

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES**



REPORT
ON
WILSON RESERVOIR
RUSSELL COUNTY
KANSAS
EPA REGION VII
WORKING PAPER No. 525

**CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA**

REPORT
ON
WILSON RESERVOIR
RUSSELL COUNTY
KANSAS
EPA REGION VII
WORKING PAPER No. 525

WITH THE COOPERATION OF THE
KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
AND THE
KANSAS NATIONAL GUARD

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F O R E W O R D

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

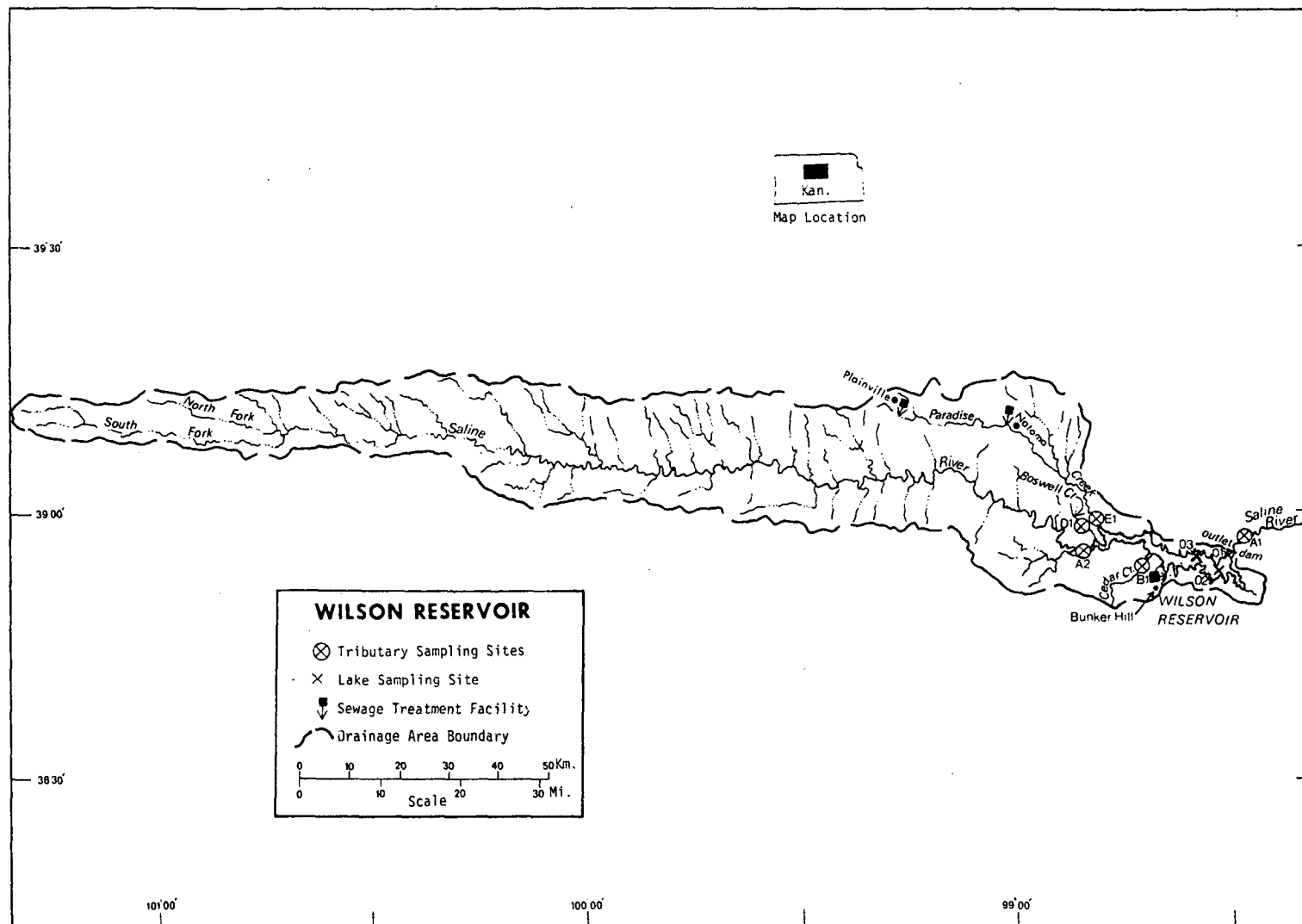
STUDY RESERVOIRS

STATE OF KANSASNAME

Cedar Bluff
Council Grove
Elk City
Fall River
John Redmond
Kanopolis
Marion
Melvern
Milford
Norton
Perry
Pomona
Toronto
Tuttle Creek
Wilson

COUNTY

Trego
Morris
Montgomery
Greenwood
Coffey, Lyon
Ellsworth
Marion
Osage
Clay, Geary
Norton
Jefferson
Osage
Greenwood, Woodson
Marshall, Pottawatomie, Riley
Russell



WILSON RESERVOIR

STORET NO. 2015

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Wilson Reservoir is mesotrophic. It ranked second in overall trophic quality among the 15 Kansas reservoirs sampled in 1974 when compared using a combination of six water quality parameters*. One of the reservoirs had less median total phosphorus, one had less and one had the same median dissolved orthophosphorus, two had less and one had the same median inorganic nitrogen, six had less mean chlorophyll a, and none of the other reservoirs had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at sampling stations 2 and 3 in June.

Survey limnologists did not observe macrophytes or surface concentrations of algae during sampling visits.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Wilson Reservoir was phosphorus limited at the time the sample was collected (04/12/74). The reservoir data indicate phosphorus limitation at all sampling stations and times.

* See Appendix A.

C. Nutrient Controllability:

1. Point Sources--During the sampling year, the listed point sources accounted for an estimated 22.1% of the total phosphorus input to Wilson Reservoir. The wastewater treatment plant at Plainville contributed 16.7%, the plant at Natoma contributed 3.9%, and the plant at Bunker Hill contributed 1.6% of the total.

The present phosphorus loading of $0.47 \text{ g/m}^2/\text{year}$ is nearly 1.4 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). Continuation of this loading may increase primary productivity and eventually cause the reservoir to become eutrophic. Because the water-body is phosphorus limited, point-source phosphorus should be reduced to the greatest practicable extent to at least slow the present rate of enrichment.

2. Non-point sources--Non-point sources contributed 77.8% of the total phosphorus load during the sampling year. The Saline River contributed 62.7%, Cedar Creek contributed 0.7%, and Paradise Creek contributed 0.3%. The ungaged minor tributaries and immediate drainage contributed an estimated 10.4%.

The phosphorus export rates of the three tributaries were quite low ($3 \text{ kg/km}^2/\text{yr}$ and less; see page 12).

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry^{††}:

1. Surface area: 36.42 kilometers².
2. Mean depth: 8.4 meters.
3. Maximum depth: >16.8 meters.
4. Volume: 305.908 x 10⁶ m³.
5. Mean hydraulic retention time: 2.8 years (based on outflow).

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

1. Tributaries -

<u>Name</u>	<u>Drainage area (km²)*</u>	<u>Mean flow (m³/sec)*</u>
Saline River	3,890.2	3.440
Cedar Creek	71.0	0.074
Paradise Creek	595.7	0.600
Minor tributaries & immediate drainage -	<u>371.7</u>	<u>1.030</u>
Totals	4,928.6	5.144

2. Outlet -

Saline River	4,965.0**	3.490
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C. Precipitation***:

1. Year of sampling: 40.7 centimeters.
2. Mean annual: 68.0 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

Wilson 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 a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, 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 16.8 meters at station 1, 15.2 meters at station 2, and 12.2 meters at station 3.

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

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WILSON RESERVOIR
STORET CODE 2015

1ST SAMPLING (4/12/74)

2ND SAMPLING (6/26/74)

3RD SAMPLING (10/ 1/74)

3 SITES

3 SITES

3 SITES

PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	9.2 - 10.5	9.7	9.5	20.6 - 24.1	22.7	23.0	16.2 - 17.4	17.0	17.2
DISS OXY (MG/L)	9.6 - 10.2	10.0	10.0	1.6 - 8.0	6.0	6.8	7.8 - 9.0	8.4	8.4
CNDCTVY (MCROMO)	1598. - 1704.	1635.	1607.	209. - 226.	219.	221.	210. - 2171.	908.	215.
PH (STAND UNITS)	8.0 - 8.2	8.2	8.2	7.9 - 8.4	8.3	8.4	7.8 - 8.3	8.0	8.0
TOT ALK (MG/L)	154. - 180.	167.	162.	*****	*****	*****	127. - 141.	135.	137.
TOT P (MG/L)	0.021 - 0.070	0.030	0.025	*****	*****	*****	0.017 - 0.027	0.021	0.020
ORTHO P (MG/L)	0.004 - 0.027	0.008	0.006	*****	*****	*****	0.002 - 0.011	0.004	0.004
NO2+NO3 (MG/L)	0.300 - 1.230	0.427	0.315	*****	*****	*****	0.040 - 0.220	0.139	0.170
AMMONIA (MG/L)	0.040 - 0.070	0.051	0.050	*****	*****	*****	0.020 - 0.080	0.034	0.030
KJEL N (MG/L)	0.500 - 0.900	0.608	0.600	*****	*****	*****	0.500 - 0.800	0.607	0.600
INORG N (MG/L)	0.350 - 1.270	0.478	0.370	*****	*****	*****	0.070 - 0.300	0.174	0.205
TOTAL N (MG/L)	0.800 - 1.830	1.036	0.970	*****	*****	*****	0.540 - 1.020	0.746	0.730
CHLRPYL A (UG/L)	5.0 - 11.8	7.3	5.0	0.8 - 2.5	1.7	1.9	15.9 - 19.4	17.6	17.5
SECCHI (METERS)	0.5 - 0.8	0.7	0.8	2.0 - 2.8	2.5	2.7	0.9 - 1.1	1.0	1.1

B. Biological Characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Algal Units per ml</u>
04/12/74	1. <u>Synedra sp.</u>	3,438
	2. <u>Chroomonas sp.</u>	1,413
	3. <u>Stephanodiscus sp.</u>	1,130
	4. <u>Oocystis sp.</u>	1,083
	5. <u>Ankistrodesmus sp.</u>	659
	Other genera	<u>1,460</u>
	Total	9,183
06/26/74	1. <u>Chroomonas sp.</u>	575
	2. <u>Cryptomonas sp.</u>	157
	3. <u>Oocystis sp.</u>	52
	4. <u>Sphaerocystis sp.</u>	<u>52</u>
	Total	836
10/01/74	1. <u>Stephanodiscus sp.</u>	1,847
	2. <u>Oscillatoria sp.</u>	1,203
	3. <u>Synedra sp.</u>	601
	4. <u>Oocystis sp.</u>	258
	5. <u>Dactylococcopsis sp.</u>	129
	Other genera	<u>516</u>
	Total	4,554

2. Chlorophyll a -

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll a (µg/l)</u>
04/12/74	1	5.0
	2	5.0
	3	11.8
06/26/74	1	0.8
	2	2.5
	3	1.9
10/01/74	1	19.4
	2	15.9
	3	17.5

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

<u>Spike (mg/l)</u>	<u>Ortho P Conc. (mg/l)</u>	<u>Inorganic N Conc. (mg/l)</u>	<u>Maximum yield (mg/l-dry wt.)</u>
Control	<0.005	0.285	0.1
0.050 P	<0.055	0.285	6.8
0.050 P + 1.0 N	<0.055	1.285	14.1
1.0 N	<0.005	1.285	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Wilson Reservoir was low at the time the sample was collected (04/12/74). Also, the increase in yield with the addition of phosphorus alone indicates that the reservoir was phosphorus limited at that time. Note that the addition

of nitrogen alone resulted in a yield no greater than that of the control.

The reservoir data indicate phosphorus limitation as well. The mean inorganic nitrogen/orthophosphorus ratios were 30/1 or greater at all sampling stations and times, and phosphorus limitation would be expected.

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 months of May, June, and July when two samples were collected. 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 calculated using mean annual concentrations and mean annual flows. 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 mean concentrations in Cedar Creek at station B-1 and the mean annual ZZ flow.

The operator of the Plainville wastewater treatment plant provided monthly effluent samples; however, flows appear to be estimates. The operator of the Natona wastewater treatment plant also provided monthly samples but flows were not available. Therefore, nutrient loads from these sources and those from the wastewater treatment plant

at Bunker Hill, which was not sampled, were estimated at 1.134 kg P and 3.401 kg N/capita/year; and flows were estimated at 0.3785 m³/capita/day.

A. Waste Sources:

1. Known municipal* -

<u>Name</u>	<u>Pop. Served</u>	<u>Treatment</u>	<u>Mean Flow (m³/d)</u>	<u>Receiving Water</u>
Plainville	2,518	tr. filter	953.1	Trib. of Paradise Creek
Natoma	590	tr. filter	223.3	Paradise Creek
Bunker Hill	240	stab. pond	90.8	Unnamed Trib./ Wilson Reservoir

2. Known industrial - None

* Treatment plant questionnaires; Anonymous, 1971.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>kg P/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Saline River	10,740	62.7
Cedar Creek	130	0.7
Paradise Creek	50	0.3
b. Minor tributaries & immediate drainage (non-point load) -	1,785	10.4
c. Known municipal STP's -		
Bunker Hill	270	1.6
Natoma	670	3.9
Plainville	2,855	16.7
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>635</u>	<u>3.7</u>
Total	17,135	100.0

2. Outputs -

Lake outlet - Saline River 5,065

3. Net annual P accumulation - 12,070 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

<u>Source</u>	<u>kg N/ yr</u>	<u>% of total</u>
a. Tributaries (non-point load) -		
Saline River	134,305	46.3
Cedar Creek	4,950	1.7
Paradise Creek	31,190	10.7
b. Minor tributaries & immediate drainage (non-point load) -	68,895	23.7
c. Known municipal STP's -		
Bunker Hill	815	0.3
Natoma	2,005	0.7
Plainville	8,565	3.0
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	<u>39,320</u>	<u>13.6</u>
Total	290,045	100.0

2. Outputs -

Lake outlet - Saline River 160,140

3. Net annual N accumulation - 129,905 kg.

D. Non-point Nutrient Export by Subdrainage Area:

<u>Tributary</u>	<u>kg P/km²/yr</u>	<u>kg N/km²/yr</u>
Saline River	3	35
Cedar Creek	2	70
Paradise Creek	<1	52

* 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.

	<u>Total Phosphorus</u>		<u>Total Nitrogen</u>	
	<u>Total</u>	<u>Accumulated</u>	<u>Total</u>	<u>Accumulated</u>
grams/m ² /yr	0.47	0.33	8.0	3.6

Vollenweider phosphorus loadings
(g/m²/yr) based on mean depth and mean
hydraulic retention time of Wilson Reservoir:

"Dangerous" (eutrophic loading)	0.34
"Permissible" (oligotrophic loading)	0.17

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 7, Wash., DC.

Kring, R. Lynn, 1977. Personal communication (revised reservoir morphometry). 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 8.107×10^{-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 2015 WILSON

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 4965.0

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS)												MEAN
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
2015A1	4965.0	1.98	2.38	2.83	4.25	5.66	6.23	5.95	4.81	2.83	1.47	1.64	1.81	3.49
2015A2	3890.2	1.10	2.04	2.63	2.49	3.68	9.06	6.51	4.53	3.40	3.11	1.47	1.13	3.44
2015B1	71.0	0.024	0.037	0.088	0.059	0.133	0.153	0.181	0.057	0.045	0.057	0.020	0.027	0.074
2015E1	595.7	0.18	0.28	0.57	0.51	1.02	1.47	1.36	0.54	0.45	0.45	0.19	0.19	0.60
2015ZZ	408.2	0.28	0.42	0.82	0.74	2.01	2.32	1.81	1.36	1.08	0.74	0.42	0.31	1.03

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 4965.0
SUM OF SUB-DRAINAGE AREAS = 4965.0

TOTAL FLOW IN = 61.58
TOTAL FLOW OUT = 41.85

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2015A1	10	74	0.365	12	0.340				
	11	74	0.283	10	0.283				
	12	74	0.226	15	0.224				
	1	75	0.212	12	0.212				
	2	75	0.810	8	0.224				
	3	75	1.543	8	0.623				
	4	75	0.575	13	0.595				
	5	75	0.578	11	0.595	24	0.538		
	6	75	7.306	14	12.573	29	12.714		
2015A2	7	75	14.357	13	12.176	26	3.964		
	8	75	7.985	30	0.566				
	9	75	0.501	13	0.538				
	10	74	0.583	12	0.481				
	11	74	1.073	10	1.189				
	12	74	1.002	15	1.019				
	1	75	1.068	12	1.189				
	2	75	1.008	8	1.189				
	3	75	1.116	8	1.133				
	4	75	1.320	13	1.246				
	5	75	0.980	11	0.963	24	0.708		
	6	75	6.881	14	4.474	29	3.625		
	7	75	1.110	13	1.076	26	0.623		
	8	75	6.060	30	1.416				
	9	75	0.830	13	0.736				

TRIBUTARY FLOW INFORMATION FOR KANSAS

05/03/76

LAKE CODE 2015 WILSON

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
2015H1	10	74	0.020	12	0.024				
	11	74	0.023	10	0.025				
	12	74	0.017	15	0.020				
	1	75	0.011	12	0.014				
	2	75	0.023	8	0.027				
	3	75	0.014	8	0.018				
	4	75	0.065	13	0.013				
	5	75	0.014	11	0.016	24	0.014		
	6	75	0.340	14	0.011	29	0.011		
	7	75	0.025	13	0.020	26	0.017		
	8	75	0.008	30	0.006				
	9	75	0.008	13	0.034				
2015E1	10	74	0.006	12	0.014				
	11	74	0.057	10	0.076				
	12	74	0.085	15	0.113				
	1	75	0.057	12	0.057				
	2	75	0.085	8	0.091				
	3	75	0.113	8	0.147				
	4	75	0.566	13	0.133				
	5	75	0.102	11	0.170	24	0.085		
	6	75	3.398	14	0.566	29	0.170		
	7	75	0.037	13	0.108	26	0.028		
	8	75	0.008	30	0.007				
	9	75	0.007	13	0.007				
2015ZZ	10	74	0.008						
	11	74	0.028						
	12	74	0.006						
	1	75	0.023						
	2	75	0.042						
	3	75	0.014						
	4	75	0.793						
	5	75	0.204						
	6	75	5.380						
	7	75	0.051						
	8	75	0.003						
	9	75	0.0						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/05/03

201501
38 57 30.0 098 29 55.0 4
WILSON RESERVOIR
20167 KANSAS

091191

11EPALES 2111202
0060 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 CONDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CAC03 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
74/04/12	10 35	0000	9.5		30	1607	8.20	163	0.060	0.900	0.320	0.011
	10 35	0005	9.5	10.0		1607	8.20	161	0.050	0.700	0.300	0.006
	10 35	0015	9.5	10.0		1607	8.20	162	0.050	0.600	0.300	0.007
	10 35	0055	9.5	9.8		1609	8.00	154	0.040	0.600	1.230	0.027
74/06/26	11 25	0000	24.1	7.8	110	225	8.40					
	11 25	0005	24.1	7.8		226	8.40					
	11 25	0015	24.1	8.0		226	8.40					
	11 25	0025	24.0	8.0		225	8.40					
	11 25	0040	22.1	5.8		215	8.30					
	11 25	0045	21.3	5.2		211	8.20					
	11 25	0055	20.8	4.6		209	8.20					
74/10/01	10 00	0000	17.3	8.0	36	213	7.80	141	0.080	0.800	0.220	0.004
	10 00	0005	17.3	8.0		213	7.80	139	0.020K	0.600	0.200	0.002
	10 00	0015	17.2	8.0		213	7.80	139	0.030	0.600	0.200	0.004
	10 00	0040	17.2	7.8		210	7.80	139	0.020	0.500	0.200	0.004
	10 00	0045	17.2	7.8		210	7.90	139	0.030	0.500	0.200	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/12	10 35	0000	0.025	5.0	
	10 35	0005	0.021		
	10 35	0015	0.023		
	10 35	0055	0.070		
74/06/26	11 25	0000		0.8	
74/10/01	10 00	0000	0.025	19.4	
	10 00	0003			1.0
	10 00	0005	0.019		
	10 00	0015	0.019		
	10 00	0040	0.017		
	10 00	0045	0.024		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/03

201502
38 55 30.0 098 31 34.0 4
WILSON RESERVOIR
20167 KANSAS

091191

11EPALES 2111202
0050 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 CONDUC TIV FIELD MICROMHO	00400 PH SU	00410 T ALK CAC03 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
74/04/12	10 55	0000	9.3		30	1600	8.20	162	0.050	0.600	0.310	0.005
	10 55	0005	9.3	10.0		1598	8.20	162	0.050	0.600	0.300	0.004
	10 55	0015	9.2	10.2		1599	8.20	162	0.050	0.500	0.300	0.006
	10 55	0050	9.2	10.2		1598	8.20	161	0.060	0.500	0.300	0.007
74/06/26	11 00	0000	23.1	7.2	105	220	8.40					
	11 00	0005	23.1	7.6		221	8.40					
	11 00	0015	22.9	7.8		220	8.40					
	11 00	0025	22.5	6.6		218	8.40					
	11 00	0035	20.8	4.0		209	8.00					
	11 00	0045	20.6	3.8		209	8.10					
74/10/01	10 30	0000	17.4	9.0	42	214	8.20	137	0.030	0.700	0.170	0.004
	10 30	0005	17.4	8.8		215	8.30	137	0.030	0.700	0.180	0.011
	10 30	0015	17.4	8.4		215	8.30	136	0.020	0.600	0.170	0.006
	10 30	0035	17.2	8.4		214	8.30	138	0.040	0.500	0.170	0.003

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCOT LT REMNING PERCENT
74/04/12	10 55	0000	0.022	5.0	
	10 55	0005	0.021		
	10 55	0015	0.025		
	10 55	0050	0.026		
74/06/26	11 00	0000		2.5	
74/10/01	10 30	0000	0.020	15.9	
	10 30	0005	0.020		
	10 30	0015	0.020		
	10 30	0035	0.018		

STORET RETRIEVAL DATE 76/05/03

201503
38 56 40.0 098 35 30.0 4
WILSON RESERVOIR
20167 KANSAS

091191

11EPALES 2111202
0038 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 CONDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CAC03 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
74/04/12	11 25	0000	10.5		18	1704	8.20	179	0.040	0.600	0.450	0.004
	11 25	0005	10.5	9.8		1703	8.20	180	0.040	0.500	0.440	0.004
	11 25	0015	10.4	9.6		1695	8.20	180	0.050	0.600	0.450	0.007
	11 25	0030	10.4	10.0		1695	8.20	173	0.070	0.600	0.430	0.008
74/06/26	10 30	0000	23.9	2.6	80	223	8.40					
	10 30	0005	23.9	7.8		226	8.40					
	10 30	0015	23.7	7.0		221	8.30					
	10 30	0025	23.0	5.4		221	8.20					
	10 30	0035	21.3	1.6		217	7.90					
74/10/01	11 00	0000	16.6	9.0	42	2170	8.03	131	0.030	0.700	0.060	0.003
	11 00	0005	16.6	9.0		2171	8.03	131	0.050	0.600	0.060	0.003
	11 00	0015	16.4	8.8		2147	7.98	129	0.030	0.600	0.040	0.004
	11 00	0030	16.3	8.4		2133	7.95	129	0.040	0.600	0.040	0.002K
	11 00	0040	16.2	8.4		2171	7.95	127	0.030	0.500	0.040	0.002

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/12	11 25	0000	0.028	11.8	
	11 25	0005	0.025		
	11 25	0015	0.028		
	11 25	0030	0.049		
74/06/26	10 30	0000		1.9	
74/10/01	11 00	0000	0.023	17.5	
	11 00	0005	0.023		
	11 00	0015	0.022		
	11 00	0025			1.0
	11 00	0030	0.027		
	11 00	0040	0.021		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY AND WASTEWATER
TREATMENT PLANT DATA

2015A1

38 59 30.0 098 28 05.0 4

SALINE RIVER

20 7.5 WILSON NW

0/WILSON RESERVOIR 091191

BRDG ON DIRT RD 2.5 MI NE OF WILSON DAM

11EPALES 2111204

0000 FEET DEPTH CLASS 00

DATE	TIME	DEPTH	00630 NO2&NO3 N-TOTAL	00625 TOT KJEL N	00610 NH3-N TOTAL	00671 PHOS-DIS ORTHO	00665 PHOS-TOT
FROM	OF						
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
74/10/12	10	09	0.336	1.300	0.090	0.010	0.045
74/11/10	12	39	0.336	1.700	0.150	0.010	0.040
74/12/15	11	45	0.400	1.200	0.100	0.005	0.030
75/01/12	10	07	0.384	3.500	0.096	0.008	0.030
75/03/08	11	14	0.236	1.350	0.136	0.016	0.070
75/04/13	15	20	0.180	1.000	0.050	0.005	0.030
75/05/11	16	40	0.135	0.850	0.140	0.010	0.060
75/05/24	16	25	0.160	1.200	0.145	0.015	0.100
75/06/14	14	40	0.115	0.750	0.075	0.020	0.040
75/06/29	16	49	0.130	0.850	0.080	0.010	0.030
75/07/13	14	30	0.170	0.837	0.040	0.005	0.030
75/07/26			0.195	1.500	0.190	0.015	0.060
75/08/30	14	00	0.125	0.600	0.085	0.010	0.030
75/09/13	11	00	0.125	0.700	0.080	0.015	0.050

STORET RETRIEVAL DATE 76/05/04

2015A2
38 58 00.0 098 51 20.0 4
SALINE RIVER
20 7.5 RUSSELL
T/WILSON RESERVOIR 091191
BRDG ON US RT 87 4 MI N OF RUSSELL
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
74/10/12	08 55		0.248	1.200	0.055	0.005K	0.030
74/11/10	10 54		0.448	1.700	0.065	0.010	0.050
74/12/15	10 00		0.736	0.500	0.057	0.005K	0.040
75/03/08	09 36		0.371	1.600	0.040	0.008K	0.020
75/04/13	13 32		0.160	1.350	0.050	0.005K	0.070
75/05/11	10 35		0.110	0.700	0.015	0.005	0.060
75/05/24	15 04		0.115	0.950	0.027	0.010	0.120
75/06/14	13 15		0.145	1.750	0.110	0.060	0.440
75/06/29	16 04		0.005	1.150	0.025	0.025	0.210
75/07/13	13 30		0.005	0.600	0.020	0.010	0.070
75/07/26	15 40		0.010	0.950	0.035	0.010	0.080
75/08/30	13 00		0.100	0.500	0.020	0.015	0.040
75/09/13	09 15		0.095	0.600	0.035	0.015	0.060

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

201581
38 56 20.0 098 42 50.0 4
CEDAR CREEK
20 7.5 DORRANCE NW
T/WILSON RESERVOIR 091191
BRDG ON RD 47 5 MI N OF BUNKER HILL
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
74/10/12	11 55		0.368	1.900	0.040	0.005	0.040
74/11/10	11 55		1.080	2.400	0.065	0.005K	0.010K
74/12/15	11 00		1.760	1.100	0.130	0.005	0.040
75/03/08	10 40		1.625	0.750	0.048	0.008K	0.010K
75/04/13	14 19		0.160				
75/05/11	11 24		0.470	0.600	0.030	0.005K	0.080
75/05/24	15 40		0.330	1.250	0.115	0.010	0.110
75/06/14	13 55		0.570	1.700	0.080	0.025	0.060
75/06/29	17 15		0.600	0.900	0.045	0.030	0.110
75/07/13	15 00		0.830	0.550	0.025	0.005K	0.020
75/07/26	09 30		0.470	1.000	0.113	0.015	0.060
75/08/30	14 30		0.960	2.400	0.035	0.027	
75/09/13	11 30		0.940	0.900	0.040		0.060

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

2015E1
39 01 00.0 098 49 00.0 4
PARADISE CREEK
20 RUSSELL CO MAP
T/WILSON RESERVOIR 091191
BRDG ON LGHT DTY RD 10 MI NE OF RUSSELL
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
74/10/12	09 21		0.032	2.400	0.075	0.020	0.085
74/11/10	11 20		0.208	3.150	0.130	0.005	0.195
75/03/08	09 18		0.177	1.100	0.058	0.008K	0.030
75/04/13	13 50		0.050	1.700	0.055	0.005	0.080
75/05/11	10 52		0.055	0.450	0.045	0.015	0.040
75/05/24	15 21		0.015	1.200	0.030	0.010	0.070
75/06/14	13 32		0.530	2.300	0.110	0.145	0.610
75/06/29	16 16		0.520	4.700	0.115	0.190	0.540
75/07/13	13 45		0.010	3.000	0.060	0.025	0.170
75/07/26	15 30		0.005	1.850	0.065	0.025	0.150
75/08/30	13 20		0.025	1.700	0.045	0.030	0.190
75/09/13	09 30		0.010	1.300	0.030	0.030	0.110

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/05/04

2015EA TF2015EA P000590
 39 11 00.0 099 01 00.0 4
 NATOMA
 20 OSBORN CO
 T/WILSON RES 091191
 PARADISE CREEK
 11EPALES 2141204
 0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 N02&N03 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
75/02/19	08 45		7.900	37.000	19.300	1.150	6.950		
75/03/17	10 30		20.800	5.600	1.280	4.000	7.400		
75/04/18			18.000	9.800	0.220	5.100	5.800		
75/04/28	10 00		15.800	10.500	0.079	2.200	5.700		
75/05/14	10 00		7.800	30.000	10.500	0.690	8.300		
75/06/04	09 00		15.800	15.500	0.300	1.150	4.600		
75/06/23	10 15		25.000	19.000	0.042	3.500	4.300		
75/07/17			15.000	6.900	0.190	1.130	2.760		
75/08/04	09 30		13.500	11.400	0.082	1.000	3.550		
75/08/25	09 15		7.500	15.500	1.200	1.880	4.000		
75/09/15			15.000	18.500	2.400	4.200	5.075		
75/10/06	09 00		2.200	35.500	17.000	1.850	8.350		
75/10/29			21.000	12.000	2.700	5.100	6.000		

STORET RETRIEVAL DATE 76/05/04

2015XA TF2015XA P002518
 39 13 30.0 099 17 30.0 4
 PLAINVILLE
 20 ROOKS CO
 T/WILSON RES 091191
 UNNAMED STREAM
 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
75/02/11	10 00		17.950	1.000K	0.080K	8.300	8.300	0.516	0.500
75/03/11	09 00		10.100	8.200	0.080K	6.100		0.524	0.500
75/04/11	09 00		5.100	4.700	1.800	0.530	8.100	0.540	0.500
75/05/11	10 00		12.500	2.500	0.170	1.800	10.000	0.540	0.500
75/06/11	09 00		11.500	1.800	0.050K	7.600	10.500	0.530	0.500
75/07/10	09 00		10.500	3.800		0.350	9.600	0.530	0.500
75/08/11	09 30		13.800	4.300	0.230	7.900	9.200	0.504	0.500
75/09/11	09 00		8.900	2.400	0.075	7.000	7.000	0.519	0.500
75/10/10	09 30		9.400	4.100	0.660	8.750	9.600	0.508	0.500
75/11/10	08 30		16.800	3.800	0.075	6.100	9.400	0.520	0.500
75/12/10	08 30		16.800	5.000	0.190	15.000	15.000	0.005	0.500

K VALUE KNOWN TO BE
 LESS THAN INDICATED