U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

FALL RIVER RESERVOIR

GREENWOOD COUNTY

KANSAS

EPA REGION VII

WORKING PAPER No. 514

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

☆G.P.O. 699-440

REPORT

ON

FALL RIVER RESERVOIR

GREENWOOD COUNTY

KANSAS

EPA REGION VII

WORKING PAPER No. 514

WITH THE COOPERATION OF THE

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT

AND THE

KANSAS NATIONAL GUARD

APRIL, 1977

CONTENTS

	Page
Foreword	ii
List of Kansas Study Reservoirs	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	10
V. Literature Reviewed	15
VI. Appendices	16

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

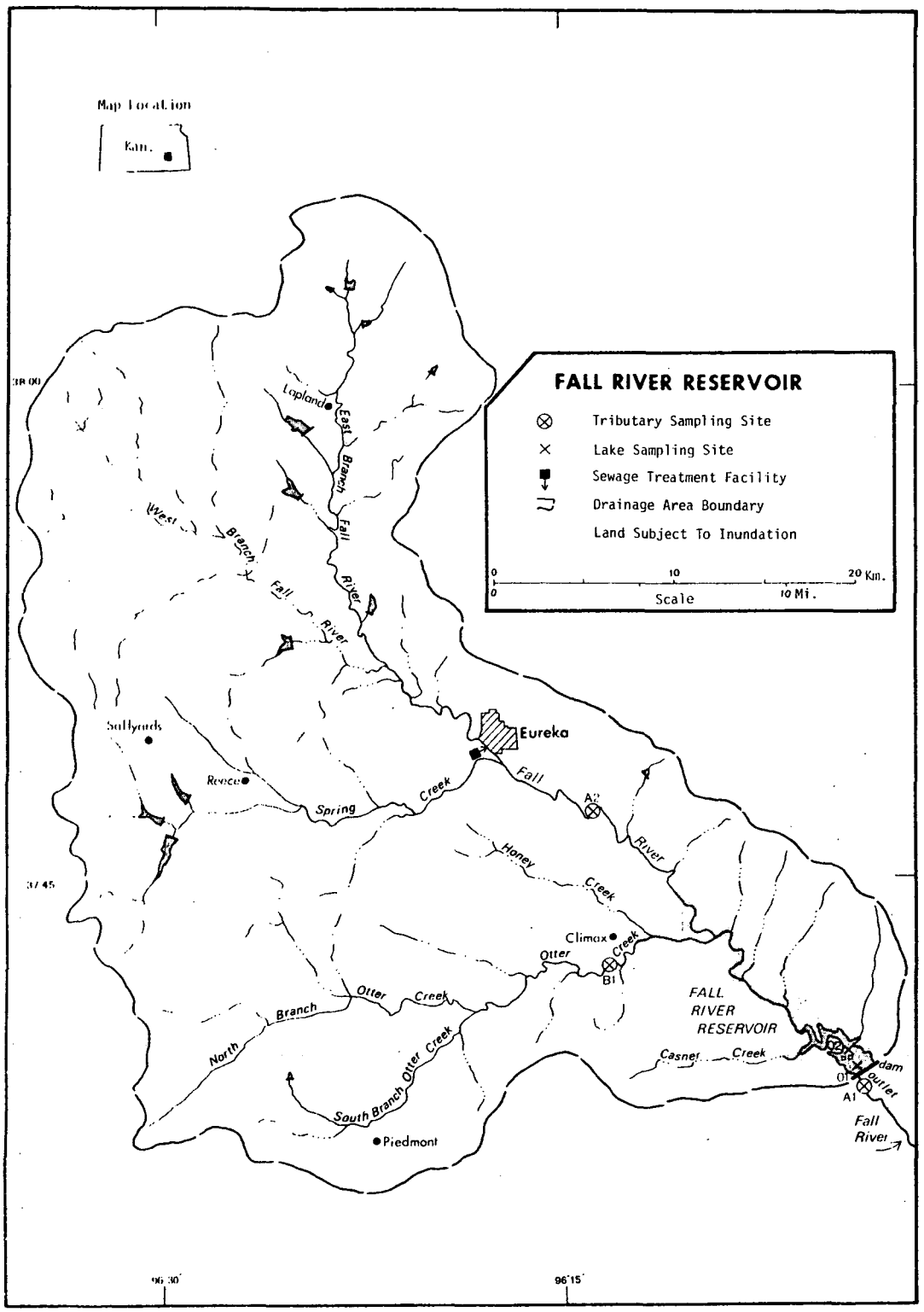
Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Potta-watomie, Riley
Wilson	Russell


Map Location
Kan.
FALL RIVER RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Land Subject To Inundation
0
10
20 Km.
0
Scale
10 Mi.
38 00
37 45
96 30'
96 15'
Lapland
East Branch Fall River
West Branch Fall River
Sallyards
Revere
Spring Creek
Eureka
Fall River
A2
Honey Creek
Climax
Otter Creek
B1
Otter Creek
North Branch Otter Creek
South Branch Otter Creek
Piedmont
FALL RIVER RESERVOIR
Casner Creek
dam
outlet
O1
A1
Fall River

FALL RIVER RESERVOIR

STORET NO. 2004

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Fall River Reservoir is potentially eutrophic. However, the reservoir becomes quite turbid during periods of runoff, and primary productivity is intermittently light-limited (Kring, 1977).

This water body ranked fifth in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six parameters*. Six of the reservoirs had less median total phosphorus, seven had less median dissolved orthophosphorus, six had less median inorganic nitrogen, four had less mean chlorophyll a, and 12 had greater mean Secchi disc transparency.

Survey limnologists did not observe algal concentrations or aquatic macrophytes but noted the reservoir was quite turbid.

B. Rate-Limiting Nutrient:

The algal assay results indicate Fall River Reservoir was phosphorus limited at the times the samples were taken (04/10/74 and 10/02/74).

The reservoir data also indicate phosphorus limitation at those times. However, the low Secchi disc transparencies, the low

* See Appendix A.

numbers of phytoplankton (page 7), and the relatively low chlorophyll a concentrations indicate productivity was light-limited at least part of the time.

C. Nutrient Controllability:

1. Point sources--The estimated phosphorus contribution of the City of Eureka amounted to 21.3% of the total load reaching Fall River Reservoir during the sampling year.

The present phosphorus loading of 1.84 $g/m^2/yr$ is nearly two times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 14). However, the mean hydraulic retention time of the reservoir is a rather short 40 days, and Vollenweider's model may not be applicable (note the apparent loss of both nitrogen and phosphorus during the sampling year; page 14).

Even complete removal of phosphorus at the Eureka wastewater treatment plant would still leave a phosphorus loading of 1.45 $g/m^2/yr$; and in view of the intermittently light-limited primary productivity in the reservoir, point-source phosphorus control would not be expected to result in a significant improvement in the trophic condition of Fall River Reservoir.

2. Non-point sources--Nearly 78% of the total phosphorus load to the reservoir during the sampling year came from non-point sources. The Fall River contributed 37.6% of the total; Otter

Creek, 18.8%; and the ungaged tributaries contributed an estimated 21.3%.

The phosphorus export rates of Fall River and Otter Creek were 9 and 11 kg/km^2/yr, respectively (see page 13) and compare well with the rates of three gaged tributaries of nearby Toronto Reservoir* (mean of 12 kg/km^2/yr).

* Working Paper No. 523.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 10.52 kilometers ^{2}.
2. Mean depth: 3.0 meters.
3. Maximum depth: 11.0 meters.
4. Volume: 29.5×10^6 m^3.
5. Fourteen-year median hydraulic retention time: 40 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Fall River	795.1	5.41
Otter Creek	334.1	2.40
Minor tributaries & immediate drainage -	375.4	2.46
Totals	1,504.6	10.27

2. Outlet -

Fall River	1,515.1**	9.26

C. Precipitation***:

1. Year of sampling: 114.5 centimeters.
2. Mean annual: 93.5 centimeters.

---

† Table of metric conversions--Appendix B.
†† Kring, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Fall River Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 9.1 meters at station 1 and 3.0 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table (the June nutrient samples were not properly preserved and were not analyzed).

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR FALL RIVER RESERVOIR
STORET CODE 2004

PARAMETER	1ST SAMPLING (4/10/74) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (6/24/74) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/ 2/74) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	11.2 - 11.9	11.7	11.8	24.7 - 25.5	25.1	25.1	16.8 - 17.2	17.0	16.8
DISS OXY (MG/L)	9.2 - 9.6	9.4	9.4	5.8 - 7.4	6.4	6.2	7.8 - 8.2	8.0	8.0
CNDCTVY (MCROMO)	295. - 478.	373.	375.	361. - 578.	403.	367.	299. - 309.	304.	301.
PH (STAND UNITS)	8.1 - 8.2	8.2	8.2	7.9 - 8.2	8.0	8.0	7.9 - 8.0	8.0	8.0
TOT ALK (MG/L)	178. - 188.	182.	181.	****** -**********			130. - 137.	133.	133.
TOT P (MG/L)	0.053 - 0.187	0.081	0.061	****** -**********			0.033 - 0.058	0.045	0.047
ORTHO P (MG/L)	0.014 - 0.019	0.016	0.016	****** -**********			0.012 - 0.021	0.016	0.017
NO2+NO3 (MG/L)	0.410 - 0.480	0.430	0.420	****** -**********			0.430 - 0.450	0.444	0.450
AMMONIA (MG/L)	0.090 - 0.150	0.105	0.095	****** -**********			0.020 - 0.030	0.023	0.020
KJEL N (MG/L)	0.400 - 0.800	0.533	0.500	****** -**********			0.200 - 0.200	0.200	0.200
INORG N (MG/L)	0.500 - 0.630	0.535	0.515	****** -**********			0.450 - 0.470	0.467	0.470
TOTAL N (MG/L)	0.810 - 1.220	0.963	0.950	****** -**********			0.630 - 0.650	0.644	0.650
CHLRPYL A (UG/L)	4.3 - 4.6	4.4	4.4	10.8 - 18.9	14.8	14.8	2.5 - 5.0	3.8	3.8
SECCHI (METERS)	0.3 - 0.3	0.3	0.3	0.3 - 0.3	0.3	0.3	0.3 - 0.3	0.3	0.3

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/10-11/74	1. *Asterionella sp.*	211
	2. *Cryptomonas sp.*	210
	3. *Chroomonas sp.*	158
	4. *Melosira sp.*	105
	5. *Stephanodiscus sp.*	105
	Other genera	106
	Total	895
06/24/76	1. *Cryptomonas sp.*	1,202
	2. *Chroomonas sp.*	791
	3. *Stephanodiscus sp.*	791
	4. *Synedra sp.*	63
	5. *Anabaena sp.*	32
	Other genera	32
	Total	2,911
10/02/74	1. *Chroomonas sp.*	550
	2. *Melosira sp.*	220
	3. *Closterium sp.*	44
	4. *Nitzschia sp.*	22
	5. *Stephanodiscus sp.*	22
	Other genera	21
	Total	879

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (μg/l)
04/10-11/74	1	4.3
	2	4.6
06/24/74	1	18.9
	2	10.8
10/02/74	1	2.5
	2	5.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. April sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.440	0.4
0.050 P	<0.055	0.440	14.0
0.050 P + 1.0 N	<0.055	1.440	21.8
1.0 N	<0.005	1.440	0.3

b. October sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.025	0.495	5.5
0.050 P	0.075	0.495	14.9
0.050 P + 1.0 N	0.075	1.495	30.1
1.0 N	0.025	1.495	4.8

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Fall River Reservoir was moderate in April and high in October. In both assay samples, yields increased when only phosphorus was added, but no such response occurred when only nitrogen was added. These results indicate Fall River Reservoir was phosphorus limited at the times the samples were taken.

The reservoir data also indicate phosphorus limitation. The mean inorganic nitrogen to orthophosphorus ratios were 33 to 1 in April and 29 to 1 in October, and phosphorus limitation would be expected. However, the low Secchi disc transparencies, the low numbers of phytoplankton, and the relatively low chlorophyll a concentrations indicate primary productivity in the reservoir was light-limited rather than nutrient-limited at least part of the time.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May and June when two samples were collected at most of the sites. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station B-1, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

The operator of the Eureka wastewater treatment plant provided monthly effluent samples but could not provide flow data. Therefore, nutrient loads were estimated at 1.134 P and 3.401 N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

---

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Eureka	3,631	tr. filter	1,374.3	Fall River

2. Known industrial - None

* Treatment plant questionnaire.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Fall River	7,290	37.6
Otter Creek	3,645	18.8
b. Minor tributaries & immediate drainage (non-point load) -	4,130	21.3
c. Known municipal STP's -		
Eureka	4,120	21.3
d. Septic tanks* -	5	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	185	1.0
Total	19,375	100.0

2. Outputs -

Reservoir outlet - Fall River 24,695

3. Net annual P loss - 5,320 kg.

* Estimate based on 20 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Fall River	244,460	48.7
Otter Creek	110,110	21.9
b. Minor tributaries & immediate drainage (non-point load) -	123,880	24.7
c. Known municipal STP's -		
Eureka	12,350	2.4
d. Septic tanks* -	215	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	11,355	2.3
Total	502,370	100.0

2. Outputs -

Reservoir outlet - Fall River 542,230

3. Net annual N loss - 39,860 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Fall River	9	307
Otter Creek	11	330

* Estimate based on 20 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.84	loss*	47.8	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and 14-year median hydraulic retention time of Fall River Reservoir:

"Dangerous" (eutrophic loading)	1.0
"Permissible" (oligotrophic loading)	0.5

* There was an apparent loss of nutrients during the sampling year. This may have been due to unknown point sources discharging below sampling station A-2 or directly to the reservoir, solubilization of previously sedimented nutrients, recharge with nutrient rich ground water, or (probably) insufficient outlet sampling in relation to the short hydraulic retention time of the reservoir.

V. LITERATURE REVIEWED

Kring, R. Lynn, 1977. Personal communication (revised morphometry; primary productivity in reservoir). KS Dept. of Health & Environment, Topeka.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
2001	CEDAR BLUFF RESERVOIR	0.017	0.055	431.667	4.217	10.800	0.004
2002	COUNCIL GROVE	0.069	0.830	485.889	9.789	10.400	0.028
2003	ELK CITY	0.030	0.590	490.400	3.212	14.000	0.003
2004	FALL RIVER RESERVOIR	0.053	0.470	488.667	7.683	9.200	0.016
2005	JOHN REDMOND RESERVOIR	0.118	1.250	492.667	9.467	8.200	0.066
2006	KANOPOLIS RESERVOIR	0.056	0.640	487.000	16.033	10.200	0.011
2007	MARION RESERVOIR	0.052	0.430	483.667	12.400	9.000	0.010
2008	MELVERN RESERVOIR	0.034	0.265	459.111	30.400	14.400	0.007
2009	MILFORD RESERVOIR	0.079	0.710	466.333	18.883	12.800	0.036
2010	NORTON RESERVOIR	0.122	0.110	476.750	21.360	8.000	0.036
2011	PERRY RESERVOIR	0.055	0.970	478.571	5.614	13.400	0.017
2012	POMONA RESERVOIR	0.040	1.240	481.333	8.312	13.000	0.021
2013	TORONTO RESERVOIR	0.067	0.425	488.500	6.583	13.000	0.011
2014	TUTTLE CREEK RESERVOIR	0.162	0.970	470.667	11.278	13.600	0.067
2015	WILSON RESERVOIR	0.023	0.265	445.222	8.867	13.400	0.004

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	2001	CEDAR BLUFF RESERVOIR	539
2	2015	WILSON RESERVOIR	439
3	2007	MARION RESERVOIR	357
4	2003	ELK CITY	350
5	2004	FALL RIVER RESERVOIR	328
6	2008	MELVERN RESERVOIR	326
7	2013	TORONTO RESERVOIR	303
8	2010	NORTON RESERVOIR	292
9	2011	PERRY RESERVOIR	279
10	2006	KANOPOLIS RESERVOIR	271
11	2012	POMONA RESERVOIR	267
12	2002	COUNCIL GROVE	230
13	2009	MILFORD RESERVOIR	214
14	2005	JOHN REDMOND RESERVOIR	164
15	2014	TUTTLE CREEK RESERVOIR	139

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
2001	CEDAR BLUFF RESERVOIR	100 (14)	100 (14)	100 (14)	93 (13)	57 (8)	89 (12)	539
2002	COUNCIL GROVE	29 (4)	29 (4)	36 (5)	43 (6)	64 (9)	29 (4)	230
2003	ELK CITY	86 (12)	50 (7)	7 (1)	100 (14)	7 (1)	100 (14)	350
2004	FALL RIVER RESERVOIR	57 (8)	57 (8)	14 (2)	71 (10)	79 (11)	50 (7)	328
2005	JOHN REDMOND RESERVOIR	14 (2)	0 (0)	0 (0)	50 (7)	93 (13)	7 (1)	164
2006	KANOPOLIS RESERVOIR	43 (6)	43 (6)	29 (4)	21 (3)	71 (10)	64 (9)	271
2007	MARION RESERVOIR	64 (9)	64 (9)	43 (6)	29 (4)	86 (12)	71 (10)	357
2008	MELVERN RESERVOIR	79 (11)	82 (11)	86 (12)	0 (0)	0 (0)	79 (11)	326
2009	MILFORD RESERVOIR	21 (3)	36 (5)	79 (11)	14 (2)	50 (7)	14 (2)	214
2010	NORTON RESERVOIR	7 (1)	93 (13)	64 (9)	7 (1)	100 (14)	21 (3)	292
2011	PERRY RESERVOIR	50 (7)	18 (2)	57 (8)	86 (12)	25 (3)	43 (6)	279
2012	POMONA RESERVOIR	71 (10)	7 (1)	50 (7)	64 (9)	39 (5)	36 (5)	267
2013	TORONTO RESERVOIR	36 (5)	71 (10)	21 (3)	79 (11)	39 (5)	57 (8)	303
2014	TUTTLE CREEK RESERVOIR	0 (0)	18 (2)	71 (10)	36 (5)	14 (2)	0 (0)	139
2015	WILSON RESERVOIR	93 (13)	82 (11)	93 (13)	57 (8)	25 (3)	89 (12)	439

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR KANSAS 05/03/76

LAKE CODE 2004 FALL RIVER

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 1515.1

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
2004A1	1515.1	5.10	5.10	11.89	11.33	14.44	16.14	13.03	3.96	9.06	8.50	7.65	4.81	9.26
2004A2	795.1	3.11	3.40	7.36	8.21	8.21	10.48	6.80	1.95	4.53	4.53	3.96	2.29	5.41
2004B1	334.1	1.13	1.25	3.11	3.68	3.11	3.68	2.52	3.68	2.24	1.50	1.87	0.96	2.40
2004ZZ	385.9	1.13	1.44	3.11	3.68	4.25	4.25	3.68	1.47	2.07	2.04	1.25	1.10	2.46

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1515.1 TOTAL FLOW IN = 123.06
SUM OF SUB-DRAINAGE AREAS = 1515.1 TOTAL FLOW OUT = 111.00

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2004A1	10	74	2.532	13	2.152				
	11	74	50.546	10	27.184				
	12	74	14.980	14	28.600				
	1	75	11.412	12	11.836				
	2	75	32.904	16	0.255				
	3	75	24.183	30	5.239				
	4	75	17.670	20	9.628				
	5	75	11.695	11	5.097	26	1.699		
	6	75	39.927	12	0.481	22	90.614		
	7	75	1.756	13	1.416				
	8	75	0.379	17	0.396				
	9	75	0.371	22	0.368				
2004A2	10	74	3.030	13	1.388				
	11	74	21.011	21	4.955				
	12	74	7.419	13	15.291				
	1	75	8.580	11	11.213				
	2	75	15.688	8	16.565				
	3	75	16.650	8	9.061				
	4	75	7.504	13	7.079				
	5	75	6.173	2	4.814	19	3.398	29	6.513
	6	75	17.217	12	18.689	28	5.380		
	7	75	1.184	13	0.623	25	0.396		
	8	75	0.912	9	0.340				
	9	75	0.278	14	0.283				

TRIBUTARY FLOW INFORMATION FOR KANSAS 05/03/76

LAKE CODE 2004 FALL RIVER

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2004B1	10	74	3.738	13	0.368				
	11	74	12.573	21	1.359				
	12	74	3.341	13	5.437				
	1	75	4.672	11	2.888				
	2	75	7.051	8	5.833				
	3	75	6.654	8	2.294				
	4	75	1.968	13	1.784				
	5	75	3.681	2	0.793	19	0.850	29	3.596
	6	75	11.185	2	1.416	12	3.398	28	1.416
	7	75	0.357	13	0.311	20	0.184	25	0.173
	8	75	0.144	9	0.0				
	9	75	0.065	14	0.059				
2004ZZ	10	74	4.248						
	11	74	10.760						
	12	74	2.832						
	1	75	4.531						
	2	75	3.964						
	3	75	5.947						
	4	75	2.010						
	5	75	6.230						
	6	75	8.495						
	7	75	0.481						
	8	75	0.082						
	9	75	0.127						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/05/03

200401
37 38 50.0 096 03 40.0 3
FALL RIVER RESERVOIR
20073 KANSAS
100391

11EPALES 2111202
0034 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/10	15 00	0000	11.9		12	375	8.20	178	0.090	0.600	0.410	0.015
	15 00	0005	11.9	9.4		375	8.20	178	0.090	0.500	0.420	0.016
	15 00	0015	11.8	9.6		478	8.10	181	0.110	0.400	0.440	0.016
	15 00	0025	11.2	9.2		418	8.20	180	0.150	0.500	0.480	0.018
74/06/24	12 55	0000	25.5	7.4	12	361	8.20					
	12 55	0005	25.5	5.8		363	8.10					
	12 55	0015	24.9	6.0		366	8.00					
	12 55	0025	24.7	7.0		364	8.00					
	12 55	0030	24.7	5.8		367	7.90					
74/10/02	13 00	0000	16.8	8.2	12	299	7.96	131	0.020	0.200K	0.450	0.017
	13 00	0005	16.8	8.0		299	7.97	131	0.020K	0.200K	0.450	0.017
	13 00	0015	16.8	7.8		301	7.96	133	0.020K	0.200K	0.450	0.012
	13 00	0025	16.8	8.0		301	7.93	130	0.020K	0.200	0.450	0.021

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/10	15 00	0000	0.058	4.3	
	15 00	0005	0.062		
	15 00	0015	0.066		
	15 00	0025	0.187		
74/06/24	12 55	0000		18.9	
74/10/02	13 00	0000	0.049	2.5	
	13 00	0005	0.038		
	13 00	0015	0.033		
	13 00	0025	0.058		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/03

200402
37 39 45.0 096 04 10.0 3
FALL RIVER RESERVOIR
20073 KANSAS

100391

11EPALES 2111202
0010 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/11	10 05	0000	11.8		10	295	8.20	188	0.100	0.800	0.420	0.019
	10 05	0005	11.8	9.4		295	8.10	187	0.090	0.400	0.410	0.014
74/06/24	13 25	0000	25.3	6.4	10	578	8.00					
	13 25	0005	25.1	6.0		386						
	13 25	0010	25.1	7.0		441	7.90					
74/10/02	13 20	0000	17.2	8.0	12	309	7.96	137	0.030	0.200K	0.440	0.014
	13 20	0005	17.2	8.0		309	8.01	135	0.020K	0.200K	0.430	0.017
	13 20	0010	17.2	8.0		309	8.02	135	0.030	0.200K	0.440	0.015

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/11	10 05	0000	0.061	4.6	
	10 05	0005	0.053		
74/06/24	13 25	0000		10.8	
74/10/02	13 20	0000	0.040	5.0	
	13 20	0002			1.0
	13 20	0005	0.047		
	13 20	0010	0.048		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/15/14

2004A1
37 38 34.0 096 03 33.0 4
FALL RIVER
20 15 SEVERY
O/FALL RIVER RESERVOIR 100391
SEC RD BRDG .3 MI DWNSTRM OF FALL RIV DM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/13	16	15	0.448	1.700	0.035	0.025	0.075
74/11/10	14	35	0.192	1.200	0.390	0.040	0.080
74/12/14	13	45	0.320	1.300	0.030	0.025	0.060
75/01/12	13	10	0.288	2.200	0.072	0.008	0.040
75/02/16	13	30	0.360	2.300	0.028	0.008K	0.030
75/03/30	13	30	0.400	1.050	0.050	0.025	0.160
75/04/20	12	30	0.110	0.750	0.070	0.010	0.040
75/05/11	13	00	0.145	0.800	0.060	0.015	0.040
75/05/26	14	00	0.145	1.100	0.105	0.010	0.040
75/06/12	16	30	0.230	4.700	0.125	0.030	0.130
75/06/22	14	00	0.420	0.800	0.035	0.015	0.150
75/07/13	13	00	0.430	0.100	0.042	0.020	0.020
75/08/17	14	00	0.720	1.500	0.055	0.290	0.400
75/09/22	13	30	0.315	0.800	0.020	0.020	0.080

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

2004A2
37 47 07.0 096 13 52.0 4
FALL RIVER
20 GREENWOOD CO MAP
T/FALL RIVER RESERVOIR
KS HWY 99 BRDG 5 MI N OF CLIMAX
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/13	13 40		0.630	2.000	0.045	0.135	0.193
74/11/21	09 50		0.528	0.800	0.030	0.040	0.050
74/12/13	14 15		0.184	0.900	0.020	0.010	0.050
75/01/11	14 00		0.168	0.800	0.248	0.010	0.030
75/02/08	13 20		0.280	0.900	0.032	0.020	0.040
75/03/08	09 30		0.304	1.300	0.024	0.016	0.040
75/04/13	11 45		0.250	1.100	0.050	0.025	0.040
75/05/02	16 35		0.375	0.300	0.025	0.035	0.120
75/05/19	13 30		0.580	0.500	0.030	0.055	0.100
75/06/28	11 10		0.460	3.300	1.050	0.030	0.080
75/07/13	10 45		0.490	0.350	0.020	0.050	0.100
75/08/09	15 40		0.410	1.250	0.025	0.090	0.230
75/09/14	10 10		0.315	0.800	0.015	0.010	0.060

STORET RETRIEVAL DATE 76/05/04

200481
37 42 30.0 096 13 30.0 4
OTTER CREEK
20 15 SEVERY
T/FALL RIVER RESERVOIR 100391
KS HWY 99 BRDG .5 MI S OF CLIMAX
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/13	14	15	0.176	1.200	0.025	0.010	0.040
74/11/21	09	35	0.520	1.300	0.035	0.010	0.010
74/12/13	14	00	0.304	1.400	0.025	0.012	0.070
75/01/11	13	40	0.264	0.500	0.040		0.020
75/02/08	13	50	0.270	0.500	0.016	0.024	0.024
75/03/08	09	00	0.352	1.050	0.016	0.008K	0.020
75/04/13	11	30	0.330	1.450	0.030	0.005	0.020
75/05/02	16	25	0.290	0.125	0.025	0.005	0.015
75/05/19	13	50	0.490	1.900	0.040	0.010	0.040
75/05/29	15	50	0.300	0.100	0.125	0.015	0.090
75/06/12	16	20	0.240	4.700	0.350	0.015	0.140
75/06/28	11	00	0.510	0.650	0.040	0.005	0.050
75/07/13	10	30	0.530	0.400	0.020	0.005	0.030
75/07/20	15	00	0.360	0.450	0.035	0.025	0.060
75/07/25	11	00	0.400	0.300	0.015	0.005	0.040
75/09/14	10	00	0.630	0.800	0.040	0.100	0.180

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

2004AA TF2004AA P003631
37 49 00.0 096 18 30.0 4
EUREKA
20 GREENWOOD COUNTY
T/FALL RIVER RES 100391
FALL RIVER
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/07/29	08	30	12.000	4.600		10.500	10.500		
75/08/05	08	30	19.000	3.500	0.050K		12.000		
75/08/12	08	30	21.000	3.600	0.125	12.000	14.000	0.300	0.300
75/08/19	08	30	20.000	3.200	0.044		11.800		
75/08/26	08	30	15.000	8.700	1.000	12.600	12.500		
75/09/02	08	30	13.800	5.500	0.830	9.500	10.500		
75/09/10	08	30	15.000	7.600	0.360	13.500	13.500		
75/09/23	08	30	16.800	9.900	0.375	12.600	13.000		
75/09/30	08	30	16.800	10.000	0.150	12.000	14.500		
75/10/14	08	30	13.200	7.400	1.100	14.500	14.500		
75/10/21	08	30	15.700	9.300	0.790	14.000	14.500		
75/11/04	08	30	16.000	9.100	0.680	14.000	15.300		

K VALUE KNOWN TO BE
LESS THAN INDICATED