.	.
17	247	307	M	73	4.5	8.39	480	195	20.0	.	.	0.78	.	0.89	.	.	.	.	.
17	248	309	D	73	9.1	8.04	456	145	19.6	.	.	0.58	.	1.74	.	.	.	.	.
17	248	310	M	73	2.2	8.05	510	160	19.9	.	.	1.12	.	2.23	.	.	.	.	.
17	248	311	U	73	1.2	8.23	514	169	19.6	.	.	2.06	.	3.04	.	.	.	.	.
17	249	311	D	73	8.3	7.89	412	126	20.6	.	.	0.60	.	1.18	.	.	.	.	.
17	249	312	M	73	2.8	8.18	434	133	20.1	.	.	1.52	.	1.21	.	.	.	.	.
17	256	309	M	73	3.3	8.36	323	129	18.9	.	.	0.28	.	0.48	.	.	.	.	.
17	256	310	D	73	8.5	8.13	324	127	18.3	.	.	0.24	.	0.25	.	.	.	.	.
17	258	305	D	73	7.8	8.34	603	75	19.0	.	.	0.24	.	0.26	.	.	.	.	.
17	258	306	M	73	5.9	8.04	631	76	19.0	.	.	0.31	.	0.33	.	.	.	.	.
17	258	307	U	73	2.9	8.38	772	77	19.6	.	.	0.73	.	0.26	.	.	.	.	.
17	373	308	D	73	39.8	7.59	1073	19	21.6	.	.	0.32	.	0.23	.	.	.	.	.
17	391	313	U	73	14.7	7.28	343	11	20.1	.	.	0.10	.	0.28	.	.	.	.	.
18	090	502	D	75	.	8.01	341	158	21.1	.	5.5	.	.	0.79	195	.	6	66900	0.035
18	090	502	D	77	.	8.19	341	96	22.5	.	4.0	.	.	0.76	.	.	3	.	.
18	091	502	D	75	.	8.05	517	155	21.5	.	19.5	.	.	1.93	390	.	21	289800	0.047
18	092	316	U	73	5.1	8.13	1998	204	19.2	.	.	1.24	.	2.10	.	.	.	.	.
18	092	317	M	73	14.2	7.93	1820	167	20.0	.	.	0.24	.	1.16	.	.	.	.	.
18	092	318	D	73	19.4	7.99	1730	164	19.6	.	.	0.17	.	0.81	.	.	.	.	.
18	093	312	D	73	17.0	7.46	575	32	22.0	.	.	0.10	.	0.16	.	.	.	.	.
18	093	313	M	73	14.9	7.58	577	28	22.3	.	.	0.09	.	0.24	.	.	.	.	.
18	093	314	M	73	12.8	7.61	557	30	22.2	.	.	0.10	.	0.38	.	.	.	.	.
18	093	315	U	73	7.5	7.34	541	30	21.9	.	.	0.36	.	0.85	.	.	.	.	.
18	093	502	D	77	.	7.65	139	25	21.2	.	2.7	.	.	0.41	.	.	2	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
18	095	502	D	77	.	8.28	381	120	22.0	.	3.0	.	.	0.73	.	.	3	.	.
18	097	502	D	77	.	8.15	402	133	21.7	.	2.4	.	.	0.65	5	.	3	.	.
18	097	503	M	77	.	8.25	400	131	21.3	.	2.4	.	.	0.66	14	.	3	.	.
18	120	313	D	73	17.7	7.76	861	74	23.3	.	.	0.02	.	0.42	.	.	.	.	.
18	120	314	M	73	14.4	7.88	841	76	23.3	.	.	0.03	.	0.46	.	.	.	.	.
18	120	315	M	73	14.0	8.12	668	77	23.2	.	.	0.08	.	0.53	.	.	.	.	.
18	120	316	M	73	14.0	7.96	595	80	24.1	.	.	0.14	.	0.56	.	.	.	.	.
18	120	317	M	73	9.6	8.19	624	81	24.0	.	.	0.17	.	0.71	.	.	.	.	.
18	120	320	M	73	6.3	8.21	1032	81	26.0	.	.	0.16	.	0.60	.	.	.	.	.
18	120	321	M	73	13.2	8.05	592	74	23.7	.	.	0.15	.	0.60	.	.	.	.	.
18	120	322	M	73	10.5	7.95	1063	77	25.5	.	.	0.22	.	0.67	.	.	.	.	.
18	120	323	M	73	5.1	8.00	1089	88	25.4	.	.	0.44	.	1.22	.	.	.	.	.
18	120	502	D	77	.	8.35	194	72	24.8	.	2.3	.	.	0.44	.	.	1	.	.
18	121	502	D	77	.	7.62	161	.	22.0	.	3.7	.	.	0.62	.	.	7	.	.
18	126	502	D	77	.	7.68	137	43	22.9	.	3.2	.	.	0.54	.	.	2	.	.
18	128	502	D	77	.	8.27	227	.	24.3	.	2.4	.	.	0.46	.	.	2	.	.
18	129	502	D	77	.	7.67	205	80	22.6	.	2.3	.	.	0.49	.	.	2	.	.
18	260	505	M	77	.	7.55	321	.	19.9	.	29.9	.	.	2.34	.	.	39	.	.
18	263	502	D	77	.	8.36	434	182	19.7	.	3.6	.	.	0.70	.	.	4	.	.
18	263	504	M	77	.	8.30	440	173	19.2	.	5.3	.	.	1.26	.	.	8	.	.
19	119	324	D	73	20.9	7.86	751	71	22.9	.	.	0.44	.	0.82	.	.	.	.	.
19	122	325	D	73	52.3	7.40	633	36	21.7	.	.	0.10	.	0.32	.	.	.	.	.
19	122	326	M	73	38.0	7.49	603	40	22.6	.	.	0.11	.	0.39	.	.	.	.	.
19	122	327	M	73	27.0	7.47	603	41	22.9	.	.	0.14	.	0.39	.	.	.	.	.
19	122	328	M	73	36.3	7.50	607	35	23.0	.	.	0.24	.	0.54	.	.	.	.	.
19	122	330	U	73	31.6	7.80	652	40	22.2	.	.	0.31	.	0.58	.	.	.	.	.
19	122	331	U	73	20.0	7.64	679	38	22.3	.	.	1.17	.	1.10	.	.	.	.	.
19	338	322	D	73	11.3	7.55	873	58	24.2	.	.	0.39	.	1.21	.	.	.	.	.
19	340	315	D	73	22.1	7.92	965	109	23.2	.	.	0.07	.	0.26	.	.	.	.	.
19	340	316	M	73	18.4	8.01	1002	108	23.6	.	.	0.09	.	0.25	.	.	.	.	.
19	340	317	M	73	20.4	8.20	961	118	23.1	.	.	0.12	.	0.26	.	.	.	.	.
19	340	318	M	73	12.1	8.00	1008	125	22.7	.	.	0.18	.	0.48	.	.	.	.	.
19	340	319	U	73	12.0	8.08	1070	134	22.3	.	.	0.28	.	0.74	.	.	.	.	.
19	340	504	M	76	6.1	7.63	272	145	24.6	.	5.8	.	.	0.76	180	168	12	.	.
19	340	504	M	78	5.7	7.35	289	167	24.4	.	3.7	.	.	1.17	195	157	39	.	.
19	340	505	U	75	10.7	8.00	304	146	27.9	.	5.6	.	.	0.93	168	156	12	.	.
19	340	505	U	76	10.2	7.95	276	152	23.5	.	6.5	.	.	0.53	176	162	14	.	.
19	340	505	U	78	10.0	7.50	292	170	23.9	.	6.3	.	.	1.22	199	177	23	.	.
19	340	506	U	75	6.6	8.19	296	144	27.4	.	5.7	.	.	0.95	169	140	29	.	.
19	340	506	U	76	6.6	7.67	321	172	23.9	.	5.7	.	.	0.50	217	204	13	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
19	340	506	U	78	6.4	7.61	345	175	25.3	.	2.7	.	.	0.73	217	209	9	.	.
19	340	507	U	75	7.7	7.90	363	156	27.7	.	7.5	.	.	0.67	176	137	39	.	.
19	340	507	U	76	6.8	7.72	286	158	24.0	.	6.3	.	.	0.40	184	171	13	.	.
19	340	507	U	78	7.0	7.49	314	176	25.6	.	3.8	.	.	0.97	194	176	18	.	.
19	340	508	M	75	16.8	7.96	294	134	27.8	.	2.1	.	.	0.45	174	158	16	.	.
19	340	508	M	76	16.8	7.70	260	141	23.4	.	3.6	.	.	0.55	169	158	11	.	.
19	340	508	M	78	16.1	7.66	268	144	24.2	.	2.3	.	.	0.61	162	140	22	.	.
19	340	509	M	76	4.3	7.72	260	138	23.3	.	5.7	.	.	0.70	161	151	11	.	.
19	340	510	M	75	9.3	8.21	193	105	27.6	.	1.6	.	.	0.50	139	123	16	.	.
19	340	510	M	76	9.6	7.70	257	133	23.1	.	2.9	.	.	0.33	158	153	5	.	.
19	342	319	D	73	18.5	8.15	612	45	21.4	.	.	0.27	.	0.79	.	.	.	.	.
19	342	321	M	73	18.1	7.89	552	53	20.8	.	.	0.27	.	1.10	.	.	.	.	.
19	342	323	U	73	13.6	7.37	565	49	20.5	.	.	0.26	.	1.28	.	.	.	.	.
19	343	312	D	73	34.5	7.78	784	62	22.5	.	.	0.03	.	0.11	.	.	.	.	.
19	343	313	M	73	33.5	7.62	806	59	22.9	.	.	0.03	.	0.11	.	.	.	.	.
19	343	314	M	73	29.9	7.58	818	59	22.8	.	.	0.04	.	0.17	.	.	.	.	.
19	343	316	U	73	19.1	7.63	809	58	22.9	.	.	0.10	.	0.22	.	.	.	.	.
19	343	317	U	73	11.6	7.49	849	61	21.5	.	.	0.07	.	0.51	.	.	.	.	.
20	081	312	M	73	6.5	7.97	1517	136	20.3	.	.	0.74	.	1.45	.	.	.	.	.
20	081	313	M	73	10.3	7.91	1496	132	20.5	.	.	0.74	.	1.80	.	.	.	.	.
20	081	314	D	73	9.2	8.20	1524	131	20.7	.	.	0.52	.	1.05	.	.	.	.	.
20	087	313	D	73	10.1	7.89	1711	169	20.5	.	.	0.26	.	0.50	.	.	.	.	.
20	087	315	M	73	10.4	8.04	1688	166	20.8	.	.	0.29	.	0.57	.	.	.	.	.
20	087	316	M	73	10.9	8.11	1675	161	20.8	.	.	0.34	.	0.61	.	.	.	.	.
20	087	317	U	73	8.4	8.08	1690	161	20.8	.	.	0.37	.	0.68	.	.	.	.	.
20	087	318	U	73	6.3	8.08	1520	157	20.2	.	.	0.56	.	1.22	.	.	.	.	.
20	088	310	D	73	5.4	7.72	1314	62	21.2	.	.	0.26	.	0.75	.	.	.	.	.
20	088	311	M	73	5.5	7.88	1361	62	21.5	.	.	0.56	.	1.03	.	.	.	.	.
20	088	312	U	73	3.4	7.59	1342	62	21.5	.	.	0.78	.	0.82	.	.	.	.	.
20	088	313	U	73	3.0	7.53	525	65	21.2	.	.	0.63	.	0.79	.	.	.	.	.
21	196	308	D	74	6.9	8.05	168	75	18.3	.	.	0.19	.	0.51	.	.	.	.	.
21	196	309	M	74	10.9	7.83	178	78	17.6	.	.	0.21	.	0.76	.	.	.	.	.
21	196	310	U	74	6.3	7.75	124	55	17.4	.	.	0.26	.	0.80	.	.	.	.	.
21	196	311	U	74	9.6	7.71	186	87	16.8	.	.	0.18	.	0.92	.	.	.	.	.
24	011	312	D	74	58.3	8.00	122	53	20.5	.	.	0.06	.	0.17	.	.	.	.	.
24	011	313	M	74	49.2	7.90	122	54	20.0	.	.	0.07	.	0.26	.	.	.	.	.
24	011	314	M	74	34.5	7.80	119	50	20.2	.	.	0.08	.	0.35	.	.	.	.	.
24	011	315	M	74	29.6	7.50	117	43	20.1	.	.	0.10	.	0.56	.	.	.	.	.
24	011	316	U	74	18.4	7.24	106	43	20.3	.	.	0.17	.	0.85	.	.	.	.	.
24	011	317	U	74	13.7	7.40	110	41	19.7	.	.	0.18	.	1.21	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

---------- POOL DATA SCREEN CODE=A ----------

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
24	013	321	D	74	59.6	8.30	210	126	19.9	.	.	0.06	.	0.15	.	.	.	.	.
24	013	322	M	74	57.2	8.30	205	128	20.1	.	.	0.05	.	0.15	.	.	.	.	.
24	013	323	M	74	47.3	8.26	202	127	20.3	.	.	0.06	.	0.17	.	.	.	.	.
24	013	324	U	74	30.3	8.22	213	141	20.3	.	.	0.06	.	0.18	.	.	.	.	.
24	013	325	M	74	46.8	8.30	195	125	20.3	.	.	0.08	.	0.15	.	.	.	.	.
24	013	326	M	74	34.6	8.48	184	126	20.5	.	.	0.08	.	0.11	.	.	.	.	.
24	013	327	M	74	25.5	8.40	182	123	20.0	.	.	0.07	.	0.16	.	.	.	.	.
24	013	328	U	74	19.6	8.45	194	117	19.6	.	.	0.07	.	0.26	.	.	.	.	.
24	016	310	M	74	55.5	7.22	43	18	23.2	.	.	0.04	.	0.15	.	.	.	.	.
24	016	311	M	74	37.0	7.06	46	19	23.2	.	.	0.05	.	0.17	.	.	.	.	.
24	016	312	U	74	30.0	6.97	47	20	23.9	.	.	0.05	.	0.19	.	.	.	.	.
24	016	313	U	74	16.3	6.79	39	17	23.3	.	.	0.06	.	0.35	.	.	.	.	.
24	022	318	D	74	54.0	8.17	237	157	20.1	.	.	0.07	.	0.16	.	.	.	.	.
24	022	319	U	74	34.0	8.22	230	152	20.7	.	.	0.05	.	0.18	.	.	.	.	.
24	022	320	M	74	48.2	8.22	250	158	20.7	.	.	0.04	.	0.17	.	.	.	.	.
24	022	321	M	74	37.4	8.27	257	160	20.7	.	.	0.08	.	0.20	.	.	.	.	.
24	022	323	M	74	29.5	8.36	247	161	20.7	.	.	0.06	.	0.31	.	.	.	.	.
24	022	324	U	74	11.4	8.39	245	158	20.8	.	.	0.10	.	0.39	.	.	.	.	.
24	193	307	D	74	12.1	8.08	214	97	17.3	.	.	0.16	.	0.55	.	.	.	.	.
24	193	308	U	74	4.4	7.98	222	105	16.1	.	.	0.10	.	0.57	.	.	.	.	.
24	193	309	M	74	6.6	8.01	219	106	17.1	.	.	0.27	.	0.87	.	.	.	.	.
24	200	317	D	74	56.8	8.40	194	95	19.6	.	.	0.09	.	0.12	.	.	.	.	.
24	200	318	U	74	34.6	8.37	203	96	19.9	.	.	0.09	.	0.19	.	.	.	.	.
24	200	319	M	74	53.5	8.18	193	95	19.8	.	.	0.14	.	0.22	.	.	.	.	.
24	200	320	M	74	38.0	8.03	189	92	19.9	.	.	0.13	.	0.24	.	.	.	.	.
24	200	321	M	74	32.7	8.07	187	86	19.9	.	.	0.12	.	0.23	.	.	.	.	.
24	200	322	U	74	19.0	8.12	179	84	19.6	.	.	0.07	.	0.29	.	.	.	.	.
24	200	323	M	74	23.5	8.23	207	104	20.3	.	.	0.08	.	0.21	.	.	.	.	.
24	200	324	M	74	42.8	8.35	214	110	20.2	.	.	0.10	.	0.23	.	.	.	.	.
24	200	325	U	74	22.1	8.27	264	121	20.3	.	.	0.17	.	0.59	.	.	.	.	.
25	105	312	D	74	3.0	8.12	404	180	16.7	.	.	1.28	.	6.02	.	.	.	.	.
25	107	308	M	74	4.0	8.43	526	131	16.8	.	.	1.76	.	2.74	.	.	.	.	.
25	267	315	D	74	24.6	7.73	399	83	20.8	.	.	0.21	.	1.28	.	.	.	.	.
25	267	316	M	74	21.0	7.93	395	84	25.3	.	.	0.26	.	1.64	.	.	.	.	.
25	267	317	M	74	18.9	7.91	339	75	21.3	.	.	0.21	.	1.43	.	.	.	.	.
25	267	318	M	74	20.1	7.52	168	41	22.3	.	.	0.71	.	3.35	.	.	.	.	.
25	267	319	U	74	12.3	7.33	83	22	20.9	.	.	1.08	.	3.98	.	.	.	.	.
25	267	321	M	74	18.2	7.98	490	94	20.9	.	.	0.37	.	2.25	.	.	.	.	.
25	267	322	U	74	10.7	8.08	642	110	21.5	.	.	0.92	.	2.20	.	.	.	.	.
25	267	323	U	74	15.0	7.76	448	101	20.8	.	.	0.87	.	3.06	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
25	273	319	M	74	16.8	8.12	1397	119	20.2	.	.	0.43	.	1.36	.	.	.	.	.
25	273	320	M	74	17.3	8.03	1270	114	20.0	.	.	0.64	.	1.55	.	.	.	.	.
25	273	324	M	74	16.7	7.79	865	110	19.7	.	.	0.87	.	2.60	.	.	.	.	.
25	275	312	D	74	21.8	7.74	282	111	19.6	.	.	0.46	.	1.90	.	.	.	.	.
25	275	313	M	74	11.7	7.79	298	112	19.6	.	.	0.45	.	1.61	.	.	.	.	.
25	275	318	U	74	10.5	8.09	335	113	22.7	.	.	0.20	.	1.37	.	.	.	.	.
25	275	319	M	74	9.3	7.50	326	111	21.6	.	.	0.50	.	2.15	.	.	.	.	.
25	275	320	M	74	9.0	7.69	308	108	21.5	.	.	1.30	.	2.34	.	.	.	.	.
25	278	306	D	74	42.9	7.94	157	73	20.7	.	.	0.09	.	0.39	.	.	.	.	.
25	278	307	M	74	34.0	8.10	161	76	20.9	.	.	0.09	.	0.39	.	.	.	.	.
25	278	308	M	74	27.1	8.15	164	75	21.3	.	.	0.11	.	0.43	.	.	.	.	.
25	278	309	U	74	13.8	8.17	169	78	21.2	.	.	0.23	.	0.91	.	.	.	.	.
25	281	307	D	74	11.8	6.46	62	23	22.8	.	.	0.31	.	1.66	.	.	.	.	.
25	281	308	M	74	10.3	6.27	60	20	22.6	.	.	0.64	.	1.52	.	.	.	.	.
25	370	303	D	74	10.2	8.24	4948	88	22.0	.	.	0.08	.	0.52	.	.	.	.	.
25	370	306	M	74	7.5	8.29	4852	84	22.7	.	.	0.11	.	0.90	.	.	.	.	.
26	354	317	D	74	7.7	8.25	317	134	23.8	.	.	0.39	.	2.27	.	.	.	.	.
26	354	318	M	74	3.7	8.29	321	136	23.9	.	.	0.72	.	2.38	.	.	.	.	.
26	354	319	M	74	5.7	8.27	315	135	24.6	.	.	0.92	.	2.63	.	.	.	.	.
26	355	318	M	74	9.5	8.26	356	115	23.7	.	.	0.23	.	0.78	.	.	.	.	.
26	355	320	M	74	8.4	8.21	357	114	24.1	.	.	0.40	.	1.14	.	.	.	.	.
26	355	322	U	74	3.0	8.14	332	106	24.0	.	.	1.77	.	3.65	.	.	.	.	.
28	219	307	D	75	19.3	8.28	826	154	18.6	.	.	0.06	.	0.80	.	.	.	.	.
28	219	308	U	75	14.2	8.29	808	154	19.0	.	.	0.06	.	0.65	.	.	.	.	.
28	219	309	M	75	17.9	8.27	820	157	18.6	.	.	0.06	.	0.64	.	.	.	.	.
28	219	310	M	75	14.3	8.33	816	152	18.0	.	.	0.09	.	0.96	.	.	.	.	.
29	106	311	M	74	4.8	8.11	1384	156	17.0	.	.	1.67	.	3.00	.	.	.	.	.
29	108	314	M	74	14.8	8.39	749	191	16.5	.	.	0.25	.	0.60	.	.	.	.	.
29	108	315	M	74	10.3	8.33	774	192	16.5	.	.	0.41	.	1.07	.	.	.	.	.
29	108	316	M	74	5.1	8.38	863	232	16.8	.	.	1.94	.	2.07	.	.	.	.	.
29	110	315	D	74	16.2	8.34	397	164	17.7	.	.	0.14	.	1.34	.	.	.	.	.
29	110	316	U	74	10.1	8.25	398	167	17.1	.	.	0.19	.	1.57	.	.	.	.	.
29	110	317	M	74	14.9	8.24	395	168	17.1	.	.	0.26	.	2.04	.	.	.	.	.
29	110	318	M	74	10.1	8.11	336	172	17.1	.	.	0.88	.	2.19	.	.	.	.	.
29	111	310	D	74	9.9	8.25	330	144	18.1	.	.	0.21	.	1.67	.	.	.	.	.
29	111	311	M	74	7.8	8.18	354	142	17.4	.	.	0.25	.	1.88	.	.	.	.	.
29	194	311	D	74	21.5	8.25	234	114	18.5	.	.	1.22	.	0.30	.	.	.	.	.
29	194	312	M	74	17.4	8.02	250	119	17.5	.	.	0.17	.	0.46	.	.	.	.	.
29	194	313	U	74	8.6	8.03	287	138	17.0	.	.	0.32	.	0.88	.	.	.	.	.
29	194	314	M	74	11.5	8.24	182	104	18.0	.	.	0.11	.	0.71	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
29	195	315	D	74	29.3	8.24	284	132	16.8	.	.	0.09	.	0.34	.	.	.	.	.
29	207	310	D	74	16.4	8.46	496	199	16.1	.	.	0.16	.	0.63	.	.	.	.	.
29	207	311	M	74	11.7	8.32	507	198	15.6	.	.	0.19	.	1.14	.	.	.	.	.
30	064	305	D	75	5.5	8.28	490	181	15.4	.	.	0.15	.	0.96	.	.	.	.	.
30	064	307	M	75	5.2	8.42	458	167	15.6	.	.	0.09	.	1.02	.	.	.	.	.
30	235	320	D	74	54.9	8.27	690	166	14.6	.	.	0.07	.	0.20	.	.	.	.	.
30	235	321	M	74	19.9	8.19	693	166	14.5	.	.	0.08	.	0.35	.	.	.	.	.
30	235	322	M	74	39.6	7.85	727	166	14.2	.	.	0.76	.	0.20	.	.	.	.	.
30	235	323	M	74	24.9	8.03	708	162	15.5	.	.	0.09	.	0.27	.	.	.	.	.
30	235	324	M	74	30.0	8.30	638	159	14.2	.	.	0.05	.	0.20	.	.	.	.	.
31	077	311	D	75	175.4	7.51	25	20	20.1	.	.	0.06	.	0.38	.	.	.	.	.
31	077	312	M	75	175.4	7.21	24	14	14.0	.	.	0.04	.	0.31	.	.	.	.	.
31	077	313	M	75	175.4	7.25	23	15	13.2	.	.	0.05	.	0.34	.	.	.	.	.
31	077	314	M	75	175.4	6.99	23	19	13.4	.	.	0.05	.	0.32	.	.	.	.	.
31	077	315	M	75	175.4	7.08	22	19	13.6	.	.	0.05	.	0.37	.	.	.	.	.
32	204	314	M	75	82.3	8.42	187	101	17.5	.	.	0.04	.	0.15	.	.	.	.	.
32	204	315	D	75	82.3	8.49	192	102	16.0	.	.	0.03	.	0.08	.	.	.	.	.
32	204	316	M	75	38.1	8.35	177	97	17.0	.	.	0.11	.	0.32	.	.	.	.	.

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
02	176	301	D	72	.	7.02	95	16	18.4	.	.	0.07	.	0.34	.	.	.	.	.
02	176	302	M	72	.	7.11	124	16	19.6	.	.	0.07	.	0.25	.	.	.	.	.
04	312	312	M	73	4.8	8.20	273	105	17.1	.	.	0.24	.	0.42	.	.	.	.	.
04	320	005	M	74	.	7.57	212	69	20.1	.	.	.	.	0.49	.	.	.	.	.
04	320	006	M	74	.	7.57	197	59	21.0	.	.	.	.	0.28	.	.	.	.	.
04	320	007	M	74	.	7.33	174	51	21.0	.	.	.	.	0.16	.	.	.	.	.
08	074	320	D	73	42.5	6.98	225	16	28.4	.	.	0.09	.	0.16	.	.	.	.	.
08	074	321	M	73	34.0	7.10	213	13	28.0	.	.	0.07	.	0.31	.	.	.	.	.
08	074	323	U	73	26.5	7.58	227	17	28.9	.	.	0.09	.	0.41	.	.	.	.	.
08	074	324	U	73	14.3	7.00	272	23	28.6	.	.	0.11	.	0.34	.	.	.	.	.
08	074	325	M	73	22.0	7.73	250	20	28.8	.	.	0.09	.	0.25	.	.	.	.	.
08	074	326	U	73	14.2	7.60	284	23	28.9	.	.	0.14	.	0.30	.	.	.	.	.
08	074	327	U	73	7.8	7.33	288	19	28.4	.	.	0.22	.	0.54	.	.	.	.	.
08	074	328	M	73	14.6	7.80	241	18	28.3	.	.	0.13	.	0.39	.	.	.	.	.
08	074	329	U	73	11.7	7.56	276	19	27.8	.	.	0.33	.	1.00	.	.	.	.	.
08	074	330	U	73	13.0	7.63	225	18	26.9	.	.	0.15	.	0.64	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
08	330	340	D	73	51.7	6.82	155	12	28.2	.	.	0.05	.	0.08	.	.	.	.	.
08	330	341	U	73	17.2	6.53	166	10	28.7	.	.	0.09	.	0.09	.	.	.	.	.
08	330	342	M	73	46.6	7.00	169	10	28.6	.	.	0.14	.	0.22	.	.	.	.	.
08	330	343	M	73	31.4	7.27	300	12	28.1	.	.	1.64	.	0.27	.	.	.	.	.
08	330	344	U	73	9.8	7.01	367	15	28.1	.	.	0.10	.	0.52	.	.	.	.	.
08	330	345	U	73	10.7	6.27	106	10	25.1	.	.	0.30	.	0.89	.	.	.	.	.
08	330	346	M	73	15.2	6.68	167	11	28.3	.	.	0.12	.	0.36	.	.	.	.	.
08	330	347	M	73	18.7	6.61	162	10	28.8	.	.	0.09	.	0.24	.	.	.	.	.
08	330	348	M	73	32.3	7.04	173	15	29.1	.	.	0.10	.	0.25	.	.	.	.	.
08	330	349	M	73	16.5	7.11	186	13	29.1	.	.	0.10	.	0.29	.	.	.	.	.
08	330	350	M	73	17.5	6.98	316	14	28.4	.	.	1.51	.	0.26	.	.	.	.	.
08	330	351	U	73	12.5	7.06	214	16	28.6	.	.	0.12	.	0.19	.	.	.	.	.
10	003	310	U	73	17.8	6.73	805	21	24.9	.	.	0.16	.	0.75	.	.	.	.	.
10	069	311	D	73	40.2	7.06	150	17	26.4	.	.	0.05	.	0.40	.	.	.	.	.
10	069	312	M	73	17.4	7.02	164	14	26.8	.	.	0.09	.	0.41	.	.	.	.	.
10	069	313	U	73	5.0	6.74	202	21	27.1	.	.	0.17	.	0.49	.	.	.	.	.
10	069	314	M	73	14.0	7.22	155	15	27.3	.	.	0.05	.	0.31	.	.	.	.	.
10	069	315	U	73	7.6	7.12	200	18	26.9	.	.	0.23	.	0.60	.	.	.	.	.
10	069	316	U	73	11.0	7.29	152	14	26.4	.	.	0.08	.	0.48	.	.	.	.	.
10	071	311	U	73	7.6	7.41	357	23	28.4	.	.	0.29	.	0.87	.	.	.	.	.
10	071	312	D	73	8.2	7.57	448	30	28.9	.	.	0.36	.	1.03	.	.	.	.	.
10	071	313	M	73	7.9	7.41	593	49	28.6	.	.	0.17	.	0.94	.	.	.	.	.
10	071	314	M	73	3.2	7.64	946	86	28.2	.	.	0.14	.	0.58	.	.	.	.	.
10	071	315	U	73	7.9	7.33	620	52	28.0	.	.	0.15	.	0.84	.	.	.	.	.
10	072	321	D	73	11.1	8.24	316	19	29.7	.	.	0.11	.	0.40	.	.	.	.	.
10	072	322	M	73	2.0	8.50	325	20	29.4	.	.	0.22	.	0.48	.	.	.	.	.
10	072	323	M	73	26.1	8.17	302	20	28.3	.	.	0.21	.	0.85	.	.	.	.	.
10	072	324	M	73	6.9	7.52	308	16	28.2	.	.	0.40	.	1.17	.	.	.	.	.
10	073	113	M	75	.	6.66	53	18	22.9	12.2	.	.	29	1.16	67	57	10	.	.
10	073	131	M	75	.	6.56	58	17	21.3	22.3	.	.	34	2.24	68	40	28	.	.
10	076	312	D	73	43.0	7.48	134	11	27.2	.	.	0.07	.	0.20	.	.	.	.	.
10	076	313	U	73	25.2	7.71	134	10	27.4	.	.	0.07	.	0.26	.	.	.	.	.
10	076	314	U	73	22.3	6.77	143	10	27.3	.	.	0.07	.	0.21	.	.	.	.	.
10	076	315	M	73	42.5	7.47	138	11	27.8	.	.	0.07	.	0.21	.	.	.	.	.
10	076	316	M	73	27.6	7.57	140	11	28.3	.	.	0.07	.	0.21	.	.	.	.	.
10	076	317	M	73	35.1	7.63	134	12	27.9	.	.	0.07	.	0.21	.	.	.	.	.
10	076	318	U	73	22.4	8.40	174	14	28.0	.	.	0.16	.	0.20	.	.	.	.	.
10	076	319	M	73	29.9	7.42	134	12	27.9	.	.	0.14	.	0.33	.	.	.	.	.
10	076	320	U	73	14.9	7.37	129	12	26.8	.	.	0.13	.	0.35	.	.	.	.	.
10	076	321	M	73	30.5	7.41	132	10	27.8	.	.	0.12	.	0.28	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
10	076	322	M	73	24.7	7.61	132	11	27.9	.	.	0.15	.	0.27	.	.	.	.	.
10	076	323	U	73	15.2	7.65	135	12	27.8	.	.	0.13	.	0.15	.	.	.	.	.
10	411	313	D	73	18.0	6.73	988	25	24.8	.	.	0.28	.	0.55	.	.	.	.	.
10	411	315	U	73	10.2	6.76	719	25	25.3	.	.	0.21	.	0.79	.	.	.	.	.
14	099	312	D	74	13.9	8.03	635	293	17.9	.	.	0.79	.	0.89	.	.	.	.	.
14	099	313	M	74	7.5	7.90	703	292	14.0	.	.	1.61	.	2.27	.	.	.	.	.
15	178	005	M	76	.	8.33	223	110	18.2	.	2.2	.	23	0.15	.	.	.	.	.
15	178	005	M	78	19.8	7.90	213	98	.	.	1.3	.	10	0.27	.	.	3	.	.
15	178	006	D	77	19.8	7.93	237	123	18.1	.	3.3	.	12	0.09	.	.	3	.	.
15	178	305	M	72	.	8.18	404	100	15.2	.	.	0.10	.	0.08	.	.	.	.	.
15	178	306	M	72	.	8.18	441	105	15.6	.	.	0.11	.	0.17	.	.	.	.	.
15	178	307	D	72	.	8.20	449	103	15.7	.	.	0.12	.	0.18	.	.	.	.	.
15	179	802	M	79	.	8.28	550	232	19.4	.	.	.	.	0.08	.	15	.	.	.
15	179	803	M	79	.	8.55	.	216	20.0	.	.	.	.	0.08	.	25	.	.	.
15	179	804	M	79	.	8.32	683	220	18.4	.	.	.	.	0.08	.	19	.	.	.
15	179	805	M	79	.	8.56	.	218	19.1	.	.	.	.	0.08	.	17	.	.	.
15	179	806	M	79	.	8.42	726	226	19.1	.	.	.	.	0.42	.	19	.	.	.
15	181	309	M	72	.	8.16	265	136	15.7	.	.	0.41	.	0.24	.	.	.	.	.
15	181	310	M	72	.	8.26	261	134	14.4	.	.	0.53	.	0.38	.	.	.	.	.
15	181	311	D	72	.	8.28	264	133	14.6	.	.	0.54	.	0.29	.	.	.	.	.
15	181	312	M	72	.	8.27	261	132	14.6	.	.	0.52	.	0.32	.	.	.	.	.
15	237	309	M	74	6.1	8.74	697	324	19.3	.	.	0.14	.	0.11	.	.	.	.	.
15	399	801	M	78	.	8.20	.	188	13.3	.	.	.	.	0.34	.	.	.	.	.
15	399	801	M	79	.	8.05	373	133	15.5	.	.	.	.	0.24	.	9	.	.	.
15	399	802	U	78	.	8.20	.	190	10.0	.	.	.	.	0.23	.	.	.	.	.
16	243	311	U	73	7.3	7.80	402	75	15.9	.	.	0.12	.	0.77	.	.	.	.	.
16	243	312	U	73	4.4	8.20	406	75	16.3	.	.	0.11	.	0.68	.	.	.	.	.
16	243	314	M	73	3.7	7.95	462	92	20.1	.	.	0.65	.	1.39	.	.	.	.	.
16	328	336	M	72	.	7.87	163	36	17.3	.	.	0.31	.	0.45	.	.	.	.	.
17	247	308	U	73	1.7	8.35	452	183	16.9	.	.	2.45	.	1.99	.	.	.	.	.
17	249	313	U	73	2.1	7.85	441	142	16.8	.	.	0.60	.	2.43	.	.	.	.	.
17	373	309	M	73	30.3	7.76	1910	26	25.6	.	.	0.08	.	0.14	.	.	.	.	.
17	373	310	U	73	14.5	7.22	1376	24	21.6	.	.	0.24	.	0.85	.	.	.	.	.
17	373	311	M	73	11.6	7.02	1040	26	18.3	.	.	0.15	.	0.57	.	.	.	.	.
17	389	328	D	73	11.7	8.20	752	55	20.7	.	.	0.54	.	0.80	.	.	.	.	.
17	389	329	M	73	4.8	7.83	675	54	20.2	.	.	0.64	.	1.43	.	.	.	.	.
17	389	330	M	73	2.4	8.27	774	54	18.5	.	.	0.62	.	1.17	.	.	.	.	.
17	389	331	U	73	2.4	7.95	689	52	24.1	.	.	0.17	.	1.18	.	.	.	.	.
17	391	310	D	73	64.0	7.08	296	11	20.6	.	.	0.12	.	0.08	.	.	.	.	.
17	391	311	M	73	12.1	7.04	276	10	20.9	.	.	0.20	.	0.15	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
17	391	312	M	73	31.9	6.98	313	11	21.0	.	.	0.16	.	0.08	.	.	.	.	.
18	090	502	D	73	.	7.91	369	135	21.3	.	.	.	.	0.63	208	.	5	113100	0.075
18	091	502	D	74	.	8.04	536	149	19.2	.	13.8	.	.	2.23	466	.	57	738500	0.262
18	091	502	D	77	.	8.04	690	.	19.8	.	2.8	.	.	0.72	.	.	17	.	.
18	092	502	D	74	.	8.03	542	152	22.5	.	0.7	.	.	0.95	308	.	4	83775	0.020
18	092	502	D	75	.	8.15	476	156	20.3	.	4.0	.	.	0.95	341	.	8	263700	0.022
18	092	502	D	77	.	8.20	529	.	21.3	.	4.5	.	.	0.82	.	.	6	.	.
18	093	317	M	73	5.8	6.86	608	30	23.3	.	.	0.48	.	1.74	.	.	.	.	.
18	094	502	D	75	.	8.13	420	139	20.9	.	3.2	.	.	0.80	321	.	6	81667	0.020
18	095	502	D	76	.	8.31	361	137	19.2	.	5.0	.	.	0.51	216	.	5	468000	.
18	097	503	M	75	.	8.20	424	176	21.2	.	4.1	.	.	0.69	285	.	5	139667	0.013
18	120	318	U	73	5.9	8.32	973	99	22.2	.	.	1.00	.	1.28	.	.	.	.	.
18	120	319	U	73	5.0	8.36	844	87	23.5	.	.	0.47	.	1.03	.	.	.	.	.
18	121	502	D	75	.	7.42	125	31	24.6	.	6.2	.	.	0.73	77	.	6	82333	0.302
18	126	502	D	74	.	7.69	131	44	20.6	.	.	.	.	0.51	76	.	6	61500	0.015
18	128	502	D	75	.	8.06	199	121	21.8	.	6.8	.	.	0.64	128	.	5	89333	0.020
18	129	502	D	74	.	7.91	254	94	19.3	.	2.5	.	.	0.66	139	.	4	113000	0.191
18	134	502	D	75	.	7.61	104	34	25.8	.	6.3	.	.	0.36	73	.	5	142975	0.011
18	134	502	D	77	.	7.61	119	.	22.2	.	2.5	.	.	0.58	.	.	2	.	.
18	263	502	D	75	.	8.16	540	256	18.4	.	8.8	.	.	0.75	367	.	17	119300	0.009
19	119	325	M	73	16.8	7.94	748	81	23.3	.	.	0.34	.	0.62	.	.	.	.	.
19	119	326	M	73	18.7	7.90	510	79	20.7	.	.	0.49	.	1.10	.	.	.	.	.
19	119	327	M	73	21.6	7.68	682	77	23.0	.	.	0.38	.	1.02	.	.	.	.	.
19	119	328	M	73	18.6	7.68	554	71	20.9	.	.	0.55	.	1.38	.	.	.	.	.
19	119	329	M	73	16.3	7.51	652	73	22.3	.	.	0.33	.	1.18	.	.	.	.	.
19	119	330	M	73	16.3	7.51	610	70	21.2	.	.	0.50	.	1.30	.	.	.	.	.
19	119	331	U	73	15.5	7.48	650	71	21.8	.	.	0.33	.	1.27	.	.	.	.	.
19	119	332	U	73	16.0	7.50	640	65	21.0	.	.	0.48	.	1.53	.	.	.	.	.
19	122	329	M	73	35.0	7.60	606	38	22.6	.	.	0.23	.	0.47	.	.	.	.	.
19	338	323	M	73	9.5	7.20	611	57	21.1	.	.	0.36	.	1.48	.	.	.	.	.
19	340	502	D	75	29.7	8.54	197	104	27.5	.	1.8	.	.	0.42	129	122	8	.	.
19	340	502	D	76	29.2	7.68	248	134	22.1	.	2.6	.	.	0.27	156	152	4	.	.
19	340	502	D	78	29.5	7.72	250	136	24.4	.	1.2	.	.	0.44	152	147	5	.	.
19	340	503	M	75	24.5	8.30	217	108	27.1	.	2.7	.	.	0.54	131	120	11	.	.
19	340	503	M	76	24.5	7.65	256	134	23.1	.	2.8	.	.	0.44	178	170	8	.	.
19	340	503	M	78	24.3	7.75	247	131	24.2	.	1.3	.	.	0.39	157	153	4	.	.
19	342	320	M	73	21.3	8.33	598	59	22.1	.	.	0.31	.	0.87	.	.	.	.	.
19	342	322	M	73	17.8	7.71	536	54	20.7	.	.	0.36	.	1.55	.	.	.	.	.
19	343	315	U	73	16.6	7.80	822	70	22.9	.	.	0.04	.	0.21	.	.	.	.	.
20	087	314	M	73	15.5	8.05	1773	168	21.0	.	.	0.26	.	0.29	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
22	014	309	D	74	51.5	6.88	57	23	22.5	.	.	0.08	.	0.08	.	.	.	.	.
22	014	310	M	74	34.9	7.45	46	21	23.0	.	.	0.13	.	0.08	.	.	.	.	.
22	014	311	U	74	10.7	6.70	63	22	22.7	.	.	0.11	.	0.20	.	.	.	.	.
22	014	312	M	74	15.5	7.03	68	25	22.8	.	.	0.10	.	0.08	.	.	.	.	.
22	014	313	M	74	13.3	7.36	75	27	23.5	.	.	0.11	.	0.19	.	.	.	.	.
22	019	313	D	74	42.7	7.30	79	25	22.2	.	.	0.06	.	0.17	.	.	.	.	.
22	019	314	M	74	39.9	7.34	76	25	22.6	.	.	0.07	.	0.17	.	.	.	.	.
22	019	315	M	74	33.4	6.96	80	23	22.2	.	.	0.06	.	0.21	.	.	.	.	.
22	019	316	U	74	18.7	6.97	98	32	22.4	.	.	0.08	.	0.60	.	.	.	.	.
22	019	317	U	74	23.0	6.75	75	18	22.5	.	.	0.08	.	0.30	.	.	.	.	.
22	019	318	U	74	21.8	6.87	80	20	22.4	.	.	0.08	.	0.20	.	.	.	.	.
22	188	311	M	73	8.7	7.18	212	19	26.4	.	.	0.53	.	2.05	.	.	.	.	.
22	188	312	D	73	11.1	7.27	61	21	27.4	.	.	0.49	.	1.78	.	.	.	.	.
22	188	313	M	73	5.5	7.05	64	22	27.3	.	.	0.54	.	2.92	.	.	.	.	.
22	189	307	U	73	6.6	6.65	49	15	27.8	.	.	0.22	.	0.94	.	.	.	.	.
22	189	308	M	73	13.9	6.75	47	15	28.2	.	.	0.15	.	0.80	.	.	.	.	.
22	189	309	D	73	12.8	7.06	48	17	29.2	.	.	0.15	.	0.78	.	.	.	.	.
22	190	310	D	73	15.4	6.75	54	15	26.6	.	.	0.29	.	1.50	.	.	.	.	.
22	190	311	U	73	9.8	6.92	54	15	27.5	.	.	0.30	.	1.54	.	.	.	.	.
22	190	312	U	73	13.4	6.88	54	17	26.9	.	.	0.26	.	1.42	.	.	.	.	.
22	192	311	D	73	16.6	7.20	60	16	27.2	.	.	0.16	.	0.65	.	.	.	.	.
22	192	312	M	73	14.3	7.28	59	16	27.8	.	.	0.16	.	0.52	.	.	.	.	.
22	192	313	M	73	14.3	7.31	58	17	27.3	.	.	0.15	.	0.57	.	.	.	.	.
22	192	314	U	73	12.7	7.07	59	17	28.1	.	.	0.19	.	0.57	.	.	.	.	.
24	012	308	D	74	9.5	6.61	73	21	20.2	.	.	0.44	.	1.66	.	.	.	.	.
24	012	309	M	74	2.7	6.65	78	22	20.4	.	.	0.61	.	2.32	.	.	.	.	.
24	021	308	M	74	2.6	6.29	34	13	20.9	.	.	0.23	.	0.74	.	.	.	.	.
24	021	309	D	74	11.4	6.26	34	12	21.4	.	.	0.19	.	0.58	.	.	.	.	.
24	022	322	M	74	30.2	8.21	256	160	20.9	.	.	0.04	.	0.10	.	.	.	.	.
25	020	323	D	74	10.4	6.95	50	17	22.7	.	.	0.15	.	0.35	.	.	.	.	.
25	020	324	M	74	9.1	6.45	62	20	22.5	.	.	0.29	.	1.29	.	.	.	.	.
25	020	325	M	74	3.8	8.65	161	70	22.4	.	.	0.19	.	0.42	.	.	.	.	.
25	102	312	D	74	12.8	8.13	328	155	16.7	.	.	0.60	.	2.44	.	.	.	.	.
25	102	313	M	74	2.9	8.23	336	162	17.1	.	.	2.13	.	3.27	.	.	.	.	.
25	102	314	M	74	5.5	8.18	330	154	16.6	.	.	0.86	.	2.17	.	.	.	.	.
25	103	307	D	74	13.7	7.87	304	122	18.3	.	.	2.45	.	4.16	.	.	.	.	.
25	104	305	D	74	10.6	8.07	417	155	18.0	.	.	1.03	.	3.07	.	.	.	.	.
25	104	306	M	74	3.8	8.03	382	162	18.0	.	.	1.18	.	3.52	.	.	.	.	.
25	105	313	M	74	1.3	8.20	380	173	18.7	.	.	2.39	.	4.46	.	.	.	.	.
25	107	307	D	74	10.6	8.36	521	130	16.3	.	.	0.71	.	1.72	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
25	112	308	D	74	7.0	8.00	375	140	17.7	.	.	1.80	.	3.33	.	.	.	.	.
25	112	309	M	74	3.8	8.01	310	153	17.8	.	.	2.64	.	3.19	.	.	.	.	.
25	267	320	U	74	5.9	8.01	623	122	21.5	.	.	1.69	.	2.55	.	.	.	.	.
25	269	309	D	74	3.8	8.38	1204	181	17.7	.	.	0.74	.	3.09	.	.	.	.	.
25	269	310	M	74	1.8	8.37	1214	183	17.6	.	.	0.55	.	2.46	.	.	.	.	.
25	273	316	D	74	8.8	8.19	1363	115	18.1	.	.	0.31	.	1.42	.	.	.	.	.
25	273	317	U	74	6.2	8.45	3700	166	18.9	.	.	2.49	.	4.33	.	.	.	.	.
25	273	321	M	74	12.0	8.18	1782	110	20.8	.	.	1.15	.	2.53	.	.	.	.	.
25	273	322	U	74	4.0	8.08	1273	160	18.4	.	.	3.12	.	5.59	.	.	.	.	.
25	273	323	U	74	7.6	8.05	1345	152	19.6	.	.	4.61	.	6.14	.	.	.	.	.
25	273	325	D	74	21.4	7.90	1157	107	22.8	.	.	0.77	.	1.91	.	.	.	.	.
25	273	326	U	74	8.1	8.02	1043	137	19.7	.	.	2.38	.	4.84	.	.	.	.	.
25	275	321	U	74	2.7	7.60	304	108	21.5	.	.	2.07	.	4.34	.	.	.	.	.
25	348	317	D	74	28.9	7.92	1436	126	22.4	.	.	0.09	.	0.37	.	.	.	.	.
25	348	318	M	74	23.6	8.32	1404	127	23.2	.	.	0.10	.	0.21	.	.	.	.	.
25	348	319	M	74	21.2	8.29	1115	136	23.5	.	.	0.11	.	0.38	.	.	.	.	.
25	348	320	U	74	4.9	8.13	729	141	24.0	.	.	2.13	.	2.79	.	.	.	.	.
25	348	321	M	74	17.5	8.20	1721	115	23.4	.	.	0.13	.	0.39	.	.	.	.	.
25	348	322	M	74	7.1	8.23	1656	112	23.6	.	.	0.20	.	0.58	.	.	.	.	.
25	348	323	U	74	3.3	8.32	2531	113	24.3	.	.	2.88	.	3.20	.	.	.	.	.
25	370	304	M	74	3.2	8.32	3999	83	22.6	.	.	2.98	.	1.93	.	.	.	.	.
26	354	101	D	74	.	8.17	341	.	25.1	40.0	.	.	.	1.57	.	.	15	.	.
26	354	101	D	75	.	7.82	325	.	26.6	.	.	.	.	2.94	.	.	16	.	.
26	354	101	D	77	.	8.06	311	139	22.7	.	.	.	.	0.81	.	198	567	.	.
26	354	101	D	78	.	8.05	317	122	27.9	.	.	.	.	0.79	.	185	5	.	.
26	354	102	M	74	.	8.16	341	.	25.8	47.5	.	.	.	3.18	.	.	24	.	.
26	354	102	M	75	.	7.92	338	.	27.3	.	.	.	.	6.40	.	.	58	.	.
26	354	103	M	74	.	8.20	340	.	26.2	52.5	.	.	.	4.05	.	.	25	.	.
26	354	103	M	75	.	7.16	308	.	26.8	.	.	.	.	5.47	.	.	25	.	.
26	355	317	D	74	15.1	8.10	356	113	23.0	.	.	0.20	.	0.61	.	.	.	.	.
26	355	319	M	74	9.3	8.20	307	105	23.6	.	.	0.20	.	1.17	.	.	.	.	.
26	355	321	U	74	7.3	8.13	344	103	24.2	.	.	1.01	.	2.62	.	.	.	.	.
26	359	109	M	75	.	6.87	144	21	24.7	2.5	.	.	.	0.45	.	.	4	.	.
26	359	110	U	75	.	6.75	260	47	24.6	45.0	.	.	.	1.58	10	.	17	.	.
26	359	110	U	76	.	6.77	282	32	27.5	72.5	.	.	.	1.48	.	.	11	.	.
26	359	110	U	78	.	6.95	638	44	28.7	280.0	.	.	300	1.48	.	441	6	.	.
26	359	319	D	74	16.2	7.86	139	17	27.5	.	.	0.04	.	0.44	.	.	.	.	.
26	359	320	M	74	11.7	7.98	135	20	28.3	.	.	0.04	.	0.45	.	.	.	.	.
26	359	321	M	74	13.9	8.15	140	20	28.3	.	.	0.04	.	0.24	.	.	.	.	.
26	359	322	M	74	16.6	7.89	150	22	28.5	.	.	0.04	.	0.19	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
26	359	323	U	74	6.4	7.70	148	28	28.7	.	.	0.07	.	0.32	.	.	.	.	.
26	359	324	U	74	5.3	7.16	312	47	28.0	.	.	0.24	.	1.06	.	.	.	.	.
26	360	303	D	74	5.8	8.14	492	133	23.2	.	.	0.90	.	1.47	.	.	.	.	.
28	218	007	D	77	.	.	.	.	23.0	.	.	.	.	0.32	.	.	.	.	.
28	219	012	D	77	.	.	.	.	25.2	.	.	.	.	0.47	.	.	.	.	.
28	219	012	D	78	.	.	.	.	.	.	.	.	.	0.47	.	.	.	.	.
29	100	305	D	74	13.4	7.87	265	87	17.1	.	.	0.26	.	0.98	.	.	.	.	.
29	100	306	M	74	8.5	7.89	266	90	17.5	.	.	0.36	.	0.97	.	.	.	.	.
29	100	307	M	74	9.8	7.92	263	90	17.6	.	.	0.39	.	1.33	.	.	.	.	.
29	100	308	M	74	9.7	7.83	267	96	17.9	.	.	0.39	.	1.18	.	.	.	.	.
29	100	309	U	74	7.1	7.67	312	132	18.2	.	.	2.42	.	2.81	.	.	.	.	.
29	100	310	U	74	7.9	7.88	269	101	18.2	.	.	0.69	.	1.67	.	.	.	.	.
29	106	310	D	74	9.8	8.01	1307	155	16.3	.	.	0.70	.	2.24	.	.	.	.	.
29	108	313	D	74	15.3	8.32	753	196	16.4	.	.	0.19	.	0.45	.	.	.	.	.
29	109	307	D	74	17.6	8.29	546	148	17.4	.	.	0.10	.	0.28	.	.	.	.	.
29	109	308	M	74	14.5	8.45	545	147	17.5	.	.	0.12	.	0.08	.	.	.	.	.
29	109	309	M	74	5.7	8.28	635	157	17.7	.	.	0.16	.	0.54	.	.	.	.	.
29	110	319	U	74	9.1	8.26	398	163	20.5	.	.	0.27	.	1.62	.	.	.	.	.
29	111	312	M	74	4.8	8.18	370	147	17.5	.	.	0.56	.	2.22	.	.	.	.	.
29	113	327	D	74	19.7	8.22	550	195	17.1	.	.	0.13	.	0.70	.	.	.	.	.
29	113	328	M	74	10.9	8.26	551	195	16.6	.	.	0.18	.	1.09	.	.	.	.	.
29	113	329	M	74	8.1	8.23	632	231	17.0	.	.	1.00	.	3.01	.	.	.	.	.
29	114	307	D	74	17.5	8.13	2365	151	16.9	.	.	0.13	.	0.46	.	.	.	.	.
29	114	308	M	74	15.9	8.29	2372	149	16.5	.	.	0.12	.	0.47	.	.	.	.	.
29	114	309	M	74	12.3	8.19	2442	155	16.9	.	.	0.18	.	0.58	.	.	.	.	.
29	194	315	U	74	3.5	8.44	248	125	21.6	.	.	0.58	.	1.22	.	.	.	.	.
29	195	316	M	74	21.3	8.16	283	132	16.7	.	.	0.11	.	0.25	.	.	.	.	.
29	195	317	U	74	21.3	8.14	283	131	16.9	.	.	0.15	.	0.45	.	.	.	.	.
29	195	318	M	74	23.1	8.20	293	130	17.2	.	.	0.09	.	0.35	.	.	.	.	.
29	195	319	U	74	17.0	8.24	281	128	17.6	.	.	0.13	.	0.34	.	.	.	.	.
29	207	312	U	74	1.6	8.46	581	206	16.5	.	.	1.80	.	2.28	.	.	.	.	.
30	064	306	M	75	3.3	8.41	463	178	15.9	.	.	0.28	.	0.13	.	.	.	.	.
30	215	304	D	74	7.4	7.74	466	209	16.9	.	.	0.15	.	0.44	.	.	.	.	.
30	215	305	M	74	6.8	7.98	465	244	17.3	.	.	0.17	.	0.50	.	.	.	.	.
30	217	306	D	74	10.7	7.88	480	250	17.0	.	.	0.13	.	0.44	.	.	.	.	.
30	217	307	M	74	9.1	7.82	478	244	16.8	.	.	0.15	.	0.44	.	.	.	.	.
30	217	308	M	74	6.3	7.76	481	247	16.4	.	.	0.12	.	0.56	.	.	.	.	.
30	235	325	M	74	23.6	8.25	560	151	13.9	.	.	0.11	.	0.51	.	.	.	.	.
30	235	326	M	74	9.8	8.21	595	165	16.1	.	.	0.42	.	1.05	.	.	.	.	.
30	235	327	U	74	3.4	8.34	789	269	16.0	.	.	2.55	.	2.20	.	.	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
30	235	328	U	74	2.0	8.12	678	173	16.8	.	.	2.31	.	4.61	.	.	.	.	.
32	204	313	M	75	35.5	8.08	161	99	13.5	.	.	0.41	.	0.34	.	.	.	.	.
32	204	317	M	75	82.3	8.38	179	98	16.7	.	.	0.21	.	0.18	.	.	.	.	.
33	300	306	D	75	78.8	8.21	40	28	16.2	.	.	0.04	.	0.49	.	.	.	.	.
34	041	112	D	71	.	7.36	56	24	19.4	.	1.0	.	.	0.15	.	40	0	.	.
34	041	112	D	72	.	7.54	57	21	20.3	.	0.9	.	.	0.12	.	44	0	.	.
34	041	112	D	73	.	7.30	60	.	19.8	.	1.1	.	.	0.16	.	49	.	.	.
34	041	112	D	74	.	6.91	54	.	21.2	.	1.1	.	.	0.12	.	.	.	.	.
34	041	112	D	75	.	7.55	65	.	18.2	.	1.9	.	.	0.21	.	.	.	.	.
34	041	112	D	76	.	7.83	57	.	19.1	.	1.4	.	.	0.28	.	.	.	.	.
34	041	112	D	78	.	7.48	67	.	20.2	.	0.9	.	.	0.27	.	500	.	.	.

WATER QUALITY SUMMARY BY STATION-YEAR
POOL DATA SCREEN CODE=A

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CPTL	TOTAL PHOSPHORUS (MG/M3)	258	56.63	52.23	4.89	293.19
CPOT	ORTHO PHOSPHORUS (MG/M3)	223	18.82	25.92	2.83	220.91
CPDS	DISSOLVED PHOSPHORUS (MG/L)	35	25.44	28.98	10.00	155.00
CNTL	TOTAL NITROGEN (MG/M3)	258	981.94	857.06	236.45	6075.00
CNIN	INORGANIC NITROGEN (MG/M3)	258	521.15	704.99	39.96	5064.16
CCHA	CHLOROPHYLL-A (MG/M3)	218	10.61	11.77	0.97	83.41
CCFU	UNCORRECTED CHLOROPHYLL-A (MG/M3)	40	13.85	7.91	2.68	31.25
CCHAMX	MAXIMUM CHLOROPHYLL-A (MG/M3)	218	16.11	16.67	1.30	97.00
CSEC	SECCHI DEPTH (M)	258	1.50	1.23	0.16	6.97
NPTL	NUMBER OF TOTAL P SAMPLING DATES	258	3.66	1.70	3.00	21.00
NCHA	NUMBER OF CHL-A SAMPLING DATES	258	3.40	0.68	3.00	7.00
NNTL	NUMBER OF TOTAL N SAMPLING DATES	258	3.57	1.26	3.00	13.00
NSEC	NUMBER OF SECCHI SAMPLING DATES	258	3.46	0.78	3.00	6.00
EPTL	CV OF MEAN TOTAL P ESTIMATE	258	0.18	0.10	0.01	0.48
ECHA	CV OF MEAN CHL-A ESTIMATE	258	0.28	0.12	0.01	0.50
ENTL	CV OF MEAN TOTAL N ESTIMATE	258	0.15	0.08	0.01	0.37
ESEC	CV OF MEAN SECCHI ESTIMATE	258	0.18	0.10	0.00	0.49
---------- POOL DATA SCREEN CODE=B ----------						
CPTL	TOTAL PHOSPHORUS (MG/M3)	267	65.82	70.93	6.33	469.52
CPOT	ORTHO PHOSPHORUS (MG/M3)	225	22.36	28.98	0.00	196.13
CPDS	DISSOLVED PHOSPHORUS (MG/L)	44	29.70	31.74	3.94	129.07
CNTL	TOTAL NITROGEN (MG/M3)	234	1056.95	1190.19	114.99	9307.14
CNIN	INORGANIC NITROGEN (MG/M3)	260	546.32	984.31	20.00	7434.28
CCHA	CHLOROPHYLL-A (MG/M3)	230	12.28	13.43	0.63	92.70
CCFU	UNCORRECTED CHLOROPHYLL-A (MG/M3)	40	8.85	8.92	1.60	45.49
CCHAMX	MAXIMUM CHLOROPHYLL-A (MG/M3)	230	20.01	24.37	1.24	181.00
CSEC	SECCHI DEPTH (M)	267	1.45	1.16	0.14	7.08
NPTL	NUMBER OF TOTAL P SAMPLING DATES	267	2.81	1.80	2.00	18.00
NCHA	NUMBER OF CHL-A SAMPLING DATES	267	2.61	0.96	2.00	7.00
NNTL	NUMBER OF TOTAL N SAMPLING DATES	267	2.37	1.72	0.00	14.00
NSEC	NUMBER OF SECCHI SAMPLING DATES	267	2.78	1.17	2.00	7.00
EPTL	CV OF MEAN TOTAL P ESTIMATE	267	0.25	0.18	0.00	0.85
ECHA	CV OF MEAN CHL-A ESTIMATE	267	0.36	0.22	0.00	0.97
ENTL	CV OF MEAN TOTAL N ESTIMATE	234	0.16	0.13	0.00	0.74
ESEC	CV OF MEAN SECCHI ESTIMATE	267	0.21	0.17	0.00	0.93

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
03	307	305	D	73	12	6	.	941	650	5.4	.	8.4	3.56	3	3	3	3	0.03	0.30	0.14	0.12
03	307	306	M	73	10	4	.	972	636	5.0	.	6.2	3.66	3	3	3	3	0.05	0.16	0.11	0.13
03	307	307	U	73	10	5	.	909	694	4.2	.	5.7	3.27	3	3	3	3	0.07	0.18	0.16	0.12
04	312	311	D	73	50	28	.	1525	1045	6.5	.	8.3	1.54	3	3	3	3	0.16	0.14	0.04	0.31
06	372	322	D	73	26	7	.	474	190	7.6	.	14.2	1.82	3	3	3	3	0.39	0.44	0.04	0.29
06	372	323	M	73	28	7	.	648	120	14.7	.	23.2	1.32	3	3	3	3	0.08	0.36	0.24	0.19
06	372	324	M	73	36	9	.	611	205	5.5	.	7.0	1.42	3	3	3	3	0.38	0.15	0.16	0.29
06	372	326	U	73	97	36	.	959	317	8.3	.	11.9	0.44	3	3	3	3	0.14	0.35	0.20	0.10
06	372	327	U	73	63	10	.	693	287	4.3	.	5.3	0.44	3	3	3	3	0.17	0.13	0.10	0.31
10	001	011	U	77	100	27	.	457	252	.	5.8	.	0.73	4	4	4	4	0.26	0.07	0.30	0.03
10	001	015	M	77	150	22	.	475	250	.	8.3	.	0.81	4	4	4	4	0.17	0.35	0.24	0.09
10	001	016	D	77	165	30	.	400	328	.	6.4	.	0.80	4	4	4	4	0.14	0.14	0.13	0.05
10	003	311	D	73	22	7	.	1043	803	2.7	.	3.7	1.22	3	3	3	3	0.45	0.33	0.04	0.31
10	004	018	M	77	195	47	.	495	197	.	6.0	.	0.82	4	4	4	4	0.38	0.14	0.07	0.12
10	008	007	D	77	277	17	.	470	258	.	6.7	.	0.90	4	4	4	4	0.36	0.18	0.22	0.05
10	008	016	D	77	130	22	.	510	218	.	16.9	.	0.72	4	4	4	3	0.35	0.38	0.31	0.07
10	008	017	D	77	132	32	.	552	293	.	11.5	.	0.68	4	4	4	3	0.26	0.24	0.30	0.09
10	008	018	D	77	170	15	.	531	268	.	12.0	.	0.68	4	3	4	3	0.17	0.29	0.27	0.06
10	072	005	D	78	31	4	.	580	136	10.1	.	18.0	1.10	5	5	3	5	0.43	0.35	0.11	0.19
10	072	006	D	78	57	4	.	413	294	11.6	.	21.0	1.13	5	5	3	5	0.46	0.33	0.37	0.09
10	072	007	M	78	52	5	.	457	146	10.4	.	21.0	0.65	5	5	3	5	0.17	0.33	0.33	0.40
10	072	009	M	78	78	5	.	437	180	15.3	.	33.0	0.93	5	5	3	5	0.26	0.41	0.14	0.18
10	072	010	M	78	72	6	.	663	224	14.8	.	25.0	0.78	5	5	3	5	0.31	0.27	0.18	0.13
10	073	118	M	75	44	.	25	520	345	9.9	.	16.4	0.50	16	5	13	4	0.13	0.26	0.04	0.15
10	073	121	M	75	68	.	32	595	377	17.2	.	32.4	0.46	13	5	10	4	0.10	0.31	0.09	0.19
10	073	124	M	75	74	.	33	725	442	11.5	.	29.5	0.46	21	6	13	5	0.07	0.33	0.08	0.21
10	411	314	M	73	26	6	.	1907	1307	4.9	.	7.2	1.35	3	3	3	3	0.23	0.24	0.14	0.17
10	411	316	U	73	39	12	.	945	569	2.8	.	3.6	0.76	3	3	3	3	0.15	0.30	0.02	0.20
15	178	005	M	77	23	7	.	650	253	4.8	.	6.1	2.87	3	3	3	3	0.29	0.16	0.13	0.05
15	237	305	D	74	270	221	.	1611	552	12.9	.	17.1	0.96	3	3	3	3	0.06	0.29	0.30	0.29
15	237	306	M	74	273	170	.	1795	300	45.2	.	61.4	0.59	3	3	3	3	0.14	0.27	0.11	0.28
15	237	307	M	74	293	163	.	2184	216	63.9	.	78.3	0.61	3	3	3	3	0.26	0.12	0.20	0.25
16	243	309	D	73	34	5	.	1122	561	8.3	.	13.2	1.04	3	3	3	3	0.11	0.30	0.26	0.11
16	243	310	M	73	33	5	.	1177	535	11.0	.	14.7	0.89	3	3	3	3	0.13	0.24	0.19	0.07
16	243	313	U	73	71	8	.	1683	574	26.3	.	52.5	0.77	3	3	3	3	0.39	0.50	0.27	0.17
16	254	305	M	73	77	9	.	1374	177	43.6	.	62.1	0.83	3	3	3	3	0.27	0.21	0.18	0.13
16	254	306	D	73	49	4	.	1064	162	28.8	.	40.2	0.93	3	3	3	3	0.26	0.20	0.11	0.06
16	317	319	M	73	77	10	.	1106	239	35.6	.	57.5	0.75	3	3	3	3	0.27	0.36	0.14	0.11
16	317	320	D	73	45	7	.	992	378	15.3	.	22.3	1.01	3	3	3	3	0.24	0.24	0.08	0.11
16	317	321	M	73	58	7	.	1028	280	29.6	.	55.3	1.02	3	3	3	3	0.07	0.44	0.10	0.10

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
16	328	337	D	73	18	6	.	899	406	2.7	.	3.6	2.69	3	3	3	3	0.16	0.31	0.11	0.39
16	328	338	M	73	13	5	.	757	373	2.7	.	4.6	2.66	3	3	3	3	0.20	0.46	0.07	0.28
16	328	339	U	73	33	9	.	646	318	4.0	.	5.8	0.85	3	3	3	3	0.44	0.39	0.10	0.23
16	328	340	M	73	19	5	.	636	365	5.5	.	7.7	2.51	3	3	3	3	0.23	0.24	0.15	0.30
16	393	312	D	73	6	6	.	659	404	1.4	.	2.0	2.79	3	3	3	3	0.09	0.23	0.10	0.34
16	393	313	M	73	5	4	.	644	394	1.0	.	1.6	2.96	3	3	3	3	0.06	0.31	0.22	0.16
16	393	314	U	73	6	5	.	550	370	1.1	.	1.6	3.49	3	3	3	3	0.06	0.29	0.08	0.05
17	241	306	M	73	25	5	.	719	442	9.5	.	10.3	1.35	3	3	3	3	0.15	0.07	0.33	0.12
17	241	307	M	73	30	6	.	899	436	9.8	.	13.4	1.17	3	3	3	3	0.30	0.18	0.23	0.16
17	241	308	U	73	32	4	.	911	350	10.6	.	20.4	0.88	3	3	3	3	0.24	0.47	0.11	0.16
17	241	309	U	73	78	7	.	1249	463	35.9	.	61.8	0.46	3	3	3	3	0.18	0.46	0.18	0.28
17	242	312	D	73	167	20	.	2887	2072	10.9	.	19.4	0.28	3	3	3	3	0.35	0.41	0.09	0.14
17	245	306	U	73	159	15	.	2091	623	83.4	.	91.2	0.36	3	3	3	3	0.34	0.07	0.02	0.14
17	245	307	M	73	104	12	.	1611	530	55.2	.	75.9	0.57	3	3	3	3	0.29	0.19	0.10	0.19
17	245	308	D	73	118	9	.	1593	356	62.8	.	85.5	0.41	3	3	3	3	0.29	0.20	0.09	0.25
17	247	306	D	73	67	27	.	3260	2588	9.7	.	14.4	0.87	3	3	3	3	0.26	0.29	0.24	0.26
17	247	307	M	73	74	22	.	3323	2691	11.5	.	14.2	0.85	3	3	3	3	0.31	0.16	0.25	0.28
17	248	309	D	73	79	24	.	3053	2237	7.9	.	14.9	0.52	3	3	3	3	0.08	0.44	0.19	0.09
17	248	310	M	73	99	28	.	2890	2015	11.4	.	16.8	0.40	3	3	3	3	0.04	0.26	0.19	0.13
17	248	311	U	73	130	50	.	3375	2073	13.3	.	15.6	0.30	3	3	3	3	0.17	0.14	0.18	0.22
17	249	311	D	73	125	25	.	2814	1436	20.2	.	25.9	0.59	3	3	3	3	0.04	0.16	0.12	0.08
17	249	312	M	73	219	43	.	3273	1548	42.5	.	60.3	0.44	3	3	3	3	0.10	0.35	0.16	0.20
17	256	309	M	73	47	11	.	979	465	24.2	.	32.3	0.92	3	3	3	3	0.20	0.20	0.11	0.06
17	256	310	D	73	34	9	.	921	495	21.5	.	41.7	1.27	3	3	3	3	0.23	0.47	0.13	0.08
17	258	305	D	73	40	9	.	1018	269	30.5	.	35.9	0.98	3	3	3	3	0.24	0.09	0.05	0.01
17	258	306	M	73	43	7	.	979	257	27.4	.	35.2	0.99	3	3	3	3	0.28	0.16	0.03	0.12
17	258	307	U	73	75	10	.	1159	203	55.2	.	97.0	0.61	3	3	3	3	0.38	0.40	0.15	0.25
17	373	308	D	73	11	5	.	485	209	4.8	.	8.3	2.85	3	3	3	3	0.17	0.36	0.13	0.34
17	391	313	U	73	15	5	.	715	556	3.1	.	4.9	2.83	3	3	3	3	0.14	0.44	0.21	0.37
18	090	502	D	75	55	.	18	2550	1822	.	3.5	.	1.14	6	3	6	6	0.20	0.43	0.07	0.19
18	090	502	D	77	28	.	12	2792	1722	.	12.3	.	0.94	6	3	6	6	0.05	0.37	0.22	0.22
18	091	502	D	75	118	.	43	6075	5064	.	12.6	.	0.44	6	4	6	6	0.22	0.29	0.24	0.21
18	092	316	U	73	173	51	.	2901	1879	28.4	.	46.7	0.36	3	3	3	3	0.09	0.42	0.04	0.15
18	092	317	M	73	75	33	.	3019	2341	8.6	.	10.1	0.73	3	3	3	3	0.30	0.09	0.16	0.08
18	092	318	D	73	64	25	.	3288	2614	10.3	.	14.2	0.94	3	3	3	3	0.34	0.27	0.14	0.04
18	093	312	D	73	16	8	.	709	233	9.5	.	17.2	2.51	3	3	3	3	0.11	0.43	0.07	0.09
18	093	313	M	73	21	6	.	595	207	6.9	.	11.4	2.40	3	3	3	3	0.14	0.35	0.10	0.13
18	093	314	M	73	23	8	.	658	232	7.1	.	10.0	1.78	3	3	3	3	0.20	0.29	0.09	0.22
18	093	315	U	73	37	6	.	680	187	7.0	.	10.6	0.97	3	3	3	3	0.22	0.28	0.17	0.29
18	093	502	D	77	20	.	10	492	217	.	5.0	.	1.89	6	4	6	5	0.40	0.15	0.14	0.06

WATER QUALITY SUMMARY BY STATION-YEAR

---------- POOL DATA SCREEN CODE=A ----------

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
18	095	502	D	77	27	.	14	2367	1555	.	9.4	.	1.04	6	4	6	6	0.15	0.27	0.11	0.13
18	097	502	D	77	16	.	10	1417	778	.	8.2	.	1.17	6	4	6	6	0.10	0.21	0.19	0.12
18	097	503	M	77	26	.	10	1580	840	.	14.9	.	0.97	5	4	5	6	0.07	0.23	0.20	0.07
18	120	313	D	73	19	7	.	753	378	4.9	.	9.2	1.83	3	3	3	3	0.16	0.44	0.21	0.10
18	120	314	M	73	24	5	.	640	354	5.6	.	9.8	1.66	3	3	3	3	0.19	0.37	0.30	0.16
18	120	315	M	73	24	5	.	683	277	6.8	.	10.1	1.43	3	3	3	3	0.02	0.26	0.29	0.14
18	120	316	M	73	25	7	.	901	357	7.2	.	10.4	1.35	3	3	3	3	0.01	0.22	0.21	0.18
18	120	317	M	73	35	8	.	704	330	10.8	.	10.9	1.02	3	3	3	3	0.08	0.01	0.30	0.15
18	120	320	M	73	30	6	.	616	303	8.4	.	9.8	1.23	3	3	3	3	0.09	0.10	0.34	0.14
18	120	321	M	73	25	6	.	579	244	7.5	.	8.5	1.27	3	3	3	3	0.04	0.07	0.31	0.05
18	120	322	M	73	27	5	.	594	290	7.4	.	10.6	1.18	3	3	3	3	0.06	0.30	0.32	0.11
18	120	323	M	73	44	5	.	678	330	10.5	.	12.9	0.68	3	3	3	3	0.22	0.13	0.31	0.25
18	120	502	D	77	15	.	11	600	462	.	5.1	.	1.78	5	3	5	6	0.15	0.06	0.28	0.15
18	121	502	D	77	19	.	11	470	239	.	2.8	.	1.45	5	3	5	4	0.34	0.07	0.13	0.42
18	126	502	D	77	25	.	15	543	330	.	2.7	.	1.64	7	6	7	4	0.25	0.21	0.15	0.36
18	128	502	D	77	18	.	10	683	485	.	5.6	.	1.68	6	5	6	6	0.27	0.14	0.27	0.10
18	129	502	D	77	17	.	14	642	448	.	3.7	.	1.72	6	4	6	6	0.15	0.14	0.26	0.12
18	260	505	M	77	234	.	79	1705	678	.	27.5	.	0.33	7	4	7	6	0.17	0.14	0.11	0.08
18	263	502	D	77	28	.	11	1471	709	.	9.5	.	1.07	7	4	7	6	0.21	0.43	0.06	0.16
18	263	504	M	77	50	.	12	1681	808	.	15.2	.	0.61	7	3	7	6	0.16	0.36	0.10	0.21
19	119	324	D	73	103	40	.	746	419	16.3	.	27.3	0.81	3	3	3	3	0.04	0.40	0.10	0.07
19	122	325	D	73	11	7	.	435	206	4.2	.	7.5	2.34	3	3	3	3	0.14	0.44	0.20	0.12
19	122	326	M	73	11	8	.	551	198	4.5	.	8.0	1.98	3	3	3	3	0.16	0.41	0.07	0.29
19	122	327	M	73	12	6	.	516	197	4.3	.	7.9	2.01	3	3	3	3	0.18	0.43	0.11	0.18
19	122	328	M	73	13	7	.	454	195	3.9	.	7.6	1.57	3	3	3	3	0.25	0.49	0.05	0.25
19	122	330	U	73	18	8	.	429	188	3.3	.	6.4	1.51	3	3	3	3	0.20	0.48	0.14	0.31
19	122	331	U	73	30	10	.	500	227	2.4	.	3.6	0.86	3	3	3	3	0.46	0.29	0.03	0.48
19	338	322	D	73	146	84	.	799	487	7.3	.	11.5	0.72	3	3	3	3	0.23	0.29	0.03	0.09
19	340	315	D	73	26	8	.	431	97	6.8	.	10.4	2.32	3	3	3	3	0.09	0.28	0.13	0.07
19	340	316	M	73	29	10	.	460	93	7.5	.	13.3	2.27	3	3	3	3	0.12	0.39	0.10	0.09
19	340	317	M	73	34	13	.	602	106	8.6	.	13.5	2.08	3	3	3	3	0.06	0.28	0.30	0.19
19	340	318	M	73	58	21	.	648	129	11.8	.	13.6	1.29	3	3	3	3	0.08	0.12	0.21	0.16
19	340	319	U	73	77	29	.	706	153	15.1	.	22.7	0.90	3	3	3	3	0.10	0.25	0.14	0.02
19	340	504	M	76	60	.	23	300	150	.	20.2	.	0.79	3	3	3	3	0.19	0.14	0.19	0.08
19	340	504	M	78	106	.	17	750	375	.	16.4	.	0.63	4	4	4	4	0.27	0.31	0.21	0.09
19	340	505	U	75	70	.	27	800	175	.	26.2	.	0.63	4	3	4	4	0.32	0.03	0.17	0.04
19	340	505	U	76	53	.	16	467	243	.	24.7	.	0.87	3	4	3	4	0.08	0.12	0.07	0.15
19	340	505	U	78	84	.	21	950	426	.	22.4	.	0.56	6	7	6	5	0.13	0.18	0.26	0.13
19	340	506	U	75	83	.	22	900	150	.	25.2	.	0.63	3	3	3	3	0.13	0.06	0.28	0.02
19	340	506	U	76	139	.	92	875	600	.	26.3	.	0.86	4	4	4	4	0.20	0.36	0.22	0.20

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
19	340	506	U	78	174	.	155	1160	800	.	22.8	.	0.77	4	5	5	4	0.25	0.27	0.19	0.09
19	340	507	U	75	38	.	10	533	150	.	21.2	.	0.83	3	3	3	3	0.12	0.05	0.06	0.08
19	340	507	U	76	45	.	20	425	175	.	31.2	.	0.84	4	4	4	3	0.08	0.27	0.22	0.16
19	340	507	U	78	90	.	38	700	432	.	16.8	.	0.72	5	6	5	4	0.17	0.16	0.12	0.08
19	340	508	M	75	27	.	15	600	150	.	18.3	.	1.10	4	3	4	3	0.41	0.19	0.07	0.06
19	340	508	M	76	27	.	10	400	150	.	14.4	.	1.10	5	5	5	5	0.19	0.09	0.11	0.05
19	340	508	M	78	46	.	16	600	207	.	21.3	.	0.88	6	6	6	4	0.20	0.24	0.12	0.15
19	340	509	M	76	45	.	15	350	175	.	11.8	.	1.01	4	4	4	4	0.20	0.20	0.18	0.10
19	340	510	M	75	17	.	10	433	150	.	12.7	.	1.22	3	3	3	3	0.40	0.03	0.08	0.00
19	340	510	M	76	24	.	10	325	150	.	10.2	.	1.71	4	4	4	4	0.26	0.19	0.19	0.32
19	342	319	D	73	69	23	.	578	270	16.3	.	24.0	0.84	3	3	3	3	0.22	0.28	0.18	0.16
19	342	321	M	73	55	15	.	610	249	6.6	.	8.4	0.79	3	3	3	3	0.04	0.13	0.22	0.21
19	342	323	U	73	54	19	.	574	348	3.6	.	5.7	0.73	3	3	3	3	0.10	0.30	0.09	0.16
19	343	312	D	73	11	7	.	410	150	1.8	.	3.3	6.40	3	3	3	3	0.20	0.42	0.19	0.36
19	343	313	M	73	8	6	.	392	205	1.5	.	2.5	6.97	3	3	3	3	0.19	0.37	0.16	0.17
19	343	314	M	73	9	7	.	441	224	1.4	.	2.6	4.98	3	3	3	3	0.15	0.41	0.16	0.24
19	343	316	U	73	9	5	.	492	179	4.7	.	7.7	2.96	3	3	3	3	0.26	0.45	0.25	0.27
19	343	317	U	73	12	5	.	414	199	7.9	.	13.2	1.41	3	3	3	3	0.18	0.40	0.04	0.13
20	081	312	M	73	101	31	.	2322	1316	27.9	.	38.8	0.47	3	3	3	3	0.07	0.27	0.11	0.16
20	081	313	M	73	79	33	.	2009	1372	12.6	.	17.8	0.47	3	3	3	3	0.01	0.21	0.03	0.04
20	081	314	D	73	73	29	.	1942	1276	11.6	.	15.0	0.74	3	3	3	3	0.08	0.16	0.07	0.10
20	087	313	D	73	41	13	.	4525	3904	11.5	.	19.7	1.27	3	3	3	3	0.30	0.36	0.26	0.33
20	087	315	M	73	50	19	.	4475	3867	19.0	.	27.7	0.96	3	3	3	3	0.31	0.28	0.29	0.39
20	087	316	M	73	71	36	.	4383	3795	15.8	.	22.6	1.00	3	3	3	3	0.29	0.22	0.27	0.31
20	087	317	U	73	112	61	.	3895	3200	24.2	.	39.5	0.78	3	3	3	3	0.36	0.39	0.23	0.41
20	087	318	U	73	97	52	.	4209	3435	11.2	.	18.8	0.67	3	3	3	3	0.32	0.41	0.23	0.42
20	088	310	D	73	44	14	.	1236	312	11.1	.	14.3	0.97	3	3	3	3	0.12	0.17	0.20	0.07
20	088	311	M	73	68	21	.	1209	240	26.4	.	35.2	0.59	3	3	3	3	0.06	0.31	0.23	0.19
20	088	312	U	73	85	12	.	1213	208	32.0	.	51.4	0.62	3	3	3	3	0.08	0.31	0.20	0.13
20	088	313	U	73	88	10	.	1186	185	24.6	.	27.2	0.71	3	3	3	3	0.06	0.06	0.17	0.07
21	196	308	D	74	31	5	.	357	103	12.3	.	14.4	1.22	3	3	3	3	0.03	0.10	0.05	0.27
21	196	309	M	74	36	6	.	375	97	10.2	.	12.8	0.99	3	3	3	3	0.05	0.17	0.07	0.27
21	196	310	U	74	37	4	.	401	93	7.6	.	9.9	1.01	3	3	3	3	0.05	0.30	0.06	0.41
21	196	311	U	74	34	4	.	409	143	8.5	.	13.1	0.88	3	3	3	3	0.21	0.32	0.05	0.24
24	011	312	D	74	11	4	.	351	137	2.7	.	3.5	4.19	4	4	4	4	0.07	0.15	0.07	0.17
24	011	313	M	74	12	4	.	403	156	2.6	.	3.4	3.10	4	4	4	4	0.13	0.14	0.22	0.22
24	011	314	M	74	22	6	.	559	250	3.6	.	6.5	2.27	4	4	4	4	0.25	0.32	0.19	0.21
24	011	315	M	74	28	7	.	616	297	3.7	.	6.0	1.53	4	4	4	4	0.13	0.22	0.11	0.28
24	011	316	U	74	52	10	.	652	283	5.5	.	7.6	1.02	4	4	4	4	0.22	0.24	0.13	0.33
24	011	317	U	74	59	17	.	702	315	5.3	.	12.4	0.74	4	4	4	4	0.11	0.44	0.04	0.21

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
24	013	321	D	74	13	5	.	556	194	2.3	.	3.4	4.77	4	4	4	4	0.18	0.20	0.08	0.20
24	013	322	M	74	14	4	.	533	176	2.8	.	3.4	4.55	4	4	4	4	0.24	0.13	0.13	0.15
24	013	323	M	74	13	3	.	440	180	2.3	.	3.2	4.41	4	4	4	4	0.13	0.18	0.26	0.17
24	013	324	U	74	16	4	.	512	169	2.6	.	3.3	4.07	4	4	4	4	0.14	0.15	0.13	0.15
24	013	325	M	74	14	3	.	526	198	3.2	.	5.0	4.31	4	4	4	4	0.12	0.26	0.16	0.18
24	013	326	M	74	15	4	.	502	208	5.4	.	10.6	4.09	4	4	4	4	0.12	0.34	0.24	0.21
24	013	327	M	74	16	4	.	549	220	6.3	.	12.7	3.19	4	4	4	4	0.08	0.34	0.20	0.14
24	013	328	U	74	25	6	.	602	221	7.0	.	10.0	2.31	4	4	4	4	0.13	0.16	0.29	0.16
24	016	310	M	74	11	5	.	389	64	2.5	.	2.9	4.67	3	3	3	3	0.11	0.11	0.12	0.17
24	016	311	M	74	11	3	.	285	73	3.4	.	5.2	3.86	3	3	3	3	0.06	0.29	0.15	0.09
24	016	312	U	74	14	4	.	280	63	4.5	.	5.3	3.35	3	3	3	3	0.17	0.13	0.03	0.09
24	016	313	U	74	16	3	.	366	73	6.7	.	8.4	1.93	3	3	3	3	0.11	0.14	0.13	0.14
24	022	318	D	74	15	8	.	504	212	2.2	.	3.6	4.65	4	4	4	4	0.10	0.32	0.19	0.16
24	022	319	U	74	14	5	.	391	170	2.3	.	2.9	4.27	4	4	4	4	0.22	0.15	0.09	0.11
24	022	320	M	74	15	5	.	421	200	2.1	.	3.6	4.43	4	4	4	4	0.20	0.31	0.17	0.22
24	022	321	M	74	15	5	.	545	219	2.7	.	3.9	3.81	4	4	4	4	0.18	0.23	0.22	0.19
24	022	323	M	74	16	4	.	448	224	3.5	.	5.1	2.53	4	4	4	4	0.08	0.17	0.23	0.26
24	022	324	U	74	23	6	.	495	213	4.8	.	7.7	1.97	4	4	4	4	0.17	0.33	0.21	0.23
24	193	307	D	74	15	4	.	321	145	4.8	.	6.6	1.50	3	3	3	3	0.08	0.20	0.18	0.37
24	193	308	U	74	14	4	.	377	159	1.2	.	2.2	1.68	3	3	3	3	0.15	0.48	0.17	0.34
24	193	309	M	74	27	4	.	312	150	4.7	.	6.1	1.02	3	3	3	3	0.22	0.23	0.22	0.41
24	200	317	D	74	18	6	.	688	224	12.3	.	22.6	2.31	4	4	4	4	0.20	0.30	0.12	0.13
24	200	318	U	74	20	5	.	608	219	13.3	.	30.9	1.91	4	4	4	4	0.13	0.46	0.06	0.10
24	200	319	M	74	23	7	.	548	246	6.5	.	9.5	2.60	4	4	4	4	0.21	0.23	0.21	0.19
24	200	320	M	74	17	6	.	485	180	4.4	.	6.6	2.82	4	4	4	4	0.07	0.20	0.06	0.17
24	200	321	M	74	17	4	.	413	133	4.0	.	6.0	3.06	4	4	4	4	0.12	0.27	0.15	0.12
24	200	322	U	74	21	5	.	478	192	6.3	.	15.2	2.23	4	4	4	4	0.11	0.47	0.10	0.15
24	200	323	M	74	28	4	.	411	139	11.9	.	28.9	1.97	4	4	4	4	0.19	0.48	0.25	0.08
24	200	324	M	74	31	12	.	747	401	7.3	.	9.3	2.46	4	4	4	4	0.32	0.21	0.35	0.19
24	200	325	U	74	90	44	.	1346	872	15.7	.	26.8	1.02	4	4	4	4	0.11	0.27	0.20	0.05
25	105	312	D	74	125	74	.	1712	1220	8.2	.	16.1	0.16	3	3	3	3	0.10	0.50	0.09	0.42
25	107	308	M	74	71	12	.	1191	595	14.7	.	24.0	0.32	3	3	3	3	0.17	0.45	0.30	0.21
25	267	315	D	74	49	27	.	742	346	2.6	.	4.2	0.74	4	4	4	4	0.11	0.21	0.02	0.17
25	267	316	M	74	53	25	.	715	346	3.0	.	4.7	0.58	4	4	4	4	0.10	0.23	0.12	0.14
25	267	317	M	74	42	12	.	705	245	4.4	.	7.5	0.65	4	4	4	4	0.12	0.26	0.06	0.14
25	267	318	M	74	106	31	.	841	450	1.8	.	2.3	0.29	5	4	5	5	0.13	0.14	0.05	0.06
25	267	319	U	74	129	36	.	898	422	2.2	.	4.2	0.25	4	4	4	4	0.16	0.32	0.06	0.11
25	267	321	M	74	83	46	.	862	424	3.9	.	5.2	0.43	4	4	4	4	0.07	0.23	0.01	0.20
25	267	322	U	74	133	87	.	1096	505	7.3	.	13.6	0.42	4	4	4	4	0.12	0.33	0.08	0.22
25	267	323	U	74	86	29	.	1001	425	3.4	.	7.5	0.32	4	4	4	4	0.23	0.40	0.06	0.23

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
25	273	319	M	74	105	68	.	1109	564	9.1	.	18.4	0.63	4	4	4	4	0.15	0.41	0.09	0.23
25	273	320	M	74	116	82	.	1060	593	6.7	.	12.4	0.58	4	4	4	4	0.17	0.45	0.12	0.23
25	273	324	M	74	151	102	.	1362	797	2.8	.	6.8	0.37	4	4	4	4	0.14	0.48	0.03	0.28
25	275	312	D	74	61	34	.	946	568	1.6	.	3.0	0.51	4	4	4	4	0.21	0.35	0.05	0.21
25	275	313	M	74	57	26	.	833	555	4.0	.	8.8	0.58	4	4	4	4	0.21	0.43	0.08	0.27
25	275	318	U	74	63	18	.	912	533	8.2	.	13.8	0.63	3	3	3	3	0.19	0.49	0.12	0.27
25	275	319	M	74	70	24	.	930	549	4.8	.	7.2	0.44	3	3	3	3	0.36	0.46	0.17	0.29
25	275	320	M	74	88	26	.	1014	563	5.0	.	7.4	0.41	3	3	3	3	0.39	0.46	0.10	0.30
25	278	306	D	74	35	20	.	933	479	3.9	.	6.6	2.07	4	4	4	4	0.15	0.39	0.10	0.26
25	278	307	M	74	29	15	.	711	432	4.5	.	7.1	2.00	4	4	4	4	0.14	0.33	0.21	0.21
25	278	308	M	74	32	14	.	736	448	7.1	.	14.4	1.64	4	4	4	4	0.13	0.41	0.20	0.11
25	278	309	U	74	55	21	.	968	518	11.1	.	24.6	0.84	4	4	4	4	0.17	0.46	0.14	0.15
25	281	307	D	74	91	32	.	702	279	5.2	.	6.5	0.56	3	3	3	3	0.18	0.13	0.04	0.33
25	281	308	M	74	103	31	.	670	211	5.0	.	8.4	0.61	3	3	3	3	0.18	0.35	0.09	0.25
25	370	303	D	74	22	10	.	570	92	11.5	.	18.7	1.24	3	3	3	3	0.12	0.39	0.06	0.08
25	370	306	M	74	25	10	.	566	105	12.3	.	18.0	0.83	3	3	3	3	0.02	0.35	0.19	0.25
26	354	317	D	74	62	18	.	654	328	7.8	.	15.0	0.41	3	3	3	3	0.05	0.47	0.27	0.10
26	354	318	M	74	69	22	.	698	324	5.5	.	8.1	0.40	3	3	3	3	0.06	0.25	0.27	0.24
26	354	319	M	74	63	21	.	613	315	7.3	.	9.1	0.36	3	3	3	3	0.04	0.13	0.31	0.15
26	355	318	M	74	34	9	.	692	238	17.9	.	29.3	0.81	3	3	3	3	0.19	0.32	0.17	0.13
26	355	320	M	74	70	29	.	808	335	19.9	.	32.9	0.61	3	3	3	3	0.25	0.33	0.15	0.29
26	355	322	U	74	246	59	.	986	431	22.9	.	25.8	0.24	3	3	3	3	0.38	0.08	0.19	0.34
28	219	307	D	75	19	4	.	386	40	2.6	.	3.9	1.16	3	3	3	3	0.13	0.29	0.09	0.03
28	219	308	U	75	18	6	.	368	52	3.0	.	5.0	1.38	3	3	3	3	0.16	0.40	0.07	0.11
28	219	309	M	75	18	6	.	331	42	2.4	.	4.1	1.43	3	3	3	3	0.15	0.35	0.20	0.05
28	219	310	M	75	26	6	.	290	44	5.1	.	8.9	0.92	3	3	3	3	0.15	0.39	0.06	0.11
29	106	311	M	74	88	7	.	1197	475	23.3	.	36.1	0.28	3	3	3	3	0.24	0.32	0.09	0.05
29	108	314	M	74	64	27	.	1198	652	15.2	.	24.4	1.02	3	3	3	3	0.48	0.39	0.21	0.39
29	108	315	M	74	72	30	.	1153	620	16.5	.	25.7	0.68	3	3	3	3	0.41	0.31	0.19	0.18
29	108	316	M	74	176	41	.	1112	467	32.6	.	51.1	0.35	3	3	3	3	0.27	0.31	0.21	0.06
29	110	315	D	74	43	23	.	1468	1108	4.1	.	5.1	0.69	3	3	3	3	0.18	0.15	0.10	0.09
29	110	316	U	74	54	15	.	1347	898	7.8	.	13.2	0.57	3	3	3	3	0.08	0.35	0.03	0.10
29	110	317	M	74	52	19	.	1644	1224	5.8	.	9.6	0.46	3	3	3	3	0.09	0.41	0.16	0.19
29	110	318	M	74	74	23	.	1603	1075	6.9	.	12.8	0.42	3	3	3	3	0.34	0.50	0.24	0.14
29	111	310	D	74	41	19	.	1558	1133	8.2	.	13.8	0.53	3	3	3	3	0.16	0.39	0.08	0.08
29	111	311	M	74	44	20	.	1444	1104	7.6	.	9.9	0.48	3	3	3	3	0.14	0.25	0.14	0.05
29	194	311	D	74	35	15	.	837	400	8.9	.	13.2	1.92	3	3	3	3	0.26	0.24	0.26	0.28
29	194	312	M	74	44	15	.	871	394	7.9	.	11.9	1.53	3	3	3	3	0.32	0.26	0.17	0.30
29	194	313	U	74	49	11	.	978	439	8.2	.	14.2	0.92	3	3	3	3	0.03	0.42	0.13	0.33
29	194	314	M	74	45	13	.	732	325	5.8	.	6.6	1.17	3	3	3	3	0.29	0.11	0.31	0.34

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
29	195	315	D	74	17	6	.	891	561	5.5	.	9.7	2.11	3	3	3	3	0.14	0.39	0.16	0.15
29	207	310	D	74	107	57	.	1112	317	20.5	.	22.1	0.87	3	3	3	3	0.13	0.06	0.21	0.38
29	207	311	M	74	106	60	.	1056	361	14.9	.	25.7	0.66	3	3	3	3	0.12	0.42	0.24	0.43
30	064	305	D	75	56	7	.	818	47	12.3	.	14.2	0.79	3	3	3	3	0.16	0.11	0.07	0.12
30	064	307	M	75	49	7	.	724	50	8.5	.	11.6	0.81	3	3	3	3	0.13	0.36	0.12	0.13
30	235	320	D	74	15	8	.	445	143	1.4	.	1.7	4.32	3	3	3	3	0.16	0.21	0.13	0.19
30	235	321	M	74	13	5	.	321	122	1.8	.	2.1	2.52	3	3	3	3	0.22	0.09	0.04	0.03
30	235	322	M	74	11	5	.	325	148	1.3	.	1.5	4.23	3	3	3	3	0.06	0.09	0.06	0.12
30	235	323	M	74	17	8	.	334	143	2.2	.	3.4	3.04	3	3	3	3	0.13	0.28	0.04	0.15
30	235	324	M	74	41	28	.	464	139	2.0	.	3.1	3.96	3	3	3	3	0.42	0.26	0.20	0.22
31	077	311	D	75	15	9	.	248	51	3.9	.	6.7	2.08	3	3	3	3	0.18	0.36	0.06	0.06
31	077	312	M	75	13	10	.	260	62	2.7	.	4.4	2.64	3	3	3	3	0.10	0.37	0.15	0.13
31	077	313	M	75	12	6	.	255	54	2.7	.	3.5	2.42	3	3	3	3	0.19	0.20	0.14	0.14
31	077	314	M	75	12	6	.	236	58	1.0	.	1.3	2.88	3	3	3	3	0.14	0.21	0.07	0.23
31	077	315	M	75	12	7	.	238	58	1.8	.	3.0	2.44	3	3	3	3	0.16	0.40	0.07	0.18
32	204	314	M	75	49	32	.	281	75	2.9	.	5.5	4.50	4	3	4	3	0.27	0.44	0.08	0.49
32	204	315	D	75	30	23	.	253	52	3.8	.	5.3	5.93	3	3	3	3	0.15	0.28	0.13	0.31
32	204	316	M	75	50	42	.	304	70	2.4	.	3.1	2.65	3	3	3	3	0.34	0.17	0.14	0.36

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
02	176	301	D	72	6	.	4	.	270	3.3	.	5.8	2.34	3	2	0	3	0.23	0.73	.	0.12
02	176	302	M	72	7	.	4	.	233	6.5	.	7.5	2.45	3	3	0	3	0.16	0.10	.	0.25
04	312	312	M	73	142	81	.	1924	1266	29.6	.	76.2	0.86	3	3	3	3	0.58	0.79	0.31	0.24
04	320	005	M	74	58	17	.	1257	865	.	3.2	.	1.75	3	2	3	3	0.44	0.69	0.10	0.56
04	320	006	M	74	13	3	.	960	593	.	4.4	.	2.59	3	3	3	3	0.25	0.49	0.18	0.27
04	320	007	M	74	20	0	.	1017	647	.	2.3	.	4.58	2	3	3	3	0.00	0.57	0.20	0.19
08	074	320	D	73	16	7	.	491	100	6.8	.	7.8	3.00	2	2	2	2	0.37	0.14	0.28	0.32
08	074	321	M	73	15	6	.	461	111	6.0	.	9.1	2.16	2	2	2	2	0.38	0.50	0.29	0.15
08	074	323	U	73	16	7	.	298	110	9.3	.	12.1	1.56	2	2	2	2	0.13	0.30	0.10	0.19
08	074	324	U	73	21	5	.	423	102	8.2	.	8.9	1.84	2	2	2	2	0.27	0.09	0.23	0.01
08	074	325	M	73	17	7	.	410	98	9.8	.	12.5	2.02	2	2	2	2	0.22	0.28	0.04	0.06
08	074	326	U	73	29	6	.	480	103	11.0	.	12.8	1.73	2	2	2	2	0.38	0.16	0.26	0.12
08	074	327	U	73	23	6	.	522	105	5.7	.	7.2	1.47	2	2	2	2	0.24	0.25	0.12	0.03
08	074	328	M	73	20	7	.	488	110	7.6	.	8.7	1.73	2	2	2	2	0.07	0.14	0.22	0.03
08	074	329	U	73	33	5	.	601	220	5.7	.	6.6	0.88	2	2	2	2	0.20	0.15	0.14	0.04
08	074	330	U	73	25	4	.	553	155	7.2	.	9.9	1.22	2	2	2	2	0.18	0.37	0.17	0.25

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
08	330	340	D	73	7	3	.	385	115	4.4	.	4.7	7.01	2	2	2	2	0.13	0.06	0.25	0.43
08	330	341	U	73	9	3	.	381	77	10.9	.	15.0	2.74	2	2	2	2	0.05	0.38	0.02	0.33
08	330	342	M	73	9	3	.	407	82	3.9	.	4.5	3.15	2	2	2	2	0.22	0.15	0.03	0.13
08	330	343	M	73	11	3	.	362	100	4.7	.	5.5	2.59	2	2	2	2	0.07	0.17	0.19	0.06
08	330	344	U	73	18	3	.	351	113	7.7	.	9.0	1.40	2	2	2	2	0.06	0.17	0.16	0.24
08	330	345	U	73	15	4	.	425	104	2.8	.	2.9	1.04	2	2	2	2	0.29	0.02	0.04	0.46
08	330	346	M	73	11	4	.	373	92	6.4	.	7.7	1.93	2	2	2	2	0.04	0.19	0.22	0.12
08	330	347	M	73	9	4	.	453	85	5.6	.	6.0	2.65	2	2	2	2	0.04	0.06	0.07	0.20
08	330	348	M	73	10	7	.	441	109	6.5	.	8.2	2.44	2	2	2	2	0.11	0.25	0.04	0.13
08	330	349	M	73	13	4	.	346	109	6.8	.	7.5	2.16	2	2	2	2	0.13	0.10	0.26	0.12
08	330	350	M	73	12	4	.	433	97	7.9	.	10.4	2.18	2	2	2	2	0.03	0.32	0.10	0.09
08	330	351	U	73	13	4	.	322	112	12.0	.	17.5	2.04	2	2	2	2	0.19	0.46	0.30	0.12
10	003	310	U	73	26	7	.	1262	883	2.5	.	3.6	1.24	3	3	3	3	0.51	0.26	0.10	0.23
10	069	311	D	73	18	7	.	989	141	4.6	.	4.6	1.94	2	2	2	2	0.14	0.00	0.45	0.07
10	069	312	M	73	17	5	.	916	155	8.7	.	11.2	1.60	2	2	2	2	0.27	0.28	0.12	0.14
10	069	313	U	73	18	4	.	727	124	8.1	.	10.1	1.45	2	2	2	2	0.24	0.25	0.01	0.05
10	069	314	M	73	12	5	.	665	92	8.3	.	9.9	1.92	2	2	2	2	0.08	0.19	0.08	0.05
10	069	315	U	73	27	5	.	630	168	8.8	.	13.5	1.22	2	2	2	2	0.20	0.54	0.30	0.13
10	069	316	U	73	24	5	.	677	124	7.0	.	9.3	1.52	2	2	2	2	0.15	0.33	0.55	0.20
10	071	311	U	73	40	8	.	814	307	10.4	.	15.3	0.89	2	2	2	2	0.36	0.47	0.03	0.14
10	071	312	D	73	43	4	.	730	262	9.6	.	10.2	0.79	2	2	2	2	0.31	0.06	0.05	0.16
10	071	313	M	73	40	9	.	773	455	6.1	.	7.2	0.91	2	2	2	2	0.43	0.18	0.07	0.06
10	071	314	M	73	25	9	.	704	288	4.5	.	6.1	1.45	2	2	2	2	0.37	0.34	0.23	0.26
10	071	315	U	73	44	20	.	1020	691	3.2	.	4.5	1.09	2	2	2	2	0.29	0.41	0.07	0.12
10	072	321	D	73	30	6	.	667	132	10.8	.	13.6	1.50	2	2	2	2	0.22	0.25	0.01	0.14
10	072	322	M	73	32	5	.	992	137	15.3	.	16.5	1.15	2	2	2	2	0.24	0.08	0.23	0.12
10	072	323	M	73	45	9	.	917	291	8.7	.	12.4	0.94	2	2	2	2	0.45	0.42	0.07	0.03
10	072	324	M	73	69	16	.	913	430	4.8	.	7.0	0.77	2	2	2	2	0.32	0.44	0.17	0.08
10	073	113	M	75	39	.	24	477	210	12.0	.	39.1	0.69	18	5	14	4	0.14	0.58	0.09	0.06
10	073	131	M	75	107	.	46	756	507	11.3	.	42.0	0.40	16	6	12	5	0.05	0.55	0.10	0.20
10	076	312	D	73	7	2	.	308	109	4.4	.	4.9	3.20	2	2	2	2	0.24	0.11	0.07	0.05
10	076	313	U	73	9	4	.	606	113	3.4	.	3.6	2.92	2	2	2	2	0.13	0.04	0.53	0.04
10	076	314	U	73	18	5	.	506	113	4.7	.	4.7	3.05	2	2	2	2	0.34	0.00	0.16	0.00
10	076	315	M	73	16	2	.	452	127	4.3	.	4.7	3.12	2	2	2	2	0.37	0.08	0.17	0.02
10	076	316	M	73	16	3	.	324	90	5.4	.	6.9	2.89	2	2	2	2	0.48	0.27	0.00	0.05
10	076	317	M	73	9	3	.	320	96	5.0	.	5.6	2.95	2	2	2	2	0.20	0.12	0.19	0.07
10	076	318	U	73	44	14	.	723	173	10.8	.	12.2	2.13	2	2	2	2	0.07	0.13	0.04	0.29
10	076	319	M	73	12	3	.	533	119	5.3	.	5.5	2.16	2	2	2	2	0.04	0.05	0.01	0.13
10	076	320	U	73	22	7	.	575	149	6.4	.	7.2	1.95	2	2	2	2	0.20	0.13	0.25	0.06
10	076	321	M	73	13	4	.	514	127	5.2	.	5.7	2.44	2	2	2	2	0.06	0.10	0.17	0.00

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
10	076	322	M	73	15	2	.	628	149	7.7	.	8.8	2.16	2	2	2	2	0.09	0.14	0.16	0.13
10	076	323	U	73	20	3	.	586	121	13.1	.	17.9	2.08	2	2	2	2	0.23	0.37	0.07	0.02
10	411	313	D	73	28	15	.	1695	1199	2.6	.	4.6	1.62	3	3	3	3	0.58	0.41	0.18	0.28
10	411	315	U	73	67	6	.	1089	595	5.8	.	7.2	1.07	3	3	3	3	0.57	0.12	0.07	0.14
14	099	312	D	74	179	91	.	5828	5120	13.5	.	25.4	0.81	2	3	2	3	0.02	0.51	0.58	0.45
14	099	313	M	74	187	104	.	6106	5537	14.3	.	17.5	0.38	2	2	2	2	0.11	0.22	0.63	0.20
15	178	005	M	76	23	5	13	.	140	8.6	.	9.6	2.75	3	3	0	3	0.18	0.06	.	0.05
15	178	005	M	78	16	3	.	710	233	7.1	.	7.9	2.23	3	3	3	3	0.33	0.09	0.06	0.20
15	178	006	D	77	19	8	.	747	257	9.7	.	19.7	2.97	3	3	3	3	0.04	0.52	0.07	0.02
15	178	305	M	72	22	.	13	.	114	15.0	.	19.1	2.58	3	3	0	3	0.25	0.23	.	0.13
15	178	306	M	72	21	.	12	.	110	11.4	.	16.3	2.18	3	3	0	3	0.16	0.30	.	0.06
15	178	307	D	72	21	.	14	.	122	11.0	.	14.0	2.18	3	3	0	3	0.21	0.14	.	0.06
15	179	802	M	79	157	.	129	.	254	30.5	.	54.3	1.58	4	3	0	3	0.30	0.39	.	0.31
15	179	803	M	79	272	.	97	.	109	83.0	.	118.0	0.69	4	3	0	4	0.31	0.40	.	0.41
15	179	804	M	79	186	.	108	.	50	74.6	.	99.9	0.79	4	3	0	4	0.24	0.31	.	0.15
15	179	805	M	79	188	.	93	.	23	74.1	.	106.0	0.71	4	3	0	4	0.18	0.32	.	0.19
15	179	806	M	79	245	.	116	.	78	72.2	.	108.3	0.45	4	3	0	3	0.26	0.42	.	0.33
15	181	309	M	72	22	.	17	.	124	5.9	.	7.5	2.61	3	3	0	3	0.31	0.14	.	0.12
15	181	310	M	72	16	.	9	.	139	5.2	.	6.9	1.95	3	3	0	3	0.01	0.21	.	0.13
15	181	311	D	72	17	.	12	.	137	7.3	.	8.4	2.13	3	3	0	3	0.19	0.11	.	0.08
15	181	312	M	72	20	.	13	.	133	6.5	.	8.7	2.06	3	3	0	2	0.24	0.21	.	0.11
15	237	309	M	74	272	196	.	1366	112	43.4	.	57.6	0.84	2	2	2	2	0.13	0.33	0.11	0.09
15	399	801	M	78	61	.	22	.	.	16.4	.	22.8	1.33	3	3	0	3	0.09	0.21	.	0.07
15	399	801	M	79	119	.	66	.	854	18.4	.	31.9	1.43	7	7	0	7	0.09	0.18	.	0.12
15	399	802	U	78	49	.	20	.	.	20.6	.	28.9	1.33	3	3	0	3	0.07	0.24	.	0.07
16	243	311	U	73	40	6	.	1273	605	9.7	.	11.7	0.99	2	2	2	2	0.36	0.20	0.19	0.03
16	243	312	U	73	50	6	.	1468	604	16.4	.	22.7	0.91	2	2	2	2	0.03	0.38	0.19	0.00
16	243	314	M	73	125	33	.	1842	991	15.8	.	15.9	0.56	2	2	2	2	0.11	0.01	0.00	0.09
16	328	336	M	72	35	.	16	.	399	12.6	.	16.7	1.30	3	3	0	3	0.33	0.16	.	0.32
17	247	308	U	73	202	36	.	3287	2284	7.7	.	11.7	0.46	2	2	2	2	0.54	0.51	0.43	0.78
17	249	313	U	73	216	76	.	3525	2119	15.5	.	20.2	0.36	2	2	2	2	0.38	0.30	0.27	0.14
17	373	309	M	73	7	5	.	471	140	5.4	.	7.0	3.66	2	2	2	2	0.16	0.28	0.02	0.00
17	373	310	U	73	14	4	.	589	203	8.6	.	16.4	0.94	3	3	3	2	0.09	0.46	0.07	0.35
17	373	311	M	73	11	4	.	545	242	3.6	.	6.4	1.52	2	2	2	2	0.14	0.75	0.01	0.60
17	389	328	D	73	65	17	.	1416	1153	23.1	.	41.9	0.73	3	3	3	3	0.06	0.51	0.09	0.26
17	389	329	M	73	78	20	.	1274	979	11.4	.	21.5	0.58	3	3	3	3	0.03	0.50	0.09	0.29
17	389	330	M	73	94	20	.	2316	1899	11.5	.	21.5	0.69	2	2	2	2	0.08	0.87	0.38	0.33
17	389	331	U	73	88	24	.	2069	1739	11.3	.	20.5	0.69	2	2	2	2	0.04	0.81	0.46	0.33
17	391	310	D	73	11	7	.	957	626	7.9	.	17.3	4.37	3	3	3	2	0.10	0.63	0.03	0.19
17	391	311	M	73	14	6	.	977	591	6.5	.	12.1	3.23	3	3	3	3	0.20	0.52	0.08	0.53

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
17	391	312	M	73	12	5	.	782	635	7.5	.	19.4	3.71	3	3	3	3	0.23	0.80	0.17	0.44
18	090	502	D	73	24	.	15	3087	2301	.	8.5	.	1.18	4	2	4	6	0.11	0.68	0.22	0.15
18	091	502	D	74	211	.	65	9307	7434	.	4.5	.	0.43	7	2	7	5	0.50	0.45	0.10	0.26
18	091	502	D	77	68	.	35	6767	4541	.	19.0	.	0.84	3	2	2	2	0.34	0.62	0.40	0.09
18	092	502	D	74	56	.	36	8180	7002	.	3.4	.	0.96	5	2	5	5	0.39	0.07	0.19	0.23
18	092	502	D	75	60	.	26	4025	3271	.	4.1	.	0.95	6	2	6	6	0.23	0.07	0.13	0.18
18	092	502	D	77	37	.	26	6212	5487	.	2.9	.	1.12	4	2	4	3	0.35	0.20	0.27	0.18
18	093	317	M	73	59	13	.	1173	370	5.5	.	6.4	0.53	2	2	2	2	0.07	0.16	0.02	0.33
18	094	502	D	75	38	.	22	3733	3090	.	5.4	.	1.07	6	3	6	6	0.27	0.58	0.07	0.12
18	095	502	D	76	32	.	12	2367	1702	.	13.6	.	1.17	6	2	6	7	0.34	0.36	0.13	0.18
18	097	503	M	75	37	.	22	2400	1812	.	14.6	.	0.95	6	2	6	5	0.16	0.72	0.16	0.09
18	120	318	U	73	186	66	.	2334	1796	14.2	.	19.6	0.61	2	2	2	2	0.07	0.38	0.18	0.00
18	120	319	U	73	47	9	.	732	320	9.5	.	10.6	0.79	3	2	3	3	0.21	0.11	0.25	0.15
18	121	502	D	75	24	.	16	540	150	.	1.6	.	1.29	7	2	5	6	0.38	0.69	0.16	0.17
18	126	502	D	74	17	.	11	971	566	.	6.5	.	1.48	6	2	7	7	0.34	0.08	0.18	0.16
18	128	502	D	75	41	.	25	1043	496	.	6.4	.	1.24	7	2	7	7	0.38	0.01	0.24	0.15
18	129	502	D	74	21	.	11	1257	759	.	3.9	.	1.33	7	2	7	7	0.18	0.41	0.13	0.13
18	134	502	D	75	21	.	15	760	620	.	3.5	.	2.23	7	3	5	5	0.24	0.18	0.35	0.09
18	134	502	D	77	14	.	11	636	361	.	3.2	.	1.52	7	4	7	2	0.19	0.15	0.22	0.60
18	263	502	D	75	48	.	16	2044	1245	.	5.0	.	1.14	8	3	8	7	0.21	0.53	0.14	0.09
19	119	325	M	73	114	37	.	724	340	26.2	.	29.1	0.79	2	2	2	2	0.00	0.11	0.04	0.10
19	119	326	M	73	107	43	.	720	428	19.0	.	28.4	0.63	2	2	2	2	0.05	0.49	0.02	0.20
19	119	327	M	73	131	50	.	731	451	13.4	.	13.9	0.74	2	2	2	2	0.03	0.03	0.04	0.17
19	119	328	M	73	130	61	.	716	461	12.0	.	18.5	0.60	2	2	2	2	0.01	0.54	0.02	0.23
19	119	329	M	73	136	63	.	726	533	11.1	.	17.0	0.69	2	2	2	2	0.13	0.53	0.03	0.07
19	119	330	M	73	139	69	.	760	506	7.6	.	12.4	0.67	2	2	2	2	0.10	0.63	0.07	0.09
19	119	331	U	73	117	54	.	815	543	6.6	.	10.0	0.70	2	2	2	2	0.01	0.52	0.03	0.09
19	119	332	U	73	145	69	.	810	496	7.2	.	9.4	0.58	2	2	2	2	0.03	0.31	0.21	0.13
19	122	329	M	73	14	6	.	454	187	4.2	.	8.5	1.74	3	3	3	3	0.15	0.52	0.18	0.30
19	338	323	M	73	138	57	.	721	443	9.4	.	10.2	0.58	2	2	2	2	0.28	0.08	0.13	0.22
19	340	502	D	75	15	.	10	450	150	.	8.1	.	1.61	4	2	4	3	0.24	0.35	0.14	0.12
19	340	502	D	76	13	.	10	320	150	.	6.0	.	2.38	5	6	5	5	0.15	0.10	0.06	0.10
19	340	502	D	78	14	.	14	440	150	.	6.9	.	1.63	5	6	5	5	0.29	0.20	0.20	0.10
19	340	503	M	75	16	.	10	475	150	.	10.8	.	1.23	4	3	4	4	0.29	0.10	0.05	0.05
19	340	503	M	76	14	.	10	367	150	.	9.4	.	1.49	3	4	3	4	0.30	0.12	0.09	0.12
19	340	503	M	78	20	.	12	533	221	.	17.3	.	1.22	6	6	6	5	0.25	0.20	0.08	0.08
19	342	320	M	73	53	12	.	736	224	10.2	.	11.1	0.89	2	2	2	2	0.17	0.08	0.33	0.14
19	342	322	M	73	57	19	.	648	316	8.0	.	12.7	0.57	2	2	2	2	0.25	0.59	0.19	0.16
19	343	315	U	73	13	5	.	508	176	4.1	.	9.1	3.18	3	3	3	3	0.13	0.60	0.23	0.22
20	087	314	M	73	45	10	.	4627	3921	21.2	.	43.5	1.22	3	3	3	3	0.28	0.54	0.27	0.21

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
22	014	309	D	74	18	6	.	455	78	13.8	.	23.3	2.36	2	2	2	2	0.07	0.68	0.14	0.31
22	014	310	M	74	21	3	.	372	50	16.3	.	29.0	2.29	2	2	2	2	0.11	0.78	0.28	0.07
22	014	311	U	74	24	3	.	361	107	11.3	.	18.9	2.08	2	2	2	2	0.06	0.67	0.16	0.02
22	014	312	M	74	18	4	.	321	73	15.6	.	25.3	2.36	2	2	2	2	0.21	0.62	0.01	0.03
22	014	313	M	74	22	3	.	356	93	15.9	.	22.1	1.70	2	2	2	2	0.27	0.39	0.04	0.01
22	019	313	D	74	23	6	.	390	60	3.1	.	3.7	4.04	2	2	2	2	0.32	0.17	0.08	0.06
22	019	314	M	74	12	7	.	285	62	3.3	.	3.4	3.91	2	2	2	2	0.00	0.03	0.05	0.09
22	019	315	M	74	15	5	.	397	80	5.4	.	7.9	2.89	2	2	2	2	0.08	0.45	0.38	0.05
22	019	316	U	74	18	3	.	266	81	6.9	.	9.5	1.29	2	2	2	2	0.07	0.37	0.18	0.89
22	019	317	U	74	20	3	.	301	103	5.6	.	7.8	2.26	2	2	2	2	0.04	0.38	0.27	0.28
22	019	318	U	74	13	2	.	281	81	7.8	.	12.3	2.51	2	2	2	2	0.06	0.57	0.04	0.15
22	188	311	M	73	140	17	.	1177	365	5.7	.	7.3	0.46	2	2	2	2	0.59	0.28	0.00	0.44
22	188	312	D	73	136	19	.	931	332	3.7	.	4.5	0.53	2	2	2	2	0.59	0.22	0.02	0.52
22	188	313	M	73	151	17	.	1139	407	4.3	.	6.0	0.33	2	2	2	2	0.61	0.38	0.09	0.38
22	189	307	U	73	63	18	.	678	203	4.0	.	5.9	0.97	2	2	2	2	0.48	0.46	0.13	0.26
22	189	308	M	73	42	7	.	734	170	4.9	.	6.1	1.08	2	2	2	2	0.52	0.23	0.01	0.29
22	189	309	D	73	43	6	.	809	183	5.5	.	6.8	1.09	2	2	2	2	0.47	0.24	0.06	0.30
22	190	310	D	73	61	10	.	896	345	4.1	.	4.7	0.62	2	2	2	2	0.38	0.13	0.19	0.51
22	190	311	U	73	62	9	.	841	310	5.3	.	6.6	0.60	2	2	2	2	0.40	0.25	0.20	0.49
22	190	312	U	73	59	7	.	746	335	6.3	.	9.3	0.63	2	2	2	2	0.48	0.48	0.13	0.52
22	192	311	D	73	45	23	.	646	204	6.6	.	7.0	1.22	2	2	2	2	0.58	0.05	0.00	0.63
22	192	312	M	73	40	6	.	586	152	8.4	.	12.7	1.37	2	2	2	2	0.64	0.50	0.06	0.67
22	192	313	M	73	30	7	.	531	148	5.8	.	7.5	1.40	2	2	2	2	0.47	0.28	0.10	0.67
22	192	314	U	73	41	7	.	613	156	7.7	.	10.4	1.31	2	2	2	2	0.62	0.35	0.02	0.65
24	012	308	D	74	62	8	.	481	153	8.6	.	9.4	0.53	2	2	2	2	0.21	0.09	0.20	0.33
24	012	309	M	74	82	8	.	597	127	12.0	.	14.1	0.38	2	2	2	2	0.29	0.17	0.09	0.20
24	021	308	M	74	47	9	.	441	163	19.7	.	35.9	0.81	2	2	2	2	0.13	0.82	0.03	0.13
24	021	309	D	74	38	5	.	446	204	19.4	.	36.5	0.94	2	2	2	2	0.06	0.88	0.04	0.03
24	022	322	M	74	16	5	.	491	215	6.3	.	16.4	3.90	4	4	4	4	0.11	0.53	0.14	0.18
25	020	323	D	74	39	5	.	561	74	18.7	.	29.6	1.22	2	2	2	2	0.09	0.58	0.06	0.25
25	020	324	M	74	49	7	.	640	188	7.9	.	9.8	0.67	2	2	2	2	0.14	0.23	0.13	0.13
25	020	325	M	74	67	7	.	745	57	34.1	.	50.6	0.79	2	2	2	2	0.02	0.48	0.17	0.16
25	102	312	D	74	61	26	.	1314	904	7.3	.	11.6	0.38	2	3	2	3	0.50	0.41	0.39	0.12
25	102	313	M	74	105	29	.	1356	809	12.3	.	20.0	0.28	2	3	2	3	0.64	0.40	0.43	0.05
25	102	314	M	74	62	27	.	1265	904	9.8	.	15.1	0.41	2	3	2	3	0.27	0.43	0.38	0.17
25	103	307	D	74	57	14	.	933	620	2.6	.	3.7	0.24	2	3	2	3	0.50	0.38	0.22	0.19
25	104	305	D	74	51	15	.	786	495	8.6	.	18.9	0.30	2	3	2	3	0.22	0.61	0.17	0.00
25	104	306	M	74	51	16	.	825	486	6.8	.	10.8	0.27	2	3	2	3	0.12	0.29	0.23	0.06
25	105	313	M	74	317	74	.	2004	1207	10.8	.	15.2	0.21	3	3	3	3	0.63	0.37	0.25	0.28
25	107	307	D	74	56	13	.	1053	607	10.1	.	21.5	0.51	3	3	3	3	0.40	0.59	0.29	0.29

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
25	112	308	D	74	64	10	.	665	468	5.9	.	12.0	0.29	2	3	2	3	0.02	0.51	0.14	0.06
25	112	309	M	74	77	11	.	825	447	7.2	.	13.5	0.30	2	3	2	3	0.12	0.46	0.18	0.03
25	267	320	U	74	129	35	.	825	308	10.6	.	25.4	0.36	4	4	4	4	0.14	0.51	0.08	0.10
25	269	309	D	74	73	16	.	752	161	7.5	.	10.8	0.30	2	2	2	2	0.06	0.43	0.08	0.00
25	269	310	M	74	66	14	.	677	135	6.6	.	10.5	0.38	2	2	2	2	0.08	0.58	0.13	0.20
25	273	316	D	74	97	60	.	1191	590	11.6	.	25.1	0.58	3	3	3	3	0.18	0.60	0.17	0.29
25	273	317	U	74	250	100	.	1109	378	23.7	.	45.6	0.20	3	3	3	3	0.10	0.53	0.10	0.47
25	273	321	M	74	130	76	.	1078	530	7.2	.	20.5	0.37	4	4	4	4	0.15	0.61	0.08	0.23
25	273	322	U	74	470	103	.	1294	357	71.8	.	154.7	0.14	3	3	3	3	0.20	0.62	0.21	0.35
25	273	323	U	74	371	123	.	1854	821	41.0	.	71.1	0.14	2	2	2	2	0.05	0.73	0.21	0.09
25	273	325	D	74	154	110	.	1419	805	3.8	.	9.6	0.50	2	3	2	3	0.26	0.77	0.09	0.38
25	273	326	U	74	273	122	.	1398	598	92.7	.	181.0	0.14	2	2	2	2	0.06	0.95	0.02	0.45
25	275	321	U	74	152	37	.	1199	550	8.0	.	15.5	0.22	3	3	3	3	0.18	0.54	0.05	0.23
25	348	317	D	74	38	19	.	588	185	7.7	.	11.8	1.78	2	3	2	3	0.12	0.39	0.04	0.17
25	348	318	M	74	37	14	.	573	138	11.3	.	16.5	2.03	2	3	2	3	0.07	0.28	0.01	0.18
25	348	319	M	74	40	16	.	650	188	10.2	.	12.7	1.57	2	3	2	3	0.02	0.21	0.14	0.23
25	348	320	U	74	176	40	.	1008	330	19.5	.	29.6	0.30	2	3	2	3	0.56	0.40	0.02	0.29
25	348	321	M	74	59	29	.	631	160	13.7	.	18.1	1.37	2	3	2	3	0.06	0.32	0.00	0.11
25	348	322	M	74	61	26	.	605	151	20.6	.	29.6	0.91	2	3	2	3	0.09	0.36	0.13	0.19
25	348	323	U	74	188	65	.	981	298	29.5	.	53.8	0.25	2	2	2	3	0.15	0.82	0.16	0.20
25	370	304	M	74	93	12	.	780	203	13.6	.	23.5	0.44	3	3	3	3	0.36	0.38	0.10	0.80
26	354	101	D	74	23	10	.	.	340	.	5.5	.	0.58	2	2	0	2	0.43	0.27	.	0.43
26	354	101	D	75	168	66	.	.	415	.	3.5	.	0.33	2	2	0	2	0.21	0.38	.	0.08
26	354	101	D	77	98	24	.	.	304	.	28.0	.	0.66	3	3	0	3	0.28	0.90	.	0.44
26	354	101	D	78	163	35	.	.	430	.	3.3	.	1.14	2	2	0	2	0.57	0.97	.	0.33
26	354	102	M	74	32	10	.	.	345	.	4.0	.	0.30	2	2	0	2	0.58	0.00	.	0.17
26	354	102	M	75	204	117	.	.	295	.	6.8	.	0.15	2	2	0	2	0.15	0.04	.	0.00
26	354	103	M	74	38	10	.	.	335	.	4.0	.	0.24	2	2	0	2	0.22	0.00	.	0.26
26	354	103	M	75	158	92	.	.	290	.	6.4	.	0.18	2	2	0	2	0.16	0.21	.	0.14
26	355	317	D	74	36	15	.	620	275	9.7	.	19.4	1.17	3	3	3	3	0.15	0.50	0.19	0.28
26	355	319	M	74	233	22	.	1104	343	17.3	.	31.7	0.63	3	3	3	3	0.85	0.42	0.37	0.46
26	355	321	U	74	167	31	.	915	448	16.5	.	20.7	0.33	3	3	3	3	0.56	0.14	0.26	0.47
26	359	109	M	75	17	10	.	.	.	.	15.5	.	1.19	2	2	0	2	0.40	0.03	.	0.09
26	359	110	U	75	82	43	.	.	.	.	45.5	.	0.37	2	2	0	2	0.27	0.47	.	0.10
26	359	110	U	76	76	17	.	.	295	.	31.0	.	0.44	2	2	0	2	0.74	0.10	.	0.37
26	359	110	U	78	248	62	.	.	400	.	14.0	.	0.55	2	2	0	2	0.68	0.29	.	0.77
26	359	319	D	74	58	42	.	486	97	2.5	.	2.6	1.99	2	2	2	2	0.61	0.02	0.45	0.30
26	359	320	M	74	62	48	.	548	87	3.8	.	4.5	1.83	2	2	2	2	0.67	0.18	0.05	0.25
26	359	321	M	74	53	41	.	446	121	7.5	.	12.0	2.35	2	2	2	2	0.59	0.59	0.15	0.30
26	359	322	M	74	59	46	.	396	86	11.1	.	17.3	2.13	2	2	2	2	0.58	0.55	0.19	0.29

WATER QUALITY SUMMARY BY STATION-YEAR

---------- POOL DATA SCREEN CODE=B ----------

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
26	359	323	U	74	66	51	.	470	91	11.4	.	13.1	1.65	2	2	2	2	0.61	0.15	0.11	0.08
26	359	324	U	74	95	51	.	715	112	3.8	.	4.8	0.86	2	2	2	2	0.48	0.25	0.08	0.06
26	360	303	D	74	110	29	.	1081	145	28.5	.	42.6	0.46	2	3	2	3	0.00	0.26	0.05	0.33
28	218	007	D	77	20	7	.	356	.	3.8	4.0	7.8	2.41	3	3	3	3	0.30	0.54	0.41	0.19
28	219	012	D	77	22	5	.	456	.	4.4	4.7	6.8	1.71	2	2	2	2	0.56	0.53	0.23	0.38
28	219	012	D	78	26	17	28	430	.	2.6	2.7	2.8	1.88	2	2	2	2	0.19	0.07	0.23	0.30
29	100	305	D	74	56	7	.	1794	1231	9.9	.	23.4	0.81	2	3	2	3	0.28	0.68	0.09	0.06
29	100	306	M	74	61	7	.	1605	1041	17.6	.	38.8	0.71	2	3	2	3	0.34	0.60	0.05	0.07
29	100	307	M	74	60	8	.	1745	1133	7.5	.	15.1	0.66	2	3	2	3	0.25	0.51	0.10	0.15
29	100	308	M	74	72	9	.	1854	1241	13.5	.	31.5	0.66	2	3	2	3	0.27	0.67	0.09	0.08
29	100	309	U	74	98	12	.	1764	971	11.8	.	25.3	0.32	2	3	2	3	0.12	0.59	0.14	0.50
29	100	310	U	74	73	9	.	1958	1152	11.9	.	28.8	0.51	2	3	2	3	0.21	0.73	0.09	0.20
29	106	310	D	74	48	12	.	1189	603	8.7	.	14.8	0.41	3	3	3	2	0.18	0.46	0.14	0.13
29	108	313	D	74	66	38	.	1214	755	11.3	.	24.6	1.37	3	3	3	3	0.40	0.62	0.19	0.50
29	109	307	D	74	37	10	.	811	334	24.5	.	58.6	1.12	3	3	3	3	0.22	0.71	0.25	0.39
29	109	308	M	74	36	4	.	932	302	36.3	.	74.7	1.23	3	3	3	3	0.27	0.55	0.17	0.37
29	109	309	M	74	34	12	.	889	339	30.4	.	60.7	0.77	3	3	3	3	0.08	0.53	0.17	0.10
29	110	319	U	74	57	21	.	1485	1056	2.4	.	2.9	0.60	2	2	2	2	0.15	0.21	0.22	0.02
29	111	312	M	74	50	22	.	1576	1090	9.5	.	11.3	0.41	3	2	3	3	0.19	0.18	0.10	0.13
29	113	327	D	74	134	105	.	1804	1417	5.1	.	7.5	1.20	2	3	2	3	0.37	0.26	0.20	0.45
29	113	328	M	74	153	106	.	1810	1404	10.1	.	14.4	0.74	2	3	2	3	0.25	0.23	0.23	0.45
29	113	329	M	74	197	75	.	1451	815	18.6	.	34.5	0.29	2	3	2	3	0.20	0.46	0.05	0.21
29	114	307	D	74	22	6	.	956	305	8.4	.	19.4	1.49	2	3	2	3	0.05	0.67	0.09	0.44
29	114	308	M	74	21	6	.	855	276	7.8	.	15.9	1.50	2	3	2	3	0.06	0.53	0.02	0.39
29	114	309	M	74	25	4	.	850	290	10.4	.	17.5	1.18	2	3	2	3	0.09	0.44	0.19	0.39
29	194	315	U	74	64	7	.	634	95	19.7	.	20.9	0.58	2	2	2	2	0.18	0.06	0.31	0.30
29	195	316	M	74	20	6	.	950	632	10.6	.	25.8	1.95	3	3	3	3	0.21	0.73	0.21	0.22
29	195	317	U	74	26	5	.	1026	688	12.3	.	29.2	1.31	3	3	3	3	0.17	0.70	0.24	0.21
29	195	318	M	74	19	7	.	815	534	5.8	.	13.0	2.03	3	3	3	3	0.06	0.63	0.15	0.18
29	195	319	U	74	28	8	.	865	556	10.7	.	21.8	1.64	3	3	3	3	0.13	0.53	0.22	0.24
29	207	312	U	74	164	71	.	929	275	47.9	.	101.6	0.29	3	3	3	3	0.45	0.57	0.36	0.06
30	064	306	M	75	66	12	.	903	47	49.2	.	124.5	0.74	3	3	3	3	0.17	0.77	0.15	0.14
30	215	304	D	74	57	20	.	1055	246	11.4	.	21.1	1.37	2	3	2	3	0.47	0.42	0.22	0.33
30	215	305	M	74	66	20	.	1101	155	19.3	.	34.5	1.02	2	3	2	3	0.56	0.43	0.26	0.26
30	217	306	D	74	60	18	.	983	177	20.0	.	27.5	1.07	2	3	2	3	0.43	0.25	0.24	0.14
30	217	307	M	74	53	18	.	946	68	17.6	.	32.1	1.13	2	3	2	3	0.45	0.41	0.12	0.13
30	217	308	M	74	52	15	.	813	68	13.5	.	21.1	1.12	2	3	2	3	0.38	0.32	0.07	0.12
30	235	325	M	74	27	13	.	316	158	7.6	.	10.8	1.42	2	3	2	3	0.01	0.32	0.06	0.26
30	235	326	M	74	37	12	.	356	162	7.2	.	8.1	0.81	2	3	2	3	0.48	0.08	0.38	0.25
30	235	327	U	74	109	14	.	732	100	30.3	.	35.5	0.34	2	3	2	3	0.44	0.10	0.56	0.18

WATER QUALITY SUMMARY BY STATION-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	STA	TYPE	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
30	235	328	U	74	386	15	.	845	305	12.7	.	14.8	0.20	2	3	2	3	0.82	0.16	0.74	0.25
32	204	313	M	75	62	51	.	286	92	3.4	.	5.9	2.37	2	2	2	2	0.27	0.74	0.23	0.80
32	204	317	M	75	44	34	.	280	83	1.3	.	1.9	4.74	3	3	3	2	0.45	0.21	0.14	0.93
33	300	306	D	75	20	10	.	288	57	3.2	.	3.8	1.75	2	2	2	2	0.09	0.17	0.24	0.13
34	041	112	D	71	45	9	.	262	41	1.0	.	1.8	5.68	8	5	6	7	0.17	0.23	0.14	0.06
34	041	112	D	72	16	7	.	264	21	1.3	.	2.5	6.50	7	7	7	6	0.15	0.21	0.23	0.12
34	041	112	D	73	10	10	.	115	25	0.9	.	1.5	5.44	6	6	6	6	0.00	0.19	0.04	0.14
34	041	112	D	74	10	10	.	186	24	0.8	.	1.8	7.08	7	7	7	7	0.00	0.23	0.22	0.09
34	041	112	D	75	13	10	.	.	34	1.5	.	3.3	3.95	7	7	0	6	0.14	0.24	.	0.19
34	041	112	D	76	10	10	.	.	20	0.6	.	1.2	3.44	6	7	0	5	0.00	0.20	.	0.24
34	041	112	D	78	12	10	.	205	47	1.0	.	1.6	3.39	4	4	4	3	0.20	0.25	0.35	0.49

Table B4

Water Quality Data Summary by Reservoir-Year

Symbol	Meaning
DIS	CE District code
RES	CE reservoir code
YEAR	year of sample

Note: Data listed by screen code (A or B) and in 2 parameter groups; screen codes reflect data reliability (see Part III of the main text) District and reservoir codes are defined in Appendix A.

WATER QUALITY SUMMARY BY RESERVOIR-YEAR
POOL DATA SCREEN CODE=A

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CDEP	STATION DEPTH (M)	66	18.90	27.11	2.18	175.40
CPHF	PH (STANDARD UNITS)	85	7.84	0.49	6.37	8.48
CCNF	CONDUCTIVITY (UMHOS/CM)	85	512.29	589.18	23.50	4599.87
CALK	ALKALINITY (MG/L)	82	97.05	59.24	10.50	293.75
CTMP	TEMPERATURE (DEG-C)	85	20.46	2.80	14.85	27.56
CTRJ	TURDIBITY (JTU)	1	17.62	.	17.62	17.62
CTRH	HACH TURBIDITY (NTU)	22	9.29	10.76	2.25	34.81
CTRN	-LOG(% TRANS./100)	62	0.48	0.49	0.05	2.15
CTCO	TRUE COLOR (PT-CO UNITS)	6	54.09	38.19	13.33	98.65
CALPH	NON-ALGAL TURBIDITY (1/M)	85	0.98	0.84	0.15	5.24
CRTL	TOTAL SOLIDS (MG/L)	8	155.36	115.94	9.50	389.58
CRFL	DISSOLVED SOLIDS (MG/L)	8	101.02	47.64	48.42	165.32
CRNF	SUSPENDED SOLIDS (MG/L)	20	8.52	9.32	1.00	38.56
CALG	ALGAL COUNT (NO/LITER)	3	166558.33	113305.93	66900.00	289800.00
CBIO	ALGAL VOLUME (ML/LITER)	3	0.03	0.02	0.01	0.05
POOL DATA SCREEN CODE=B						
CDEP	STATION DEPTH (M)	33	14.27	13.46	2.82	78.80
CPHF	PH (STANDARD UNITS)	70	7.71	0.51	6.27	8.43
CCNF	CONDUCTIVITY (UMHOS/CM)	69	345.36	365.02	34.33	2393.00
CALK	ALKALINITY (MG/L)	61	96.82	74.20	11.35	292.83
CTMP	TEMPERATURE (DEG-C)	71	21.46	4.17	11.65	28.91
CTRJ	TURDIBITY (JTU)	4	105.73	117.87	23.75	280.00
CTRH	HACH TURBIDITY (NTU)	22	3.48	3.17	0.67	13.77
CTRN	-LOG(% TRANS./100)	36	0.50	0.56	0.04	2.45
CTCO	TRUE COLOR (PT-CO UNITS)	3	111.11	163.72	10.00	300.00
CALPH	NON-ALGAL TURBIDITY (1/M)	73	0.95	0.97	0.12	4.93
CRTL	TOTAL SOLIDS (MG/L)	13	226.27	135.16	10.00	465.93
CRFL	DISSOLVED SOLIDS (MG/L)	9	164.84	186.86	8.80	500.00
CRNF	SUSPENDED SOLIDS (MG/L)	25	32.25	112.00	0.00	566.67
CALG	ALGAL COUNT (NO/LITER)	12	196156.24	205325.84	61500.00	738500.00
CBIO	ALGAL VOLUME (ML/LITER)	11	0.09	0.11	0.01	0.30

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
03	307	73	23.8	7.11	74	11	18.2	.	.	0.12	.	0.17	.	.	.	.	.
04	312	73	6.9	8.06	273	105	17.3	.	.	0.20	.	0.45	.	.	.	.	.
06	372	73	16.0	7.48	503	33	21.9	.	.	0.32	.	1.11	.	.	.	.	.
10	001	77	.	7.21	148	46	19.7	.	34.8	.	98	1.11	.	82	.	.	.
10	003	73	20.2	6.74	795	20	24.9	.	.	0.16	.	0.75	.	.	.	.	.
10	004	77	.	7.12	123	42	23.8	.	24.0	.	64	1.06	.	72	.	.	.
10	008	77	.	7.16	148	41	23.2	.	31.2	.	99	1.06	.	84	.	.	.
10	072	78	.	7.36	63	17	26.7	.	8.4	.	21	0.83	.	55	6	.	.
10	073	75	.	6.69	56	17	22.1	17.6	.	.	31	1.77	64	48	15	.	.
10	411	73	13.9	6.69	816	25	25.4	.	.	0.25	.	0.80	.	.	.	.	.
15	178	77	19.5	7.97	230	118	18.3	.	2.7	.	13	0.16	.	.	3	.	.
15	237	74	6.4	8.48	652	294	17.0	.	.	0.15	.	0.37	.	.	.	.	.
16	243	73	6.6	7.92	422	79	18.3	.	.	0.26	.	0.85	.	.	.	.	.
16	254	73	5.4	7.71	220	44	18.2	.	.	0.33	.	0.23	.	.	.	.	.
16	317	73	6.2	8.00	208	53	18.5	.	.	0.20	.	0.43	.	.	.	.	.
16	328	73	20.0	7.57	138	23	16.3	.	.	0.17	.	0.49	.	.	.	.	.
16	393	73	28.8	6.51	521	11	22.3	.	.	0.11	.	0.30	.	.	.	.	.
17	241	73	4.6	8.25	294	48	19.2	.	.	0.43	.	0.82	.	.	.	.	.
17	242	73	2.3	7.56	559	72	19.1	.	.	2.15	.	3.31	.	.	.	.	.
17	245	73	3.3	8.25	397	134	19.3	.	.	1.71	.	0.67	.	.	.	.	.
17	247	73	5.6	8.30	466	188	19.0	.	.	1.28	.	1.26	.	.	.	.	.
17	248	73	4.2	8.11	493	158	19.7	.	.	1.25	.	2.34	.	.	.	.	.
17	249	73	4.4	7.97	429	134	19.2	.	.	0.91	.	1.61	.	.	.	.	.
17	256	73	5.9	8.24	323	128	18.6	.	.	0.26	.	0.37	.	.	.	.	.
17	258	73	5.6	8.26	669	76	19.2	.	.	0.43	.	0.28	.	.	.	.	.
17	373	73	24.1	7.40	1350	24	20.0	.	.	0.20	.	0.45	.	.	.	.	.
17	391	73	30.7	7.10	307	10	20.7	.	.	0.14	.	0.15	.	.	.	.	.
18	090	75	.	8.01	341	158	21.1	.	5.5	.	.	0.79	195	.	6	66900	0.035
18	090	77	.	8.19	341	96	22.5	.	4.0	.	.	0.76	.	.	3	.	.
18	091	75	.	8.05	517	155	21.5	.	19.5	.	.	1.93	390	.	21	289800	0.047
18	092	73	12.9	8.02	1849	178	19.6	.	.	0.55	.	1.36	.	.	.	.	.
18	093	73	11.6	7.37	572	30	22.3	.	.	0.23	.	0.68	.	.	.	.	.
18	093	77	.	7.65	139	25	21.2	.	2.7	.	.	0.41	.	.	2	.	.
18	095	77	.	8.28	381	120	22.0	.	3.0	.	.	0.73	.	.	3	.	.
18	097	77	.	8.20	401	132	21.5	.	2.4	.	.	0.66	10	.	3	.	.
18	120	73	10.5	8.07	835	81	24.0	.	.	0.26	.	0.74	.	.	.	.	.
18	120	77	.	8.35	194	72	24.8	.	2.3	.	.	0.44	.	.	1	.	.
18	121	77	.	7.62	161	.	22.0	.	3.7	.	.	0.62	.	.	7	.	.
18	126	77	.	7.68	137	43	22.9	.	3.2	.	.	0.54	.	.	2	.	.
18	128	77	.	8.27	227	.	24.3	.	2.4	.	.	0.46	.	.	2	.	.

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
18	129	77	.	7.67	205	80	22.6	.	2.3	.	.	0.49	.	.	2	.	.
18	134	75	.	7.61	104	34	25.8	.	6.3	.	.	0.36	73	.	5	142975	0.011
18	260	77	.	7.55	321	.	19.9	.	29.9	.	.	2.34	.	.	39	.	.
18	263	77	.	8.33	437	178	19.5	.	4.5	.	.	0.98	.	.	6	.	.
19	119	73	17.9	7.67	644	73	21.9	.	.	0.43	.	1.13	.	.	.	.	.
19	122	73	34.3	7.56	626	38	22.5	.	.	0.33	.	0.54	.	.	.	.	.
19	338	73	10.4	7.38	742	58	22.6	.	.	0.37	.	1.34	.	.	.	.	.
19	340	73	17.0	8.04	1001	119	23.0	.	.	0.14	.	0.40	.	.	.	.	.
19	340	75	15.1	8.16	266	128	27.6	.	3.9	.	.	0.64	155	136	19	.	.
19	340	76	12.7	7.72	271	145	23.4	.	4.7	.	.	0.50	175	165	10	.	.
19	340	78	14.2	7.58	286	157	24.6	.	3.0	.	.	0.79	182	165	17	.	.
19	342	73	17.9	7.89	573	52	21.1	.	.	0.29	.	1.12	.	.	.	.	.
19	343	73	24.2	7.65	815	62	22.6	.	.	0.05	.	0.22	.	.	.	.	.
20	081	73	8.7	8.03	1512	133	20.5	.	.	0.67	.	1.43	.	.	.	.	.
20	087	73	10.3	8.04	1676	164	20.7	.	.	0.35	.	0.64	.	.	.	.	.
20	088	73	4.3	7.68	1136	63	21.4	.	.	0.56	.	0.85	.	.	.	.	.
21	196	74	8.4	7.83	164	74	17.5	.	.	0.21	.	0.75	.	.	.	.	.
24	011	74	34.0	7.64	116	47	20.1	.	.	0.11	.	0.57	.	.	.	.	.
24	013	74	40.1	8.34	198	127	20.1	.	.	0.07	.	0.17	.	.	.	.	.
24	016	74	34.7	7.01	44	18	23.4	.	.	0.05	.	0.22	.	.	.	.	.
24	022	74	35.0	8.26	246	158	20.7	.	.	0.06	.	0.21	.	.	.	.	.
24	193	74	7.7	8.02	218	103	16.9	.	.	0.18	.	0.66	.	.	.	.	.
24	200	74	35.9	8.22	203	98	19.9	.	.	0.11	.	0.26	.	.	.	.	.
25	105	74	2.2	8.16	392	176	17.7	.	.	1.84	.	5.24	.	.	.	.	.
25	107	74	7.3	8.39	524	130	16.5	.	.	1.24	.	2.23	.	.	.	.	.
25	267	74	16.3	7.81	399	81	21.7	.	.	0.70	.	2.42	.	.	.	.	.
25	273	74	11.9	8.08	1520	129	19.8	.	.	1.68	.	3.23	.	.	.	.	.
25	275	74	10.9	7.73	309	111	21.1	.	.	0.83	.	2.29	.	.	.	.	.
25	278	74	29.5	8.09	163	75	21.0	.	.	0.13	.	0.53	.	.	.	.	.
25	281	74	11.0	6.37	61	22	22.7	.	.	0.47	.	1.59	.	.	.	.	.
25	370	74	6.9	8.28	4600	85	22.4	.	.	1.06	.	1.12	.	.	.	.	.
26	355	74	8.8	8.17	342	109	23.8	.	.	0.63	.	1.66	.	.	.	.	.
28	219	75	16.4	8.29	817	154	18.5	.	.	0.07	.	0.76	.	.	.	.	.
29	106	74	7.3	8.06	1345	156	16.7	.	.	1.18	.	2.62	.	.	.	.	.
29	108	74	11.4	8.36	785	203	16.5	.	.	0.70	.	1.04	.	.	.	.	.
29	109	74	12.6	8.34	575	150	17.5	.	.	0.12	.	0.30	.	.	.	.	.
29	110	74	12.1	8.24	385	167	17.9	.	.	0.35	.	1.75	.	.	.	.	.
29	111	74	7.5	8.20	351	144	17.7	.	.	0.34	.	1.93	.	.	.	.	.
29	194	74	12.5	8.20	240	120	18.5	.	.	0.48	.	0.71	.	.	.	.	.
29	195	74	22.4	8.19	285	130	17.0	.	.	0.11	.	0.35	.	.	.	.	.

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
29	207	74	9.9	8.41	528	201	16.1	.	.	0.72	.	1.35	.	.	.	.	.
30	064	75	4.6	8.37	470	175	15.6	.	.	0.17	.	0.70	.	.	.	.	.
30	235	74	23.1	8.17	675	175	15.1	.	.	0.72	.	1.07	.	.	.	.	.
31	077	75	175.4	7.21	23	17	14.9	.	.	0.05	.	0.35	.	.	.	.	.
32	204	75	145.8	8.35	179	99	16.2	.	.	0.16	.	0.21	.	.	.	.	.

POOL DATA SCREEN CODE=B

DIS	RES	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
02	176	72	.	7.07	110	16	19.0	.	.	0.07	.	0.30	.	.	.	.	.
04	320	74	.	7.49	194	59	20.7	.	.	.	.	0.31	.	.	.	.	.
08	074	73	20.1	7.43	250	19	28.3	.	.	0.14	.	0.43	.	.	.	.	.
08	330	73	23.3	6.87	207	12	28.3	.	.	0.36	.	0.30	.	.	.	.	.
10	069	73	15.9	7.07	170	16	26.8	.	.	0.11	.	0.45	.	.	.	.	.
10	071	73	7.0	7.47	593	48	28.4	.	.	0.22	.	0.85	.	.	.	.	.
10	072	73	11.5	8.11	312	19	28.9	.	.	0.24	.	0.72	.	.	.	.	.
10	076	73	27.8	7.54	138	11	27.7	.	.	0.10	.	0.24	.	.	.	.	.
14	099	74	10.7	7.97	669	293	15.9	.	.	1.20	.	1.58	.	.	.	.	.
15	178	72	.	8.19	431	103	15.5	.	.	0.11	.	0.15	.	.	.	.	.
15	178	76	.	8.33	223	110	18.2	.	2.2	.	23	0.15	.	.	.	.	.
15	178	78	19.8	7.90	213	98	.	.	1.3	.	10	0.27	.	.	3	.	.
15	179	79	.	8.43	653	222	19.2	.	.	.	.	0.15	.	19	.	.	.
15	181	72	.	8.24	263	134	14.8	.	.	0.50	.	0.31	.	.	.	.	.
15	399	78	.	8.20	.	189	11.6	.	.	.	.	0.29	.	.	.	.	.
15	399	79	.	8.05	373	133	15.5	.	.	.	.	0.24	.	9	.	.	.
16	328	72	.	7.87	163	36	17.3	.	.	0.31	.	0.45	.	.	.	.	.
17	389	73	5.3	8.06	723	54	20.9	.	.	0.49	.	1.14	.	.	.	.	.
18	090	73	.	7.91	369	135	21.3	.	.	.	.	0.63	208	.	5	113100	0.075
18	091	74	.	8.04	536	149	19.2	.	13.8	.	.	2.23	466	.	57	738500	0.262
18	091	77	.	8.04	690	.	19.8	.	2.8	.	.	0.72	.	.	17	.	.
18	092	74	.	8.03	542	152	22.5	.	0.7	.	.	0.95	308	.	4	83775	0.020
18	092	75	.	8.15	476	156	20.3	.	4.0	.	.	0.95	341	.	8	263700	0.022
18	092	77	.	8.20	529	.	21.3	.	4.5	.	.	0.82	.	.	6	.	.
18	094	75	.	8.13	420	139	20.9	.	3.2	.	.	0.80	321	.	6	81667	0.020
18	095	76	.	8.31	361	137	19.2	.	5.0	.	.	0.51	216	.	5	468000	.
18	097	75	.	8.20	424	176	21.2	.	4.1	.	.	0.69	285	.	5	139667	0.013
18	121	75	.	7.42	125	31	24.6	.	6.2	.	.	0.73	77	.	6	82333	0.302
18	126	74	.	7.69	131	44	20.6	.	.	.	.	0.51	76	.	6	61500	0.015

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
18	128	75	.	8.06	199	121	21.8	.	6.8	.	.	0.64	128	.	5	89333	0.020
18	129	74	.	7.91	254	94	19.3	.	2.5	.	.	0.66	139	.	4	113000	0.191
18	134	77	.	7.61	119	.	22.2	.	2.5	.	.	0.58	.	.	2	.	.
18	263	75	.	8.16	540	256	18.4	.	8.8	.	.	0.75	367	.	17	119300	0.009
22	014	74	25.2	7.09	62	24	22.9	.	.	0.10	.	0.13	.	.	.	.	.
22	019	74	29.9	7.03	81	24	22.4	.	.	0.07	.	0.28	.	.	.	.	.
22	188	73	8.4	7.17	112	21	27.0	.	.	0.52	.	2.25	.	.	.	.	.
22	189	73	11.1	6.82	48	16	28.4	.	.	0.17	.	0.84	.	.	.	.	.
22	190	73	12.9	6.85	54	16	27.0	.	.	0.28	.	1.49	.	.	.	.	.
22	192	73	14.5	7.22	59	17	27.6	.	.	0.17	.	0.58	.	.	.	.	.
24	012	74	6.1	6.63	76	21	20.3	.	.	0.52	.	1.99	.	.	.	.	.
24	021	74	7.0	6.27	34	13	21.2	.	.	0.21	.	0.66	.	.	.	.	.
25	020	74	7.8	7.35	91	36	22.5	.	.	0.21	.	0.69	.	.	.	.	.
25	102	74	7.1	8.18	331	157	16.8	.	.	1.20	.	2.63	.	.	.	.	.
25	103	74	13.7	7.87	304	122	18.3	.	.	2.45	.	4.16	.	.	.	.	.
25	104	74	7.2	8.05	400	158	18.0	.	.	1.11	.	3.30	.	.	.	.	.
25	112	74	5.4	8.00	343	146	17.7	.	.	2.22	.	3.26	.	.	.	.	.
25	269	74	2.8	8.37	1209	182	17.7	.	.	0.65	.	2.78	.	.	.	.	.
25	348	74	15.2	8.20	1513	124	23.5	.	.	0.80	.	1.13	.	.	.	.	.
26	354	74	5.7	8.22	329	135	24.9	46.7	.	0.68	.	2.68	.	.	21	.	.
26	354	75	.	7.64	324	.	26.9	.	.	.	.	4.93	.	.	33	.	.
26	354	77	.	8.06	311	139	22.7	.	.	.	.	0.81	.	198	567	.	.
26	354	78	.	8.05	317	122	27.9	.	.	.	.	0.79	.	185	5	.	.
26	359	74	11.7	7.79	171	26	28.2	.	.	0.08	.	0.45	.	.	.	.	.
26	359	75	.	6.81	202	34	24.6	23.8	.	.	.	1.01	10	.	10	.	.
26	359	76	.	6.77	282	32	27.5	72.5	.	.	.	1.48	.	.	11	.	.
26	359	78	.	6.95	638	44	28.7	280.0	.	.	300	1.48	.	441	6	.	.
26	360	74	5.8	8.14	492	133	23.2	.	.	0.90	.	1.47	.	.	.	.	.
28	218	77	.	.	.	.	23.0	.	.	.	.	0.32	.	.	.	.	.
28	219	77	.	.	.	.	25.2	.	.	.	.	0.47	.	.	.	.	.
28	219	78	.	.	.	.	.	.	.	.	.	0.47	.	.	.	.	.
29	100	74	9.4	7.84	274	99	17.7	.	.	0.75	.	1.49	.	.	.	.	.
29	113	74	12.9	8.24	577	207	16.9	.	.	0.43	.	1.60	.	.	.	.	.
29	114	74	15.2	8.20	2393	152	16.8	.	.	0.14	.	0.51	.	.	.	.	.
30	215	74	7.1	7.86	466	227	17.1	.	.	0.16	.	0.47	.	.	.	.	.
30	217	74	8.7	7.82	480	247	16.7	.	.	0.13	.	0.48	.	.	.	.	.
33	300	75	78.8	8.21	40	28	16.2	.	.	0.04	.	0.49	.	.	.	.	.
34	041	71	.	7.36	56	24	19.4	.	1.0	.	.	0.15	.	40	0	.	.
34	041	72	.	7.54	57	21	20.3	.	0.9	.	.	0.12	.	44	0	.	.
34	041	73	.	7.30	60	.	19.8	.	1.1	.	.	0.16	.	49	.	.	.

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	YEAR	CDEP	CPHF	CCNF	CALK	CTMP	CTRJ	CTRH	CTRN	CTCO	CALPH	CRTL	CRFL	CRNF	CALG	CBIO
34	041	74	.	6.91	54	.	21.2	.	1.1	.	.	0.12	.	.	.	.	.
34	041	75	.	7.55	65	.	18.2	.	1.9	.	.	0.21	.	.	.	.	.
34	041	76	.	7.83	57	.	19.1	.	1.4	.	.	0.28	.	.	.	.	.
34	041	78	.	7.48	67	.	20.2	.	0.9	.	.	0.27	.	500	.	.	.

WATER QUALITY SUMMARY BY RESERVOIR-YEAR
POOL DATA SCREEN CODE=A

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CPTL	TOTAL PHOSPHORUS (MG/M3)	85	66.83	58.21	5.63	277.04
CPOT	ORTHO PHOSPHORUS (MG/M3)	67	22.70	28.12	3.83	187.72
CPDS	DISSOLVED PHOSPHORUS (MG/L)	18	21.34	17.57	10.00	79.05
CNTL	TOTAL NITROGEN (MG/M3)	85	1159.05	973.24	247.34	6075.00
CNIN	INORGANIC NITROGEN (MG/M3)	85	651.38	800.26	44.54	5064.16
CCHA	CHLOROPHYLL-A (MG/M3)	65	13.04	11.52	1.18	67.13
CCFU	UNCORRECTED CHLOROPHYLL-A (MG/M3)	20	9.73	6.56	2.68	27.47
CCHAMX	MAXIMUM CHLOROPHYLL-A (MG/M3)	65	20.97	17.48	1.73	84.19
CSEC	SECCHI DEPTH (M)	85	1.33	0.96	0.19	4.32
NPTL	NUMBER OF TOTAL P SAMPLING DATES	85	3.80	1.89	2.11	16.80
NCHA	NUMBER OF CHL-A SAMPLING DATES	85	3.28	0.71	2.11	6.00
NNTL	NUMBER OF TOTAL N SAMPLING DATES	85	3.70	1.52	2.11	12.40
NSEC	NUMBER OF SECCHI SAMPLING DATES	85	3.53	1.07	2.11	6.00
EPTL	CV OF MEAN TOTAL P ESTIMATE	85	0.18	0.09	0.04	0.42
ECHA	CV OF MEAN CHL-A ESTIMATE	85	0.26	0.10	0.06	0.49
ENTL	CV OF MEAN TOTAL N ESTIMATE	85	0.14	0.06	0.05	0.35
ESEC	CV OF MEAN SECCHI ESTIMATE	85	0.17	0.09	0.03	0.45
---------- POOL DATA SCREEN CODE=B ----------						
CPTL	TOTAL PHOSPHORUS (MG/M3)	73	57.49	52.99	6.55	248.29
CPOT	ORTHO PHOSPHORUS (MG/M3)	51	18.81	22.20	3.33	97.06
CPDS	DISSOLVED PHOSPHORUS (MG/L)	24	26.34	23.28	4.03	108.62
CNTL	TOTAL NITROGEN (MG/M3)	57	1541.61	2005.60	114.99	9307.14
CNIN	INORGANIC NITROGEN (MG/M3)	68	897.34	1606.22	20.00	7434.28
CCHA	CHLOROPHYLL-A (MG/M3)	51	9.76	10.15	0.63	66.88
CCFU	UNCORRECTED CHLOROPHYLL-A (MG/M3)	25	9.20	8.93	1.60	30.99
CCHAMX	MAXIMUM CHLOROPHYLL-A (MG/M3)	51	14.83	15.48	1.24	97.29
CSEC	SECCHI DEPTH (M)	73	1.59	1.39	0.22	7.08
NPTL	NUMBER OF TOTAL P SAMPLING DATES	73	3.47	1.99	2.00	8.00
NCHA	NUMBER OF CHL-A SAMPLING DATES	73	2.83	1.35	2.00	7.00
NNTL	NUMBER OF TOTAL N SAMPLING DATES	73	2.66	2.28	0.00	8.00
NSEC	NUMBER OF SECCHI SAMPLING DATES	73	3.45	1.75	2.00	7.00
EPTL	CV OF MEAN TOTAL P ESTIMATE	73	0.24	0.16	0.00	0.74
ECHA	CV OF MEAN CHL-A ESTIMATE	73	0.32	0.20	0.01	0.97
ENTL	CV OF MEAN TOTAL N ESTIMATE	57	0.17	0.10	0.03	0.52
ESEC	CV OF MEAN SECCHI ESTIMATE	73	0.20	0.14	0.04	0.77

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
03	307	73	11	5	.	941	660	4.9	.	6.8	3.49	3	3	3	3	0.04	0.18	0.11	0.10
04	312	73	96	54	.	1724	1156	18.0	.	42.2	1.20	3	3	3	3	0.37	0.49	0.19	0.24
06	372	73	50	14	.	677	224	8.1	.	12.3	1.09	3	3	3	3	0.20	0.24	0.13	0.19
10	001	77	138	27	.	444	277	.	6.8	.	0.78	4	4	4	4	0.16	0.18	0.19	0.05
10	003	73	24	7	.	1152	843	2.6	.	3.6	1.23	3	3	3	3	0.42	0.26	0.07	0.24
10	004	77	195	47	.	495	197	.	6.0	.	0.82	4	4	4	4	0.38	0.14	0.07	0.12
10	008	77	177	22	.	516	259	.	11.8	.	0.75	4	4	4	3	0.23	0.22	0.22	0.05
10	072	78	58	5	.	510	196	12.4	.	23.6	0.92	5	5	3	5	0.27	0.26	0.19	0.18
10	073	75	67	.	32	615	376	12.4	.	31.9	0.50	17	5	12	4	0.08	0.33	0.06	0.13
10	411	73	40	10	.	1409	917	4.0	.	5.6	1.20	3	3	3	3	0.34	0.23	0.09	0.16
15	178	77	21	7	.	698	255	7.2	.	12.9	2.92	3	3	3	3	0.18	0.33	0.09	0.03
15	237	74	277	188	.	1739	295	41.3	.	53.6	0.75	3	3	3	3	0.13	0.20	0.16	0.20
16	243	73	59	11	.	1428	645	14.6	.	21.8	0.86	3	3	3	3	0.18	0.25	0.16	0.08
16	254	73	63	7	.	1219	169	36.2	.	51.1	0.88	3	3	3	3	0.23	0.18	0.13	0.09
16	317	73	60	8	.	1042	299	26.8	.	45.0	0.93	3	3	3	3	0.17	0.29	0.09	0.09
16	328	73	21	6	.	735	366	3.7	.	5.4	2.18	3	3	3	3	0.22	0.28	0.09	0.24
16	393	73	6	5	.	618	390	1.2	.	1.7	3.08	3	3	3	3	0.06	0.23	0.12	0.18
17	241	73	41	6	.	945	423	16.4	.	26.5	0.96	3	3	3	3	0.18	0.27	0.18	0.15
17	242	73	167	20	.	2887	2072	10.9	.	19.4	0.28	3	3	3	3	0.35	0.41	0.09	0.14
17	245	73	127	12	.	1765	503	67.1	.	84.2	0.44	3	3	3	3	0.25	0.14	0.06	0.16
17	247	73	114	28	.	3290	2521	9.6	.	13.4	0.73	3	3	3	3	0.30	0.27	0.25	0.37
17	248	73	102	34	.	3106	2108	10.8	.	15.7	0.40	3	3	3	3	0.09	0.25	0.15	0.13
17	249	73	187	48	.	3204	1701	26.1	.	35.4	0.46	3	3	3	3	0.17	0.23	0.15	0.12
17	256	73	40	10	.	950	480	22.8	.	37.0	1.10	3	3	3	3	0.19	0.31	0.10	0.06
17	258	73	52	9	.	1052	243	37.7	.	56.0	0.86	3	3	3	3	0.25	0.21	0.08	0.13
17	373	73	11	4	.	523	198	5.6	.	9.5	2.24	3	3	3	2	0.11	0.38	0.07	0.30
17	391	73	13	6	.	858	602	6.2	.	13.4	3.53	3	3	3	3	0.14	0.49	0.11	0.33
18	090	75	55	.	18	2550	1822	.	3.5	.	1.14	6	3	6	6	0.20	0.43	0.07	0.19
18	090	77	28	.	12	2792	1722	.	12.3	.	0.94	6	3	6	6	0.05	0.37	0.22	0.22
18	091	75	118	.	43	6075	5064	.	12.6	.	0.44	6	4	6	6	0.22	0.29	0.24	0.21
18	092	73	104	36	.	3070	2278	15.8	.	23.6	0.67	3	3	3	3	0.22	0.24	0.10	0.08
18	093	73	31	8	.	763	246	7.2	.	11.1	1.64	3	3	3	3	0.13	0.25	0.08	0.17
18	093	77	20	.	10	492	217	.	5.0	.	1.89	6	4	6	5	0.40	0.15	0.14	0.06
18	095	77	27	.	14	2367	1555	.	9.4	.	1.04	6	4	6	6	0.15	0.27	0.11	0.13
18	097	77	21	.	10	1498	809	.	11.6	.	1.07	6	4	6	6	0.07	0.19	0.17	0.09
18	120	73	44	12	.	838	453	8.4	.	11.1	1.19	3	3	3	3	0.10	0.19	0.21	0.11
18	120	77	15	.	11	600	462	.	5.1	.	1.78	5	3	5	6	0.15	0.06	0.28	0.15
18	121	77	19	.	11	470	239	.	2.8	.	1.45	5	3	5	4	0.34	0.07	0.13	0.42
18	126	77	25	.	15	543	330	.	2.7	.	1.64	7	6	7	4	0.25	0.21	0.15	0.36
18	128	77	18	.	10	683	485	.	5.6	.	1.68	6	5	6	6	0.27	0.14	0.27	0.10

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
18	129	77	17	.	14	642	448	.	3.7	.	1.72	6	4	6	6	0.15	0.14	0.26	0.12
18	134	75	21	.	15	760	620	.	3.5	.	2.23	7	3	5	5	0.24	0.18	0.35	0.09
18	260	77	234	.	79	1705	678	.	27.5	.	0.33	7	4	7	6	0.17	0.14	0.11	0.08
18	263	77	39	.	12	1576	759	.	12.4	.	0.84	7	4	7	6	0.16	0.35	0.07	0.17
19	119	73	125	54	.	750	464	13.3	.	18.4	0.69	2	2	2	2	0.05	0.33	0.06	0.10
19	122	73	16	7	.	477	200	3.8	.	7.1	1.72	3	3	3	3	0.18	0.33	0.10	0.22
19	338	73	142	71	.	760	465	8.4	.	10.8	0.65	3	3	3	3	0.22	0.20	0.07	0.13
19	340	73	45	16	.	569	116	10.0	.	14.7	1.77	3	3	3	3	0.07	0.22	0.15	0.10
19	340	75	38	.	15	599	154	.	17.5	.	1.04	4	3	4	3	0.22	0.11	0.11	0.05
19	340	76	47	.	23	425	216	.	17.2	.	1.23	4	4	4	4	0.15	0.14	0.12	0.12
19	340	78	76	.	39	733	373	.	17.7	.	0.92	5	6	5	4	0.17	0.17	0.13	0.08
19	342	73	58	18	.	629	281	8.9	.	12.4	0.76	3	3	3	3	0.13	0.24	0.16	0.13
19	343	73	10	6	.	443	189	3.6	.	6.4	4.32	3	3	3	3	0.14	0.34	0.14	0.19
20	081	73	84	31	.	2091	1322	17.4	.	23.9	0.56	3	3	3	3	0.05	0.18	0.06	0.09
20	087	73	69	32	.	4352	3687	17.1	.	28.6	0.98	3	3	3	3	0.24	0.29	0.20	0.27
20	088	73	71	14	.	1211	237	23.5	.	32.0	0.72	3	3	3	3	0.07	0.19	0.16	0.10
21	196	74	34	5	.	386	109	9.6	.	12.5	1.02	3	3	3	3	0.09	0.19	0.05	0.24
24	011	74	31	8	.	547	240	3.9	.	6.6	2.14	4	4	4	4	0.13	0.21	0.11	0.19
24	013	74	16	4	.	527	196	4.0	.	6.4	3.96	4	4	4	4	0.11	0.17	0.15	0.13
24	016	74	13	4	.	330	68	4.2	.	5.4	3.45	3	3	3	3	0.10	0.14	0.09	0.10
24	022	74	16	5	.	471	208	3.4	.	6.2	3.65	4	4	4	4	0.12	0.24	0.14	0.15
24	193	74	19	4	.	337	151	3.6	.	5.0	1.40	3	3	3	3	0.13	0.27	0.16	0.31
24	200	74	29	10	.	636	290	9.1	.	17.3	2.27	4	4	4	4	0.13	0.25	0.14	0.10
25	105	74	221	74	.	1858	1214	9.5	.	15.6	0.19	3	3	3	3	0.39	0.38	0.16	0.31
25	107	74	64	13	.	1122	601	12.4	.	22.8	0.41	3	3	3	3	0.27	0.45	0.26	0.22
25	267	74	90	36	.	854	386	4.4	.	8.3	0.45	4	4	4	4	0.10	0.23	0.05	0.12
25	273	74	212	95	.	1287	603	27.0	.	54.5	0.37	3	3	3	3	0.12	0.45	0.09	0.23
25	275	74	82	28	.	972	553	5.3	.	9.3	0.47	3	3	3	3	0.20	0.34	0.08	0.20
25	278	74	38	17	.	837	469	6.6	.	13.2	1.64	4	4	4	4	0.12	0.31	0.13	0.15
25	281	74	97	32	.	686	245	5.1	.	7.4	0.58	3	3	3	3	0.16	0.23	0.06	0.25
25	370	74	47	11	.	639	133	12.5	.	20.1	0.84	3	3	3	3	0.18	0.30	0.10	0.40
26	355	74	131	28	.	854	345	17.4	.	26.6	0.63	3	3	3	3	0.35	0.25	0.18	0.27
28	219	75	20	5	.	344	45	3.3	.	5.5	1.22	3	3	3	3	0.12	0.28	0.09	0.07
29	106	74	68	9	.	1193	539	16.0	.	25.4	0.34	3	3	3	3	0.18	0.34	0.10	0.08
29	108	74	94	34	.	1169	623	18.9	.	31.4	0.85	3	3	3	3	0.31	0.34	0.16	0.26
29	109	74	36	9	.	877	325	30.4	.	64.6	1.04	3	3	3	3	0.17	0.49	0.16	0.26
29	110	74	56	20	.	1510	1072	5.4	.	8.7	0.55	3	3	3	3	0.15	0.27	0.13	0.10
29	111	74	45	20	.	1526	1109	8.4	.	11.7	0.47	3	3	3	3	0.14	0.24	0.09	0.07
29	194	74	48	12	.	810	331	10.1	.	13.3	1.23	3	3	3	3	0.19	0.20	0.19	0.24
29	195	74	22	7	.	910	594	9.0	.	19.9	1.81	3	3	3	3	0.12	0.47	0.15	0.16

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=A

DIS	RES	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
29	207	74	125	63	.	1033	318	27.8	.	49.8	0.61	3	3	3	3	0.23	0.33	0.23	0.27
30	064	75	57	8	.	815	48	23.3	.	50.1	0.78	3	3	3	3	0.13	0.40	0.10	0.10
30	235	74	73	12	.	460	158	7.4	.	9.0	2.32	3	3	3	3	0.27	0.15	0.23	0.15
31	077	75	13	8	.	247	57	2.4	.	3.8	2.49	3	3	3	3	0.12	0.25	0.08	0.12
32	204	75	47	37	.	281	74	2.8	.	4.3	4.04	3	3	3	3	0.24	0.30	0.11	0.45

POOL DATA SCREEN CODE=B

DIS	RES	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
02	176	72	7	.	4	.	251	4.9	.	6.6	2.39	3	3	0	3	0.17	0.41	.	0.17
04	320	74	31	7	.	1078	702	.	3.3	.	2.97	3	3	3	3	0.25	0.47	0.14	0.31
08	074	73	22	6	.	473	121	7.7	.	9.6	1.76	2	2	2	2	0.20	0.20	0.15	0.12
08	330	73	11	4	.	390	100	6.7	.	8.2	2.61	2	2	2	2	0.10	0.17	0.13	0.18
10	069	73	20	5	.	767	134	7.6	.	9.8	1.61	2	2	2	2	0.15	0.24	0.25	0.09
10	071	73	38	10	.	808	401	6.8	.	8.7	1.03	2	2	2	2	0.28	0.25	0.09	0.13
10	072	73	44	9	.	872	248	9.9	.	12.4	1.09	2	2	2	2	0.25	0.26	0.12	0.08
10	076	73	17	4	.	506	124	6.3	.	7.3	2.59	2	2	2	2	0.18	0.12	0.15	0.08
14	099	74	183	97	.	5967	5328	13.9	.	21.4	0.60	2	3	2	3	0.07	0.36	0.52	0.32
15	178	72	21	.	13	.	115	12.5	.	16.5	2.32	3	3	0	3	0.17	0.19	.	0.07
15	178	76	23	5	13	.	140	8.6	.	9.6	2.75	3	3	0	3	0.18	0.06	.	0.05
15	178	78	16	3	.	710	233	7.1	.	7.9	2.23	3	3	3	3	0.33	0.09	0.06	0.20
15	179	79	209	.	109	.	103	66.9	.	97.3	0.85	4	3	0	4	0.20	0.29	.	0.23
15	181	72	19	.	13	.	133	6.2	.	7.9	2.19	3	3	0	3	0.17	0.14	.	0.09
15	399	78	55	.	21	.	.	18.5	.	25.8	1.33	3	3	0	3	0.07	0.20	.	0.06
15	399	79	119	.	66	.	854	18.4	.	31.9	1.43	7	7	0	7	0.09	0.18	.	0.12
16	328	72	35	.	16	.	399	12.6	.	16.7	1.30	3	3	0	3	0.33	0.16	.	0.32
17	389	73	81	20	.	1769	1442	14.3	.	26.3	0.67	3	3	3	3	0.04	0.52	0.22	0.24
18	090	73	24	.	15	3087	2301	.	8.5	.	1.18	4	2	4	6	0.11	0.68	0.22	0.15
18	091	74	211	.	65	9307	7434	.	4.5	.	0.43	7	2	7	5	0.50	0.45	0.10	0.26
18	091	77	68	.	35	6767	4541	.	19.0	.	0.84	3	2	2	2	0.34	0.62	0.40	0.09
18	092	74	56	.	36	8180	7002	.	3.4	.	0.96	5	2	5	5	0.39	0.07	0.19	0.23
18	092	75	60	.	26	4025	3271	.	4.1	.	0.95	6	2	6	6	0.23	0.07	0.13	0.18
18	092	77	37	.	26	6212	5487	.	2.9	.	1.12	4	2	4	3	0.35	0.20	0.27	0.18
18	094	75	38	.	22	3733	3090	.	5.4	.	1.07	6	3	6	6	0.27	0.58	0.07	0.12
18	095	76	32	.	12	2367	1702	.	13.6	.	1.17	6	2	6	7	0.34	0.36	0.13	0.18
18	097	75	37	.	22	2400	1812	.	14.6	.	0.95	6	2	6	5	0.16	0.72	0.16	0.09
18	121	75	24	.	16	540	150	.	1.6	.	1.29	7	2	5	6	0.38	0.69	0.16	0.17
18	126	74	17	.	11	971	566	.	6.5	.	1.48	6	2	7	7	0.34	0.08	0.18	0.16

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
18	128	75	41	.	25	1043	496	.	6.4	.	1.24	7	2	7	7	0.38	0.01	0.24	0.15
18	129	74	21	.	11	1257	759	.	3.9	.	1.33	7	2	7	7	0.18	0.41	0.13	0.13
18	134	77	14	.	11	636	361	.	3.2	.	1.52	7	4	7	2	0.19	0.15	0.22	0.60
18	263	75	48	.	16	2044	1245	.	5.0	.	1.14	8	3	8	7	0.21	0.53	0.14	0.09
22	014	74	21	4	.	373	80	14.6	.	23.7	2.16	2	2	2	2	0.13	0.50	0.12	0.11
22	019	74	17	5	.	320	78	5.4	.	7.4	2.82	2	2	2	2	0.11	0.28	0.16	0.30
22	188	73	142	18	.	1082	368	4.6	.	5.9	0.44	2	2	2	2	0.49	0.24	0.04	0.37
22	189	73	49	10	.	740	185	4.8	.	6.3	1.05	2	2	2	2	0.40	0.27	0.07	0.23
22	190	73	61	9	.	828	330	5.2	.	6.9	0.62	2	2	2	2	0.34	0.26	0.14	0.41
22	192	73	39	11	.	594	165	7.2	.	9.4	1.32	2	2	2	2	0.46	0.27	0.05	0.52
24	012	74	72	8	.	539	140	10.3	.	11.7	0.46	2	2	2	2	0.22	0.12	0.13	0.24
24	021	74	43	7	.	444	184	19.6	.	36.2	0.88	2	2	2	2	0.09	0.74	0.03	0.08
25	020	74	51	6	.	649	106	20.3	.	30.0	0.89	2	2	2	2	0.08	0.37	0.10	0.15
25	102	74	76	28	.	1312	872	9.8	.	15.6	0.36	2	3	2	3	0.40	0.34	0.33	0.10
25	103	74	57	14	.	933	620	2.6	.	3.7	0.24	2	3	2	3	0.50	0.38	0.22	0.19
25	104	74	51	16	.	806	491	7.7	.	14.8	0.29	2	3	2	3	0.15	0.41	0.18	0.04
25	112	74	71	10	.	745	458	6.6	.	12.8	0.29	2	3	2	3	0.07	0.42	0.14	0.04
25	269	74	70	15	.	715	148	7.1	.	10.6	0.34	2	2	2	2	0.06	0.44	0.09	0.12
25	348	74	85	30	.	719	207	16.1	.	24.6	1.18	2	3	2	3	0.17	0.31	0.07	0.15
26	354	74	48	15	.	655	331	5.7	.	7.9	0.38	3	3	2	3	0.21	0.20	0.33	0.18
26	354	75	177	92	.	.	333	.	5.6	.	0.22	2	2	0	2	0.14	0.21	.	0.08
26	354	77	98	24	.	.	304	.	28.0	.	0.66	3	3	0	3	0.28	0.90	.	0.44
26	354	78	163	35	.	.	430	.	3.3	.	1.14	2	2	0	2	0.57	0.97	.	0.33
26	359	74	65	47	.	510	99	6.7	.	9.0	1.80	2	2	2	2	0.45	0.27	0.16	0.18
26	359	75	49	27	.	.	.	.	30.5	.	0.78	2	2	0	2	0.29	0.29	.	0.08
26	359	76	76	17	.	.	295	.	31.0	.	0.44	2	2	0	2	0.74	0.10	.	0.37
26	359	78	248	62	.	.	400	.	14.0	.	0.55	2	2	0	2	0.68	0.29	.	0.77
26	360	74	110	29	.	1081	145	28.5	.	42.6	0.46	2	3	2	3	0.00	0.26	0.05	0.33
28	218	77	20	7	.	356	.	3.8	4.0	7.8	2.41	3	3	3	3	0.30	0.54	0.41	0.19
28	219	77	22	5	.	456	.	4.4	4.7	6.8	1.71	2	2	2	2	0.56	0.53	0.23	0.38
28	219	78	26	17	28	430	.	2.6	2.7	2.8	1.88	2	2	2	2	0.19	0.07	0.23	0.30
29	100	74	70	9	.	1787	1128	12.0	.	27.1	0.61	2	3	2	3	0.19	0.48	0.07	0.18
29	113	74	162	95	.	1688	1212	11.3	.	18.8	0.74	2	3	2	3	0.23	0.27	0.14	0.32
29	114	74	23	5	.	887	290	8.9	.	17.6	1.39	2	3	2	3	0.05	0.45	0.10	0.33
30	215	74	62	20	.	1078	200	15.4	.	27.8	1.19	2	3	2	3	0.45	0.37	0.21	0.26
30	217	74	55	17	.	914	104	17.0	.	26.9	1.11	2	3	2	3	0.34	0.27	0.13	0.11
33	300	75	20	10	.	288	57	3.2	.	3.8	1.75	2	2	2	2	0.09	0.17	0.24	0.13
34	041	71	45	9	.	262	41	1.0	.	1.8	5.68	8	5	6	7	0.17	0.23	0.14	0.06
34	041	72	16	7	.	264	21	1.3	.	2.5	6.50	7	7	7	6	0.15	0.21	0.23	0.12
34	041	73	10	10	.	115	25	0.9	.	1.5	5.44	6	6	6	6	0.00	0.19	0.04	0.14

WATER QUALITY SUMMARY BY RESERVOIR-YEAR

POOL DATA SCREEN CODE=B

DIS	RES	YEAR	CPTL	CPOT	CPDS	CNTL	CNIN	CCHA	CCFU	CCHAMX	CSEC	NPTL	NCHA	NNTL	NSEC	EPTL	ECHA	ENTL	ESEC
34	041	74	10	10	.	186	24	0.8	.	1.8	7.08	7	7	7	7	0.00	0.23	0.22	0.09
34	041	75	13	10	.	.	34	1.5	.	3.3	3.95	7	7	0	6	0.14	0.24	.	0.19
34	041	76	10	10	.	.	20	0.6	.	1.2	3.44	6	7	0	5	0.00	0.20	.	0.24
34	041	78	12	10	.	205	47	1.0	.	1.6	3.39	4	4	4	3	0.20	0.25	0.35	0.49

APPENDIX C

U. S. Army Corps of Engineers Model Testing Data Sets

Table C1: Nutrient Input/Output Data Set
Table C2: Nutrient Loading/Water Quality Response Data Set
Table C3: Oxygen Status Data Set

Note: Data summaries precede listings; tables C1 and C2 include only data passing screening criteria described in Part III of the main text and listed in Table 14.

Table C1

Nutrient Input/Output Data Set

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
IPTL	INFLOW TOTAL P (MG/M3)	62	179.13	185.85	13.46	1050.46
OPTL	OUTFLOW TOTAL P (MG/M3)	62	72.17	56.67	8.29	224.80
IPDS	INFLOW DISSOLVED P (MG/M3)	62	61.97	67.92	6.68	375.65
OPDS	OUTFLOW DISSOLVED P (MG/M3)	62	30.52	30.44	5.22	174.14
INTL	INFLOW TOTAL N (MG/M3)	62	2214.49	1824.22	190.25	9469.81
ONTL	OUTFLOW TOTAL N (MG/M3)	62	1596.49	1266.84	245.54	7298.11
ININ	INFLOW INORGANIC N (MG/M3)	62	1082.84	1378.57	32.50	7526.29
ONIN	OUTFLOW INORGANIC N (MG/M3)	62	812.55	1052.74	47.61	5952.35
ZMEA	MEAN DEPTH (M)	62	9.81	8.97	1.53	57.59
THYD	RESIDENCE TIME (YR)	62	0.32	0.33	0.01	1.89
QSOV	OVERFLOW RATE (M/YR)	62	81.59	123.88	3.23	779.14
SEDM	SEDIMENTATION RATE (KG/M2-YR)	17	35.79	39.80	3.97	142.10

NUTRIENT INPUT/OUTPUT DATA SET

DIS	RES		IPTL	OPTL	IPDS	OPDS	INTL	ONTL	ININ	ONIN	ZMEA	THYD	QSOV	SEDM
03	307	BELTZVILLE	13.5	10.9	6.7	6.7	1160	1149	704	739	13.4	0.243	55.1	.
04	312	F J SAYERS (BLA	168.2	82.9	106.7	41.6	2691	2032	1804	1236	4.5	0.046	98.0	.
06	372	JOHN H KERR	132.4	25.9	36.6	13.4	1351	1225	363	302	9.3	0.246	37.7	23.56
08	074	CLARK HILL	55.7	24.3	15.9	8.7	697	892	274	225	10.7	0.263	40.8	.
08	330	HARTWELL	54.0	9.2	21.0	5.7	695	1004	257	208	14.0	0.541	25.8	.
10	003	HOLT	38.6	34.3	11.2	10.5	1274	1676	623	824	10.9	0.014	779.1	.
10	069	ALLATOONA	75.9	25.7	16.7	8.6	734	562	302	220	9.2	0.157	58.5	.
10	071	SEMINOLE (WOODR	94.7	75.8	30.6	22.8	1406	1334	445	314	3.0	0.017	174.1	.
10	072	WALTER F GEORGE	94.9	90.2	33.0	33.3	1033	1145	430	462	5.9	0.083	71.3	.
10	076	SIDNEY LANIER	79.5	18.6	32.4	5.2	1045	801	474	412	15.3	0.894	17.1	.
10	411	BANKHEAD	64.1	52.6	15.0	11.5	1679	1557	915	728	9.4	0.038	245.6	.
14	099	RED ROCK	612.5	217.2	181.1	120.3	9470	7298	7130	5952	3.5	0.036	96.7	.
15	237	ASHTABULA (BALD	294.8	224.8	155.6	174.1	2883	2211	777	512	3.8	0.485	7.8	8.18
16	243	BERLIN	261.4	57.6	151.6	21.0	2906	2109	1797	1165	5.2	0.222	23.2	.
16	317	SHENANGO RIVER	96.8	70.0	35.2	13.3	1516	1491	707	656	3.1	0.051	61.0	.
16	328	ALLEGHENY (KINZ	45.8	31.2	12.3	9.0	688	1301	374	640	13.1	0.165	79.8	.
17	241	ATWOOD	88.3	27.5	21.2	9.5	2426	948	1562	362	4.4	0.304	14.3	.
17	242	BEACH CITY	257.6	210.2	53.1	35.6	4111	3811	3000	2565	1.5	0.013	117.1	.
17	245	CHARLES MILL	175.6	156.2	50.8	26.4	3292	2920	1894	1411	1.7	0.035	47.0	12.31
17	248	DELAWARE	267.2	175.0	95.0	71.9	4503	4001	3245	2868	3.1	0.035	88.8	9.75
17	249	DILLON	168.7	130.2	91.2	49.3	2577	2588	1670	1750	3.5	0.024	142.3	24.18
17	256	PLEASANT HILL	56.0	55.6	24.8	27.6	2047	1560	1414	1006	5.7	0.083	68.8	.
17	373	JOHN W FLANNAGA	78.0	12.3	7.4	5.3	1309	1341	436	382	19.5	0.315	62.0	.
17	389	BLUESTONE	45.9	45.7	18.2	19.2	1390	1418	1015	1062	9.8	0.022	455.2	45.31
17	391	SUMMERSVILLE	24.1	15.1	6.8	6.8	916	858	700	701	20.1	0.061	330.6	.
18	092	MISSISSINEWA	336.1	131.8	107.3	61.3	5697	3955	3432	2908	7.3	0.092	79.8	.
18	093	MONROE	30.5	12.8	8.8	5.6	938	701	596	351	5.2	0.459	11.4	.
18	120	BARREN RIVER	55.4	47.3	45.5	18.3	2022	1239	1086	877	8.0	0.159	50.2	.
19	119	BARKLEY	133.1	122.5	48.3	41.6	1187	1138	637	505	5.0	0.023	218.1	.
19	122	CUMBERLAND (WOL	58.1	33.8	12.5	7.9	1038	905	377	608	22.2	0.289	76.8	.
19	340	J PERCY PRIEST	139.7	102.9	92.7	56.1	880	886	699	522	8.2	0.208	39.6	.
19	342	OLD HICKORY	106.0	94.1	32.3	26.2	1009	927	453	414	5.8	0.018	322.5	16.36

NUTRIENT INPUT/OUTPUT DATA SET

DIS	RES		IPTL	OPTL	IPDS	OPDS	INTL	ONTL	ININ	ONIN	ZMEA	THYD	QSOV	SEDM
19	343	DALE HOLLOW	17.4	8.3	7.5	5.6	662	1485	377	818	14.5	0.675	21.4	.
20	081	CARLYLE	198.3	120.8	61.9	56.6	4205	3599	2963	2100	3.7	0.122	30.1	13.37
20	087	SHELBYVILLE	174.4	105.6	98.1	53.8	8228	6194	7526	4788	6.0	0.201	30.0	.
20	088	REND	306.2	86.1	55.6	23.3	2698	1418	924	371	3.2	0.579	5.6	.
22	189	ENID	285.6	64.9	82.4	23.2	1652	875	479	372	5.6	0.310	18.1	.
24	011	BEAVER	62.4	16.3	16.8	6.0	1013	773	482	279	17.7	0.946	18.7	.
24	013	BULL SHOALS	18.2	12.4	7.6	5.7	766	777	474	370	21.1	0.437	48.3	.
24	200	TABLE ROCK	48.7	18.1	46.4	12.8	2101	1418	930	556	19.5	0.592	33.0	.
25	020	MILLWOOD	62.3	48.3	17.2	12.3	723	459	200	118	2.3	0.025	90.3	.
25	105	JOHN REDMOND	375.9	178.0	105.6	71.4	3450	1976	1375	741	2.5	0.054	45.7	53.86
25	267	EUFAULA	360.2	191.0	83.0	59.2	1935	1475	282	484	7.4	0.315	23.7	60.35
25	269	FORT SUPPLY	73.4	51.5	20.2	14.9	1492	892	451	77	2.3	0.704	3.2	13.55
25	273	KEYSTONE	386.8	109.1	124.1	85.9	3131	1463	875	771	8.1	0.066	121.6	122.73
25	278	TENKILLER FERRY	93.2	47.9	54.8	30.6	1957	1843	780	631	16.0	0.340	47.0	.
25	281	WISTER	71.3	70.8	21.8	26.5	956	903	133	166	3.1	0.070	44.4	3.97
25	348	TEXOMA (DENNISO	402.5	92.0	85.1	46.4	2705	1188	451	245	9.7	0.407	23.9	142.10
26	347	CANYON	18.5	11.3	8.2	5.7	1403	727	957	425	13.6	0.571	23.7	.
26	354	LAVON	227.9	49.0	76.1	23.8	2161	888	678	203	5.0	0.291	17.1	19.18
26	355	LEWISVILLE(GARZ	258.2	77.0	90.7	43.8	1988	956	560	449	6.6	0.439	15.1	16.84
26	361	SOMERVILLE	120.9	65.7	49.0	20.1	1834	1225	272	90	4.6	0.311	14.8	.
26	362	STILLHOUSE HOLL	49.0	17.2	14.4	6.1	1366	649	447	258	11.9	0.453	26.3	.
29	106	KANOPOLIS	587.1	89.7	138.8	29.1	2676	1584	615	436	4.8	0.316	15.2	.
29	108	MILFORD	530.6	59.6	210.7	28.4	2767	1491	985	237	7.8	1.109	7.0	.
29	111	POMONA	138.7	59.5	53.6	14.8	3243	2280	1067	722	5.5	0.370	14.9	.
29	113	TUTTLE CREEK	1050.5	136.1	271.3	77.1	4884	2298	1861	1197	7.7	0.356	21.7	.
29	207	HARLAN COUNTY	438.8	121.9	375.6	66.1	7473	1235	999	178	6.8	1.886	3.6	22.80
30	235	SAKAKAWEA(GARRI	356.6	27.2	22.2	12.1	1430	547	178	167	18.0	0.896	20.1	.
31	077	DWORSHAK	19.3	16.6	8.0	7.8	694	387	35	78	57.6	0.596	96.7	.
33	300	HILLS CREEK	40.2	35.7	31.1	24.0	190	246	32	48	36.9	0.291	126.9	.
35	029	MENDOCINO	129.6	62.5	26.6	25.3	947	750	151	118	13.5	0.248	54.3	.

Table C2

Nutrient Loading/Water Quality Response Data Set

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
CPTL	TOTAL PHOSPHORUS (MG/M3)	43	75.98	62.44	10.17	277.04
OPTL	OUTFLOW TOTAL P (MG/M3)	43	77.52	59.16	8.29	224.80
CNTL	TOTAL NITROGEN (MG/M3)	43	1255.61	887.27	247.34	4352.30
CSEC	SECCHI DEPTH (M)	43	1.32	1.03	0.19	4.32
CCHA	CHLOROPHYLL-A (MG/M3)	43	13.65	12.06	2.42	67.13
CALPH	NONALGAL TURBIDITY (1/M)	43	1.12	1.02	0.15	5.24
IPTL	INFLOW TOTAL P (MG/M3)	43	183.45	182.74	13.36	936.81
IPDS	INFLOW DISSOLVED P (MG/M3)	43	65.09	66.97	6.68	357.65
INTL	INFLOW TOTAL N (MG/M3)	43	2380.67	1704.49	674.42	8184.93
ININ	INFLOW INORGANIC N (MG/M3)	43	1208.62	1308.16	34.80	7459.61
ZMEA	MEAN DEPTH (M)	43	9.95	9.61	1.42	57.98
THYD	RESIDENCE TIME (YR)	43	0.32	0.35	0.01	1.43
QSOV	OVERFLOW RATE (M/YR)	43	88.96	126.05	4.42	715.30
SEDM	SEDIMENTATION RATE (KG/M2-YR)	13	29.87	32.57	3.97	122.73

NUTRIENT LOADING/WATER QUALITY RESPONSE DATA SET

DIS	RES		YEAR	CPTL	OPTL	CNTL	CSEC	CCHA	CALPH	IPTL	IPDS	INTL	ININ	ZMEA	THYD	QSOV	SEDM
03	307	BELTZVILLE	73	10.7	10.9	941	3.49	4.9	0.17	13.4	6.7	1162	704	13.5	0.247	54.5	.
04	312	F J SAYERS (BLA	73	96.5	82.9	1724	1.20	18.0	0.45	166.3	104.8	2683	1788	4.7	0.048	99.1	.
06	372	JOHN H KERR	73	50.0	25.9	677	1.09	8.1	1.11	135.5	33.6	1412	378	9.3	0.176	53.2	23.56
10	003	HOLT	73	24.2	34.3	1152	1.23	2.6	0.75	38.0	11.0	1282	631	10.9	0.015	715.3	.
10	411	BANKHEAD	73	40.1	52.6	1409	1.20	4.0	0.80	64.4	15.1	1682	914	9.4	0.041	226.7	.
15	237	ASHTABULA (BALD	74	277.0	224.8	1739	0.75	41.3	0.37	298.9	155.7	2913	832	3.7	0.351	10.6	8.18
16	243	BERLIN	73	58.8	57.6	1428	0.86	14.6	0.85	249.6	136.7	2889	1833	5.2	0.196	26.6	.
16	317	SHENANGO RIVER	73	59.8	70.0	1042	0.93	26.8	0.43	96.5	35.1	1518	709	3.2	0.051	62.1	.
16	328	ALLEGHENY (KINZ	73	20.9	31.2	735	2.18	3.7	0.49	45.4	12.2	681	370	13.4	0.176	76.1	.
17	241	ATWOOD	73	41.3	27.5	945	0.96	16.4	0.82	93.4	22.8	2423	1541	4.5	0.382	11.8	.
17	242	BEACH CITY	73	167.2	210.2	2887	0.28	10.9	3.31	258.9	49.7	4343	3261	1.4	0.008	175.7	.
17	245	CHARLES MILL	73	127.0	156.2	1765	0.44	67.1	0.67	176.8	50.9	3356	1970	1.6	0.029	56.0	12.31
17	248	DELAWARE	73	102.5	175.0	3106	0.40	10.8	2.34	267.6	92.1	4728	3533	3.1	0.027	113.8	9.75
17	249	DILLON	73	186.6	130.2	3204	0.46	26.1	1.61	164.4	87.6	2532	1650	3.0	0.017	180.0	24.18
17	256	PLEASANT HILL	73	40.4	55.6	950	1.10	22.8	0.37	50.9	22.0	2138	1509	5.3	0.053	99.5	.
17	373	JOHN W FLANNAGA	73	10.6	12.3	523	2.24	5.6	0.45	72.2	7.7	1306	430	19.6	0.413	47.4	.
17	391	SUMMERSVILLE	73	12.8	15.1	858	3.53	6.2	0.15	24.2	6.7	930	709	21.0	0.056	376.3	.
18	092	MISSISSINEWA	73	103.9	131.8	3070	0.67	15.8	1.36	337.7	107.6	5737	3459	7.4	0.079	93.9	.
18	093	MONROE	73	31.1	12.8	763	1.64	7.2	0.68	28.9	8.1	922	633	5.6	0.407	13.7	.
18	120	BARREN RIVER	73	44.2	47.3	838	1.19	8.4	0.74	56.6	46.2	2022	1073	7.6	0.151	50.6	.
19	119	BARKLEY	73	124.8	122.5	750	0.69	13.3	1.13	133.2	48.4	1187	637	4.8	0.022	220.3	.
19	122	CUMBERLAND (WOL	73	15.6	33.8	477	1.72	3.8	0.54	57.9	12.7	1050	373	22.7	0.382	59.5	.
19	340	J PERCY PRIEST	73	45.1	102.9	569	1.77	10.0	0.40	139.9	92.8	881	699	8.3	0.220	37.6	.
19	342	OLD HICKORY	73	57.8	94.1	629	0.76	8.9	1.12	102.5	31.5	1024	444	5.8	0.021	280.6	16.36
19	343	DALE HOLLOW	73	10.2	8.3	443	4.32	3.6	0.22	17.6	7.7	674	379	14.4	0.765	18.8	.
20	081	CARLYLE	73	84.4	120.8	2091	0.56	17.4	1.43	198.3	61.9	4214	2972	3.7	0.122	30.5	13.37
20	087	SHELBYVILLE	73	69.3	105.6	4352	0.98	17.1	0.64	175.9	98.9	8185	7460	6.3	0.209	30.2	.
20	088	REND	73	71.1	86.1	1211	0.72	23.5	0.85	309.6	56.4	2729	929	3.1	0.696	4.4	.
24	011	BEAVER	74	30.7	16.3	547	2.14	3.9	0.57	62.5	16.9	1013	482	17.7	1.025	17.3	.
24	013	BULL SHOALS	74	15.9	12.4	527	3.96	4.0	0.17	18.2	7.6	764	473	21.3	0.502	42.4	.
24	200	TABLE ROCK	74	29.4	18.1	636	2.27	9.1	0.26	47.7	45.9	2105	927	19.7	0.588	33.4	.
25	105	JOHN REDMOND	74	221.1	178.0	1858	0.19	9.5	5.24	381.9	101.3	3492	1475	3.0	0.044	69.1	53.86

NUTRIENT LOADING/WATER QUALITY RESPONSE DATA SET

DIS	RES		YEAR	CPTL	OPTL	CNTL	CSEC	CCHA	CALPH	IPTL	IPDS	INTL	ININ	ZMEA	THYD	QSOV	SEDM
25	267	EUFAULA	74	90.0	191.0	854	0.45	4.4	2.42	359.4	88.7	1963	285	7.4	0.451	16.4	60.35
25	273	KEYSTONE	74	211.7	109.1	1287	0.37	27.0	3.23	386.7	124.1	3128	873	8.1	0.068	118.7	122.73
25	278	TENKILLER FERRY	74	37.7	47.9	837	1.64	6.6	0.53	93.4	54.7	1967	785	16.0	0.324	49.3	.
25	281	WISTER	74	96.9	70.8	686	0.58	5.1	1.59	71.1	21.6	951	131	3.0	0.070	43.0	3.97
26	355	LEWISVILLE(GARZ	74	131.0	77.0	854	0.63	17.4	1.66	318.5	135.0	2403	821	6.4	1.049	6.1	16.84
29	106	KANOPOLIS	74	68.1	89.7	1193	0.34	16.0	2.62	936.8	146.0	2916	346	5.5	0.126	44.0	.
29	108	MILFORD	74	94.5	59.6	1169	0.85	18.9	1.04	656.8	196.2	2411	1308	8.2	0.305	26.8	.
29	111	POMONA	74	45.2	59.5	1526	0.47	8.4	1.93	138.7	53.8	3245	1070	5.7	0.314	18.0	.
29	207	HARLAN COUNTY	74	125.3	121.9	1033	0.61	27.8	1.35	401.6	357.7	7411	999	7.5	1.432	5.2	22.80
30	235	SAKAKAWEA(GARRI	74	72.9	27.2	460	2.32	7.4	1.07	221.2	19.0	1301	140	18.0	1.317	13.6	.
31	077	DWORSHAK	75	13.0	16.6	247	2.49	2.4	0.35	19.3	8.0	696	35	58.0	0.597	97.2	.

Table C3

Oxygen Status Data Set

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
DTMAX	TOP-TO-BOTTOM TEMP. DIFFERENCE (DEG-C)	63	13.381	5.191	6.000	24.000
ZTHERM	MID THERMOCLINE DEPTH (M)	63	8.272	3.444	2.400	25.915
PZMAX	MAXIMUM O2 PROFILE DEPTH (M)	63	31.431	20.206	3.049	91.463
PZDOM	MINIMUM DEPTH OF ANOXIC COND. (M)	63	16.521	19.664	1.524	91.463
TH	MEAN HYPOLIMNION TEMP. (DEG-G)	63	14.452	4.437	7.500	22.500
CPTL	TOTAL PHOSPHORUS (MG/M3)	63	43.978	42.704	5.470	234.167
CCHA	CHLOROPHYLL-A (MG/M3)	51	9.092	9.497	1.036	58.983
CSEC	SECCHI DEPTH (M)	63	1.886	1.245	0.330	6.115
IPTL	INFLOW TOTAL P (MG/M3)	46	108.025	122.612	13.363	656.829
OPTL	OUTFLOW TOTAL P (MG/M3)	46	52.911	55.692	8.286	279.132
THYD	RESIDENCE TIME (YR)	62	0.533	0.745	0.007	4.321
QSOV	OVERFLOW RATE (M/YR)	62	66.436	122.062	1.042	812.107
ZMEA	MEAN DEPTH (M)	63	11.520	9.163	1.601	57.982
ZH	MEAN HYPOLIMNION DEPTH (M)	63	8.680	8.848	0.624	55.270

OXYGEN STATUS DATA SET

OXYGEN STATUS GROUP=OXIC

DIS	RES		DTMAX	ZTHERM	PZMAX	PZDOM	TH	CPTL	CCHA	CSEC	IPTL	OPTL	THYD	QSOV	ZMEA	ZH
30	235	SAKAKAWEA(GARRI	15	25.9	57.9	57.9	10.5	22.9	3.3	2.90	221.2	27.2	1.317	13.6	18.0	9.2
31	077	DWORSHAK	18	9.0	61.0	61.0	7.5	13.0	2.4	2.49	19.3	16.6	0.597	97.2	58.0	55.3
32	204	KOOKANUSA(LIBBY	15	9.0	91.5	91.5	7.5	47.2	2.8	4.04	23.1	24.1	0.412	77.9	32.1	26.6
33	300	HILLS CREEK	15	9.0	67.1	67.1	7.5	20.1	3.2	1.75	40.0	35.7	0.291	127.5	37.1	32.8
34	041	FOLSOM	18	9.1	68.6	68.6	10.5	16.6	1.0	5.07	.	.	0.104	151.8	15.8	14.5

OXYGEN STATUS GROUP=INTERMEDIATE

DIS	RES		DTMAX	ZTHERM	PZMAX	PZDOM	TH	CPTL	CCHA	CSEC	IPTL	OPTL	THYD	QSOV	ZMEA	ZH
03	307	BELTZVILLE	18	6.1	36.6	15.2	13.5	10.9	5.2	3.61	13.4	10.9	0.247	54.5	13.5	11.9
16	393	TYGART	12	10.7	36.6	21.3	19.5	5.5	1.2	2.88	19.9	32.0	0.038	437.2	16.8	9.5
17	373	JOHN W FLANNAGA	21	7.6	50.3	39.6	10.5	9.6	4.6	2.68	72.2	12.3	0.413	47.4	19.6	17.8
17	391	SUMMERSVILLE	21	9.1	76.2	53.4	13.5	12.1	7.3	3.77	24.2	15.1	0.056	376.3	21.0	17.3
19	122	CUMBERLAND (WOL	18	7.6	54.9	36.6	10.5	12.2	4.2	1.93	57.9	33.8	0.382	59.5	22.7	18.3
19	343	DALE HOLLOW	21	9.1	42.7	18.3	10.5	9.1	1.6	6.11	17.6	8.3	0.765	18.8	14.4	10.2
22	014	DE GRAY	24	6.7	51.8	30.5	7.5	19.9	15.4	2.18	.	.	1.130	13.2	14.9	13.7
22	019	OUACHITA (BLAKE	24	7.6	53.4	36.0	7.5	16.5	4.0	3.61	22.0	15.8	1.102	14.7	16.2	14.0
24	011	BEAVER	21	9.8	59.5	38.1	7.5	18.2	3.2	2.77	62.5	16.3	1.025	17.3	17.7	15.5
24	013	BULL SHOALS	21	8.2	57.9	39.6	7.5	14.3	3.7	4.22	18.2	12.4	0.502	42.4	21.3	19.1
24	016	GREERS FERRY	21	8.2	54.9	39.6	7.5	10.9	2.9	4.27	34.5	11.4	1.158	16.1	18.7	15.0
24	022	NORFOLK	18	9.1	53.4	18.3	7.5	15.2	3.4	3.86	16.4	19.3	0.628	28.6	18.0	15.4

OXYGEN STATUS DATA SET

OXYGEN STATUS GROUP=ANOXIC

DIS	RES		DTMAX	ZTHERM	PZMAX	PZDOM	TH	CPTL	CCHA	CSEC	IPTL	OPTL	THYD	QSOV	ZMEA	ZH
06	372	JOHN H KERR	15	10.7	30.5	7.6	16.5	29.9	9.2	1.52	135.5	25.9	0.176	53.2	9.3	6.9
08	074	CLARK HILL	15	6.1	42.7	6.1	16.5	17.1	7.6	2.22	55.6	24.3	0.250	42.7	10.7	9.6
08	330	HARTWELL	15	7.6	51.8	10.7	16.5	10.2	5.8	3.01	54.0	9.2	0.583	23.8	13.9	12.8
10	073	WEST POINT	9	6.7	22.9	5.2	22.5	66.7	12.4	0.50	.	.	0.152	46.8	7.1	5.2
10	076	SIDNEY LANIER	18	6.1	44.2	10.7	13.5	12.7	5.3	2.70	79.7	18.6	0.932	16.2	15.1	13.1
15	178	GULL	9	12.2	19.8	11.3	13.5	20.6	9.7	2.54	33.5	18.9	3.254	3.9	12.6	5.6
15	181	LEECH	12	14.0	25.9	15.2	10.5	18.8	6.2	2.19	51.3	22.2	4.321	1.0	4.5	5.2
15	399	EAU GALLE	6	2.4	3.0	2.4	13.5	90.0	17.4	1.38	.	.	0.069	45.5	3.1	2.7
16	243	BERLIN	6	7.6	22.9	4.3	19.5	64.1	11.7	0.83	249.6	57.6	0.196	26.6	5.2	3.7
16	328	ALLEGHENY (KINZ	12	9.1	30.5	10.7	13.5	21.4	5.8	2.29	45.4	31.2	0.176	76.1	13.4	10.3
17	241	ATWOOD	9	6.1	10.7	4.3	16.5	27.3	9.7	1.26	93.4	27.5	0.382	11.8	4.5	2.1
17	245	CHARLES MILL	9	3.7	7.6	2.4	13.5	111.2	59.0	0.49	176.8	156.2	0.029	56.0	1.6	0.6
17	247	DEER CREEK	6	7.6	13.7	5.5	16.5	70.4	10.6	0.86	90.1	127.7	0.050	88.0	4.4	0.8
17	249	DILLON	6	4.6	9.1	2.4	19.5	171.7	31.3	0.52	164.4	130.2	0.017	180.0	3.0	1.6
17	258	TAPPAN	9	5.5	9.1	4.3	16.5	41.3	28.9	0.99	30.1	29.9	0.482	9.0	4.3	2.2
17	389	BLUESTONE	6	9.1	13.7	9.1	19.5	78.9	15.3	0.67	46.0	45.7	0.007	812.1	6.1	1.5
18	090	CAGLES MILL	15	6.1	15.2	2.4	13.5	35.8	.	1.09	.	.	0.130	45.4	5.9	3.5
18	091	HUNTINGTON	6	4.6	9.1	4.0	19.5	132.3	.	0.57	.	.	0.029	146.7	4.2	2.0
18	092	MISSISSINEWA	9	7.6	21.3	5.5	16.5	58.5	9.4	0.94	337.7	131.8	0.079	93.9	7.4	4.8
18	093	MONROE	15	7.6	16.8	5.5	16.5	27.7	7.3	1.82	28.9	12.8	0.407	13.7	5.6	2.2
18	094	SALAMONIE	12	7.6	21.3	3.7	16.5	38.3	.	1.07	.	.	0.167	38.6	6.5	4.2
18	095	C M HARDEN (MAN	12	7.6	16.8	5.5	16.5	29.4	.	1.11	.	.	0.317	23.0	7.3	4.2
18	097	BROOKVILLE	18	7.6	29.0	5.5	10.5	26.2	.	1.03	.	.	0.696	15.4	10.7	8.2
18	120	BARREN RIVER	15	7.6	21.3	6.1	13.5	26.8	7.7	1.34	56.6	47.3	0.151	50.6	7.6	4.2
18	121	BUCKHORN	12	7.6	18.3	8.2	16.5	21.9	.	1.37	.	.	0.077	99.6	7.7	6.2
18	126	GREEN RIVER	18	6.7	24.4	5.5	13.5	20.8	.	1.56	.	.	0.331	27.4	9.1	6.0
18	128	NOLIN RIVER	18	6.7	29.0	7.3	13.5	29.5	.	1.46	.	.	0.265	33.8	9.0	6.9
18	129	ROUGH RIVER	15	7.6	19.8	4.6	13.5	18.7	.	1.53	.	.	0.241	29.2	7.0	4.0
18	134	CAVE RUN	15	6.7	21.3	5.5	10.5	17.5	.	1.88	.	.	0.291	28.2	8.2	4.9
18	260	WEST FORK OF MI	9	2.4	6.1	1.5	16.5	234.2	.	0.33	.	.	0.073	34.8	2.6	2.2

OXYGEN STATUS DATA SET

OXYGEN STATUS GROUP=ANOXIC

DIS	RES		DTMAX	ZTHERM	PZMAX	PZDOM	TH	CPTL	CCHA	CSEC	IPTL	OPTL	THYD	QSOV	ZMEA	ZH
18	263	CLARENCE J BROW	12	6.7	13.7	4.5	13.5	42.1	.	0.94	.	.	.	.	5.3	2.4
19	340	J PERCY PRIEST	18	7.6	29.0	5.5	13.5	32.9	8.7	1.44	139.9	102.9	0.220	37.6	8.3	6.4
20	087	SHELBYVILLE	9	6.1	15.2	6.1	19.5	51.7	16.9	1.11	175.9	105.6	0.209	30.2	6.3	4.5
22	188	ARKABUTLA	9	4.6	12.2	4.6	19.5	142.5	4.6	0.44	110.0	279.1	0.173	25.2	4.4	2.4
22	189	ENID	9	7.6	13.7	8.2	19.5	42.6	5.2	1.09	284.6	64.9	0.331	18.8	6.2	2.8
22	190	GRENADA	9	9.1	15.2	6.7	19.5	60.6	4.1	0.62	122.3	105.7	0.457	12.9	5.9	2.1
22	192	SARDIS	9	7.6	16.8	4.3	19.5	38.4	7.0	1.33	79.9	18.4	0.430	17.5	7.5	4.2
24	200	TABLE ROCK	21	9.1	65.5	12.2	7.5	22.3	7.8	2.54	47.7	18.1	0.588	33.4	19.7	17.4
25	267	EUFAULA	6	17.0	24.4	15.2	22.5	66.6	3.2	0.54	359.4	191.0	0.451	16.4	7.4	3.2
25	278	TENKILLER FERRY	12	13.7	42.7	9.1	16.5	31.9	5.2	1.90	93.4	47.9	0.324	49.3	16.0	11.4
25	281	WISTER	6	6.1	10.7	3.7	22.5	96.9	5.1	0.58	71.1	70.8	0.070	43.0	3.0	1.8
26	355	LEWISVILLE(GARZ	6	9.1	16.8	9.1	19.5	93.3	16.2	0.80	318.5	77.0	1.049	6.1	6.4	3.1
26	359	SAM RAYBURN (MC	12	10.7	25.9	7.6	19.5	49.7	6.3	1.90	.	.	2.659	2.9	7.7	3.8
29	108	MILFORD	6	15.2	19.8	15.2	19.5	94.5	18.9	0.85	656.8	59.6	0.305	26.8	8.2	3.0
29	194	POMME DE TERRE	15	7.6	25.9	4.6	10.5	41.4	7.5	1.54	43.6	64.6	0.515	18.3	9.4	6.8
29	195	STOCKTON	12	7.6	30.5	8.5	16.5	18.9	7.3	2.03	75.3	20.1	0.792	13.6	10.8	7.8

APPENDIX D

Model Residual Summaries and Analyses

Table D1

Key to Appendix D Tables

Model Category:	Internal	P Retention	Load/Response
Report Section:	V	VI	VI
	Table		
Model Code and Data Set Definitions	16,19*	22*	25,26,27*
Statistical Summaries:			
Original Parameters	D2	D4	D6
Optimal Parameters	D3	D5	D7
Regional Analyses	D8	D9	D10
Correlation Matrices	D11	D12	D13
Stepwise Regressions	D14	D15	D16

* In the main text.

Table D2

Error Statistics for Internal Models with Original Parameters

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
B01A01	218	-0.049	.289	.086	-2.48	.012	-0.93	0.65	0.417	5.14	.181
B01A02	218	-0.112	.304	.104	-5.42	<.001	-1.14	0.50	0.291	5.92	.184
B01A03	218	-0.358	.400	.287	-13.21	<.001	-1.65	0.41	-0.949	16.52	.316
B02A01	218	-0.381	.350	.267	-16.05	<.001	-1.51	0.41	-0.811	15.65	.360
B03A01	218	-0.346	.351	.242	-14.56	<.001	-1.39	0.29	-0.643	13.47	.297
B04A01	218	-0.231	.234	.108	-14.60	<.001	-1.01	0.33	0.267	7.10	.264
B05A01	218	-0.093	.253	.072	-5.40	<.001	-0.81	0.51	0.508	4.31	.186
S01A01	218	-0.244	.294	.145	-12.26	<.001	-1.26	0.27	-0.391	8.29	.175
S01A02	218	-0.274	.286	.156	-14.16	<.001	-1.23	0.28	-0.497	8.88	.215
S02A01	218	-0.405	.298	.252	-20.11	<.001	-1.28	0.21	-1.417	14.59	.379
S03A01	218	-0.395	.289	.239	-20.22	<.001	-1.34	0.15	-1.288	13.73	.338
S04A01	258	-0.022	.189	.036	-1.89	.070	-0.56	0.64	0.655	3.86	.132
S04A02	258	-0.093	.185	.043	-8.02	<.001	-0.56	0.58	0.591	4.91	.148
S05A01	258	-0.027	.212	.045	-2.03	.050	-0.52	0.73	0.565	4.88	.132
S05A02	258	-0.173	.212	.075	-13.11	<.001	-0.66	0.59	0.286	9.23	.216
S06A01	258	-0.233	.197	.093	-18.98	<.001	-0.64	0.46	0.112	11.50	.262

Statistic Definitions

N	number of observations
MEAN	mean residual (bias)
STD	standard deviation
MSE	mean squared error (uncorrected for degrees of freedom used in parameter estimation)
T	t-test for H0: mean=0
PRT	probability if greater T, given H0
MIN	minimum residual
MAX	maximum residual
R2	R-Squared
CHI2	Chi-Squared (see Part IV of main text)
MAD	median absolute deviation

Table D3

Error Statistics for Internal Models with Optimized Parameters

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
S01X01	218	-0.005	0.285	0.081	-0.25	.201	-0.929	0.565	0.308	4.85	0.192
S02X01	218	-0.001	0.294	0.086	-0.06	.239	-0.887	0.555	0.264	5.22	0.206
S03X01	218	-0.010	0.285	0.081	-0.50	.154	-0.934	0.560	0.307	4.84	0.189
S04X01	258	0.004	0.185	0.034	0.31	.190	-0.484	0.673	0.675	3.45	0.124
S04X02	212	0.001	0.153	0.023	0.12	.226	-0.370	0.311	0.774	2.86	0.117
S05X01	258	0.010	0.194	0.038	0.82	.103	-0.432	0.662	0.641	3.81	0.125
S05X02	212	-0.001	0.154	0.024	-0.09	.233	-0.342	0.333	0.773	2.90	0.125
S06X01	258	0.003	0.185	0.034	0.25	.201	-0.485	0.673	0.675	3.45	0.124
S06X02	212	0.000	0.153	0.023	0.03	.243	-0.363	0.314	0.774	2.86	0.120
B01X01	218	-0.003	0.289	0.083	-0.15	.220	-0.914	0.681	0.437	4.96	0.184
B01X02	189	0.005	0.266	0.070	0.26	.199	-0.845	0.624	0.507	4.10	0.175
B01X03	161	0.006	0.237	0.056	0.31	.189	-0.630	0.515	0.637	3.40	0.156
B01X04	137	-0.006	0.211	0.044	-0.31	.189	-0.487	0.435	0.717	2.60	0.148
B01X05	62	-0.006	0.197	0.038	-0.23	.204	-0.461	0.411	0.759	2.89	0.135
B02X01	218	0.007	0.294	0.086	0.33	.186	-0.935	0.687	0.414	5.26	0.178
B02X02	62	-0.005	0.212	0.044	-0.20	.210	-0.490	0.370	0.719	3.36	0.155
B03X01	218	-0.005	0.285	0.081	-0.25	.202	-0.887	0.686	0.450	4.91	0.179
B03X02	73	0.016	0.239	0.057	0.57	.570	-0.630	0.445	0.661	2.83	0.153
B04X01	218	-0.005	0.219	0.048	-0.32	.187	-0.659	0.596	0.674	2.58	0.136
B04X02	189	0.007	0.201	0.040	0.45	.163	-0.673	0.590	0.718	2.22	0.129
B05X01	218	-0.023	0.251	0.063	-1.33	.046	-0.772	0.543	0.572	3.68	0.169

Table D4

Error Statistics for Phosphorus Retention Models with Original Parameters

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
R01A01	62	-0.265	0.243	0.128	-8.59	<.001	-0.918	0.077	.135	10.97	0.190
R01A02	62	-0.155	0.227	0.074	-5.37	<.001	-0.672	0.276	.499	6.44	0.125
R02A01	62	-0.209	0.252	0.106	-6.53	<.001	-0.942	0.459	.287	8.89	0.150
R02A02	62	-0.178	0.252	0.094	-5.56	<.001	-0.898	0.553	.368	7.96	0.118
R02A03	62	-0.153	0.252	0.086	-4.77	<.001	-0.863	0.621	.420	7.43	0.142
R02A04	62	0.213	0.299	0.133	5.60	<.001	-0.408	1.316	.104	17.92	0.187
R03A01	62	-0.173	0.237	0.085	-5.75	<.001	-0.828	0.184	.426	7.12	0.124
R03A02	62	-0.190	0.242	0.094	-6.21	<.001	-0.867	0.153	.369	7.88	0.114
R03A03	62	-0.190	0.239	0.092	-6.26	<.001	-0.852	0.161	.379	7.72	0.118
R03A04	62	-0.123	0.225	0.065	-4.29	<.001	-0.654	0.308	.564	5.62	0.122
R03A05	62	-0.055	0.224	0.052	-1.95	.056	-0.622	0.363	.647	4.83	0.141
R03A06	62	-0.058	0.226	0.054	-2.01	.049	-0.656	0.341	.638	4.89	0.151
R03A07	62	0.021	0.264	0.069	0.63	.529	-0.736	0.350	.534	7.91	0.226
R04A01	62	-0.185	0.243	0.092	-6.00	<.001	-0.838	0.157	.377	7.67	0.119
R04A02	62	-0.268	0.263	0.140	-8.02	<.001	-1.009	0.055	.058	12.21	0.209
R04A03	62	-0.126	0.228	0.067	-4.34	<.001	-0.673	0.284	.547	5.77	0.111
R05A01	62	-0.133	0.252	0.080	-4.16	<.001	-0.868	0.527	.461	6.72	0.111
R06A01	62	-0.131	0.238	0.073	-4.33	<.001	-0.837	0.422	.508	6.18	0.125
R06A02	62	-0.095	0.229	0.060	-3.26	.002	-0.761	0.418	.593	5.40	0.121
R06A03	62	0.010	0.230	0.052	0.34	.736	-0.669	0.444	.647	5.57	0.160
R07A01	62	-0.210	0.247	0.104	-6.68	<.001	-0.939	0.383	.298	8.74	0.149
R08A01	56	0.243	0.269	0.130	6.78	<.001	-0.376	0.977	.114	18.39	0.226
R09A01	62	0.743	1.407	2.500	4.16	<.001	-0.392	7.747	-15.8	395.7	0.353
R10A01	62	-0.035	0.232	0.054	-1.19	.240	-0.703	0.535	.635	5.17	0.134
R10A02	62	-0.143	0.238	0.076	-4.74	<.001	-0.788	0.521	.486	6.66	0.120
R11A01	62	0.077	0.248	0.066	2.44	.018	-0.625	0.396	.554	8.45	0.223
R11A02	62	-0.019	0.276	0.075	-0.55	.582	-0.803	0.324	.494	8.04	0.220
R11A03	62	0.083	0.252	0.069	2.60	.012	-0.634	0.398	.533	8.92	0.224
R12A01	62	-0.026	0.194	0.038	-1.07	.289	-0.501	0.372	.747	4.08	0.121
R13A01	62	-0.100	0.219	0.057	-3.60	<.001	-0.719	0.218	.613	4.99	0.132
R13A02	62	0.036	0.206	0.043	1.37	.176	-0.526	0.409	.709	5.04	0.168
R13A03	62	-0.078	0.229	0.058	-2.68	.009	-0.718	0.245	.613	5.10	0.135
R14A01	62	-0.082	0.206	0.049	-3.15	.003	-0.624	0.325	.672	4.27	0.135
R15A01	62	-0.060	0.185	0.037	-2.55	.013	-0.539	0.375	.749	3.90	0.121
R15A02	62	-0.122	0.193	0.051	-4.96	<.001	-0.605	0.277	.653	4.83	0.114
R15A03	62	-0.033	0.184	0.034	-1.42	.161	-0.519	0.415	.768	3.82	0.118
R16A01	17	-0.031	0.243	0.056	-0.53	.601	-0.526	0.444	.099	5.25	0.156

Table D5

Error Statistics for Phosphorus Retention Models with Optimal Parameters

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
All Data											
R01X01	62	-0.030	0.234	0.055	-0.99	.324	-0.488	0.483	0.633	6.06	0.120
R02X01	62	-0.038	0.262	0.069	-1.13	.264	-0.701	0.888	0.534	7.18	0.137
R03X01	62	0.001	0.223	0.049	0.03	.978	-0.538	0.440	0.671	5.13	0.139
R04X01	62	-0.000	0.226	0.050	-0.01	.993	-0.495	0.446	0.660	5.55	0.141
R05X01	62	0.000	0.251	0.062	0.01	.992	-0.726	0.702	0.581	6.42	0.164
R06X01	62	-0.002	0.226	0.050	-0.08	.936	-0.650	0.440	0.663	5.30	0.157
R07X01	62	0.002	0.226	0.050	0.07	.946	-0.663	0.452	0.660	5.27	0.157
R08X01	62	-0.001	0.239	0.056	-0.02	.984	-0.713	0.534	0.622	5.68	0.152
R09X01	62	-0.182	0.296	0.119	-4.84	<.001	-0.931	1.005	0.199	10.97	0.167
R10X01	62	0.002	0.222	0.048	0.06	.951	-0.559	0.447	0.675	5.11	0.130
R11X01	62	0.000	0.239	0.056	0.01	.992	-0.625	0.361	0.622	6.38	0.189
R12X01	62	0.014	0.189	0.035	0.57	.568	-0.434	0.441	0.763	4.48	0.109
R13X01	62	0.001	0.206	0.042	0.04	.969	-0.554	0.380	0.718	4.56	0.165
R14X01	62	0.001	0.169	0.028	0.04	.969	-0.376	0.427	0.810	3.17	0.108
R15X01	62	0.005	0.168	0.028	0.21	.833	-0.402	0.398	0.813	3.54	0.100
R16X01	17	-0.065	0.232	0.055	-1.16	.261	-0.552	0.347	0.123	4.70	0.155
Restricted Data Set*											
R01X02	56	-0.035	0.199	0.040	-1.33	.189	-0.464	0.407	0.724	4.47	0.088
R02X02	56	-0.039	0.222	0.050	-1.31	.194	-0.486	0.790	0.655	5.35	0.111
R03X02	56	0.002	0.182	0.033	0.07	.942	-0.394	0.358	0.775	3.65	0.117
R04X02	56	-0.000	0.188	0.035	-0.00	.997	-0.426	0.362	0.760	3.99	0.130
R05X02	56	-0.000	0.205	0.041	-0.01	.996	-0.474	0.534	0.715	4.63	0.144
R06X02	56	-0.002	0.179	0.031	-0.09	.928	-0.404	0.351	0.783	3.73	0.116
R07X02	56	0.002	0.179	0.032	0.10	.917	-0.406	0.357	0.781	3.70	0.114
R08X02	56	0.001	0.190	0.035	0.03	.976	-0.443	0.428	0.756	3.99	0.117
R09X02	56	-0.162	0.241	0.083	-5.02	.000	-0.651	0.794	0.427	8.05	0.148
R10X02	56	0.003	0.180	0.032	0.12	.903	-0.398	0.369	0.780	3.58	0.111
R11X02	56	0.000	0.206	0.042	0.01	.992	-0.530	0.285	0.711	5.31	0.171
R12X02	56	0.007	0.166	0.027	0.30	.765	-0.417	0.368	0.813	3.42	0.107
R13X02	56	0.005	0.174	0.030	0.23	.815	-0.459	0.315	0.794	3.55	0.132
R14X02	56	0.002	0.155	0.024	0.08	.940	-0.404	0.378	0.837	2.70	0.100
R15X02	56	0.006	0.159	0.025	0.29	.773	-0.416	0.375	0.828	3.11	0.094

* Inflow Total P < 500 mg/m3, Inflow Ortho-P/Total P > .12

Table D6

Error Statistics for Phosphorus Loading Models with Original Parameters

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
P01A01	43	-0.255	0.249	0.126	-6.70	<.000	-1.104	0.154	0.133	16.25	0.223
P01A02	43	-0.148	0.266	0.091	-3.66	<.001	-1.041	0.291	0.373	11.44	0.198
P02A01	43	-0.206	0.255	0.106	-5.31	<.000	-1.050	0.270	0.270	13.14	0.225
P02A02	43	-0.177	0.260	0.097	-4.46	<.000	-1.025	0.325	0.329	11.88	0.189
P02A03	43	-0.154	0.265	0.092	-3.80	<.000	-1.004	0.368	0.365	11.10	0.187
P02A04	43	0.196	0.348	0.157	3.68	.001	-0.648	0.954	-0.082	21.29	0.215
P03A01	43	-0.167	0.244	0.086	-4.47	<.000	-1.007	0.247	0.406	10.94	0.169
P03A02	43	-0.183	0.244	0.092	-4.92	<.000	-1.017	0.230	0.367	11.65	0.190
P03A03	43	-0.183	0.245	0.092	-4.90	<.000	-1.022	0.227	0.367	11.66	0.176
P03A04	43	-0.118	0.262	0.081	-2.96	.005	-1.001	0.331	0.443	10.21	0.189
P03A05	43	-0.053	0.254	0.066	-1.37	.179	-0.915	0.402	0.547	8.71	0.154
P03A06	43	-0.055	0.248	0.063	-1.44	.157	-0.906	0.390	0.564	8.47	0.155
P03A07	43	0.031	0.251	0.062	0.82	.416	-0.781	0.485	0.570	9.39	0.139
P04A01	43	-0.175	0.249	0.091	-4.60	<.000	-1.024	0.234	0.370	11.74	0.163
P04A02	43	-0.257	0.252	0.128	-6.68	<.000	-1.077	0.192	0.119	16.38	0.204
P04A03	43	-0.119	0.260	0.080	-2.99	.005	-1.002	0.308	0.449	10.17	0.172
P05A01	43	-0.130	0.254	0.080	-3.36	.002	-0.973	0.343	0.448	9.89	0.155
P06A01	43	-0.132	0.245	0.076	-3.52	.001	-0.932	0.346	0.476	9.27	0.168
P06A02	43	-0.098	0.256	0.074	-2.50	.016	-0.910	0.448	0.492	8.92	0.140
P06A03	43	0.007	0.248	0.060	0.19	.847	-0.768	0.508	0.586	8.47	0.150
P07A01	43	-0.207	0.252	0.105	-5.37	<.000	-1.046	0.269	0.276	13.02	0.224
P08A01	39	0.246	0.455	0.262	3.37	.002	-0.613	1.865	-0.905	41.45	0.219
P09A01	43	0.657	1.222	1.890	3.53	.001	-0.559	5.126	-12.029	203.6	0.295
P10A01	43	-0.036	0.253	0.064	-0.92	.361	-0.866	0.476	0.560	8.19	0.130
P10A02	43	-0.143	0.262	0.088	-3.57	.001	-1.005	0.367	0.396	10.61	0.185
P11A01	43	0.090	0.227	0.059	2.59	.013	-0.583	0.522	0.597	8.71	0.159
P11A02	43	-0.008	0.259	0.065	-0.21	.838	-0.829	0.458	0.549	9.40	0.165
P11A03	43	0.096	0.232	0.062	2.71	.010	-0.606	0.535	0.574	9.37	0.171
P12A01	43	-0.022	0.217	0.047	-0.67	.503	-0.756	0.410	0.678	5.63	0.127
P13A01	43	-0.092	0.223	0.057	-2.71	.010	-0.844	0.297	0.608	7.22	0.135
P13A02	43	0.046	0.203	0.042	1.50	.141	-0.562	0.474	0.707	5.62	0.121
P13A03	43	-0.071	0.234	0.059	-1.98	.055	-0.873	0.326	0.595	7.70	0.134
P14A01	43	-0.076	0.216	0.051	-2.29	.027	-0.812	0.285	0.645	6.60	0.140
P15A01	43	-0.054	0.199	0.042	-1.79	.080	-0.638	0.420	0.712	4.90	0.107
P15A02	43	-0.116	0.210	0.057	-3.63	.001	-0.794	0.319	0.610	6.87	0.160
P15A03	43	-0.027	0.196	0.038	-0.92	.364	-0.566	0.462	0.737	4.44	0.117
P16A01	13	-0.044	0.188	0.035	-0.84	.417	-0.396	0.156	0.252	7.05	0.112

(continued)

Table D6 (continued)

Error Statistics for Phosphorus Loading Models with Original Parameters (ct)

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
B10A01	43	-0.691	0.511	0.733	-8.88	<.001	-1.865	0.264	-5.527	40.29	0.736
B11A01	43	-0.283	0.326	0.184	-5.70	<.001	-1.041	0.327	-0.636	10.66	0.325
B11A02	43	-0.179	0.288	0.113	-4.09	<.001	-0.872	0.429	-0.006	6.84	0.246
B11A03	43	-0.077	0.260	0.072	-1.93	.060	-0.691	0.583	0.360	4.68	0.187
B11A04	43	-0.058	0.272	0.075	-1.40	.169	-0.714	0.575	0.328	4.93	0.211
B11A05	43	-0.117	0.277	0.089	-2.77	.008	-0.786	0.507	0.211	5.56	0.212
B11A06	43	-0.223	0.299	0.137	-4.90	<.001	-0.938	0.371	-0.221	8.14	0.294
B11A07	43	-0.093	0.356	0.133	-1.71	.095	-0.894	0.546	-0.182	8.26	0.259
B12A01	43	-0.191	0.292	0.120	-4.28	<.001	-0.877	0.346	-0.067	7.56	0.298
B13A01	43	-0.092	0.262	0.075	-2.30	.027	-0.686	0.537	0.329	4.80	0.189
B14A01	43	-0.006	0.302	0.089	-0.14	.891	-0.593	0.718	0.204	5.76	0.189
S10A01	43	-0.243	0.207	0.101	-7.69	<.001	-0.758	0.163	0.044	12.95	0.264
S10A02	43	-0.151	0.180	0.054	-5.53	<.001	-0.575	0.271	0.485	6.67	0.184
S10A03	43	-0.545	0.255	0.360	-14.02	<.001	-1.155	-0.095	-2.410	49.01	0.543

Table D7

Error Statistics for Phosphorus Loading Models with Optimal Parameters

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
All Data											
P01X01	43	-0.078	0.284	0.085	-1.81	.077	-0.911	0.396	0.415	10.58	0.221
P02X01	43	-0.070	0.285	0.084	-1.60	.116	-0.925	0.529	0.420	9.85	0.170
P03X01	43	0.001	0.242	0.057	0.04	.971	-0.826	0.418	0.606	8.37	0.146
P04X01	43	0.000	0.249	0.061	0.00	.999	-0.842	0.419	0.582	8.65	0.153
P05X01	43	-0.000	0.248	0.060	-0.00	1.000	-0.828	0.445	0.585	8.44	0.118
P06X01	43	-0.000	0.242	0.057	-0.01	.991	-0.787	0.487	0.605	8.15	0.139
P07X01	43	-0.001	0.243	0.058	-0.03	.973	-0.785	0.489	0.603	8.22	0.137
P08X01	43	-0.001	0.244	0.058	-0.02	.987	-0.811	0.463	0.598	8.21	0.135
P09X01	43	-0.173	0.285	0.109	-3.99	<.001	-1.047	0.348	0.245	13.27	0.234
P10X01	43	0.001	0.242	0.057	0.03	.976	-0.822	0.430	0.607	8.25	0.147
P11X01	43	0.001	0.217	0.046	0.02	.981	-0.563	0.431	0.682	6.07	0.127
P12X01	43	0.015	0.207	0.042	0.47	.643	-0.670	0.433	0.711	5.54	0.105
P13X01	43	0.000	0.202	0.040	0.01	.992	-0.561	0.447	0.726	4.97	0.110
P14X01	43	-0.001	0.169	0.028	-0.03	.980	-0.433	0.389	0.807	3.64	0.110
P15X01	43	0.005	0.170	0.028	0.21	.836	-0.432	0.359	0.804	3.79	0.107
P16X01	13	-0.063	0.180	0.034	-1.27	.226	-0.401	0.121	0.264	7.34	0.096
B10X01	43	0.001	0.274	0.074	0.02	.982	-0.543	0.711	0.345	4.89	0.182
B11X01	43	0.001	0.256	0.064	0.02	.982	-0.569	0.689	0.432	4.33	0.178
B12X01	43	-0.027	0.259	0.066	-0.69	.494	-0.578	0.615	0.408	4.65	0.202
B13X01	43	0.002	0.256	0.064	0.06	.952	-0.546	0.670	0.431	4.29	0.172
B14X01	43	-0.000	0.302	0.089	-0.00	.997	-0.587	0.730	0.205	5.77	0.185
B15X01	43	-0.003	0.231	0.052	-0.08	.934	-0.533	0.548	0.536	3.35	0.165
S10X01	43	0.009	0.175	0.030	0.35	.726	-0.360	0.443	0.717	3.08	0.109
S11X01	43	0.006	0.149	0.022	0.27	.788	-0.312	0.301	0.795	2.48	0.091

(continued)

Table D7 (continued)

Error Statistics for Phosphorus Loading Models with Optimal Parameters (ct)

MODEL	N	MEAN	STD	MSE	T	PRT	MIN	MAX	R2	CHI2	MAD
---------- Restricted Data Set * ----------											
P01X02	39	-0.076	0.218	0.052	-2.16	.037	-0.452	0.342	0.639	8.01	0.195
P02X02	39	-0.072	0.216	0.051	-2.08	.044	-0.440	0.435	0.651	7.02	0.168
P03X02	39	0.000	0.182	0.032	0.01	.991	-0.338	0.373	0.776	5.99	0.131
P04X02	39	-0.000	0.186	0.034	-0.00	.998	-0.365	0.371	0.767	6.17	0.132
P05X02	39	-0.000	0.182	0.032	-0.00	.997	-0.345	0.394	0.777	5.75	0.126
P06X02	39	0.000	0.181	0.032	0.00	.999	-0.340	0.413	0.779	5.77	0.119
P07X02	39	-0.003	0.186	0.034	-0.09	.928	-0.301	0.437	0.767	5.85	0.141
P08X02	39	0.001	0.182	0.032	0.04	.971	-0.316	0.417	0.776	5.68	0.119
P09X02	39	-0.142	0.212	0.064	-4.18	<.001	-0.510	0.301	0.558	9.60	0.192
P10X02	39	-0.000	0.181	0.032	-0.00	.997	-0.326	0.391	0.780	5.75	0.120
P11X02	39	0.001	0.175	0.030	0.02	.982	-0.341	0.381	0.793	4.65	0.123
P12X02	39	0.007	0.157	0.024	0.26	.792	-0.276	0.375	0.834	3.80	0.096
P13X02	39	0.001	0.158	0.024	0.06	.953	-0.302	0.380	0.833	3.59	0.105
P14X02	39	-0.000	0.140	0.019	-0.01	.990	-0.240	0.361	0.869	2.79	0.100
P15X02	39	0.005	0.145	0.020	0.20	.839	-0.252	0.353	0.859	3.01	0.105
P15X03	39	-0.003	0.154	0.023	-0.12	.902	-0.338	0.369	0.841	3.42	0.100
B10X02	39	0.002	0.281	0.077	0.03	.973	-0.581	0.681	0.352	5.18	0.206
B11X02	39	-0.001	0.261	0.067	-0.02	.987	-0.607	0.658	0.439	4.58	0.177
B12X02	39	0.000	0.268	0.070	0.01	.991	-0.562	0.631	0.410	4.97	0.199
B13X02	39	0.001	0.263	0.067	0.03	.975	-0.576	0.642	0.432	4.58	0.186
B14X02	39	0.002	0.315	0.096	0.04	.971	-0.594	0.722	0.187	6.27	0.190
B15X02	39	-0.010	0.241	0.057	-0.25	.803	-0.543	0.538	0.521	3.67	0.169
S10X02	39	0.004	0.151	0.022	0.17	.862	-0.306	0.335	0.788	2.71	0.109
S11X02	39	0.000	0.145	0.021	0.01	.991	-0.317	0.305	0.803	2.48	0.084
---------- Low-Turbidity Data Set ** ----------											
B11X03	29	-0.008	0.244	0.057	-0.18	.857	-0.445	0.538	0.582	3.85	0.187
B15X03	29	-0.005	0.203	0.040	-0.14	.890	-0.378	0.411	0.709	2.71	0.168
S10X03	29	0.002	0.112	0.012	0.09	.928	-0.213	0.196	0.828	1.66	0.101
S11X03	29	-0.009	0.106	0.011	-0.43	.667	-0.201	0.179	0.845	1.37	0.086

* Inflow Total P < 500 mg/m3, Inflow Ortho-P/Total P > .12
** Above constraints, plus turbidity < 1.58 1/m, inflow N/P > 8

Table D8

Regional Analysis of Internal Model Residuals

Model	B01X01			B01X03			B01X05		
Region	N	Mean	Gr.	N	Mean	Gr.	N	Mean	Gr.*
02 NAD	4	.13	ABCD	4	.14	AB	3	.29	A
03 SAD	16	.00	BCDE	9	-.07	BC	1	-.08	BC
04A ORD-Pitts.	15	.13	ABC	15	.09	AB	9	-.00	B
04B ORD-Hunt.	22	.25	A	18	.21	A	6	.16	AB
04C ORD-Louis.	16	.11	ABCD	15	.05	AB	2	.18	AB
04D ORD-Nash.	21	-.01	CDE	17	-.01	BC	6	.04	AB
05 NCD	4	.04	ABCDE	1	-.05	BC	1	-.19	BC
06 LMVD	16	.18	AB	15	.05	AB	0		
07A SWD-L.Rock	36	-.01	CDE	36	-.02	BC	28	-.04	B
07B SWD-Other	36	-.25	E	15	-.11	BC	0		
08 MRD	24	-.06	DE	13	-.16	C	6	-.24	C
09 NPD	8	-.27	E	3	-.24	C	0		
Among Regions									
Sum of Squares		5.437			1.795			.911	
Deg. of Freedom		11			11			8	
Mean Square		.494			.163			.114	
Within Regions									
Sum of Squares		12.642			7.210			1.448	
Deg. of Freedom		206			149			53	
Mean Square		.061			.048			.027	
F Ratio		8.05			3.37			4.17	
Prob > F		<.001			<.001			<.001	
R-Squared **		.301			.199			.387	

* means followed by the same letter are not significantly different at $p<.05$, Duncan's multiple range test

** percent of total residual variance explained by regional effects

(continued)

Table D8 (ct)

Regional Analysis of Internal Model Residuals (ct)

Model	B04X02			B05X01			S05X02		
Region	N	Mean	Gr.	N	Mean	Gr.	N	Mean	Gr.*
02 NAD	4	.06	AB	4	.04	ABCDE	4	.10	A
03 SAD	14	.06	AB	16	.01	BCDE	14	-.07	AB
04A ORD-Pitts.	15	.04	AB	15	.07	ABC	15	-.01	A
04B ORD-Hunt.	22	.10	A	22	.19	A	22	.03	A
04C ORD-Louis.	16	.02	AB	16	.05	ABCD	30	-.05	AB
04D ORD-Nash.	17	.03	AB	21	-.02	BCDE	26	-.02	A
05 NCD	1	-.11	B	4	.06	ABCD	1	.23	A
06 LMVD	16	-.01	AB	16	.13	AB	16	.05	A
07A SWD-L.Rock	36	.01	AB	36	-.08	CDE	36	.12	A
07B SWD-Other	27	-.07	B	36	-.19	DE	27	-.11	B
08 MRD	18	-.05	B	24	-.06	CDE	18	-.01	A
09 NPD	3	.05	AB	8	-.26	E	3	-.05	AB
Among Regions									
Sum of Squares		0.490			5.242			1.167	
Deg. of Freedom		11			11			11	
Mean Square		.045			.295			.106	
Within Regions									
Sum of Squares		7.100			10.383			3.819	
Deg. of Freedom		177			206			200	
Mean Square		.040			.050			.019	
F Ratio		1.11			5.85			5.55	
Prob > F		.356			<.001			<.001	
R-Squared **		.065			.234			.234	

* means followed by the same letter are not significantly different at p<.05, Duncan's multiple range test

** percent of total residual variance explained by regional effects

Table D9

Regional Analysis of Phosphorus Retention Model Residuals

Model		R03X02		R12X02		R13X02		R14X02		R15X02	
Region	N	Mean	Gr.	Mean	Gr.	Mean	Gr.	Mean	Gr.	Mean	Gr.
02 NAD	2	.04	AB	-.00	AB	.01	A	-.03	C	-.02	B
03 SAD	9	-.09	B	-.10	B	-.10	A	-.12	C	-.11	B
04A ORD-Pitts.	3	-.07	B	-.06	AB	-.05	A	-.06	C	-.06	B
04B ORD-Hunt.	8	.03	AB	.04	AB	.09	A	.00	C	.02	AB
04C ORD-Louis.	3	.01	AB	-.01	AB	-.01	A	-.00	C	-.02	B
04D ORD-Nash.	5	.10	AB	.08	AB	.10	A	.08	ABC	.08	AB
05 NCD	1	.28	AB	.37	A	.32	A	.38	A	.37	A
06 LMVD	4	-.08	B	-.02	AB	-.03	A	.01	BC	-.01	B
07A SWD-L.Rock	3	.04	AB	-.05	AB	-.10	A	-.04	C	-.04	B
07B SWD-Other	13	-.03	B	-.01	AB	-.02	A	.00	C	-.00	B
08 MRD	2	.02	AB	.13	AB	.01	A	.09	ABC	.13	AB
09 NPD	2	.32	A	.21	A	.18	A	.26	AB	.25	A
10 SPD	1	-.00	AB	.02	AB	.01	A	.08	ABC	.06	AB
Among Regions											
Sum of Squares		.484		.417		.413		.482		.462	
Deg. of Freedom		12		12		12		12		12	
Mean Square		.040		.035		.034		.040		.038	
Within Regions											
Sum of Squares		1.338		1.096		1.254		.836		.929	
Deg. of Freedom		43		43		43		43		43	
Mean Square		.031		.026		.029		.019		.022	
F Ratio		1.30		1.36		1.18		2.07		1.76	
Prob > F		.255		.221		.327		.041		.082	
R-Squared **		.267		.275		.248		.367		.332	

* means followed by the same letter are not significantly different at $p<.05$, Duncan's multiple range test

** percent of total residual variance explained by regional effects

Table D10

Regional Analysis of Phosphorus Loading Model Residuals

Predicted Var.		Phosphorus				Chlorophyll				Transparency			
Model Code		P13X02		P15X02		B11X03		B15X03		S10X03		S11X03	
Region	N	Mean	Gr.	Mean	Gr.	Mean	Gr.	Mean	Gr.	Mean	Gr.	Mean	Gr.*
02 NAD	2	.03	AB	-.00	ABC	.11	ABC	.11	AB	.09	A	.10	A
03 SAD	3	-.09	B	-.04	BC	-.35	C	-.30	C	-.04	A	-.08	A
04A ORD-Pitts.	3	-.07	B	-.16	C	-.03	BC	-.05	BC	.05	A	.06	A
04B ORD-Hunt.	4	-.00	B	-.08	BC	.33	A	.28	A	-.07	A	-.03	A
04C ORD-Louis.	3	.07	AB	.06	ABC	-.01	ABC	.00	ABC	-.06	A	-.07	A
04D ORD-Nash.	4	-.04	B	-.05	BC	-.12	BC	-.10	BC	-.02	A	-.02	A
05 NCD	1	.40	A	.29	A	.28	AB	.19	AB	.07	A	.11	A
06 LMVD	3	-.08	B	-.19	C	.02	ABC	-.07	BC	-.01	A	.04	A
07A SWD-L.Rock	3	.08	AB	.06	ABC	.01	ABC	.02	AB	.08	A	.09	A
07B SWD-Other	1	-.08	B	.00	ABC	-.19	BC	-.09	BC	.13	A	.05	A
08 MRD	1	.07	AB	.10	ABC	.11	ABC	.15	AB	-.03	A	-.09	A
09 NPD	1	.02	AB	.15	AB	-.14	BC	.01	ABC	-.10	A	-.20	A
Among Regions													
Sum of Squares		.290		.343		1.030		.738		.112		.158	
Deg. of Freedom		11		11		11		11		11		11	
Mean Square		.026		.031		.094		.067		.010		.014	
Within Regions													
Sum of Squares		.315		.178		.635		.419		.240		.156	
Deg. of Freedom		17		17		17		17		17		17	
Mean Square		.019		.010		.037		.025		.014		.009	
F Ratio		1.43		2.97		2.51		2.72		0.72		1.56	
Prob > F		.247		.021		.043		.031		.705		.198	
R-Squared **		.480		.658		.619		.637		.318		.503	

* means followed by the same letter are not significantly different at $p<.05$, Duncan's multiple range test

** percent of total residual variance explained by regional effects

Table D11

Correlation of Internal Model Residuals with Various Reservoir Characteristics

Factor	Model S05X02	B01X01	B01X03	B01X05	B04X02	B05X01
Number of Sta-Yrs	212	218	161	62	189	218
Year Impounded	.016	-.159*	-.164*	.108	-.068	-.119*
Shoreline Dev. Ratio	.296*	-.197*	-.176*	-.305*	-.118	-.193*
Length/Width	.183*	-.197*	-.247*	-.097	-.008	-.218*
Drainage A./Surf. A	-.113	-.433*	-.433*	-.246*	-.179*	-.333*
Surface Area	.144*	-.373*	-.290*	-.521*	-.209*	-.354*
Volume	.178*	-.395*	-.330*	-.505*	-.160*	-.403*
Mean Depth	.180*	-.289*	-.291*	-.258*	-.011	-.346*
Maximum Depth	.199*	-.310*	-.307*	-.267*	-.039	-.353*
Station Total Depth	.266*	-.327*	-.300*	-.301*	-.174*	-.409*
Residence Time	.092	.001	.062	-.238*	.000	-.055
Overflow Rate	.013	-.190*	-.270*	.084	-.008	-.163*
Alkalinity	.139*	.008	-.088	-.448*	-.180*	.000*
pH	.184*	.212*	.141*	-.296*	.006	.168*
Conductivity	-.067	.118*	.043	-.103	-.020	.141*
Temperature	-.132*	.067	.121	.318*	.085	.104
Non-Algal Turb.	-.534*	-.285*	-.300*	-.086	-.055	-.106
Turb.*Mean Depth	-.446*	-.587*	-.600*	-.289*	-.074	-.436*
Total P	.030	-.001	.005	-.003	.017	.149*
Total N	.092	.182*	.077	.336*	.063	.242*
Ortho-P	.002	-.277*	-.264*	-.141	-.122*	-.114*
Inorganic N	.041	-.004	-.102	.189	-.008	.063
Total N/P	.065	.184*	.083	.264*	.049	.047
Inorganic N/P	.051	.266*	.121	.269*	.120*	.176*

* correlation coefficient significant ($p < .10$)

Table D12

Correlation of Phosphorus Retention Model Residuals with Various Reservoir Characteristics

Factor	Model R03X02	R12X02	R13X02	R14X02	R15X02
Year Impounded	.013	-.026	-.035	.029	.005
Shoreline Dev. Ratio	-.186	-.274*	-.275*	-.236*	-.248*
Length/Width	.111	.061	.183	.075	.092
Drainage A./Surf. A.	.204	.359*	.448*	.294*	.382*
Surface Area	-.204	-.226*	-.301*	-.149	-.159
Volume	-.103	-.225*	-.342*	-.119	-.131
Mean Depth	.298*	.072	-.027	.166	.153
Maximum Depth	.230*	-.010	-.107	.077	.062
Residence Time	.016	.007	-.273*	.017	.031
Overflow Rate	.127	.130	.237*	-.030	.105
Inflow Total P	-.488*	-.123	-.066	.001	-.038
Inflow Total N	-.266*	-.002	.034	.043	.024
Inflow Ortho-P	-.355*	-.009	.009	.121	.078
Inflow Inorganic N	-.219	-.071	.027	-.086	-.101
Inflow Ortho-P/Total P	.285*	.266*	.182	.292*	.283*
Sedimentation Rate (n=17)	-.563*	-.492*	-.502*	-.401*	-.367

* correlation coefficient significant at $p < .10$
based upon 56 observations, except sedimentation rate

Table D13

Correlation of Loading Model Residuals with Various Reservoir Characteristics

Predicted Variable:	Model Phosphorus		Chlorophyll		Transparency	
Factor	P13X02	P15X02	B11X03	B15X03	S10X03	S11X03
Year Impounded	-.020	.050	-.062	-.030	.115	.064
Shoreline Dev. Ratio	.137	.232	-.292	- .306	.197	.177
Length/Width	.153	.379*	-.383*	-.319*	-.057	-.212
Drainage Area/Surf. A.	.074	.418*	-.267	-.128	-.105	-.443*
Surface Area	-.014	.076	-.430*	-.457*	.098	.035
Volume	-.137	.127	-.530*	-.455*	.232	.052
Mean Depth	-.288	.158	-.461*	-.243	.359*	.058
Maximum Depth	-.239	.198	-.470*	-.263	.409*	.113
Residence Time	.012	-.021	.074	.080	.291	.375
Overflow Rate	-.198	.124	-.374*	-.241	-.075	-.358*
Alkalinity	.383*	.242	.337*	.275	.039	.111
Conductivity	-.073	-.214	-.101	-.225	-.074	-.033
Ph	.348*	.155	.532*	.488*	.055	.195
Temperature	-.150	-.188	-.362*	-.444*	-.170	-.142
Non-Algal Turbidity	-.097	-.129	-.346*	-.461*	-.362*	-.460*
Turb.*Mean Depth	-.396*	.054	-.805*	-.673*	.061	-.348*
Total N/P	-.512*	-.406*	-.148	-.067	.244	.200
Inorganic N/P	-.503*	-.503*	-.117	-.105	.024	.030
Inflow N/P	.030	.110	.237	.361*	-.082	-.063
Inflow Total P	.008	-.093	.011	-.088	.044	.006
Inflow Total N	.036	-.036	.217	.181	-.008	-.044
Inflow Ortho-P	.144	.095	.115	.065	.116	.058
Inflow Inorganic N	-.014	-.208	.256	.166	.065	.161
Inflow Ortho-P/Total P	.343*	.448*	.263	.362*	.192	.131
Sedimentation Rate(n=6)	-.801*	-.494	-.591	-.460	.108	-.386

* correlation coefficient significant at $p < .10$
based upon data from 29 reservoirs

Table D14

Results of Stepwise Regressions of Internal Model Residuals Against Various Reservoir Characteristics

	Model					
Factor	S05X02	B01X01	B01X03	B01X05	B04X02	B05X01
Number of Station-Yrs With Complete Factor Data	170	185	117	59	161	185
Intercept	-2.11*	-3.20	.69	-7.87	.28	.22
Year Impounded				.004		
Surface Area			-.07	-.13(1)	-.42(1)	-.09
Volume					.33	
Mean Depth						
Maximum Depth						
Station Total Depth	.20				-.21	-.22
Drainage A./Surface A.	-.11	-.17	-.14		-.09	-.11
Length/Width						
Shoreline Dev. Ratio	.14(1)					
Residence Time						
Surface Overflow Rate	.11	.13				
pH	.11	.33				
Temperature				.025		
Alkalinity		-.33				
Conductivity						
Total Phosphorus						.19
Ortho Phosphorus		-.18	-.11			
Total Nitrogen	.53	.96				
Inorganic Nitrogen	-.25	-.45				
Total N/P						
Inorganic N/P						
Non-Algal Turbidity	-					-.34(1)
Turbidity*Mean Depth	-	-.24(1)	-.31(1)			
R-Squared	.389	.610	.435	.355	.179	.402
Mean Squared Residual	.016	.034	.033	.026	.034	.038

(1) variable entered first in stepwise regression

* coefficient in multiple linear regression equation; all coefficients significant at $p < .05$

** all independent variables transformed to base-10 logarithms except pH, temperature, and year impounded

Table D15

Results of Stepwise Regressions of P Retention Model Residuals Against Various Reservoir Characteristics

Factor**	Model R03X02	R12X02	R13X02	R14X02	R15X02
Number of Reservoir With Complete Factor Data	51	51	51	51	51
Intercept	.28*	-.24	-.30	***	-.14
Year Impounded					
Surface Area					
Volume					
Mean Depth					
Maximum Depth					
Drainage A./Surface A.	.11	.12(1)	.15(1)		.13(1)
Length/Width					
Shoreline Dev. Ratio					
Residence Time					
Surface Overflow Rate					
Inflow Total P	-.25(1)				
Inflow Ortho P					
Inflow Total N					
Inflow Inorganic N					
Inflow Ortho P/Total P					.28
R-Squared	.329	.117	.165	.000	.208
Mean Squared Residual	.026	.025	.025	-	.021

(1) variable entered first in stepwise regression
* coefficient in multiple linear regression equation; all coefficients significant at $p < .05$
** all independent variables transformed to base-10 logarithms
*** no factors met .05 significance level

Table D16

Results of Stepwise Regressions of Loading Model Residuals Against Various Reservoir Characteristics

Predicted Var.	Phosphorus		Chlorophyll		Transparency	
Model Code	P13X02	P15X02	B11X03	B15X03	S10X03	S11X03
Number of Reservoirs with Complete Factor Data	27	27	27	27	27	27
Intercept	.14	***	.58	.54	-.77	.23
Year Impounded						
Surface Area						
Volume						
Mean Depth						
Maximum Depth					.32(1)	
Station Total Depth						
Drainage A./Surface A.						-.11(1)
Length/Width						
Shoreline Dev. Ratio						
Residence Time			.14			
Surface Overflow Rate						
pH						
Temperature				-.032		
Alkalinity						
Conductivity						
Inflow Total P						
Inflow Ortho P						
Inflow Total N						
Inflow Inorganic N					.19	
Inflow N/P				.26	-.16	
Inflow Ortho P/Total P						
Non-Algal Turbidity						
Turbidity*Mean Depth	-.21(1)		-.70(1)	-.42(1)		
R-Squared	.204	.000	.741	.702	.500	.176
Mean Squared Residual	.018	-	.018	.015	.007	.010

(1) variable entered first in stepwise regression
* coefficient in multiple linear regression equation; all coefficients significant at $p < .05$
** all independent variables transformed to base-10 logarithms except pH, temperature, and year impounded
*** no variables met .05 significance level

Appendix E

Compilation of Empirical Eutrophication Models

This appendix summarizes the results of a literature review on empirical eutrophication models. Models have been classified into the following general categories:

PART I: Internal Relationships--Chlorophyll
PART II: Internal Relationships--Transparency
PART III: Nutrient Load/Response Relationships
PART IV: Hypolimnetic Oxygen Depletion Models
PART V: Trophic State Discriminant Functions

The review does not cover ranking schemes, index systems, or any of the various methods of defining "trophic state". Since in-depth discussion of each model is not feasible within this context, the following aspects are summarized:

- author(s) and date*
- data set characteristics
  - number of lakes or reservoirs
  - region
  - averaging periods
  - other characteristics which may restrict model applicability
- model equation(s) and parameter value(s)
- statistics
  - percent of variance explained
  - mean squared error

Models have been converted to consistent sets of units and symbols, as summarized in Table E1. Descriptions are arranged chronologically within each of the above categories.

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* See References section on page 222 of main text for complete listing.

Table E1

Variable, Subscript, and Statistic Definitions

Variable Definitions

P = total phosphorus (mg/m3)
N = total nitrogen (mg/m3)
S = Secchi depth (m)
B = chlorophyll-a (mg/m3)
Qs = surface overflow rate (m/yr)
T = hydraulic residence time (yr)
Z = mean depth (m)
Zmx = maximum depth (m)
Zm = mixed depth (m)
Lp = phosphorus loading (mg/m2-yr)
Pi = average inflow phosphorus concentration (mg/m3) = Lp/Qs
Pv = Vollenweider normalized P loading = Pi/(1 + sqrt(T))
HOD = hypolimnetic oxygen depletion rate (g/m2-day)
HODv = volumetric HOD (g/m3-day)
R = retention coefficient
I = trophic state index
U = first-order settling velocity (m/yr)
K = first-order sedimentation rate (1/yr)
D = discriminant function

Subscript Definitions

an = annual
eu = euphotic zone
sp = spring
su = summer
wn = winter
gs = growing season
mx = maximum value
o = outflow
i = inflow
p = phosphorus
n = nitrogen

Statistic Definitions

n = number of lakes or reservoirs in data set
S2 = mean squared error (base-10 logorithms)
R2 = percent of variance explained
log = base-10 logarithm
ln = base-e logarithm

PART I: INTERNAL RELATIONSHIPS--CHLOROPHYLL

Sakamoto, 1966: (as calculated by Dillon and Rigler, 1974)
28 lakes , excluding "very low" N/P values

$\log(Bsu) = -1.13 + 1.58 \log(Psp)$ (R2=.96)

Edmondson, 1972: Lake Washington (18 < P < 66)

$\log(Ban) = -0.73 + 1.25 \log(Pan)$

Dillon & Rigler, 1974: 46 natural lakes, N/P > 12

$\log(Bsu) = -1.14 + 1.45 \log(Psp)$ (R2=.90,S2=.047)

Norvell & Frink, 1975: 23 Connecticut lakes (7 < Psp < 70)

$\log(Bsu) = -1.52 + 1.80 \log(Psp)$ (R2=.68)

$\log(Bsu) = -1.28 + 1.62 \log(Psu)$ (R2=.79)

$Bsu = .99\ Psp - 10.1$ (R2=.74)

$Bsu = .86\ Psu - 8.2$ (R2=.88)

Jones & Bachman, 1976: 143 northern lakes

$\log(Bsu) = -1.09 + 1.46 \log(Psu)$ (R2=.90)

Carlson, 1977: 43 northern temperate lakes

$\log(Bsu) = 1.45 \log(Psu) - 1.06$ (R2=.72)

Williams et al., 1977: eastern EPA/NES lakes

$\log(Bgs) = -.05 + .64 \log(Pgs)$ (all 418 eastern lakes)

$\log(Bgs) = -.11 + .70 \log(Pgs)$ (318 lakes with T > 14 days)

Lee, Rast, & Jones, 1977: US portion of OECD North American Project

$Bmx = 1.6\ Bsu + 3.74$ (R2=.92, for Bsu > 5 ug/l)

Schindler, 1978 : approx. 60 lakes, mostly northern glacial
Ni/Pi > 5

log(Ban) = -0.85 + 1.21 log(Pan) (R2=.77)

Oglesby & Schaffner, 1978: 16 New York lakes

Bsu = -2.90 + .574 Pwn (R2=.82)

Walker & Kuhner, 1978: EPA/NES data from midwestern impoundments
22 lakes and 23 reservoirs
none N-limited

a = non-algal turbidity = 1./Sgs - .02 Bgs

log(Bgs) =-.256 +1.103 log(Pgs) - .055 a -.219 log(Z) -.0049 Qs
(22 lakes, R2=.925, S2=.018)

log(Bgs) = .490 + .875 log(Pgs) - .231 a -.586 log(Z) -.0007 Qs
(26 reservoirs, R2=.742, S2=.022)

Oskam, 1973: light-limited chlorophyll (theoretical)

BL = (27/Zm - Ew)/Eb

Zm = mixed depth (m)
Ew = non-algal extinction coef (1/m)
Eb = algal extinction coef (m2/mg)

Meta Systems, 1979: EPA/NES data from midwestern impoundments
22 lakes and 23 reservoirs; none N-limited

Light-limited chlorophyll:

BL = F/Zm - a/.02 , (minimum=20 mg/m3)
F = light integral = 440
a = non-algal turbidity = 1/Sgs - .02 Bgs
Zm = mixed depth (m)

P-Limited chlorophyll : BP = Pgs - 2.2

N-Limited chlorophyll : BN = (Ngs-2.2)/7

regression : 1/Bgs = 1.866/BP + 1.363/BL (R2=.82,S2=.023)

general model : 1/Bgs = KP/BP + KN/BN + KL/BL
KP,KN,KL = empirical parameters

Vermont Department of Water Resources, 1979 : 29 Vermont Lakes

$$\log(Bgs) = -0.27 + .898 \log(Psp) \qquad (R2=.82, S2=.022)$$

$$\log(Bsu) = -0.30 + .895 \log(Psp) \qquad (R2=.79, S2=.026)$$

$$\log(Bmx) = -0.15 + 1.09 \log(Psp) \qquad (R2=.83, S2=.029)$$

Walker, 1979: 45 northern temperate lakes

$$\log(Bsu) = -1.07 + 1.39 \log(Psu) \qquad (R2=.81, S2=.058)$$

Placke & Bruggink, 1980: TVA reservoirs

30 stations, tributary reservoirs ($10 < P < 30$)

$$\log(Bgs) = 1.56 \log(Pgs) - 1.04$$

22 stations, tributary reservoirs ($N/P > 10$)

$$\log(Bgs) = 1.90 \log(Pgs) - 1.38$$

19 stations, mainstem reservoirs ($20 < P < 30$)

$$\log(B) = 0.73 \log(Pgs) - 0.55$$

Smith, 1980: 56 northern lakes "variable yield model"

$$\log(Bsu) = 1.55 \log(Psu) - 1.55 \log[6.026/(.0204(Nsu/Psu)+.334)]$$

N/P :	25	17	10	7
intercept:	-1.36	-1.51	-1.67	-1.75

equivalent to:

$$\log(Bsu) = -3.71 + 1.55 \log(Nsu + 16.4\ Psu)$$

for 21 lakes with $N/P > 32.6$:

$$\log(Bsu) = 1.55 \log(Psu) - 1.25 \qquad (R2=.97)$$

Clasen, 1980: OECD Reservoir and Shallow Lakes Project, 46 water bodies
excluded 3 "turbid" reservoirs from regressions;
all but 2 have $N/P > 15$

$$\log(Ban) = -.37 + 0.88 \log(Pan) \qquad (S2=.055)$$

$$\log(Bmx) = 0.74\ Pan \qquad (S2=.060)$$

$$\log(Bmx) = -.24 + 1.07 \log(Pan) \qquad (S2=.059)$$

Fricker, 1980: OECD Alpine Lakes Project , 25 lakes
1 with N/P < 11

log(Ban) = -.080 + .596 log(Pan) (R2=.35,S2=.097)

log(Ban) = -.152 + .604 log(Psp) (R2=.36,S2=.096)

Ryding, 1980: OECD Nordic Project, 10 lakes

Bmx = 1.96 Bsu - .24

Bmx = 2.06 Ban + 1.96

Bsu = -5.0 + 0.61 Psu

log(Bsu) = -0.54 + 1.093 log(Psp)

Hern et al., 1981: 757 EPA/NES lakes and reservoirs

log(Bsu) = -0.11 + 0.64 log(Psu) (R2=.36)

Kerekes, 1981: OECD Summary Analysis
approx. 60 lakes

log(Bgs) = -.55 + .96 log(Pan) (R2=.77,S2=.063)

log(Bmx) = -.19 + 1.05 log(Pan) (R2=.81,S2=.066)

PART II: INTERNAL RELATIONSHIPS -- TRANSPARENCY

Transparency vs. Chlorophyll

Norvell, Frink, & Hill, 1979: 23 Connecticut lakes

1/Ssu = .137 + .0167 Bsu (R2=.80)

log(Ssu) = .857 - .383 log(Bsu) (R2=.69)

1/Ssu = .078 + .0066 Color + .0171 Bsu (R2=.89)

Carlson, 1977: 147 northern lakes

log(Ssu) = 0.89 - 0.68 log(Bsu) (R2=.86)

Rast & Lee, 1978 : OECD North American Project

log(Ssu) = 0.803 - .473 log(Bsu) (R2=.72)

Jones & Bachman, 1978: > 100 lakes

$$\log(Ssu) = .807 - .549 \log(Bsu + .03)$$

Brezonik, 1978: 55 Florida lakes , 4 < Color < 550 Pt Co Units

$$\log(San) = .63 - .55 \log(Ban) \qquad (R2=.75)$$

$$1/San = .48 + .032\ Ban \qquad (R2=.59)$$

$$1/San = .106 + .128\ Turb,FTU + .0025\ Color \qquad (R2=.89)$$

Oglesby & Schaffner, 1978: 16 New York lakes

$$\log(Ssu) = .961 - .606 \log(Bsu) \qquad (R2=.85)$$

Theoretical model:

$$1/S = a + b\ B$$

a = non-algal turbidity and color (1/m)

b = .020	(Walker & Kuhner, 1978)
b = .014	(Lorenzen, 1980)
b = .014, a=.214	(Clasen, 1980): fit of OECD reservoirs
b = .032, a=.48	(Brezonik, 1978): fit of Florida lakes
b = .008-.054	(Carlson, 1980): literature range

Walker, 1979: 45 northern lakes

$$\log(1/Ssu - a) = 0.74 \log(Bsu) - 1.23 \qquad (R2=.80, S2=.063)$$

a = non-algal turbidity (1/m)

a = .04 + .003 Color , averaged .08 1/m in 45 lakes

Placke & Bruggink, 1980: TVA tributary reservoirs

$$\log(Sgs) = 0.596 - .315 \log(Bgs)$$

Hern et al., 1981: 757 EPA/NES lakes and reservoirs

$$\log(Ssu) = 1.09 - .86 \log(Bsu) \qquad (R2=.31)$$

Transparency vs. Phosphorus

Carlson, 1977: northern lakes

$\log(Ssu) = 1.68 - \log(Psu)$, or $Ssu = 48/Psu$

$\log(Sgs) = 1.81 - \log(Pgs)$, or $Ssu = 64/Psu$ (R2=.79)

Oglesby & Schaffner, 1978: 16 New York lakes

$\log(Ssu) = 1.36 - .764 \log(Pwn)$

Walker, 1979: 45 northern lakes

$\log(1/Ssu - .08) = 1.03 \log(Psu) - 2.03$

Placke & Bruggink, 1980: 11 TVA tributary reservoirs

$\log(Sgs) = 1.05 - .608 \log(Pgs)$

Verduin et al., 1976:

SS = suspended solids (g/m3)

$1/S = .06\ SS$

PART III: NUTRIENT LOAD RESPONSE RELATIONSHIPS

Vollenweider, 1969: K = phosphorus sedimentation rate (1/yr)

$$P = Pi / (1 + Kp\ T)$$

$$Kp = 10 / Z$$

or, $$Kp = 5.5\ Z^{-.85}$$

Kirchner & Dillon, 1975: 15 So. Ontario lakes, Rp estimated from Psp

$$Rp = .426 \exp(-.271\ Qs) + .574 \exp(-.00949\ Qs) \qquad (R2=.88)$$

Chapra, 1975: 15 southern Ontario lakes

$$Psp = Pi\ Qs/(Qs + Up)\ ,\ Up = 16\ m/yr$$

Dillon & Kirchner, 1975: northern lakes

$$Up = 13.2\ m/yr$$

Jones & Bachman, 1976: 51 northern lakes

$$Psu = .84\ Pi / (1 + .65\ T) \qquad (R2=.85)$$

$$\log (Bsu) = -1.09 + 1.46 \log[.84\ Pi / (1 + .65\ T)] \qquad (R2=.79)$$

Chapra & Tarapchak, 1976: composite model, N/P > 12

$$Up = 12.4\ m/yr$$

$$Pan = .9\ Psp \qquad (20\ lakes)$$

$$\log(Bsu) = -1.08 + 1.449 \log[\ Pi\ Qs / (Qs+Up)]$$

Larsen & Mercier, 1976: 20 EPA/NES northeastern/northcentral lakes

$$Po = Pi/(1 + .89\ T^{.51}) \qquad (R2=.88)$$

Vollenweider, 1976: 60 northern lakes

$$Pv = Pi/(1+T^{.5})$$

$$\log(Ban) = -.44 + .91 \log(Pv) \qquad (R2=.75)$$

Walker, 1977a: 105 northern temperate lakes and reservoirs

model: $Po/Pi = 1/(1+K\ T)$, $K = a\ (1/T)^b$

data set	number	a	b	R2	S2(Po/Pi)
all	105	.912	.492	.723	.023
oligotrophic	22	.817	.489	.849	.013
mesotrophic	23	.778	.517	.704	.025
eutrophic	60	1.050	.434	.693	.027
Pi < 100 mg/m3	71	.824	.546	.727	.018*

* S2 for log(Po) = .029

multivariate model: 105 northern lakes and reservoirs

$$\log(Po) = 1.029 \log(Pi) - .145 \log(Lp) - .310 \log(T) - .023 \qquad (R2=.901,\ S2=.032)$$

Walker, 1977b: 71 eastern/central EPA/NES lakes and reservoirs

$$\log(Bgs) = -.27 + .77 \log(Px) \qquad (R2=.71,\ S2=.068)$$

$$Px = Pi/(1.+.82\ T^{.45})$$

P_x = P concentration at location x

Reckhow, 1977; 1979a, b: 95 northern temperate lakes and reservoirs

95 lakes, "quasi-general":

$$Pgs = Pi\ Qs\ /\ (11.6 + 1.2\ Qs) \qquad (R2=.915, S2=.016)$$

33 oxic lakes, Qs < 50 m/yr:

$$Pgs = Pi\ Qs\ /\ [18\ Z/(10+Z) + 1.05\ Qs \exp(.012\ Qs)] \qquad (R2=.876, S2=.015)$$

28 lakes Qs > 50 m/yr:

$$Pgs = Pi\ Qs\ /\ [2.77\ Z + 1.05\ Qs \exp(.0011\ Qs)] \qquad (R2=.949, S2=.013)$$

21 anoxic lakes:

$$Pgs = Pi\ Qs\ /\ (.17\ Z + 1.13\ Qs) \qquad (R2=.948, S2=.011)$$

Ostrofski, 1978: northern lakes

$$Rp = .201 \exp(-.0425\ Qs) + .574 \exp(-.00949\ Qs)$$

Oglesby & Schaffner, 1978: 16 New York Lakes
T > .5 year

LPAV = bio-available P load per volume of mixed layer (mg/m3-yr)
BAP = total soluble P + labile P
labile P < 5% total particuate P exported from watershed

$Pwn = .992 + .338\ LPAV$ (R2 = .83)

$Bsu = -4.05 + .24\ LPAV$ (R2 = .78)

$Bsu = -2.90 + .574\ Pwn$ (R2 = .82)

$\log(Ssu) = 1.36 - .764 \log(Pwn)$ (R2 = .81)

$\log(Ssu) = .961 - .606 \log(Bsu)$ (R2 = .85)

Rast & Lee, 1978: US portion of OECD North American Project
54 lakes and reservoirs

$\log(B) = -.259 + .76 \log(Pv)$

$\log(S) = .925 - .359 \log(Pv)$

$\log(HOD) = -1.07 + .467 \log(Pv)$

Walker & Kuhner, 1978: midwestern impoundments, 12 reservoirs, 4 lakes

Sr = sedimentation rate (kg/m2-yr), est. from sediment surveys

$Po/Pi = Qs/(Qs + Up)$ (n=16,R2=.73,S2=.014)

$Up = Sr - 4$

$Pgs = .78\ Po$ (n=50,R2=.88,S2=.020)

Schindler, 1978: approx. 60 lakes, mostly northern glacial
Ni/Pi > 5

$\log(Ban) = .968 \log(Pi^*) - 0.620$ (R2=.58)

$\log(Pan) = .779 \log(Pi^*) + .214$ (R2=.77)

$Pi^* = (Pst\ T + Pi)/(1 + T)$

Pst = mean lake total P conc. at start of monitoring period

Schindler, Fee, & Ruszczynski , 1978: 15 Canadian experimental lakes

mean annual regressions

Pan = 8.11 + .194 Pv	n=31, R2=.76
Pan = 8.46 + .081 Pi	n=31, R2=.83
Pan = 5.50 + .25 Pi*	n=22, R2=.90
Ban = 1.13 + .21 Pv	n=31, R2=.71
Ban = 1.35 + .088 Pi	n=31, R2=.79
Ban = -1.78 + 0.27 Pi*	n=22, R2=.79
Ban = -5.26 + 0.98 Pan	n=42, R2=.85

growing season, epilimnetic regressions

Pgs = 8.48 + .22 Pv	n=31, R2=.69
Pgs = 9.12 + .09 Pi	n=31, R2=.73
Pan = 5.54 + .27 Pi*	n=22, R2=.76
Bgs = .03 + .27 Pv	n=31, R2=.64
Bgs = .28 + .11 Pi	n=31, R2=.73
Bgs = -3.56 + 0.33 Pi*	n=22, R2=.66
Bgs = -7.29 + 1.19 Pgs	n=41, R2=.69

(Pi* defined in Shindler,1978 (see above))

Norvell, Frink, & Hill, 1979: 33 Connecticuit lakes and reservoirs

Psp = Pi (Qs + 1.2)/(Qs + 12) (std error = 6.9 ppb)

Higgins & Kim, 1981: 10 TVA tributary reservoirs (Rp>0, Pi>25)

CSTR P retention models:

Up = 92 m/yr

Rp = 1 - Po/Pi = 1.54 - .22 ln(Qs) (R2=.85)

plug flow P retention model:

Px = P concentration at location X
Tx = time-of-travel to X

Px/Pi = exp(-Kp Tx)

Kp = 61/Z (or, Up = 61 m/yr)

Mueller, 1980: EPA/NES western reservoirs (Rp>0)
5 oligotrophic, 16 mesotrophic, 47 eutrophic

$Pgs = Pi/(16.4 + Qs)$ (R2=.27,S2=.17)

$Pgs = Pi\ (1-Rp)$

$Rp = .29\ \exp(-.556\ Qs)+.71\ \exp(-.00483\ Qs)$ (R2=.26,S2=.14)

*$Pgs = .882\ Pi\ /\ (1 + 1.61\ T)$ (R2=.45,S2=.11)

*$Pgs = Pi/(1 + 2.09\ T^{.832})$ (R2=.46.S2=.10)

*approximate form:

$Pgs = Pi\ /\ (\ 1 + 2\ T)$ (R2=.46,S2=.11)
(i.e., Kp = 2 1/yr)

$Pgs = Po$ (R2=.74,S2=.040)

Clasen, 1980: OECD Reservoir and Shallow Lakes Project ,
46 Waterbodies, 23% natural, 20% pumped storage,
47% "semi-artificial reservoirs"
70% eutrophic, 20% oligotrophic, 10% mesotrophic
$.6 < Qs < 773$, $1.7 < Z < 76$, $5 < Pi < 4900$

$Pan = Pi/(1 + 2.271\ T^{.586})$ (S2=.070)
[approx = $Pi/(1 + 2\ T^{.5})$] (S2=.071)

$Pan = Pi/(1 + 7.239\ T^{.608}Z^{-.500})$ (S2=.065)
[approx = $Pi/(1 + 7/(Qs^{.5})$] (S2=.065)

$\log(Pan) = -.11 + 0.85\ \log(Pi)$ (R2=.89,S2=.063)

$\log(Pan) = (1 - .25\ T^{.32})\ \log(Pi)$ (S2=.050)

$Pe = Pi/(1 + 2\ T^{.5})$

$Ban = 50\ (\ 1 - \exp(-.007\ Pe))$ (S2=.047)

$\log(Ban) = .06 + .58\ \log(Pe)$ (S2=.077)

$\log(Ban) = -.02 + .58\ \log(Pv)$ (S2=.079)

Fricker, 1980: OECD Alpine Project

$\log(Pan) = 1.013\ \log(Pi) -.348$ (R2=.72, S2=.082)

$\log(Peu) = .882\ \log(Pi) -.182$ (R2=.74, S2=.071)

for lakes with T > 1 year , Rp > 0:

$P/Pi = 1/(1 + 1.417\ T^{.0489})$

log(Kp) = .971 - .692 log(Z) (R2=.29,S2=.078)

log(Peu) = .906 log(Pv) + .104 (R2=.73,S2=.072)

excluding "non-fitting lakes":

log(Peu) = .754 log(Pv) + .254 (R2=.78,S2=.047)

log(Ban) = .675 log(Pv) - .219 (R2=.81,S2=.050)

log(Bsu) = .706 log(Pv) - .219 (R2=.75,S2=.083)

log(Bmx) = .837 log(Pv) + .050 (R2=.86,S2=.052)

log(Ssu) =-.200 log(Pv) + .925 (R2=.46,S2=.019)

Ryding, 1980 : OECD Nordic Project, 10 lakes

log(Pan) = -.02 + .96 log(Pv) (R2=.72)

log(Nan) = -1.19 + .60 log(Nv) (R2=.71)

log(Bsu) = -.31 + .81 log(Pv) (R2=.67)

log(Nsu) = -2.18 + 1.12 log(Nv) (R2=.58)

log(Ssu) = 1.12 - .51 log(Pv) (R2=.62)

Ban = 1.2 + 1.3 Lp + .05 Ln

Ban Zm = 46.9 + 7.4 T - 12.2 (Zmx/Z)

log(Ban) = 1.01 log(Pv) - .82 (R2=.59)

log(Ban) = 1.26 log(Nv) - 2.82 (R2=.61)

log(Kp) = -.53 log(Z) + .52 (R2=.18)

Walker, 1980: EPA/NES data from 26 southeastern reservoirs with Sgs*Bgs > 10 (i.e., low nonalgal turbidity (3 < Bgs < 16 mg/m3)

log(Bgs) = 0.49 + .339 log(Phk) (R2=.72,S2=.008)

Phk = Higgins & Kim (1981) normalized inflow P (mg/m3)

= Pi Qs / (Qs + 92)

* error statistics refer to predictions of log(Pgs)

Kerekes, 1981: OECD Summary Analysis, approx 87 waterbodies

$\log(Pan) = .19 + .82 \log(Pv)$ (R2=.85,S2=.037,n=87)

$\log(Po) = .13 + .92 \log(Pan)$ (R2=.90,S2=.030,n=62)

$\log(Po) = .07 + .98 \log(Peu)$ (R2=.92,S2=.023,n=59)

$\log(Ban) = -.43 + .79 \log(Pv)$ (R2=.77,S2=.066,n=67)

$\log(Bmx) = -.13 + .89 \log(Pv)$ (R2=.79,S2=.081,n=45)

Canfield and Bachman, 1981: 290 natural lakes, 433 reservoirs
626 from EPA National Eutrophication Survey

natural lakes:

$K = .162(L_p/Z)^{.458}$ (R2=.69,S2=.059)*

reservoirs:

$K = .114(L_p/Z)^{.589}$ (R2=.67,S2=.061)*

both:

$K = .129(L_p/Z)^{.549}$ (R2=.66,S2=.066)*

PART IV: HYPOLIMNETIC OXYGEN DEPLETION MODELS

Lasenby, 1975: 21 natural lakes

$$\log(HOD) = .35 - 1.35 \log(Ssu) \qquad (R2=.72)$$

Rast & Lee, 1978: OECD North American Project, 32 lakes

$$\log(HOD) = -1.07 + .467 \log(Pv)$$

Reckhow, 1978: oxic vs. anoxic discriminant function
northern temperate lakes

$$D = -11.5 - 4.61 \log(Lp/1000) + 5.73 \log(Z) + 4.1 \log(Qs)$$

$$prob(oxic) = 1./(1+\exp(-D))$$

Cornett & Rigler, 1979: 20 lakes

$$1000\ HOD = -277 + .5\ Ap + 5\ Th^{1.74} + 150 \ln(Zh) \qquad (R2=.75)$$

Ap = P accumulation rate (mgP/m2-yr)
Th = mean hypolimnion temperature (deg C)
Zh = mean hypolimnion thickness (m)

Walker, 1979: 30 natural lakes

$$I = \text{trophic index} = -15.6 + 46.1 \log(Psu)$$
$$= 20.0 + 33.2 \log(Bsu)$$
$$= 75.3 + 44.8 \log(1/Ssu - .08)$$

$$\log(HOD) = -3.58 + .0204\ I + 4.55 \log(Z) - 2.04\ [\log(Z)]^2$$

(Z < 20 meters, R2=.91,S2=.010)

Welch & Perkins, 1979: 26 lakes

$$\log(HOD) = -1.49 + 0.39 \log(Lp\ T) \qquad (R2=.53)$$

Ryding, 1980: OECD Nordic Project, 10 lakes

$$\log(HODv) = .67 \log(Pv) - 2.42 \qquad (R2=.40)$$

Vollenweider & Kerekes, 1980: 33 OECD study lakes

$$\log(HOD) = .585 \log(Pv) -1.07 \qquad (R2=.52)$$

PART V: TROPHIC STATE DISCRIMINANT FUNCTIONS

Vollenweider, 1968: northern lakes

$D = Lp\ Z^{-.6}$, oligotrophic < 25 < mesotrophic < 50 < eutrophic

Vollenweider, 1975: northern lakes

$D = 0.1\ Lp\ Qs^{-.5}$; oligotrophic < 10 < mesotrophic < 20 < eutrophic

Vollenweider, 1976: northern lakes

$D = Pi/(1+T^{.5})$, oligotrophic < 10 < mesotrophic < 20 < eutrophic

Walker, 1977a, b: 100 northern temperate lakes, EPA/NES classification
trophic state probabilities

$Px = Pi/(1 + .82\ T^{.45})$

$D = .001\ Px^{.82} Lp^{.18}$, $Dt = -(D^{-.25})$

$xe = \exp(-18.51-20.49\ Dt)$
$xm = \exp(-36.77-29.33\ Dt)$
$xo = \exp(-53.80-35.65\ Dt)$

$xs = xe + xm + xo$

$prob(e) = xe/xs$
$prob(m) = xm/xs$
$prob(o) = xo/xs$

Yeasted & Morel, 1978: trophic state
northern temperate lakes , mostly EPA/NES

$De = -12.54 \log(Pi/1000) + 1.65 \log(T) - 5.89$
$Dm = -25.06 \log(Pi/1000) + 5.15 \log(T) - 18.87$
$Do = -31.48 \log(Pi/1000) + 9.13 \log(T) - 30.01$

Ciecka, Fabian, & Merilatt, 1979 : midwestern lakes and reservoirs
D > 0 implies eutrophic

$D = 1.68 + 1.77 \ln(Lp/1000) - .64 \ln(Qs) -.07 [\ln(Qs)]^2$

APPENDIX F

Independent Data Sets

	Data Sources			
	CE	EPA/NES	TVA	OECD/RSL
Data Tables	App. C	F-1	F-2	F-3,4
Figures:				
Internal Models	F-1	F-4	F-7	F-10
Loading Models - Pv*	F-2	F-5	F-8	F-11
Loading Models - Pn**	F-3	F-6	F-9	F-12

CE = Corps of Engineers Data Set (See Appendices B,C)
EPA/NES = EPA National Eutrophication Survey (USEPA, 1978)
TVA = Tennesse Valley Authority Reservoirs (Higgins and Kim, 1981)
OECD/RSL = OECD Reservoir and Shallow Lakes Program (Clasen, 1980)

* Vollenweider normalized P loading
** Equation (61) (see Part VI, main text) P loading

Table F-1
EPA/NES Data on CE Reservoirs

disres*	code	pi	ni	po	tp	chla	secchi	zmean	t
02176	1	24	851	18.2	6.9	5.2	2.4	12.6	.230
03307	1	16	1174	11.5	10.0	4.9	3.5	12.9	.380
04312	3	182	1071	95.5	64.6	15.1	1.2	1.6	.030
06372	1	132	1288	24.5	43.7	8.7	1.0	10.7	.338
08074	1	55	724	20.9	24.0	6.8	1.5	11.0	.371
08330	1	50	776	8.9	12.9	6.2	2.0	13.8	.831
10003	1	35	1513	22.4	18.2	2.2	1.3	7.9	.015
10069	1	62	645	21.9	20.0	7.4	1.4	9.3	.281
10076	1	81	891	8.5	15.8	5.4	2.6	19.5	1.584
10411	1	107	1096	36.3	28.8	4.0	1.2	3.1	.019
14099	1	617	7413	245.5	177.8	14.8	0.7	3.0	.026
15178	1	30	1174	18.6	21.9	12.6	2.3	9.1	2.884
15181	1	44	2570	20.0	15.1	6.2	2.2	4.7	5.248
15237	1	302	2884	245.5	257.0	40.7	0.7	4.0	.831
16243	1	263	2691	64.6	41.7	15.5	0.9	4.9	.223
16254	1	112	2187	61.7	57.5	36.3	0.9	2.7	.955
16317	1	89	1202	66.1	57.5	26.9	0.9	2.5	.057
16328	1	49	758	30.9	15.8	3.7	2.2	14.5	.209
16393	1	21	631	19.5	6.0	1.2	3.1	17.4	.055
17241	1	174	2290	60.3	30.9	16.2	1.0	4.7	.489
17242	2	182	3388	151.4	123.0	11.0	0.3	1.2	.008
17245	1	178	2884	147.9	125.9	67.6	0.4	1.7	.055
17247	1	126	3311	102.3	97.7	10.0	0.8	5.0	.114
17248	2	240	4265	138.0	85.1	11.0	0.4	3.3	.063
17249	1	275	3890	134.9	162.2	27.5	0.5	3.0	.025
17256	1	71	1778	55.0	36.3	22.9	1.1	4.8	.095
17258	0	41	1318	83.2	39.8	38.0	0.9	4.6	.660
17373	1	45	1174	13.2	11.0	6.0	2.1	18.2	.323
17389	1	45	1288	39.8	74.1	14.8	0.7	5.8	.008
17391	1	18	812	16.6	11.0	6.2	3.5	20.9	.138
18092	1	246	4897	123.0	107.2	15.8	0.7	7.2	.141
18093	1	35	1122	19.1	25.1	6.9	1.6	5.2	.660
18120	1	72	1659	46.8	26.9	8.1	1.2	5.8	.218
19119	3	166	1230	169.8	128.8	12.6	0.6	4.6	.043
19122	1	50	1258	30.9	15.8	3.8	1.7	24.0	.616
19338	0	123	851	173.8	141.3	8.1	0.7	4.3	.005
19340	3	214	1230	190.5	56.2	10.0	1.8	8.5	.380
19342	1	79	1000	87.1	57.5	8.9	0.8	5.6	.030
19343	1	30	1000	10.0	10.0	3.6	4.3	14.5	1.202
20081	1	195	3090	120.2	83.2	17.4	0.6	2.7	.173
20087	1	295	6165	102.3	61.7	17.4	1.0	5.0	.363
20088	1	251	2570	125.9	70.8	23.4	0.7	4.7	1.202
21196	0	25	1047	39.8	33.1	9.5	1.0	3.0	.038
22014	1	19	316	16.6	19.1	12.3	2.0	14.8	1.318
22019	1	20	524	16.6	15.1	4.3	2.8	16.2	1.862

* See page F-4 for key

(continued)

Table F-1 (continued)

disres	code	pi	ni	po	tp	chla	secchi	zmean	t
22188	0	89	758	223.9	199.5	6.5	0.4	9.1	.295
22189	3	288	1737	61.7	61.7	6.6	0.9	15.5	1.122
22190	1	105	1096	95.5	51.3	6.0	0.6	16.6	1.096
22192	1	74	955	61.7	40.7	6.5	1.3	16.6	1.096
23352	1	126	1412	33.1	30.9	12.9	1.5	4.1	.602
23353	0	107	955	120.2	104.7	19.1	0.5	3.0	.154
23413	1	47	691	50.1	51.3	18.2	0.9	1.8	.114
24011	1	60	1174	13.8	21.9	3.9	2.1	17.8	1.513
24012	0	37	933	69.2	57.5	8.9	0.4	2.6	.067
24013	1	20	1318	12.3	15.1	3.9	3.5	20.4	.707
24016	1	25	588	13.2	12.0	3.8	3.3	21.4	2.238
24021	0	20	691	39.8	38.9	15.8	0.8	2.5	.046
24022	0	14	1047	17.8	15.1	3.4	3.6	17.4	.977
24193	0	10	1047	28.2	17.0	3.6	1.4	4.1	.036
24200	1	71	1318	18.2	21.9	9.1	2.3	19.1	.912
25020	1	49	676	52.5	39.8	15.1	0.8	2.2	.049
25102	2	316	5248	104.7	69.2	9.8	0.4	3.9	.602
25103	2	115	1584	63.1	30.2	3.2	0.2	2.4	.123
25104	0	68	1737	85.1	52.5	7.8	0.3	3.0	.109
25105	2	288	3235	166.0	117.5	9.5	0.2	2.0	.063
25107	2	240	3715	67.6	52.5	12.3	0.4	4.1	2.398
25112	0	54	1349	75.9	67.6	6.6	0.3	2.5	.060
25267	3	347	2238	218.8	81.3	4.4	0.4	10.0	.851
25269	2	59	933	46.8	69.2	9.8	0.4	12.0	1.584
25273	2	324	2630	144.5	134.9	21.4	0.4	7.8	.151
25275	2	182	1862	70.8	58.9	5.1	0.4	5.8	.302
25278	1	91	2187	49.0	38.9	6.6	1.6	15.5	.660
25281	0	55	776	69.2	79.4	4.8	0.5	2.3	.043
25348	3	339	2511	134.9	41.7	12.6	1.2	5.8	.478
25370	1	105	1862	31.6	22.9	10.2	1.1	5.2	2.818
26345	3	589	2818	51.3	15.8	7.9	3.1	10.7	1.584
26347	1	11	1047	6.6	10.0	2.5	3.0	14.1	1.000
26354	2	219	2138	50.1	63.1	5.4	0.4	6.5	1.412
26355	1	178	1584	56.2	44.7	14.1	0.6	6.0	.851
26359	1	55	660	31.6	28.8	6.3	1.5	7.8	1.412
26360	1	107	5370	89.1	97.7	24.5	0.5	6.5	10.964
26361	1	76	1318	50.1	52.5	24.5	0.7	4.3	.602
26362	1	32	933	12.0	18.2	3.9	2.4	11.2	1.000
26364	1	123	1737	29.5	28.2	6.9	1.8	8.1	.794
28219	1	74	1174	4.5	20.0	3.3	1.2	11.7	3.020
29100	1	363	3020	64.6	70.8	12.0	0.6	6.8	1.000
29106	3	490	3235	107.2	56.2	15.8	0.3	4.5	.331
29108	3	661	3630	74.1	79.4	19.1	0.9	7.8	.776
29109	1	145	3311	55.0	33.9	30.2	1.0	6.0	1.096
29110	3	427	3235	104.7	55.0	5.6	0.5	3.7	.776
29111	2	81	1905	67.6	39.8	8.3	0.5	6.5	.524

(continued)

Table F-1 (continued)

disres	code	pi	ni	po	tp	chla	secchi	zmean	t
29113	3	1023	5495	166.0	162.2	11.2	0.8	8.1	.380
29114	1	155	2630	46.8	22.9	8.9	1.4	8.3	2.818
29194	1	59	1737	36.3	42.7	9.3	1.3	9.5	.851
29195	1	71	2570	15.5	21.9	8.9	1.8	7.2	1.071
29207	1	398	3467	81.3	112.2	27.5	0.6	7.8	1.412
30064	3	1047	5623	158.5	53.7	23.4	0.8	5.2	3.630
30215	3	575	4466	144.5	60.3	15.5	1.2	3.7	2.884
30217	1	363	3890	72.4	43.7	17.0	1.1	5.5	2.818
30235	3	380	1584	26.3	15.8	6.9	2.3	19.1	1.584
31077	1	22	631	16.6	10.0	2.4	2.5	55.0	.831
32204	0	3	42	23.4	44.7	2.7	4.1	38.0	.741
33300	3	39	195	34.7	38.0	2.3	1.7	38.9	.416
34048	1	37	912	18.2	12.9	3.6	3.0	47.9	1.698
35029	1	96	1202	58.9	20.0	3.1	1.6	19.1	.457
35039	1	76	645	46.8	37.2	9.1	2.5	10.0	1.584

disres = CE district/reservoir code (see Table 1)
code: 0 = Rp < -.1 1 = used in error analysis
2 = turbidity > 1.58 1/m 3 = inflow N/P < 8
pi = inflow total p concentration (mg/m3)
ni = inflow total n concentration (mg/m3)
po = outflow total p concentration (mg/m3)
tp = median, reservoir total p concentration (mg/m3)
chla = mean chlorophyll-a (mg/m3)
secchi = mean secchi depth (m)
zmean = mean depth (m)
t = mean hydraulic residence time (yrs)
R_p = retention coefficient of phosphorus
N/P = total nitrogen/phosphorus ratio

Table F-2
TVA Reservoir Data

Reservoir	pi	ni	tp	chla	secchi	zmean	t
---------- Mainstem Tennessesee River ----------							
Kentucky	74	717	81	9.1	1.0	5.0	.038
Pickwick	51	709	56	3.9	0.9	6.5	.017
Wilson	56	685	53	5.9	1.4	12.3	.013
Wheeler	35	618	-	4.4	-	5.3	.021
Guntersville	38	654	44	4.8	1.1	4.2	.024
Nickajack	36	623	51	2.8	1.1	6.8	.007
Chickamauga	26	575	31	3.0	1.1	5.0	.017
Watts Bar	40	739	32	6.2	1.0	7.3	.035
Ft Loudon	44	1033	54	5.9	0.9	7.3	.026
---------- Tributary ----------							
Chatuge	21	360	14	5.5	2.7	9.5	.435
Cherokee	155	1424	51	10.9	1.7	13.9	.216
Douglas	67	722	26	6.3	1.6	10.7	.117
Fontana	45	581	11	4.1	2.6	37.8	.282
Hiwasse	21	343	15	5.0	2.4	20.2	.153
Normandy	170	770	-	15.0	1.2	9.5	.369
Norris	38	944	-	2.1	3.9	16.3	.372
So Holston	34	732	14	6.5	2.6	23.4	.550
Tims Ford	24	721	21	6.1	2.4	14.9	.561
Watauga	51	724	-	2.9	2.7	24.5	.687

pi = inflow total p (mg/m3)
ni = inflow total n (mg/m3)
tp = median total p (mg/m3) (EPA/NES)
chla = mean, summer chlorophyll-a (mg/m3)
secchi = mean, summer transparency (m)
zmean = mean depth (m)
t = mean hydraulic residence time (years)

Table F-3
Impoundments in the OECD/RSL Data Base

#	Impoundment	Type	Country
01	De Grote Rug	p	Netherlands
02	Laugh Leane	l	Ireland
03	Louch Ennel	l	Ireland
04	Hundred dn Dertig	p	Netherlands
05	Petrusplaat	p	Netherlands
06	Braakmann II	p	Netherlands
07	Braakmann III	p	Netherlands
08	Biwa North	l	Japan
09	Biwa South	l	Japan
10	Kasamigaura West	l	Japan
11	Kasamigaura North	l	Japan
12	Nisramont	*	Belguim
13	Eupen	*	?
14	Brielse Meer	r	Netherlands
15	El Burguillo	r	Spain
16	Lough Neagh	l	United Kingdom
17	Farmoor	p	United Kingdom
18	Grafham Water	r	United Kingdom
19	Loch Leven	l	United Kingdom
20	Queen Elizabeth II	p	United Kingdom
21	Mt. Bold	r	Australia
22	Wahnbach	r	Germany
23	Oleftal	r	Germany
24	Prospect	p	Australia
25	Sorpe	r	Germany
26	Mohne	r	Germany
27	Verse	r	Germany
28	Sose	r	Germany
29	Furwigge	r	Germany
30	Vechten	*	Netherlands
31	Tjeukemeer	*	Netherlands
32	Enneppe	*	Germany
33	Blackhawk	r	U.S. - Wisconsin
34	Twin Valley	r	U.S. - Wisconsin
35	Kerr Res. Roanoke	r	U.S. - Virginia
36	Isles	r	U.S. - Minnesota
37	Cox Hollow	r	U.S. - Wisconsin
38	Dutch Hollow	r	U.S. - Wisconsin
39	Kerr Res. Nutbush	r	U.S. - Virginia
40	Virginia	r	U.S. - Wisconsin
41	Redstone	r	U.S. - Wisconsin
42	Camelot Sherwood	r	U.S. - Wisconsin
43	Stewart	r	U.S. - Wisconsin

code number in OECD/RSL data base (Table F-4)
Type: l = natural lake, r = reservoir,
p = pumped storage impoundment
* = not specified in OECD/RSL report
(r assumed)

Table F-4
OECD Reservoir and Shallow Lakes Project Data

resyr*	c	pi	ni	tp	tn	chla	secchi	zmean	t
1.74	3	529	5757	83	3700	16.0	1.1	5.3	.457
1.75	3	514	4443	72	2700	13.0	1.5	5.5	.471
1.76	3	629	5657	88	2670	23.0	1.3	4.5	.385
2.73	2	26	-	-	-	4.6	2.8	13.7	.363
2.74	2	22	-	-	-	5.7	2.6	13.7	.304
3.75	2	328	-	70	-	26.0	1.4	7.5	2.100
3.76	2	151	-	38	-	27.0	1.3	7.5	1.680
4.74	3	486	5932	330	5600	5.0	2.8	14.7	.218
4.75	3	455	5713	300	4900	6.0	3.4	14.7	.225
4.76	3	558	6353	360	5500	6.0	3.4	14.7	.219
5.74	3	331	5579	170	5400	4.0	3.5	12.4	.097
5.75	3	293	4947	200	4700	6.0	3.6	12.4	.097
5.76	3	357	5518	200	5200	8.0	2.9	12.4	.094
6.74	3	550	13666	190	8100	32.0	2.0	9.3	.850
6.75	3	644	11600	250	7000	71.0	1.7	8.4	.760
6.76	3	300	10833	340	3200	47.0	2.0	6.2	1.170
7.74	3	232	6800	29	6600	17.0	3.0	9.3	.560
7.75	3	311	7444	21	4500	20.0	3.5	8.0	1.330
7.76	3	125	4125	100	1800	44.0	3.0	7.3	1.380
8.74	2	39	566	8	-	2.1	7.8	6.5	5.990
8.75	2	41	592	7	381	1.8	8.1	6.5	6.170
8.76	2	40	568	8	363	2.1	7.9	6.5	5.820
9.74	2	23	453	24	-	5.1	2.5	0.8	.034
9.75	2	22	509	15	441	3.5	3.0	0.8	.035
9.76	2	23	495	21	459	5.5	2.0	3.8	.033
10.74	2	232	3498	49	1260	35.2	1.2	3.9	.608
10.75	2	232	3498	51	1357	19.1	1.2	3.4	.608
10.76	2	232	3498	64	1143	35.7	1.4	3.9	.608
11.74	2	183	2707	58	980	28.3	1.2	4.2	.450
11.75	2	183	2707	53	1000	18.8	1.2	4.2	.450
11.76	2	183	2707	59	906	30.5	1.1	4.2	.450
12.74	1	-	-	-	-	8.4	2.8	6.4	.008
12.75	1	82	-	-	-	34.6	2.2	6.4	.016
12.76	1	-	-	-	-	11.6	2.1	6.4	.022
13.74	1	-	-	-	-	0.7	3.0	18.5	.370
13.75	1	-	-	-	-	2.1	4.0	17.5	.340
13.76	1	-	-	-	-	1.4	4.3	16.8	.300
14.74	1	1071	9611	230	5300	21.5	1.1	5.4	.290
14.75	1	1056	9105	360	4100	27.8	1.4	5.4	.430
15.74	1	55	889	27	889	8.0	2.5	20.3	.410
15.75	1	70	976	40	1095	9.0	2.2	20.4	.395
15.76	1	119	1444	42	988	16.0	2.3	17.7	.287
16.74	2	179	2081	121	400	21.0	1.7	8.9	1.170
17.71	3	386	-	-	-	20.0	4.3	8.9	.470
17.72	3	454	-	-	-	18.0	3.8	9.1	.500
17.73	3	745	-	-	-	16.5	3.8	9.1	.430
18.69	5	-	-	-	1830	9.9	3.4	9.5	5.800
18.73	5	4900	-	-	3990	8.0	4.2	9.5	5.800

* See page F-8 for key

(continued)

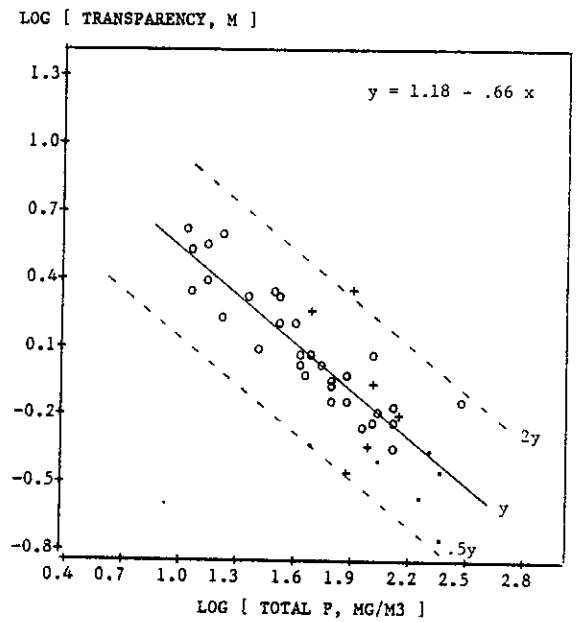
Table F-4 (continued)

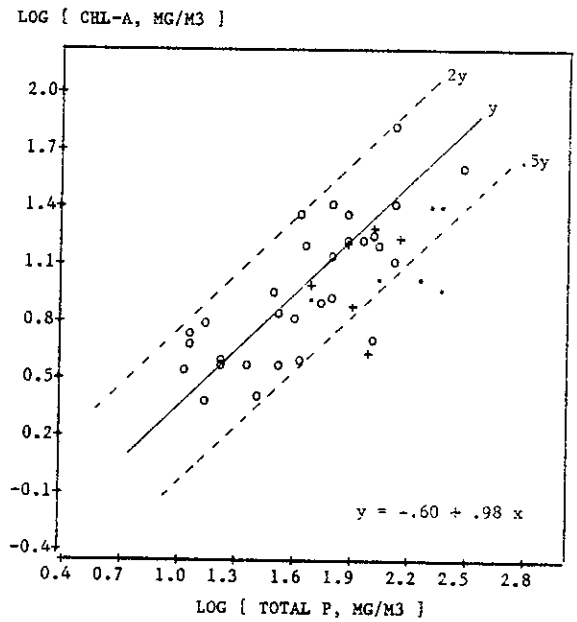
resyr	c	pi	ni	tp	tn	chla	secchi	zmean	t
19.74	2	146	3567	68	1520	39.0	1.4	3.9	.588
20.69	3	-	-	-	-	2.0	3.0	15.3	.147
21.73	5	231	1894	98	1330	3.0	-	13.4	.400
21.75	5	150	1905	97	1420	3.0	1.0	13.3	.330
21.76	5	153	1593	101	1500	4.0	1.4	12.7	.480
22.74	1	82	-	25	-	4.7	4.0	17.8	.740
22.75	1	85	-	22	-	6.0	4.0	17.7	1.370
22.76	1	100	-	16	-	5.1	4.0	17.3	1.270
23.75	1	9	-	12	-	1.7	6.1	15.5	.610
23.76	1	6	-	8	-	5.6	5.7	13.7	.430
24.75	3	14	359	11	-	3.0	3.2	9.7	.115
24.76	3	12	402	10	-	3.1	2.1	9.7	.119
25.74	1	198	3805	42	2190	8.6	4.0	20.4	1.140
26.73	1	366	4063	75	-	21.6	2.2	12.9	.760
26.75	1	453	5463	77	3040	10.2	2.9	12.9	.670
27.76	1	33	2894	12	1630	2.9	8.2	20.0	1.510
28.74	1	14	-	4	-	-	6.9	18.8	.350
28.75	1	6	-	5	-	0.6	6.6	18.5	.670
28.76	1	7	-	4	-	1.5	6.4	16.4	.520
29.76	1	19	2781	8	1620	2.4	11.5	8.3	.400
30.74	1	-	-	-	-	4.5	-	6.0	9.300
31.75	1	-	-	-	-	50.0	-	1.8	-
32.74	1	822	6628	168	4380	-	3.9	12.2	.330
32.75	1	533	4363	208	4670	-	2.9	12.2	.330
33.73	1	229	2396	85	-	15.0	3.6	4.9	.500
34.73	1	223	2019	65	-	19.0	1.5	3.8	.450
35.75	4	105	734	-	-	13.0	1.4	10.3	.200
36.71	1	449	-	-	-	53.0	1.0	2.7	.600
37.73	1	288	2972	80	-	27.0	1.5	3.8	.592
38.73	1	600	6285	260	-	34.0	0.8	3.0	1.820
39.75	4	449	1517	-	-	21.1	1.2	8.0	4.980
40.73	1	1044	14711	85	-	29.0	1.7	1.7	1.370
41.73	1	519	6010	70	-	13.0	1.6	4.3	1.430
42.73	1	93	1278	35	-	6.3	2.0	3.0	.110
43.73	4	2666	3083	60	1240	50.0	1.4	1.9	.080

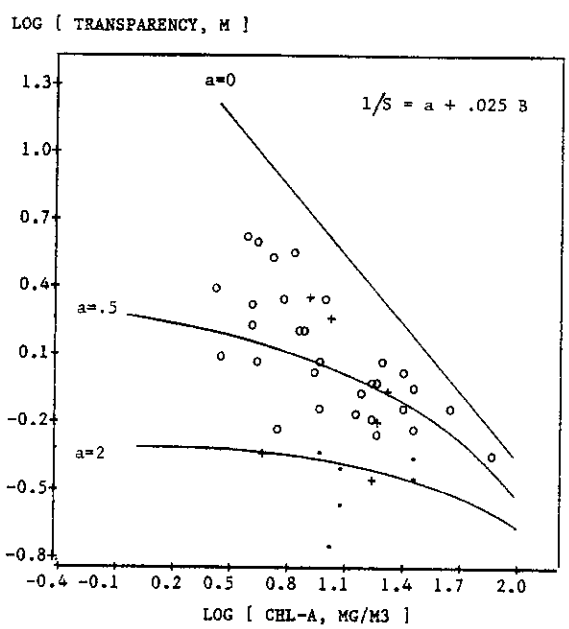
resyr = impoundment code (see Table F-3).year
c = code: 1 = reservoir 2 = natural lake
3 = pumped storage (artificial) reservoir
4 = inflow N/P < 8
5 = reservoir excluded from error analysis
pi = inflow total p (mg/m3)
ni = inflow total n (mg/m3)
tp = mean, annual, euphotic zone total p (mg/m3)
tn = mean, annual, euphotic zone total n (mg/m3)
chla = mean, annual, euphotic zone chlorophyll-a (mg/m3)
secchi = median, annual secchi depth (m)
zmean = mean depth (m)
t = hydraulic residence time (yrs)

Figure F-1

Internal Model Evaluations Using the CE Data Set







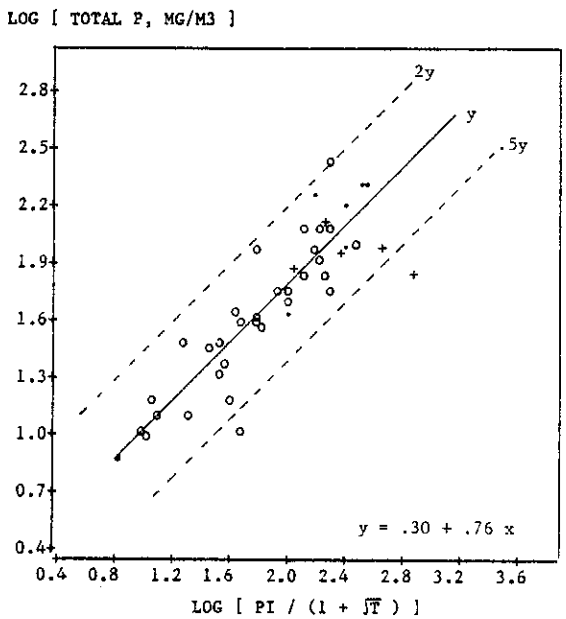
Symbol	Meaning
o	CE Reservoir
+	Inflow Total N/P < 8
.	Turbidity > 1.58 1/m

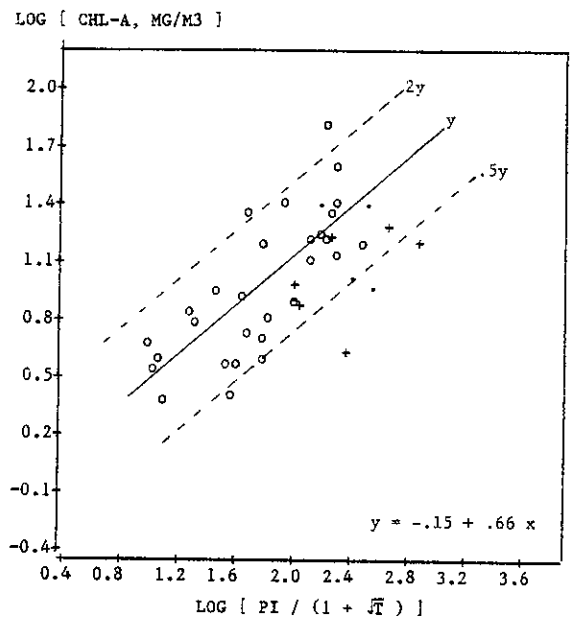
line = regression for CE reservoirs and CE data set

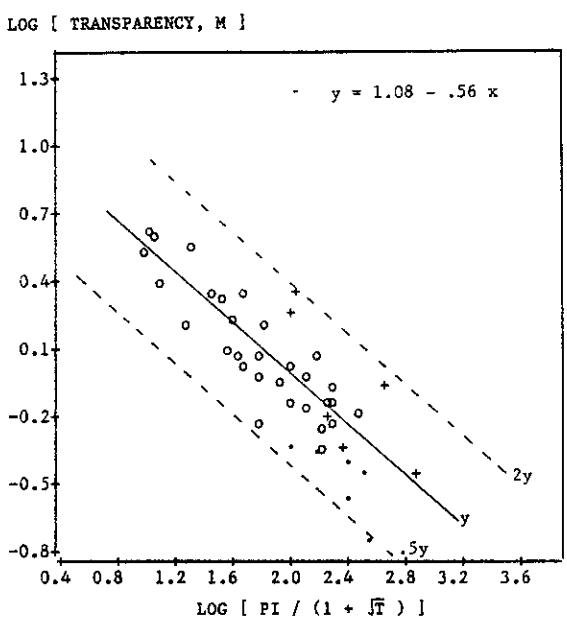
dashed line = 2-fold accuracy limits

Figure F-2

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the CE Data Set







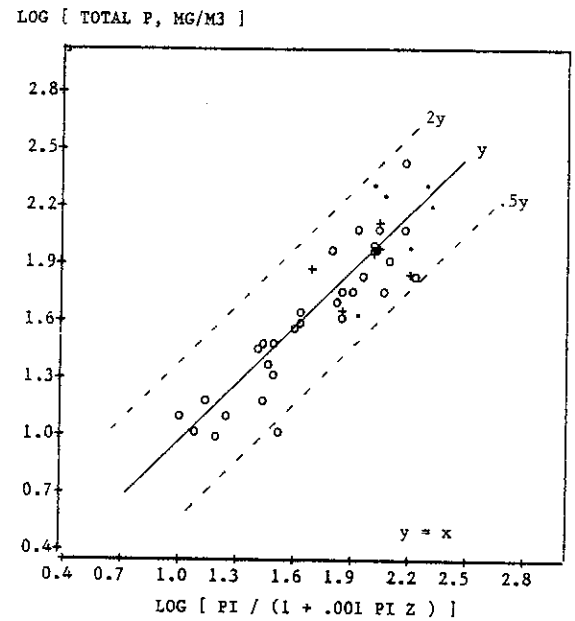
Symbol	Meaning
o	CE Reservoir
+	Inflow Total N/P < 8
.	Turbidity > 1.58 1/m

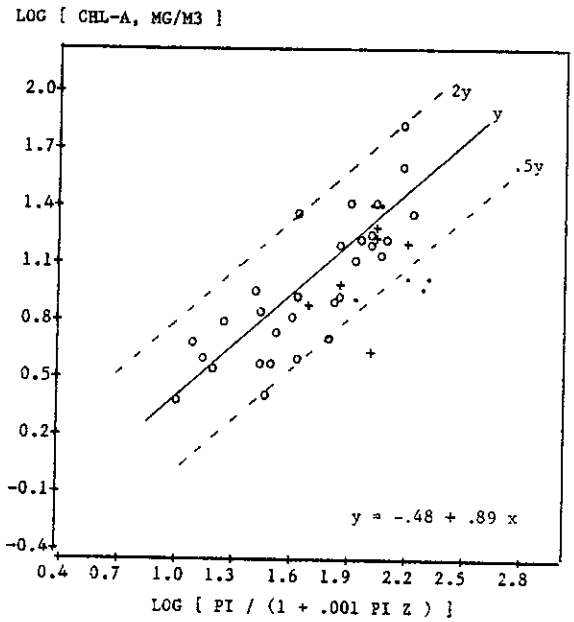
line = regression for CE reservoirs and CE data set

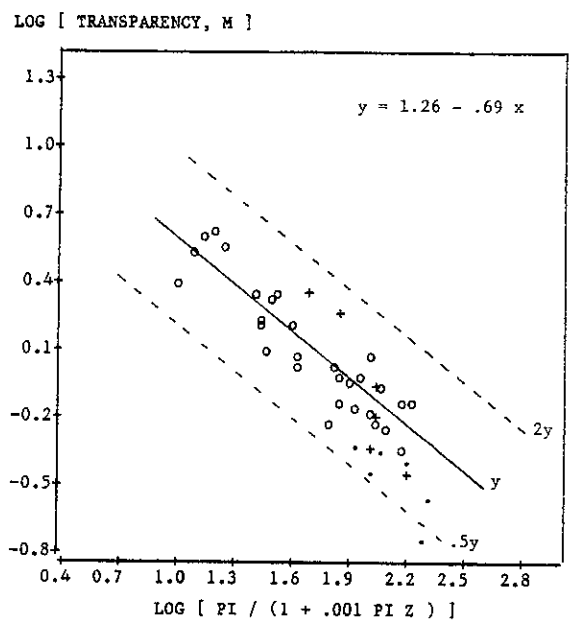
dashed line = 2-fold accuracy limits

Figure F-3

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the CE Data Set





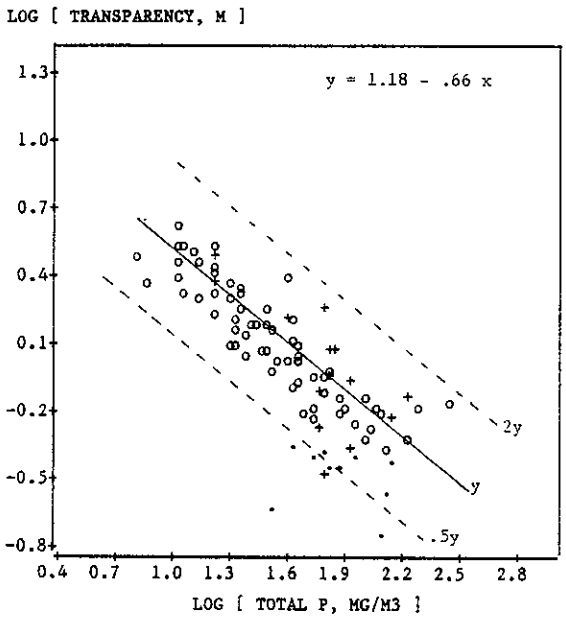


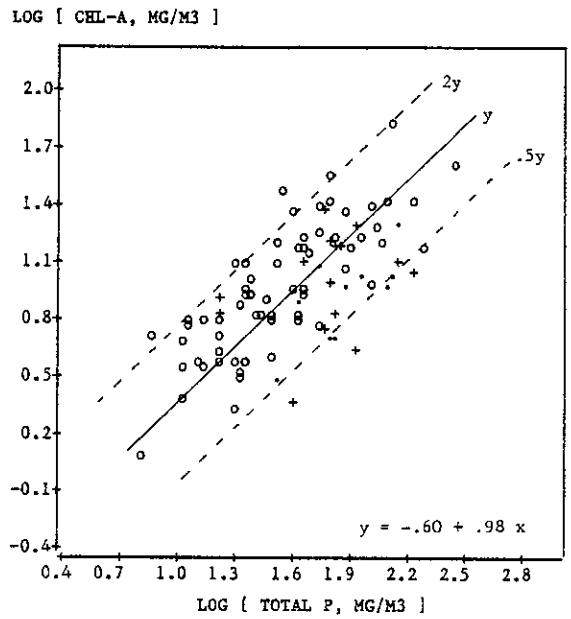
Symbol	Meaning
o	CE Reservoir
+	Inflow Total N/P < 8
.	Turbidity > 1.58 1/m

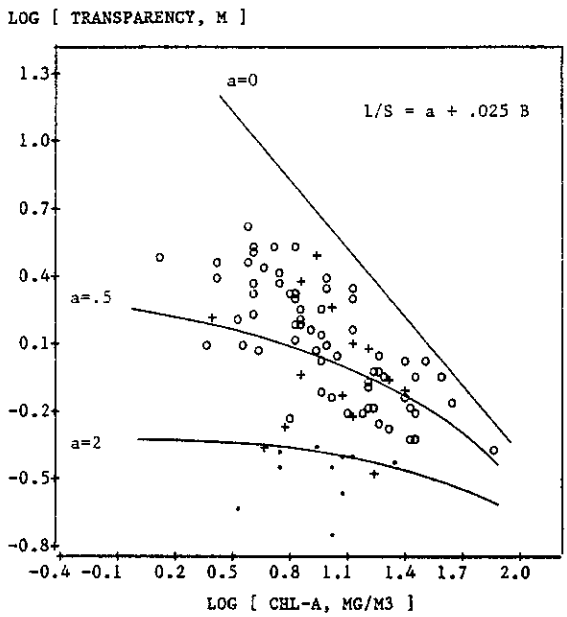
line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits
PI = average inflow phosphorus concentration (mg/m3)
Z = mean depth (m)

Figure F-4

Internal Model Evaluations Using the EPA/NES Data Set







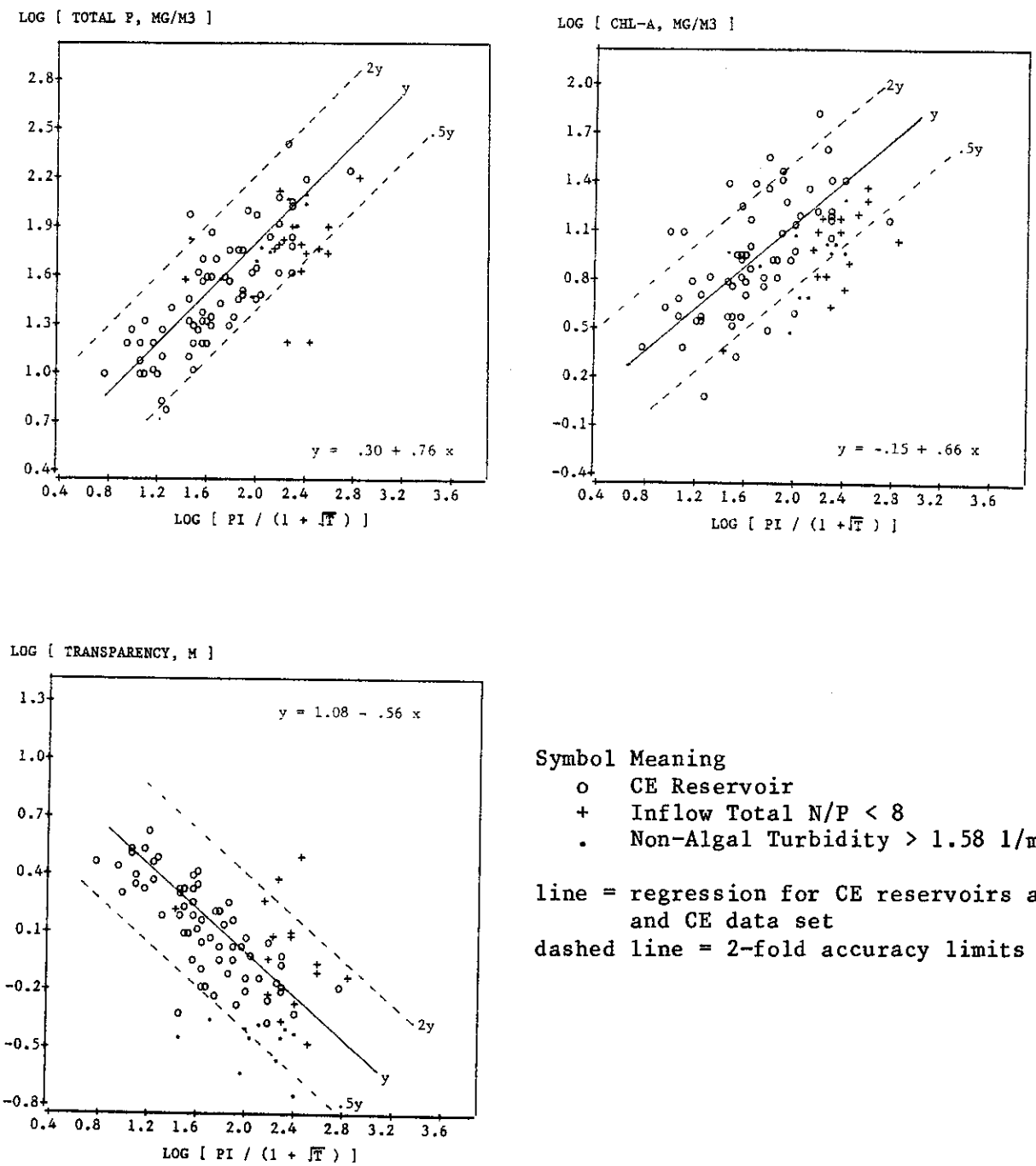
Symbol Meaning
- o CE Reservoir
- + Inflow Total N/P < 8
- . Non-Algal Turbidity > 1.58 1/m

line = regression for CE reservoirs and and CE data set

dashed line = 2-fold accuracy limits

Figure F-5

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the EPA/NES Data Set



Symbol Meaning

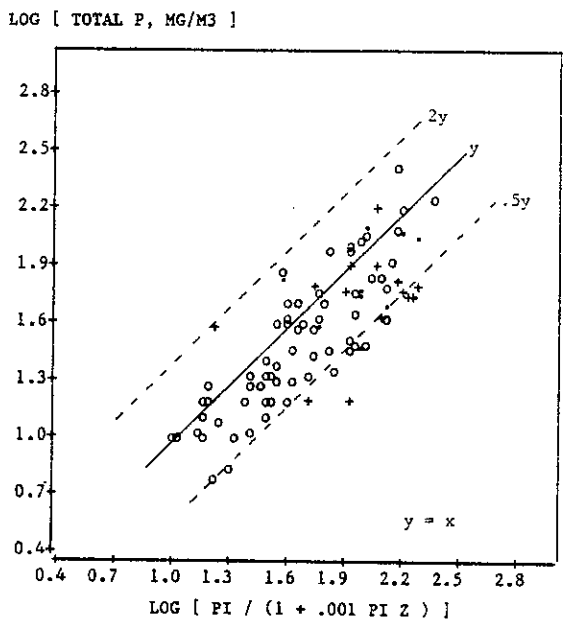
- o CE Reservoir
- + Inflow Total N/P < 8
- . Non-Algal Turbidity > 1.58 1/m

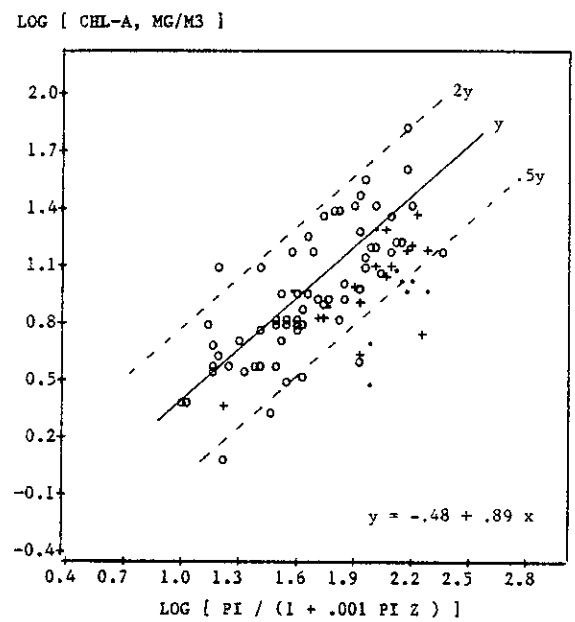
line = regression for CE reservoirs and and CE data set

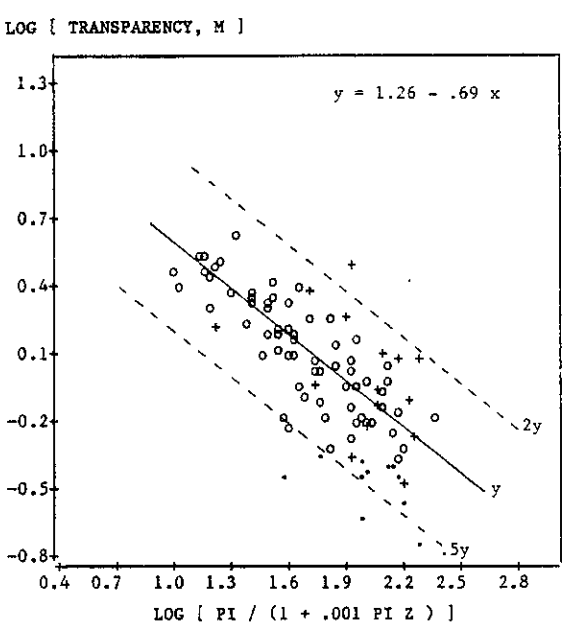
dashed line = 2-fold accuracy limits

Figure F-6

Observed vs. Predicted Water Quality Using P_n for Normalized Phosphorus Loading and the EPA/NES Data Set





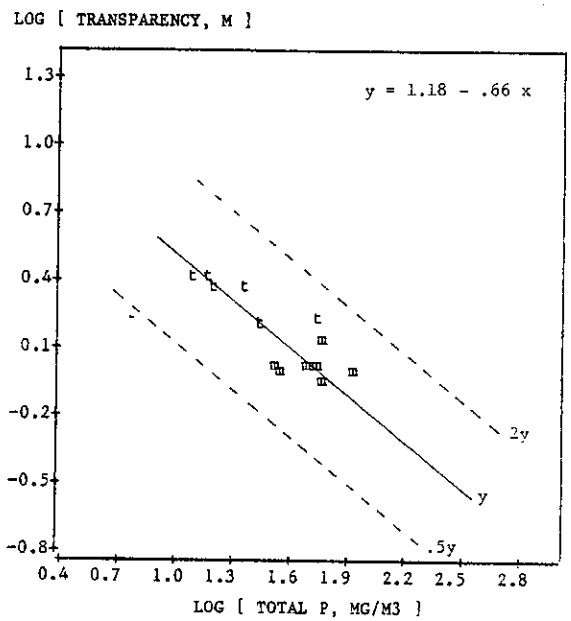


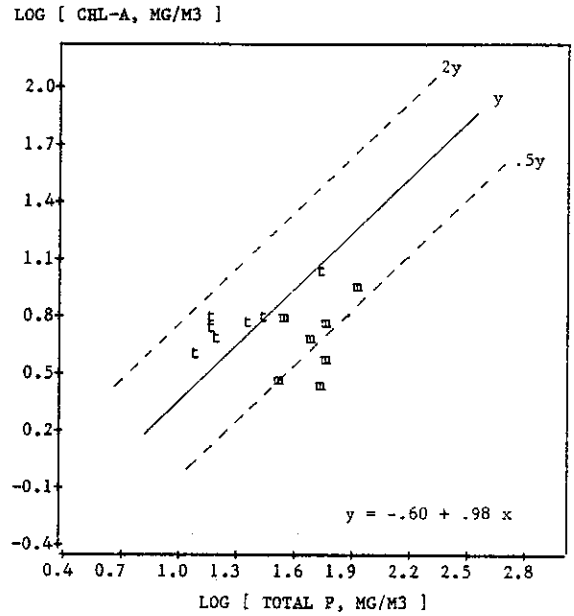
Symbol Meaning
- o CE Reservoir
- + Inflow Total N/P < 8
- . Non-Algal Turbidity > 1.58 1/m

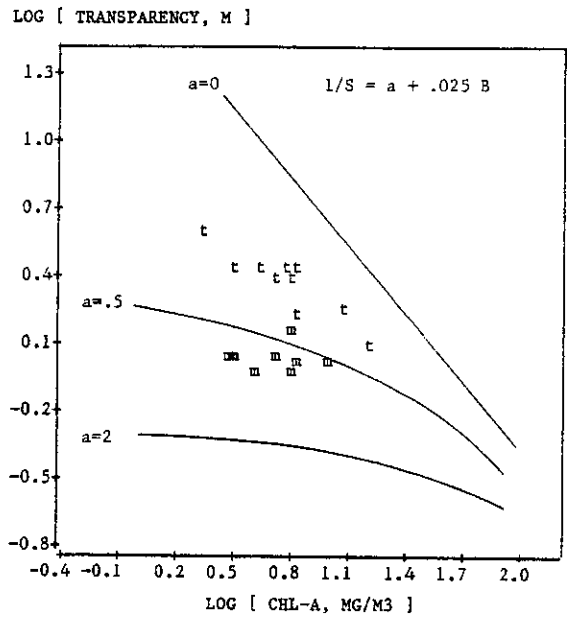
line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits
PI = average inflow phosphorus concentration (mg/m3
Z = mean depth (m)

Figure F-7

Internal Model Evaluations Using the TVA Data Set







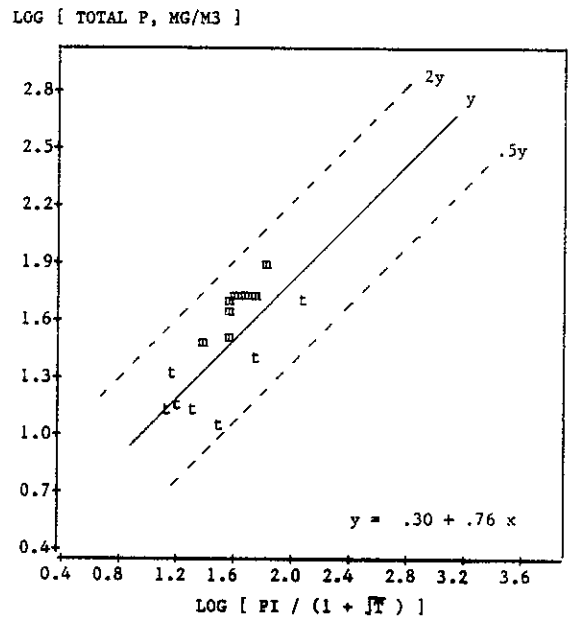
Symbol	Meaning
t	TVA Tributary Reservoir
m	TVA Mainstem Reservoir

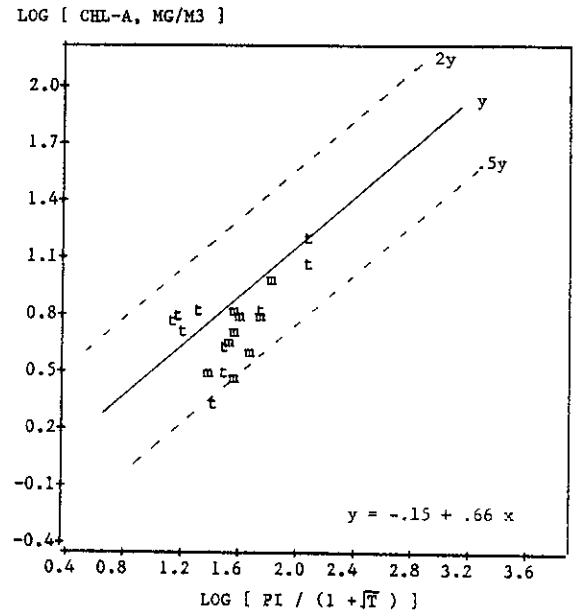
line = regression for CE reservoirs and CE data set

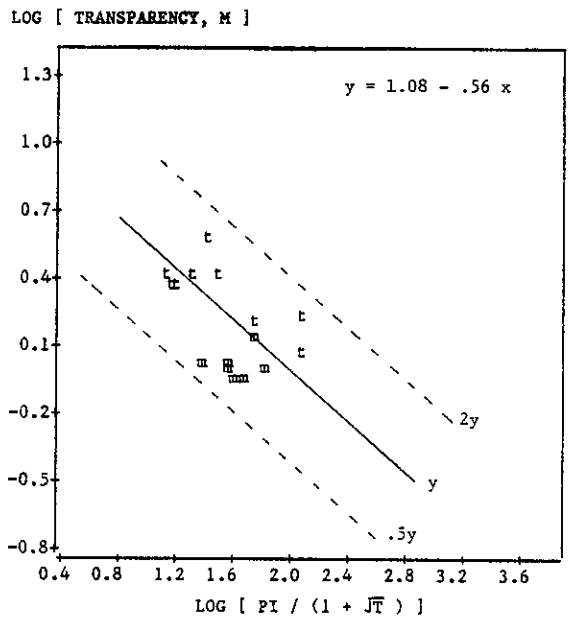
dashed line = 2-fold accuracy limits

Figure F-8

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the TVA Data Set





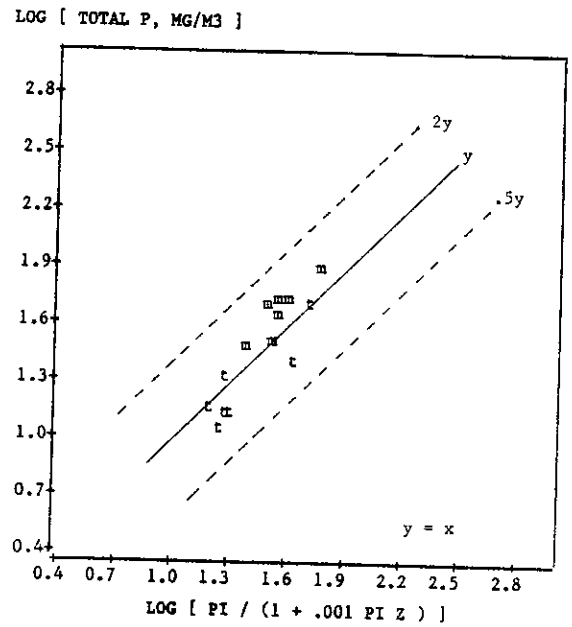


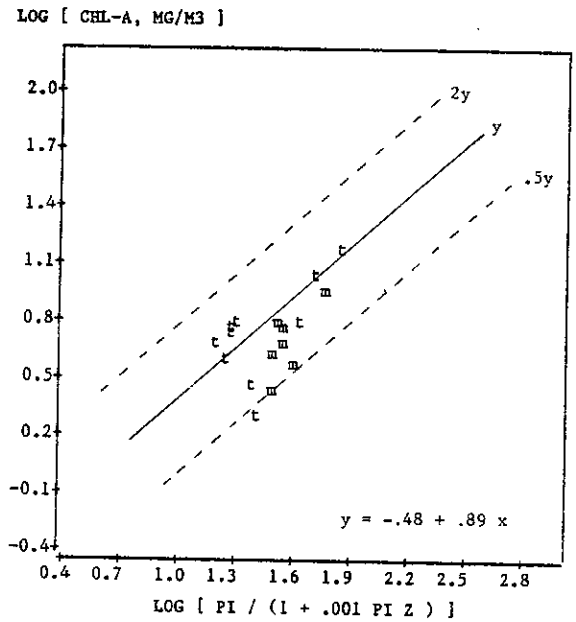
Symbol	Meaning
t	TVA Tributary Reservoir
m	TVA Mainstem Reservoir

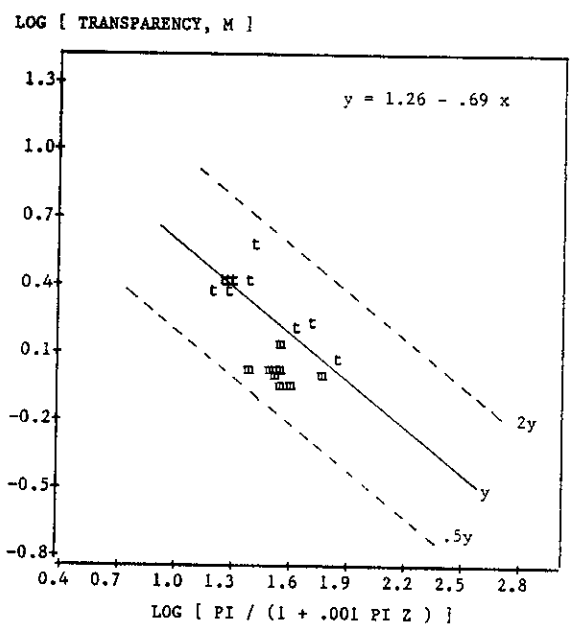
line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits

Figure F-9

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the TVA Data Set





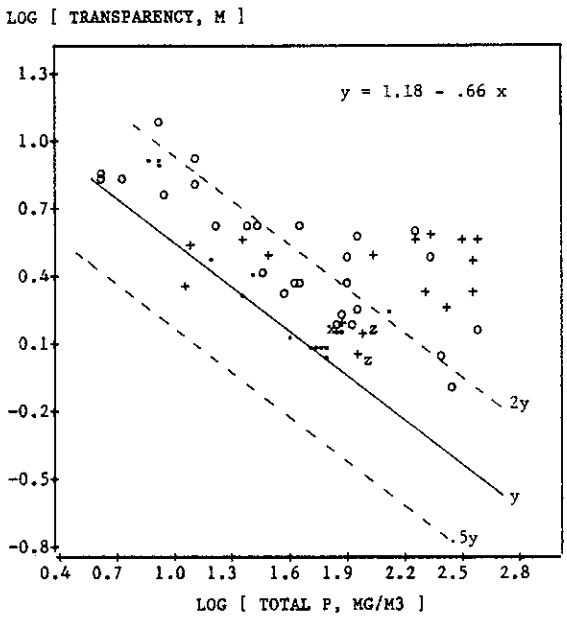


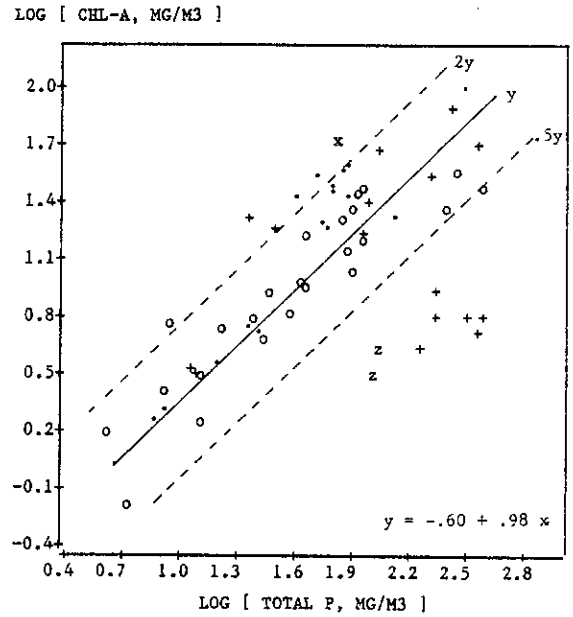
Symbol	Meaning
t	TVA Tributary Reservoir
m	TVA Mainstem Reservoir

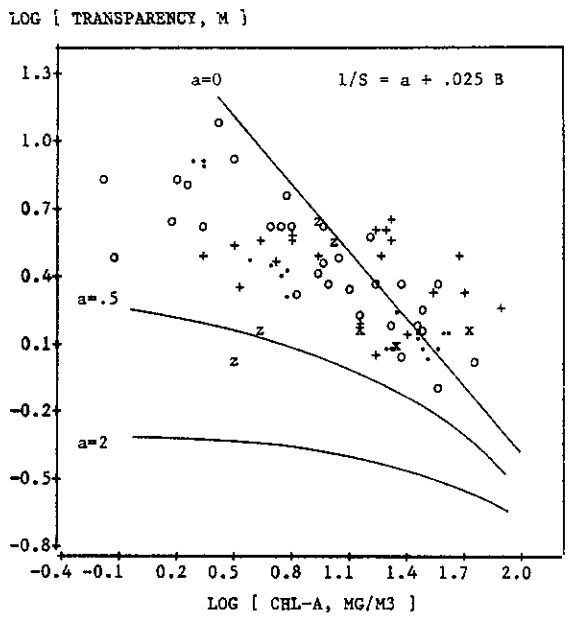
line = regression for CE reservoirs and CE data set
dashed line = 2-fold accuracy limits
PI = average inflow phosphorus concentration (mg/m3)
Z = mean depth (m)

Figure F-10

Internal Model Evaluations Using the OECD/RSL Data Set







Symbol Meaning

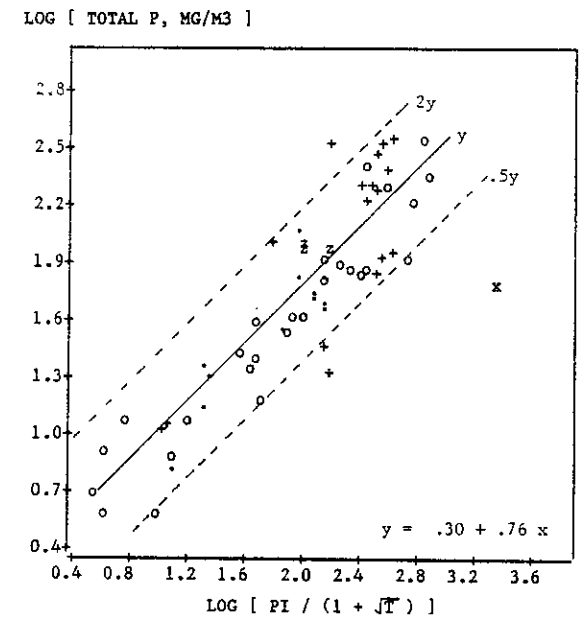
- o Reservoir
- x Inflow Total N/P < 8
- z Excluded Res.(Grafam or Mt Bold)
- + Pumped Storage Reservoir
- . Natural Lake

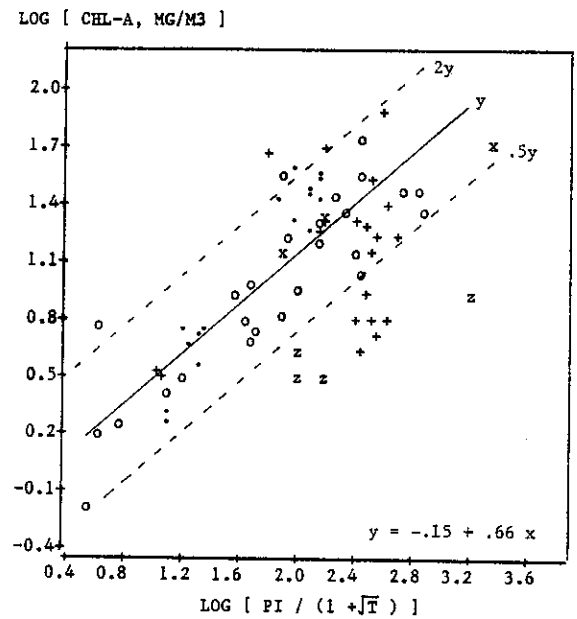
line = regression for CE reservoirs and CE data set

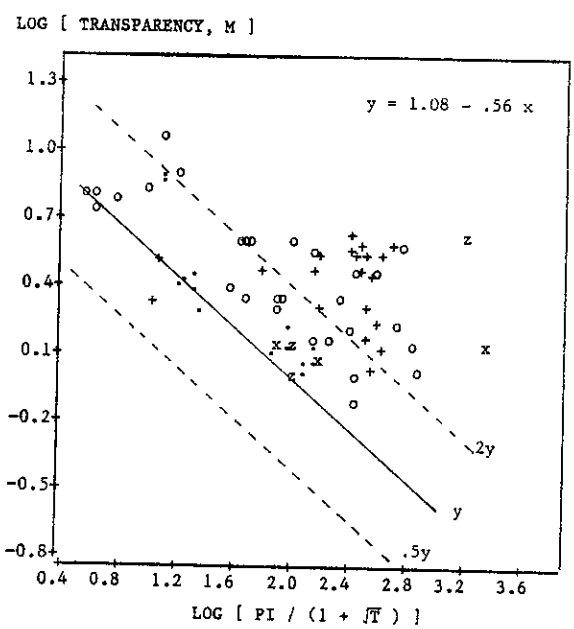
dashed line = 2-fold accuracy limits

Figure F-11

Observed vs. Predicted Water Quality Using Pv for Normalized Phosphorus Loading and the OECD/RSL Data Set







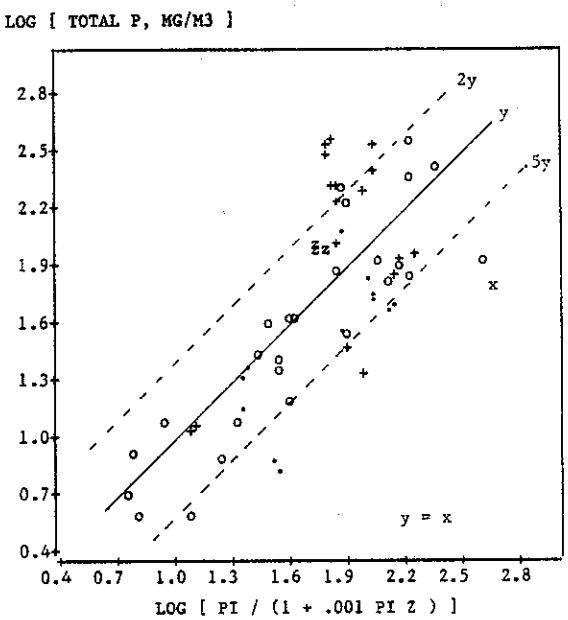
Symbol	Meaning
o	Reservoir
x	Inflow Total N/P < 8
z	Excluded Res. (Grafam or Mt. Bold)
+	Pumped Storage Reservoir
.	Natural Lake

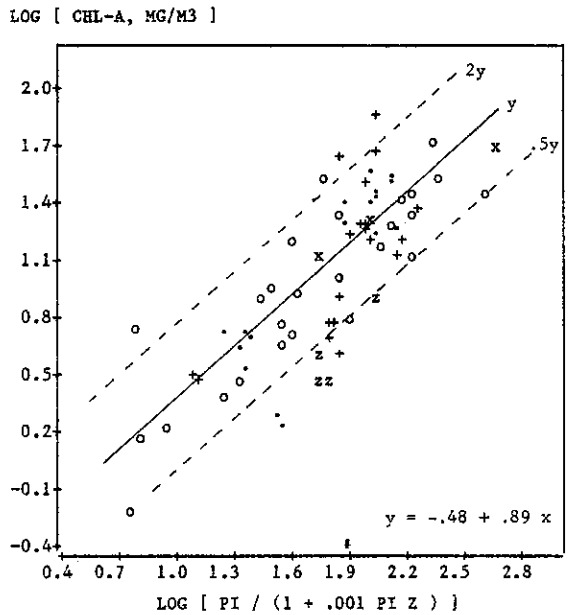
line = regression for CE reservoirs and CE data set

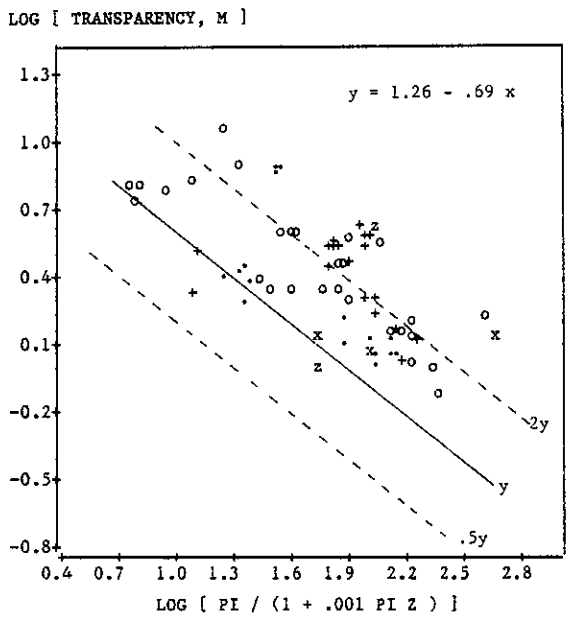
dashed line = 2-fold accuracy limits

Figure F-12

Observed vs. Predicted Water Quality Using Pn for Normalized Phosphorus Loading and the OECD/RSL Data Set







Symbol	Meaning
o	Reservoir
x	Inflow Total N/P < 8
z	Excluded Res.(Grafam or Mt Bold)
+	Pumped Storage Reservoir
.	Natural Lake

line = regression for CE reservoirs and CE data set

dashed line = 2-fold accuracy limits

PI = average inflow phosphorus concentration (mg/m3)

Z = mean depth (m)

APPENDIX G: NOTATION

' = superscript denoting estimated value

= superscript denoting pool-monitoring year

an = annual (subscript)

A = effect of nonchlorophyll-related materials on S (turbidity) (1/m)

AE = average absolute error

AG = drainage area of gauged tributaries (km^2)

Ap = total phosphorus accumulation (trapping) rate (mg/m^2-yr)

AR = reservoir surface area (km^2)

As = surface area at elevation E (acres)

AT = drainage area at reservoir discharge (km^2)

AU = drainage area of ungaged tributaries (km^2)

b = sensitivity of inflow concentration to flow

= regression slope

B = chlorophyll-a (mg/m^3)

CI' = inflow concentration estimate at QI' (g/m^3)

CV = coefficient of variation of reservoir mean estimate

CGN = average nutrient concentration in sampled, but ungauged tributaries not under point source influence (g/m^3)

CIC = corrected inflow concentration (g/m^3)

Csi = depth-averaged value on date i

CVS^2 = mean squared within-station coefficient of variation

CV(X) = coefficient of variation for mean X

CICE = inflow concentration, adjusted for evaporation (g/m^3)

Csij = measurement for station s , date i , depth j

C1-C5 = polynominal coefficients

D = derivative of predicted Y with respect to X

= discriminant function

= discriminant score (oxic for D > 0)

DI = derivative of $\log(P_o)$ with respect to $\log(P_i)$

DK = derivative of $\log(P_o)$ with respect to log(K)

dof = error degrees of freedom used in computing mean squared error and R-squared

DOsp = oxygen concentration at onset of stratification (g/m^3)

E = elevation (feet above mean sea level)

E0 = elevation at zero volume (feet above msl)

eu = euphotic zone (subscript)

E1,A1,V1 = elevation, area, and volume at first level

E2,A2,V2 = elevation, area, and volume at second level

F = fraction of loading attributed to point sources, septic tanks, and wildfowl

= F Statictic with p and n-p degrees of freedom

FE = evaporation/total inflow

Fm = morphometric factor

f(y) = normal frequency distribution function

gs = growing season (subscript)

Ho = the null hypothesis

HOD = hypolimnetic oxygen depletion rate (g/m^2-day)

HODa = estimated areal oxygen depletion rate (g/m^2-day)

HODv = volumetric HOD (g/m^3-day)

i = inflow (subscript)

I = trophic state index

K = first-order sedimentation rate (1/yr)

KE = effective rate constant for mixed model

K2 = slope parameter = 0.025 m^2/mg

ln = base-e logarithm

log = base-10 logarithm

Lp = total phosphorus loading (mg/m^2-yr)

M = total number of stations in the reservoir

mx = maximum value (subscript)

Med = median error

MSE = mean squared error

MSE* = minimum mean squared error

M1 = mean of group 1

M2 = mean of group 2

n = average number of sampling dates
= number of lakes or reservoirs in data set
= nitrogen (subscript)
= number of sampling dates/growing season
= number of impoundment-years

N = total N (mg/m^3)

No = organic nitrogen (mg/m^3)

Nsi = number of depths sampled in date i

o = outflow (subscript)

p = phosphorus (subscript)
= number of model parameters

P = total phosphorus (mg/m^3)

P* = probable classification error

Pi = average inflow phosphorus concentration (mg/m^3) = Lp/Qs

Pn = equation (61) normalized P loading = $P_i/(1 + 0.001\ PiZ)$

Po = average outflow total P concentration

Pv = Vollenweider normalized P loading = $P_i/(1 + sqrt(T))$

PC1 = first principal component

PC2 = second principal component

QD = discharge from reservoir (cubic hectometres/yr)

QD' = total discharge (including withdrawals) (cubic hectometres/yr)

QE = evaporation (cubic hectometres/yr)

QG = gauged tributary input (cubic hectometres/yr)

QI = total water input (cubic hectometres/yr = 10^6 m^3/yr)

QI' = total inflow (cubic hectometres/yr)

QN = net inflow (error, see equation (15)) (cubic hectometres/yr)

QO = total reservoir outflow (including evaporation) (cubic hectometres/yr)

QP = precipitation input (cubic hectometres/yr)

Qs = surface overflow rate (m/yr)

QU = estimated ungaged tributary input (cubic hectometres/yr)

QV = change in water storage (cubic hectometres/yr)

QV' = change-in-storage (cubic hectometres/yr)

QW = withdrawal from reservoir (cubic hectometres/yr)

QGN = inflow from gauged tributaries not under the influence of point sources (cubic hectometres/yr)

QIC = corrected total inflow (cubic hectometres/yr)

QIM = mean inflow over monitoring period, cubic hectometres/yr

QIS = mean inflow on tributary sampling days, cubic hectometres/yr

R = retention coefficient

R-squared = fraction of variance explained

R2 = percent of variance explained

sp = spring (subscript)

su = summer (subscript)

S = transparency (m)

SE^2 = mean squared error

SE_m^2 = model mean squared error

SE_t^2 = total mean squared error

Sr = sedimentation rate (kg/m^2-yr)

S1 = standard deviation of group 1

S2 = mean squared error (base-10 logarithms)

= standard deviation of group 2

T = length of monitoring period (yr)

= total hydraulic residence time (yr)

Th = mean hypolimnetic temperature (deg C)

TDO = days of oxygen supply at onset of stratification (days)

U = first-order settling velocity (m/yr)

V = total volume (acre-feet)

Var(X) = variance of estimated independent variable

Var(Y) = variance of estimated dependent variable

VD = dead storage (acre-feet)

VU1 = useable volume below first-listed elevation point (acre-ft)

VU2 = useable volume below second-listed elevation point (acre-ft)

V_x = estimated data error variance of independent variable

V_y = variance of dependent variable

= estimated data error variance of dependent variable

V1 = reservoir volume at beginning of period (cubic hectometres)

V2 = reservoir volume at end of period (cubic hectometres)

wn = winter (subscript)

W = weighting factor used for a given observation

WA = input from atmosphere (mt/yr)

WG = input from gauged tributaries (mt/yr)

WI = total input (metric tons/yr)

WO = total nutrient outflow (mt/yr)

WP = input from point source discharges (mt/yr)

WU = input from ungaged tributaries (mt/yr)

WV = change in nutrient storage (mt/yr)

WX = input from septic tanks and wildfowl (mt/yr)

WGN = nutrient input from gauged tributaries not under the influence of upstream point sources (mt/yr)

WIC = corrected total loading (mt/yr)

$|X-X'|$ = absolute value of $X-X'$

X^* = critical value of discriminating variable

y = standard normal variable (mean = 0, standard deviation = 1)

Y = mean depth ratio

YA = atmospheric nutrient loading (kg/km^2-yr)

YE = average evaporation rate (m/yr)

YP = precipitation rate (m/yr)

Z = total depth (feet) (Part I, equation (1) only)

= mean depth (m)

Z^* = normalized distance between groups 1 and 2

Zh = mean hypolimnetic depth = volume/area (m)

Zm = mixed depth (m)

Zmx = maximum depth (m)