

WP656

REPORT
ON
O. C. FISHER (SAN ANGELO) RESERVOIR
TOM GREEN COUNTY
TEXAS
EPA REGION VI
WORKING PAPER No. 656

WITH THE COOPERATION OF THE
TEXAS WATER QUALITY BOARD
AND THE
TEXAS NATIONAL GUARD
MARCH, 1977

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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 fresh water 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.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division 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 Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

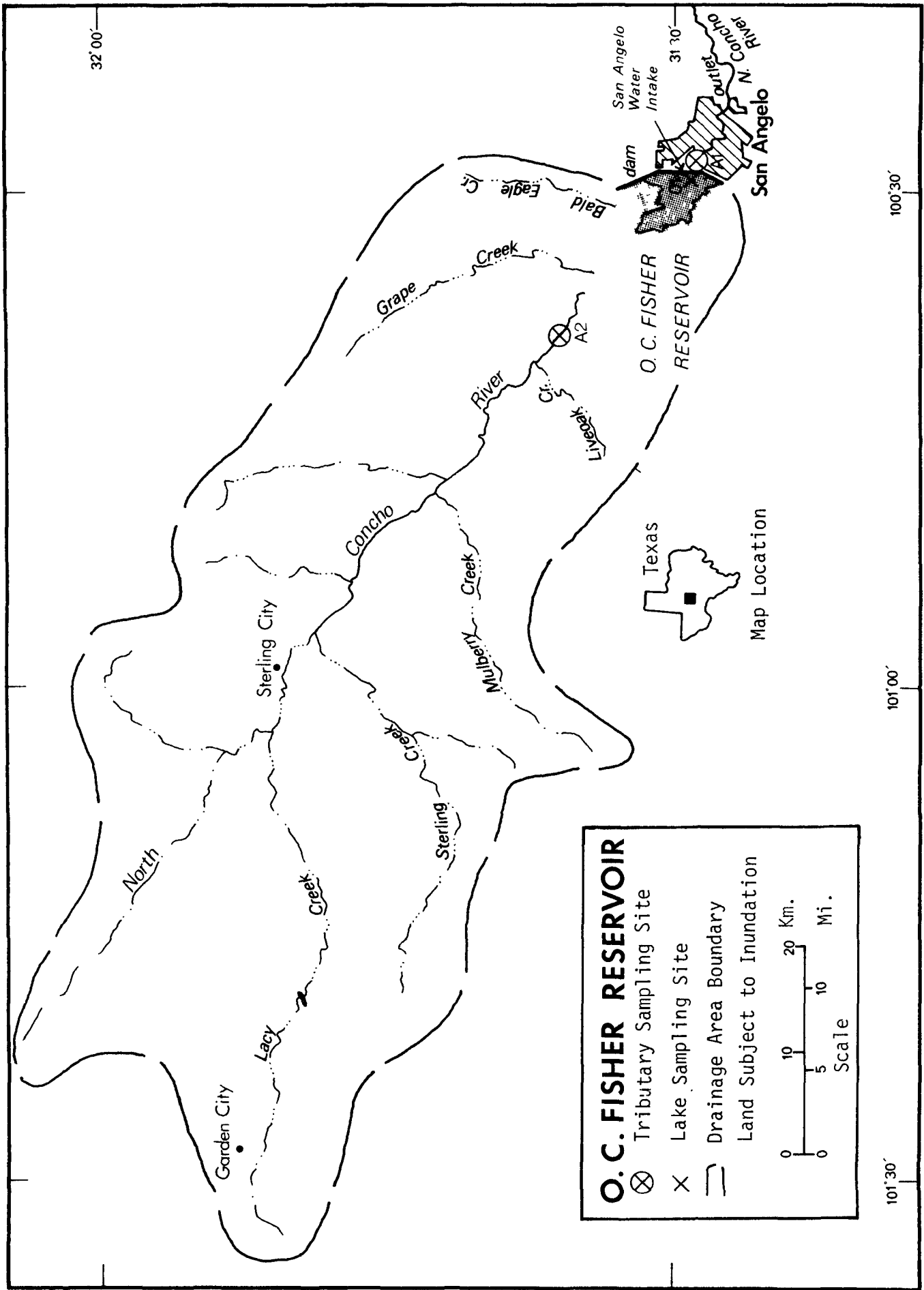
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

<u>NAME</u>	<u>COUNTY</u>
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass



O. C. FISHER RESERVOIR

STORET NO. 4826

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that O. C. Fisher Reservoir is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

O. C. Fisher Reservoir ranked thirty-second in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Thirty-three of the reservoirs had less median total phosphorus, 20 had less and one had the same median dissolved orthophosphorus, 21 had less median inorganic nitrogen, all of the other reservoirs had less chlorophyll a, and 35 had greater mean Secchi disc transparency.

Survey limnologists noted surface concentrations of algae in August.

B. Rate-Limiting Nutrient:

The algal assay results indicate the reservoir was nitrogen limited at the time the sample was taken (10/29/74). The reservoir data indicate nitrogen limitation in March as well but phosphorus limitation in May.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources impacted O. C. Fisher Reservoir during the sampling year.

There are no lakeshore septic tanks because construction of shoreline dwellings is prohibited*.

Based on the reservoir morphometry at the conservation-pool level, the present phosphorus loading of 0.06 g/m²/yr is about equal to that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading (see page 12). If Vollenweider's oligotrophic level is applicable to Texas water bodies, non-point phosphorus loadings to the reservoir in past years must have been much greater than measured during the sampling year since Survey data indicate O. C. Fisher Reservoir is eutrophic.

2. Non-point sources--All of the phosphorus input to the reservoir was contributed by non-point sources during the sampling year. The North Concho River contributed 63.1% of the total load, and the ungaged minor tributaries and immediate drainage added an estimated 12.5%.

The phosphorus export rate of the North Concho River was less than 1 kg/km²/yr) (see page 11). This rate compares favorably with the rates of three tributaries of nearby Twin Buttes Reservoir*** (also less than 1 kg/km²/yr).

* Koederitze, 1976.

** Anonymous, 1976.

*** Working Paper No. 666.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]A. Morphometry (at conservation-pool level)^{††}:

1. Surface area: 21.85 kilometers².
2. Mean depth: 6.5 meters.
3. Maximum depth: >8.5 meters.
4. Volume: 142.769 x 10⁶ m³.
5. Mean hydraulic retention time: 11.0 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>
North Concho River	3,234.9	0.665
Minor tributaries & immediate drainage -	<u>599.5</u>	<u>0.131</u>
Totals	3,834.4	0.796

2. Outlet -

San Angelo water supply**	0.0	0.200
North Concho River	<u>3,853.9***</u>	<u>0.210</u>
Total	3,853.9***	0.410

C. Precipitation****:

1. Year of sampling: 63.8 centimeters.
2. Mean annual: 44.5 centimeters.

† Table of metric conversions--Appendix B.

†† Barrows, 1977.

* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".

** Koederitze, 1976.

*** Includes area of reservoir.

**** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

O. C. Fisher Reservoir was sampled four times in 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 one station on the reservoir (see map, page vi). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was collected for phytoplankton identification and enumeration; and a similar sample was collected for chlorophyll a analysis. During the last visit, a single 18.9-liter depth-integrated sample was taken for algal assays. The maximum depth sampled was 8.5 meters.

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

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SAN ANGELO RESERVOIR
STORET CODE 4826

PARAMETER	1ST SAMPLING (3/ 4/74)			2ND SAMPLING (5/15/74)			3RD SAMPLING (8/ 5/74)		
	1 SITES			1 SITES			1 SITES		
	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	15.1 - 15.3	15.2	15.3	25.6 - 25.8	25.7	25.6	25.4 - 25.6	25.5	25.5
DISS OXY (MG/L)	9.8 - 10.4	10.1	10.1	7.8 - 8.0	7.9	7.9	4.8 - 5.0	4.9	4.8
CNDCTVY (MC+OMO)	454. - 459.	456.	455.	607. - 607.	607.	607.	641. - 642.	642.	642.
PH (STAND UNITS)	8.3 - 8.3	8.3	8.3	8.3 - 8.4	8.3	8.3	7.9 - 8.0	8.0	8.0
TOT ALK (MG/L)	167. - 168.	168.	168.	154. - 154.	154.	154.	*****	*****	*****
TOT P (MG/L)	0.041 - 0.053	0.047	0.048	0.108 - 0.117	0.111	0.108	*****	*****	*****
ORTHO P (MG/L)	0.010 - 0.011	0.011	0.011	0.006 - 0.007	0.007	0.007	*****	*****	*****
NO2+NO3 (MG/L)	0.040 - 0.080	0.060	0.060	0.050 - 0.080	0.067	0.070	*****	*****	*****
AMMONIA (MG/L)	0.030 - 0.040	0.033	0.030	0.050 - 0.070	0.063	0.070	*****	*****	*****
KJEL N (MG/L)	0.800 - 1.000	0.900	0.900	1.000 - 1.200	1.067	1.000	*****	*****	*****
INORG N (MG/L)	0.070 - 0.110	0.093	0.100	0.100 - 0.150	0.130	0.140	*****	*****	*****
TOTAL N (MG/L)	0.880 - 1.060	0.960	0.940	1.050 - 1.270	1.133	1.080	*****	*****	*****
CHLRPYL A (UG/L)	13.1 - 13.1	13.1	13.1	24.7 - 24.7	24.7	24.7	42.6 - 42.6	42.6	42.6
SECCHI (METERS)	0.6 - 0.6	0.6	0.6	0.3 - 0.3	0.3	0.3	0.3 - 0.3	0.3	0.3

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR SAN ANGELO RESERVOIR
 STORET CODE 4826

4TH SAMPLING (10/29/74)

PARAMETER	1 SITES		
	RANGE	MEAN	MEDIAN
TEMP (C)	18.1 - 18.5	18.4	18.4
DISS OXY (MG/L)	5.6 - 5.6	5.6	5.6
CONDUCTVY (MICROMO)	217. - 231.	224.	224.
PH (STAND UNITS)	7.9 - 8.3	8.0	8.0
TOT ALK (MG/L)	112. - 113.	112.	112.
TOT P (MG/L)	0.090 - 0.134	0.105	0.098
ORTHO P (MG/L)	0.044 - 0.054	0.050	0.050
NO2+NO3 (MG/L)	0.120 - 0.240	0.157	0.135
AMMONIA (MG/L)	0.020 - 0.040	0.032	0.035
KJEL N (MG/L)	0.500 - 1.400	0.800	0.650
INORG N (MG/L)	0.140 - 0.280	0.190	0.170
TOTAL N (MG/L)	0.640 - 1.520	0.957	0.835
CHLRPYL A (UG/L)	18.3 - 18.3	18.3	18.3
SECCHI (METERS)	0.8 - 0.8	0.8	0.8

B. Biological characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Algal Units per ml</u>
03/04/74	1. <u>Nitzschia sp.</u>	9,005
	2. <u>Ankistrodesmus sp.</u>	4,407
	3. <u>Chroomonas sp.</u>	2,810
	4. <u>Dactylococcopsis sp.</u>	2,363
	5. <u>Kirchneriella sp.</u>	2,299
	Other genera	<u>9,265</u>
	Total	30,149
05/15/74	1. <u>Nitzschia sp.</u>	3,289
	2. <u>Cyclotella sp.</u>	2,388
	3. <u>Raphidiopsis sp.</u>	1,172
	4. <u>Scenedesmus sp.</u>	902
	5. <u>Stephanodiscus sp.</u>	901
	Other genera	<u>7,119</u>
	Total	15,771
08/05/74	1. <u>Oscillatoria sp.</u>	25,208
	2. <u>Raphidiopsis sp.</u>	10,905
	3. <u>Dactylococcopsis sp.</u>	8,355
	4. Pennate diatoms	5,381
	5. <u>Merismopedia sp.</u>	3,044
	Other genera	<u>19,332</u>
	Total	72,225
10/29/74	1. <u>Chlamydomonas sp.</u>	3,512
	2. <u>Cyclotella sp.</u>	1,115
	3. <u>Cryptomonas sp.</u>	725
	4. <u>Chroomonas sp.</u>	502
	5. <u>Nitzschia sp.</u>	502
	Other genera	<u>2,005</u>
	Total	8,361

2. Chlorophyll a -

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll a (µg/l)</u>
03/04/74	1	13.1
05/15/74	1	24.7
08/05/74	1	42.6
10/29/74	1	18.3

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	0.035	0.109	5.2
0.050 P	0.085	0.109	4.9
0.050 P + 1.0 N	0.085	1.109	23.8
1.0 N	0.035	1.109	15.4

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of O. C. Fisher Reservoir was high at the time the sample was collected (10/29/74). The increased yield with the addition of nitrogen and the lack of response to phosphorus added alone indicate the reservoir was nitrogen limited at that time.

The reservoir data indicate nitrogen limitation in March also (the mean inorganic nitrogen/orthophosphorus ratio was 8/1) but phosphorus limitation in May (the mean N/P ratio was 19/1).

IV. NUTRIENT LOADINGS (See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from the tributary site indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

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

In this report, nutrient loads for the sampled tributary were calculated using mean annual concentrations and mean annual flows. Nutrient loads for the outlet (A-1) and the San Angelo water supply withdrawal were estimated using the mean reservoir concentrations at station 1 and the mean annual flows. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Concho River at station A-2 and the mean annual ZZ flow.

No known wastewater treatment plants impacted O. C. Fisher Reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

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) -		
North Concho River	880	63.1
b. Minor tributaries & immediate drainage (non-point load) -	173	12.5
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	<u>340</u>	<u>24.4</u>
Total	1,395	100.0

2. Outputs -

Lake outlet - San Angelo water supply	565
North Concho River	<u>595</u>
Total	1,160

3. Net annual P accumulation - 235 kg.

* Koederitze, 1976.

** 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) -		
North Concho River	40,850	58.4
b. Minor tributaries & immediate drainage (non-point load) -	8,050	11.5
c. Known municipal STP's - None	-	-
d. Septic tanks - None*	-	-
e. Known industrial - None	-	-
f. Direct precipitation** -	<u>21,010</u>	<u>30.1</u>
Total	69,910	100.0

2. Outputs -

Lake outlet - San Angelo water supply	6,375
North Concho River	<u>6,695</u>
Total	13,070

3. Net annual N accumulation - 56,840 kg.

D. Non-point Nutrient Export by Subdrainage Area:

<u>Tributary</u>	<u>kg P/km²/yr</u>	<u>kg N/km²/yr</u>
North Concho River	<1	13

* Koederitze, 1976.

** 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	0.06	0.01	3.2	2.6

Vollenweider phosphorus loadings
(g/m²/yr) based on mean depth and mean
hydraulic retention time of O. C. Fisher Reservoir at conservation-
pool level:

"Dangerous" (eutrophic loading)	0.16
"Permissible" (oligotrophic loading)	0.08

V. LITERATURE REVIEWED

Barrows, David, 1977. Personal communication (reservoir morphometry and hydraulic retention time). Canyon Proj. Off., Fort Worth Distr., Corps of Engrs., New Braunfels, TX.

Koederitze, Thomas (Supt.), 1976. Personal communication (municipal water withdrawal from O. C. Fisher Reservoir and description of lakeshore development). Water Department, San Angelo.

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.

Yost, I. D., 1976. Personal communication (estimate of evaporation from central Texas lakes). U.S. Geol. Surv., Austin.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4809	CANYON RESERVOIR	445
2	4823	LAKE MEREDITH	441
3	4813	EAGLE MOUNTAIN LAKE	430
4	4816	KEMP LAKE	423
5	4801	AMISTAD LAKE	402
6	4805	BROWNWOOD LAKE	394
7	4802	BASTROP LAKE	393
8	4838	WHITE RIVER RESERVOIR	390
9	4825	POSSUM KINGDOM RESERVOIR	387
10	4835	TRAVIS LAKE	384
11	4803	BELTON RESERVOIR	384
12	4831	STILLHOUSE HOLLOW RESERV	372
13	4812	DIVERSION LAKE	372
14	4808	CALAVERAS LAKE	362
15	4839	WHITNEY LAKE	357
16	4822	MEDINA LAKE	342
17	4827	SAM RAYBURN RESERVOIR	322
18	4828	E V SPENCE RESERVOIR	321
19	4837	TWIN BUTTES RESERVOIR	311
20	4810	LAKE COLORADO CITY	310
21	4824	PALESTINE LAKE	302
22	4818	LAKE OF THE PINES	298
23	4807	CADDO LAKE	297
24	4814	FT PHANTOM HILL LAKE	296
25	4806	LAKE BUCHANAN	261
26	4830	STAMFORD LAKE	259
27	4819	LAVON RESERVOIR	258
28	4832	TAWAKONI LAKE	253

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	4821	LYNDON B JOHNSON LAKE	238
30	4834	TEXOMA LAKE	217
31	4829	SOMERVILLE LAKE	208
32	4826	SAN ANGELO RESERVOIR	200
33	4833	TEXARKANA LAKE	176
34	4815	GARZA LITTLE ELM RESERVO	173
35	4836	TRINIDAD	169
36	4804	BRAUNIG LAKE	159
37	4811	CORPUS CRISTI LAKE	155
38	4817	HOUSTON LAKE	139
39	4820	LIVINGSTON LAKE	91

PERCENT OF LAKES WITH HIGHER VALUES THAN INDICATED IN COLUMN BELOW

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS OXYGEN P	INDEX NO
4801	AMISTAD LAKE	95 (36)	5 (2)	100 (38)	100 (38)	39 (14)	63 (21)	402
4802	HASTROP LAKE	79 (30)	76 (28)	82 (31)	47 (18)	17 (0)	92 (34)	393
4803	BELTON RESERVOIR	92 (35)	26 (10)	97 (37)	68 (26)	17 (0)	84 (31)	384
4804	BRAUNIG LAKE	5 (2)	42 (16)	50 (19)	8 (3)	49 (17)	5 (2)	159
4805	BROWNWOOD LAKE	66 (25)	70 (26)	29 (11)	87 (33)	58 (22)	84 (31)	394
4806	LAKE BUCHANAN	47 (18)	21 (7)	74 (28)	63 (24)	17 (0)	39 (14)	261
4807	CADDO LAKE	26 (10)	91 (33)	42 (16)	32 (12)	76 (29)	30 (10)	297
4808	CALAVERAS LAKE	45 (17)	100 (38)	47 (18)	11 (4)	67 (25)	92 (34)	362
4809	CANYON RESERVOIR	99 (37)	8 (3)	95 (36)	97 (37)	49 (17)	97 (37)	445
4810	LAKE COLORADO CITY	39 (14)	76 (28)	26 (10)	42 (16)	88 (33)	39 (14)	310
4811	CORPUS CRISTI LAKE	8 (3)	47 (18)	18 (7)	13 (5)	61 (23)	8 (3)	155
4812	DIVERSION LAKE	68 (26)	83 (31)	32 (12)	29 (11)	97 (37)	63 (21)	372
4813	EAGLE MOUNTAIN LAKE	71 (27)	91 (33)	34 (13)	79 (30)	79 (30)	76 (28)	430
4814	FT PHANTOM HILL LAKE	24 (9)	66 (25)	21 (8)	74 (28)	95 (36)	16 (6)	296
4815	GARZA LITTLE ELM RESERVO	34 (13)	13 (5)	16 (6)	34 (13)	55 (21)	21 (7)	173
4816	KEMP LAKE	76 (29)	61 (22)	55 (21)	55 (21)	84 (32)	92 (34)	423
4817	HOUSTON LAKE	16 (6)	16 (6)	0 (0)	24 (9)	72 (27)	11 (4)	139
4818	LAKE OF THE PINES	54 (20)	76 (28)	66 (25)	39 (15)	17 (0)	46 (17)	298
4819	LAVON RESERVOIR	21 (8)	29 (11)	3 (1)	84 (32)	100 (38)	21 (7)	258
4820	LIVINGSTON LAKE	3 (1)	3 (1)	39 (15)	26 (10)	17 (0)	3 (1)	91
4821	LYNDON B JOHNSON LAKE	39 (14)	11 (4)	53 (20)	66 (25)	39 (14)	30 (10)	238
4822	MEDINA LAKE	99 (37)	0 (0)	89 (34)	37 (14)	17 (0)	100 (38)	342
4823	LAKE MEREDITH	82 (31)	91 (33)	71 (27)	95 (36)	39 (14)	63 (21)	441
4824	PALESTINE LAKE	54 (20)	32 (12)	63 (24)	53 (20)	49 (17)	51 (19)	302
4825	POSSUM KINGDOM RESERVOIR	74 (28)	91 (33)	84 (32)	58 (22)	17 (0)	63 (21)	387
4826	SAN ANGELO RESERVOIR	13 (5)	45 (17)	8 (3)	0 (0)	88 (33)	46 (17)	200
4827	SAM RAYBURN RESERVOIR	59 (22)	39 (15)	68 (26)	76 (29)	17 (0)	63 (21)	322
4828	E V SPENCE RESERVOIR	50 (19)	83 (31)	45 (17)	50 (19)	17 (0)	76 (28)	321

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 O ₂ P	INDEX NO
4829	SOMERVILLE LAKE	29 (11)	55 (21)	24 (9)	3 (1)	67 (25)	30 (10)	204
4830	STAMFORD LAKE	18 (7)	97 (37)	5 (2)	18 (7)	82 (31)	39 (14)	259
4831	STILLHOUSE HOLLOW RESERV	88 (33)	37 (14)	87 (33)	92 (35)	17 (0)	51 (19)	372
4832	TAWAKONI LAKE	32 (12)	70 (26)	37 (14)	21 (8)	63 (24)	30 (10)	253
4833	TEXARKANA LAKE	11 (4)	51 (19)	13 (5)	16 (6)	72 (27)	13 (5)	176
4834	TEXOMA LAKE	39 (14)	34 (13)	61 (23)	45 (17)	17 (0)	21 (7)	217
4835	TRAVIS LAKE	88 (33)	21 (7)	92 (35)	82 (31)	17 (0)	84 (31)	384
4836	TRINIDAD	0 (0)	61 (22)	11 (4)	5 (2)	92 (35)	0 (0)	169
4837	TWIN BUTTES RESERVOIR	59 (22)	21 (7)	58 (22)	61 (23)	49 (17)	63 (21)	311
4838	WHITE RIVER RESERVOIR	84 (32)	61 (22)	76 (29)	89 (34)	17 (0)	63 (21)	390
4839	WHITNEY LAKE	63 (24)	51 (19)	79 (30)	71 (27)	17 (0)	76 (28)	357

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLOR A	15- MIN DO	MEDIAN DISS ORTHO P
4801	AMISTAD LAKE	0.013	0.500	371.474	2.742	14.900	0.009
4802	BASTROP LAKE	0.022	0.090	419.917	12.392	15.000	0.007
4803	BELTON RESERVOIR	0.016	0.185	378.312	8.025	15.000	0.007
4804	BRAUNIG LAKE	0.134	0.150	461.625	22.762	14.800	0.062
4805	BROWNWOOD LAKE	0.027	0.100	470.375	4.887	14.400	0.007
4806	LAKE BUCHANAN	0.036	0.250	437.625	8.606	15.000	0.012
4807	CADD0 LAKE	0.055	0.070	463.333	14.808	11.400	0.013
4808	CALAVERAS LAKE	0.038	0.060	461.667	22.500	13.000	0.007
4809	CANYON RESERVOIR	0.010	0.450	384.812	2.500	14.800	0.006
4810	LAKE COLORADO CITY	0.042	0.090	473.625	12.675	10.200	0.012
4811	CORPUS CRISTI LAKE	0.113	0.130	475.187	19.756	14.000	0.050
4812	DIVERSION LAKE	0.025	0.080	470.111	15.867	9.000	0.009
4813	EAGLE MOUNTAIN LAKE	0.024	0.070	469.625	5.662	11.000	0.008
4814	FT PHANTOM HILL LAKE	0.060	0.105	474.909	6.317	9.800	0.022
4815	GARZA LITTLE ELM RESERVO	0.045	0.380	475.782	14.156	14.600	0.018
4816	KEMP LAKE	0.023	0.110	455.000	10.217	10.400	0.007
4817	HOUSTON LAKE	0.097	0.260	486.187	16.650	12.400	0.036
4818	LAKE OF THE PINES	0.031	0.090	440.000	12.919	15.000	0.011
4819	LAVON RESERVOIR	0.063	0.180	485.333	5.400	8.800	0.018
4820	LIVINGSTON LAKE	0.196	0.555	465.469	16.112	15.000	0.128
4821	LYNDON B JOHNSON LAKE	0.042	0.420	456.500	8.100	14.900	0.013
4822	MEDINA LAKE	0.010	0.600	403.562	12.944	15.000	0.004
4823	LAKE MEREDITH	0.021	0.070	439.312	3.037	14.900	0.009
4824	PALESTINE LAKE	0.031	0.180	442.625	10.619	14.800	0.010
4825	POSSUM KINGDOM RESERVOIR	0.023	0.070	419.045	9.495	15.000	0.009
4826	SAN ANGELO RESERVOIR	0.098	0.140	481.000	24.675	10.200	0.011
4827	SAM RAYBURN RESERVOIR	0.029	0.150	439.458	6.267	15.000	0.009
4828	E V SPENCE RESERVOIR	0.036	0.080	462.583	11.775	15.000	0.008

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	M ² AN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
4829	SOMERVILLE LAKE	0.053	0.115	473.833	24.491	13.000	0.013
4830	STAMFORD LAKE	0.073	0.160	482.714	18.457	10.600	0.012
4831	STILLHOUSE HOLLOW RESERV	0.018	0.160	406.250	3.917	15.000	0.010
4832	TAWAKONI LAKE	0.046	0.100	466.417	18.246	13.200	0.013
4833	TEXARKANA LAKE	0.106	0.120	478.500	19.119	12.400	0.030
4834	TEXOMA LAKE	0.042	0.160	451.321	12.493	15.000	0.018
4835	TRAVIS LAKE	0.018	0.250	389.913	5.595	15.000	0.007
4836	TRINIDAD	0.389	0.110	479.500	24.300	10.000	0.240
4837	TWIN BUTTES RESERVOIR	0.029	0.250	454.917	8.708	14.800	0.009
4838	WHITE RIVER RESERVOIR	0.020	0.110	434.500	4.333	15.000	0.009
4839	WHITNEY LAKE	0.028	0.120	430.500	6.912	15.000	0.008

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 TEXAS 07/02/78

LAKE CODE 4826 O. C. FISHER

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 3853.9

TRIBUTARY	SUP-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS)												MEAN
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
4826A1	3853.9	0.057	0.028	0.028	0.065	0.142	0.198	0.255	0.255	0.142	1.133	0.113	0.057	0.210
4826A2	3234.9	0.011	0.065	0.093	0.708	1.784	0.481	0.425	0.396	1.557	2.350	0.025	0.023	0.665
4826ZZ	619.0	0.065	0.011	0.017	0.136	0.340	0.093	0.079	0.076	0.283	0.453	0.006	0.006	0.131

TOTAL DRAINAGE AREA OF LAKE = 3853.9
 SUM OF SUB-DRAINAGE AREAS = 3853.9
 TOTAL FLOW IN = 9.49
 TOTAL FLOW OUT = 2.49

NOTE *** SAME AS SAN ANGELO LAKE.

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4826A1	9	74	0.0	7	0.0				
	10	74	0.0	5	0.0				
	11	74	0.0	2	0.0				
	12	74	0.0	8	0.0				
	1	75	0.0	5	0.0				
	2	75	0.0	1	0.0				
	3	75	0.0	2	0.0				
	4	75	0.0	6	0.0	20	0.0		
4826A2	5	75	0.0	4	0.0				
	6	75	0.0	7	0.0				
	7	75	0.0	20	0.0				
	8	75	0.0	3	0.0				
	9	74	22.512	7	0.0				
	10	74	1.897	5	0.198				
	11	74	0.340	2	0.623				
	12	74	0.198	8	0.198				
	1	75	0.142	5	0.170				
	2	75	0.142	1	0.142				
	3	75	0.085	2	0.113				
	4	75	0.085	6	0.170	20	0.057		
	5	75	0.736	4	0.085	25	0.311		
	6	75	0.003	22	0.003				
	7	75	0.003	20	0.003				
	8	75	0.014	3	0.0				

LAKE CODE 4826 U. C. FISHER

MEAN MONTHLY FLOWS AND DAILY FLOWS (CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW
4826ZZ	9	74	4.248				
	10	74	0.283				
	11	74	0.057				
	12	74	0.028				
	1	75	0.028				
	2	75	0.028				
	3	75	0.028				
	4	75	0.028				
	5	75	0.142				
	6	75	0.006				
	7	75	0.0				
	8	75	0.0				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STOPET RETRIEVAL DATE 74-02/11

482601
 31 29 03.0 100 29 01.0
 SAN ANGELO RESERVOIR
 44451 TEXAS

11EPALES 2111202
 3 0015 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CONDUCTIVITY FIELD MICROMHO	00400 PH SU	00410 T ALK CAC03 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT N MG/L	00630 N02&N03 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/04	15 00	0000	15.3		22	454	8.30	168	0.040	1.000	0.060	0.010
	15 00	0005	15.3	9.8		455	8.30	167	0.030	0.900	0.040	0.011
	15 00	0010	15.1	10.4		459	8.30	168	0.030	0.800	0.060	0.011
74/05/15	16 10	0000	25.8		12	607	8.40	154	0.070	1.200	0.070	0.007
	16 10	0005	25.6	8.0		607	8.35	154	0.050	1.000	0.050	0.006
	16 10	0010	25.6	7.8		607	8.30	154	0.070	1.000	0.080	0.007
74/08/05	11 50	0000	25.6	5.0	12	642	8.05					
	11 50	0004	25.5	4.8		642	8.00					
	11 50	0008	25.4	4.8		641	7.90					
74/10/29	11 25	0000	18.5	5.6	30	217	8.25	112	0.020	1.400	0.120	0.048
	11 25	0005	18.4	5.6		224	8.00	112	0.030	0.800	0.130	0.054
	11 25	0015	18.4	5.6		223	8.00	112	0.040	0.500	0.140	0.053
	11 25	0028	18.1			231	7.90	113	0.040	0.500	0.240	0.044

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLORPHYL A UG/L	03031 INCDT LT REMNING PERCENT
74/03/04	15 00	0000	0.041	13.1	
	15 00	0005	0.048		
	15 00	0010	0.053		
74/05/15	16 10	0000	0.108	24.7	1.0
	16 10	0003	0.108		
	16 10	0005	0.108		
	16 10	0010	0.117		
74/08/05	11 50	0000	0.134	42.6	5.0
74/10/29	11 25	0000	0.134	18.3	
	11 25	0003			
	11 25	0005	0.101		
	11 25	0006			
	11 25	0015	0.096		1.0
	11 25	0028	0.090		

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 7/6/03/10

4d2ba1
31 29 00 100 28 45.0 4
N CUNCHO RIVER
48363 7.5 SAN ANGELO S
0/SAN ANGELO LAKE
AT BOTTOM OF SAN ANGELO DAM SPILLWAY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NH3-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
74/09/07	14 30		0.016	2.100	0.010	0.025	0.130

STORET RETRIEVAL DATE 75/03/10

4825A2
 31 35 35.0 100 38 15.0 4
 N COMCHO RIVER
 4R 15 CARLSBAD
 T/5AN ANGELO LAKE
 2NDRY RD BRDG 0.5 MI SW JCT HWY 87
 HEPALES 2111204
 0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NH3-N TOTAL MG/L	00625 TOT KJFL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS URTHO MG/L P	00665 PHOS-TOT MG/L P
74/10/05	15	45	4.900	0.725	0.005	0.010	0.040
74/11/02	14	20	1.160	0.706	0.025	0.050	0.110
74/12/08	11	30	3.210	0.900	0.032	0.008	0.030
75/01/05	10	00	2.760	1.600	0.040	0.005K	0.030
75/02/01	16	00	2.040	0.500	0.024	0.016	0.040
75/03/02	10	30	0.810	0.600	0.015	0.005	0.020
75/04/06	12	30	0.185	0.900	0.045	0.010	0.010
75/04/20	11	25	0.090	0.800	0.045	0.005	0.010
75/05/04	11	15	0.052	0.650	0.025	0.010	0.010
75/05/25	13	45	0.075	0.625	0.015	0.005	0.070
75/06/22	11	30	0.010	1.050	0.020	0.015	0.070
75/07/20	12	00	0.005	0.500	0.025	0.010	0.050
75/08/03	11	45	0.025	0.450	0.035	0.010	0.060

K VALUE KNOWN TO BE
 LESS THAN INDICATED