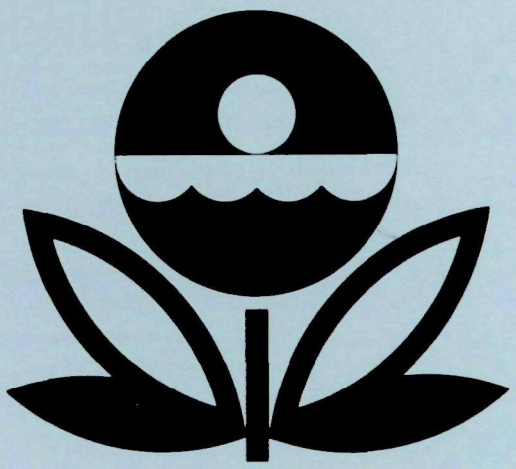
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT

ON

UPPER TWIN LAKE

MONO COUNTY

CALIFORNIA

EPA REGION IX

WORKING PAPER No. 762

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPORT
ON
UPPER TWIN LAKE
MONO COUNTY
CALIFORNIA
EPA REGION IX
WORKING PAPER No. 762

WITH THE COOPERATION OF THE
CALIFORNIA STATE WATER RESOURCES CONTROL BOARD
AND THE
CALIFORNIA NATIONAL GUARD

JUNE, 1978

CONTENTS

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water 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 concentration (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 California State Water Resources Control Board and the nine Regional Water Quality Control Boards for professional involvement, to the California National Guard for conducting the tributary sampling phase of the Survey, and to those California wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Division of Planning and Research of the State Water Resources Control Board provided invaluable lake documentation and counsel during the Survey, coordinated the reviews of the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

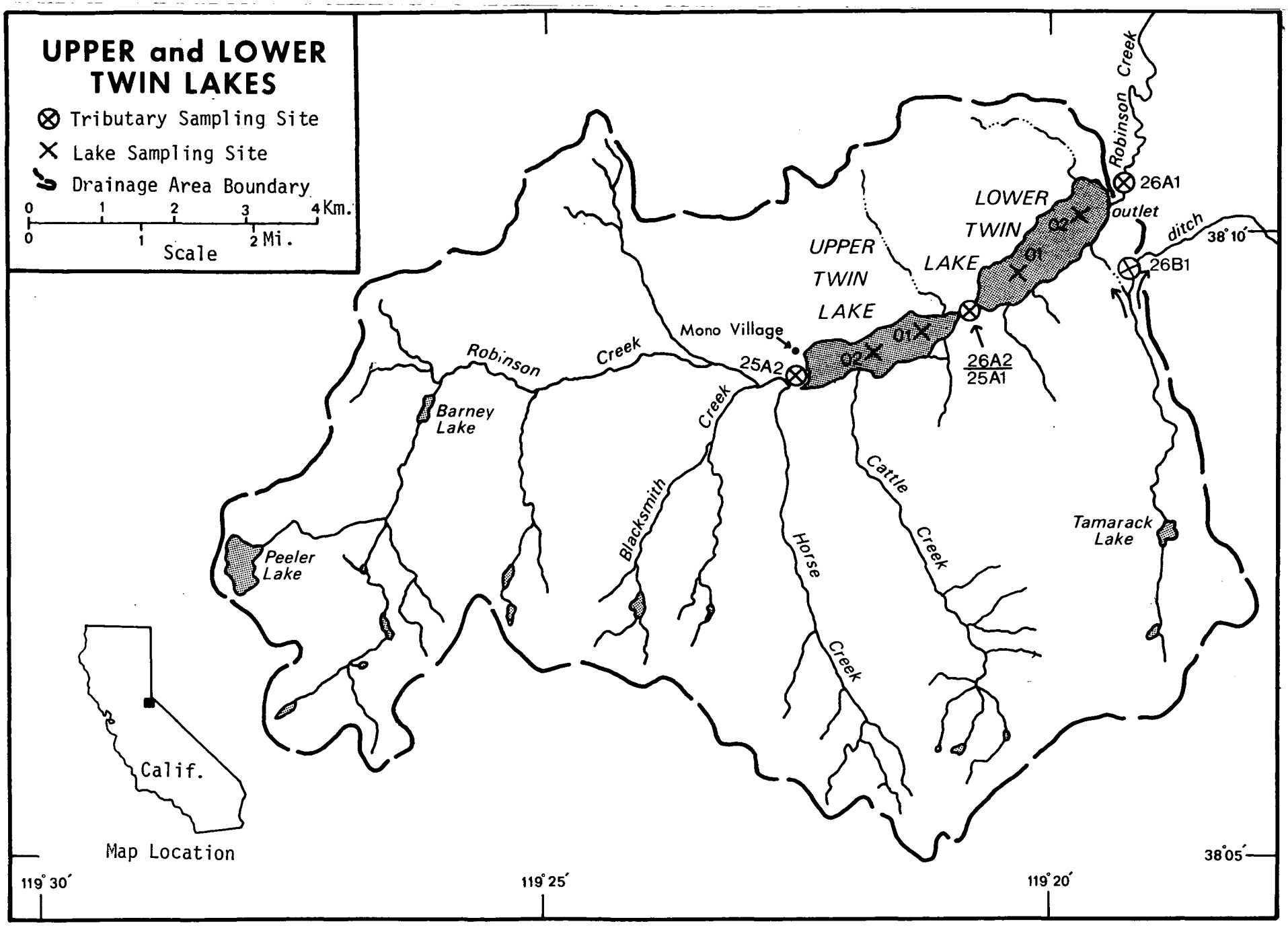
Major General Glen C. Ames, the Adjutant General of California, and Project Officer Second Lieutenant Terry L. Barrie, who directed the volunteer efforts of the California National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of California

Name	County
Amador	Amador
Boca	Nevada
Britton	Shasta
Casitas	Ventura
Crowley	Mono
Don Pedro	Tuolumne
Elsinore	Riverside
Fallen Leaf	El Dorado
Hennessey	Napa
Henshaw	San Diego
Iron Gate	Siskiyou
Lopez	San Luis Obispo
Mary	Mono
Mendocino	Mendocino
Nicasio	Marin
Lower Otay	San Diego
Pillsbury	Lake
Santa Margarita	San Luis Obispo
Shasta	Shasta
Shaver	Fresno
Silver	Mono
Tahoe	El Dorado, Placer, CA; Carson City, Douglas, Washoe, NV
Tulloch	Calaveras, Tuolumne
Lower Twin	Mono
Upper Twin	Mono


UPPER and LOWER TWIN LAKES
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 1 2 3 4 Km.
0 1 2 Mi.
Scale
Robinson Creek
26A1
outlet
ditch
38° 10'
LOWER TWIN LAKE
UPPER TWIN LAKE
26B1
Mono Village
25A2
26A2
25A1
Robinson Creek
Barney Lake
Creek
Blacksmith
Horse
Creek
Cattle
Creek
Tamarack Lake
Peeler Lake
Calif.
Map Location
38°05'
119° 30'
119° 25'
119° 20'

UPPER TWIN LAKE

STORET NO. 0625

I. CONCLUSIONS

A. Trophic Condition*:

Survey data indicate that Upper Twin Lake is early mesotrophic. It ranked fifth in overall trophic quality among the 24 California lakes and reservoirs sampled in 1975 when compared using a combination of six water quality parameters**. Seven of the water bodies had less median total phosphorus, four had less and two had the same median dissolved orthophosphorus, none had less and four had the same median inorganic nitrogen, eight had less mean chlorophyll a, and three had greater mean Secchi disc transparency. Essentially no depression of dissolved oxygen occurred at depths as great as 31.4 meters.

Survey limnologists observed some submerged macrophytes but no surface concentrations of algae. Extensive macrophyte growths are reported to occur at the west end of the lake (Bailey, 1977).

Others have noted that the water quality of Upper Twin Lake is good and have assessed the lake as oligotrophic (Johns, 1975).

B. Rate-Limiting Nutrient:

The algal assay results are not considered representative of conditions in the lake at the times samples were taken.

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* Trophic Assessment is based on levels of nutrients, dissolved oxygen, and chlorophyll a; phytoplankton kinds and numbers; and transparency (Allum et al., 1977).

** See Appendix A.

The lake data indicate nitrogen limitation in June and November and phosphorus limitation in July.

C. Nutrient Controllability:

1. Point sources--No known wastewater treatment plants impacted Upper Twin Lake during the sampling year. Septic tanks serving Mono Village and lakeshore dwellings accounted for an estimated 1.2% of the total phosphorus load, but a shoreline survey would have to be conducted to determine the actual inputs from those sources. However, septic tank failures in the past have resulted in contamination and enrichment of the adjacent waters (Johns, 1975).

The present phosphorus loading of 0.84 g/m^2/year is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading but is more than his suggested oligotrophic loading (see page 11). Because the lake is phosphorus limited much of the time, all phosphorus inputs should be minimized to the greatest practicable extent to protect the existing quality of this water body.

2. Non-point sources--Non-point sources accounted for 98.9% of the total phosphorus input during the sampling year. Robinson Creek contributed 65.9%, and the ungaged minor tributaries and immediate drainage contributed an estimated 30.7%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 1.07 kilometers^2.
2. Mean depth: 14.3 meters.
3. Maximum depth: 34.1 meters.
4. Volume: 15.301 x 10^6 m^3.
5. Mean hydraulic retention time: 136 days.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Robinson Creek	54.4	0.889
Minor tributaries & immediate drainage -	20.9	0.414
Totals	75.3	1.303

2. Outlet -

Robinson Creek	76.4**	1.303

C. Precipitation***:

1. Year of sampling: 8.1 centimeters.
2. Mean annual: 14.5 centimeters.

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† Table of metric conversions--Appendix B.
†† Uttormark (in press).
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Upper Twin Lake was sampled three times during the open-water season of 1975 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 in June and from two stations in July and November (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 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 28.7 meters at station 1 and 31.4 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR UPPER TWIN LAKES
STORET CODE 0625

PARAMETER	2nd SAMPLING (7/ 1/75) 2 SITES RANGE	MEAN	MEDIAN	3rd SAMPLING (11/ 6/75) 2 SITES RANGE	MEAN	MEDIAN	1st SAMPLING (6/10/75) 1 SITES RANGE	MEAN	MEDIAN
TEMP (C)	6.7 - 10.3	9.2	9.5	10.3 - 10.6	10.5	10.5	4.1 - 10.8	7.2	6.8
DISS OXY (MG/L)	7.6 - 8.8	8.4	8.6	7.8 - 8.4	8.1	8.0	7.6 - 9.2	8.6	8.9
CNDCTVY (MCROMO)	29. - 48.	36.	34.	17. - 17.	17.	17.	30. - 39.	35.	35.
PH (STAND UNITS)	7.4 - 8.2	7.8	7.8	7.4 - 7.4	7.4	7.4	7.5 - 8.1	7.8	7.7
TOT ALK (MG/L)	20. - 29.	25.	25.	21. - 47.	33.	34.	20. - 29.	24.	23.
TOT P (MG/L)	0.013 - 0.029	0.017	0.015	0.013 - 0.029	0.018	0.018	0.009 - 0.023	0.013	0.010
ORTHO P (MG/L)	0.002 - 0.003	0.002	0.002	0.004 - 0.010	0.006	0.006	0.005 - 0.014	0.011	0.011
NO2+NO3 (MG/L)	0.020 - 0.020	0.020	0.020	0.020 - 0.020	0.020	0.020	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.020 - 0.030	0.021	0.020	0.020 - 0.020	0.020	0.020	0.030 - 0.040	0.032	0.030
KJEL N (MG/L)	0.200 - 0.400	0.242	0.200	0.200 - 0.200	0.200	0.200	0.200 - 0.200	0.200	0.200
INORG N (MG/L)	0.040 - 0.050	0.041	0.040	0.040 - 0.040	0.040	0.040	0.050 - 0.060	0.052	0.050
TOTAL N (MG/L)	0.220 - 0.420	0.262	0.220	0.220 - 0.220	0.220	0.220	0.220 - 0.220	0.220	0.220
CHLRPYL A (UG/L)	2.5 - 3.1	2.8	2.8	4.1 - 4.5	4.3	4.3	2.5 - 2.5	2.5	2.5
SECCHI (METERS)	5.2 - 5.2	5.2	5.2	5.8 - 5.8	5.8	5.8	3.4 - 3.4	3.4	3.4

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/10/75	1. *Melosira sp.*	122
	2. *Stephanodiscus sp.*	61
	3. *Tabellaria sp.*	61
	4. *Anabaena sp.*	31
	Total	275
07/01/75	1. *Synedra sp.*	265
	2. *Asterionella sp.*	166
	3. *Stephanodiscus sp.*	33
	4. *Melosira sp.*	33
	5. *Chroomonas* (?) *sp.*	33
	Total	530
11/06/75	1. *Melosira sp.*	231
	2. *Cryptomonas sp.*	115
	3. *Dinobryon sp.*	38
	Total	384

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
06/10/75	1	-
	2	2.5
07/01/75	1	2.5
	2	3.1
11/06/75	1	4.5
	2	4.1

C. Limiting Nutrient Study:

The algal assay results are not considered representative of conditions in the lake at the times the samples were collected (06/10/75 and 11/06/75) due to significant changes in nutrient concentrations in the samples during shipment from the field to the laboratory. However, the lake data indicate that nitrogen was limiting in June and November and phosphorus was limiting in July; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 5/1 in June, 21/1 in July, and 7/1 in November.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the California 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 March and May when two samples were collected. Sampling was begun in November, 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 California District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and 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 Robinson Creek at station A-2 and the mean annual ZZ flow.

The nutrient contributions of the Mono Village wastewater treatment facilities were estimated at 0.1134 kg P and 4.263 kg N/capita/year; and the contributing population was estimated on the basis of flow (0/3785 m^3/capita/day).

A. Waste Sources:

1. Known domestic* -

Name	Pop. Served	Treatment	Mean flow (m^3/day)	Receiving Water
Mono Village	55	septic tank/ leach field	20.74	Upper Twin Lake

2. Known industrial - none

* Bailey, 1977.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Robinson Creek	590	65.9
b. Minor tributaries & immediate drainage (non-point load) -	275	30.7
c. Known domestic STP's -		
Mono Village	5	0.6
d. Septic tanks* -	5	0.6
e. Known industrial - None	-	-
f. Direct precipitation** -	20	2.2
Total	895	100.0

2. Outputs -

Lake outlet - Robinson Creek 615

3. Net annual P accumulation - 280 kg.

* Estimate based on 12 lakeshore 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) -		
Robinson Creek	21,505	65.1
b. Minor tributaries & immediate drainage (non-point load) -	10,015	30.3
c. Known domestic STP's -		
Mono Village	235	0.7
d. Septic tanks*	130	0.4
e. Known industrial - None	-	-
f. Direct precipitation** -	1,155	3.5
Total	33,040	100.0

2. Outputs -

Lake outlet - Robinson Creek 36,200

3. Net annual N loss - 3.160 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Robinson Creek	11	395

* Estimate based on 12 lakeshore 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	0.84	0.26	30.9	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Upper Twin Lake:

"Dangerous" (eutrophic loading)	1.16
"Permissible" (oligotrophic loading)	0.58

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, underestimation of septic tank contributions, or (possibly) insufficient outlet sampling in relation to the hydraulic retention time of the lake. Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's former National Eutrophication and Lake Restoration Branch (Malueg et al., 1975).

V. LITERATURE REVIEWED

Allum, M.O., R.E. Glessner, and J.H. Gakstatter, 1977. An evaluation of the National Eutrophication Survey data. Working Paper No. 900, Corvallis Env. Res. Lab., Corvallis, OR.

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Malueg, Kenneth W., D. Phillips Larsen, Donald W. Schults, and Howard T. Mercier; 1975. A six-year water, phosphorus, and nitrogen budget for Shagawa Lake, Minnesota. Jour. Environ. Qual., vol. 4, no. 2, pp. 236-242.

Uttormark, Paul D. (in press). TSI and LCI: A comparison of two lake classification techniques. North American Project Rept., EPA Order No. P5J11904-J, Corvallis, OR.

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
0601	AMADOR RESERVOIR	0.040	0.390	408.667	22.383	14.600	0.020
0602	BOCA LAKE	0.012	0.040	372.833	1.700	6.800	0.003
0603	LAKE BRITTON	0.067	0.115	448.500	4.811	11.200	0.047
0604	CASITAS RESERVOIR	0.029	0.050	400.250	3.192	14.000	0.014
0605	CROWLEY LAKE	0.046	0.045	374.750	5.800	12.200	0.034
0606	DON PEDRO RESERVOIR	0.013	0.060	381.733	3.564	11.400	0.004
0607	LAKE ELSINORE	0.469	0.120	489.214	70.572	8.000	0.092
0608	FALLEN LEAF RESERVOIR	0.007	0.040	24.357	0.786	8.800	0.005
0609	LAKE HENNESSEY	0.027	0.060	416.000	4.525	15.000	0.012
0610	LAKE HENSHAW	0.138	0.070	461.000	26.783	9.800	0.073
0611	IRON GATE RESERVOIR	0.184	0.690	440.333	6.217	13.800	0.124
0614	LOPEZ LAKE	0.371	0.090	372.000	8.658	15.000	0.343
0615	LAKE MARY	0.010	0.040	296.000	2.550	10.600	0.002
0616	LAKE MENDOCINO	0.020	0.050	436.500	3.100	9.400	0.008
0617	NICASIO RESERVOIR	0.055	0.345	482.778	6.633	9.800	0.013
0618	LOWER OTAY RESERVOIR	0.058	0.180	447.250	15.933	15.000	0.013
0619	LAKE PILLSBURY	0.022	0.060	466.667	6.389	8.200	0.008
0620	SANTA MARGARITA LAKE	0.037	0.070	400.000	9.122	14.800	0.014
0621	SHASTA LAKE	0.021	0.060	381.542	4.087	9.000	0.015
0622	SHAVER	0.014	0.060	346.400	1.700	7.400	0.004
0623	SILVER LAKE	0.012	0.055	356.000	1.800	7.000	0.003
0624	TULLOCK RESERVOIR	0.025	0.060	433.000	13.878	7.400	0.009
0625	UPPER TWIN LAKES	0.015	0.040	300.200	3.340	7.400	0.004
0626	LOWER TWIN LAKES	0.014	0.040	248.000	2.900	11.400	0.003

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 NU
0601	AMADOR RESERVOIR	35 (8)	4 (1)	43 (10)	9 (2)	17 (4)	26 (6)	134
0602	BOCA LAKE	89 (20)	98 (22)	70 (16)	91 (21)	100 (23)	91 (20)	539
0603	LAKE BRITTON	17 (4)	22 (5)	17 (4)	48 (11)	43 (10)	17 (4)	164
0604	CASITAS RESERVOIR	43 (10)	74 (17)	48 (11)	70 (16)	22 (5)	37 (8)	294
0605	CROWLEY LAKE	30 (7)	78 (18)	65 (15)	43 (10)	30 (7)	22 (5)	268
0606	DON PEDRO RESERVOIR	83 (19)	54 (11)	57 (13)	61 (14)	37 (8)	78 (17)	370
0607	LAKE ELSINORE	0 (0)	17 (4)	0 (0)	0 (0)	78 (18)	9 (2)	104
0608	FALLEN LEAF RESERVOIR	100 (23)	87 (19)	100 (23)	100 (23)	70 (16)	70 (16)	527
0609	LAKE HENNESSEY	48 (11)	54 (11)	39 (9)	52 (12)	4 (0)	52 (12)	249
0610	LAKE HENSHAW	13 (3)	33 (7)	13 (3)	4 (1)	54 (12)	13 (3)	130
0611	IRON GATE RESERVOIR	9 (2)	0 (0)	26 (6)	39 (9)	26 (6)	4 (1)	104
0614	LOPEZ LAKE	4 (1)	26 (6)	74 (17)	26 (6)	4 (0)	0 (0)	134
0615	LAKE MARY	96 (22)	87 (19)	91 (21)	83 (19)	48 (11)	100 (23)	505
0616	LAKE MENDOCINO	65 (15)	70 (16)	30 (7)	74 (17)	61 (14)	63 (14)	363
0617	NICASIO RESERVOIR	26 (6)	9 (2)	4 (1)	30 (7)	54 (12)	46 (10)	169
0618	LOWER OTAY RESERVOIR	22 (5)	13 (3)	22 (5)	13 (3)	4 (0)	46 (10)	120
0619	LAKE PILLSBURY	57 (13)	41 (9)	9 (2)	35 (8)	74 (17)	63 (14)	279
0620	SANTA MARGARITA LAKE	39 (9)	33 (7)	52 (12)	22 (5)	13 (3)	37 (8)	196
0621	SHASTA LAKE	61 (14)	54 (11)	61 (14)	57 (13)	65 (15)	30 (7)	328
0622	SHAVER	78 (18)	41 (9)	83 (19)	96 (22)	87 (19)	78 (17)	463
0623	SILVER LAKE	89 (20)	65 (15)	78 (18)	87 (20)	96 (22)	91 (20)	506
0624	TULLOCK RESERVOIR	52 (12)	54 (11)	35 (8)	17 (4)	87 (19)	57 (13)	302
0625	UPPER TWIN LAKES	70 (16)	98 (22)	87 (20)	65 (15)	87 (19)	78 (17)	485
0626	LOWER TWIN LAKES	74 (17)	87 (19)	96 (22)	78 (18)	37 (8)	91 (20)	463

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	0602	BOCA LAKE	539
2	0608	FALLEN LEAF RESERVOIR	527
3	0623	SILVER LAKE	506
4	0615	LAKE MARY	505
5	0625	UPPER TWIN LAKES	485
6	0626	LOWER TWIN LAKES	463
7	0622	SHAVER	463
8	0606	DON PEDRO RESERVOIR	370
9	0616	LAKE MENDOCINO	363
10	0621	SHASTA LAKE	328
11	0624	TULLOCK RESERVOIR	302
12	0604	CASITAS RESERVOIR	294
13	0619	LAKE PILLSBURY	279
14	0605	CROWLEY LAKE	268
15	0609	LAKE HENNESSEY	249
16	0620	SANTA MARGARITA LAKE	196
17	0617	NICASIO RESERVOIR	169
18	0603	LAKE BRITTON	164
19	0614	LOPEZ LAKE	134
20	0601	AMADOR RESERVOIR	134
21	0610	LAKE HENSHAW	130
22	0618	LOWER OTAY RESERVOIR	120
23	0607	LAKE ELSINORE	104
24	0611	IRON GATE RESERVOIR	104

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 CALIFORNIA 09/24/76

LAKE CODE 0625 UPPER TWIN LAKES

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 76.4

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0625A1	76.4	0.21	0.28	0.31	1.13	2.49	4.67	3.82	2.41	1.22	0.45	0.16	0.11	1.303
0625A2	54.4	0.22	0.24	0.31	0.79	2.21	3.06	1.93	0.79	0.37	0.24	0.24	0.25	0.889
0625ZZ	20.7	0.10	0.11	0.13	0.26	0.74	1.05	0.62	0.26	0.14	0.11	0.11	0.11	0.414

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 76.4
SUM OF SUB-DRAINAGE AREAS = 75.1
TOTAL FLOW IN = 14.40
TOTAL FLOW OUT = 17.27

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0625A1	11	74	0.255	15	0.396				
	12	74	0.008	13	0.023				
	1	75	0.057	15	0.045				
	2	75	0.425						
	3	75	0.453	14	0.396	15	0.396		
	4	75	0.396	27	0.368				
	5	75	2.124	12	1.048	30	4.049		
	6	75	5.607	6	6.768				
	7	75	4.078	7	4.842	24	3.341		
	8	75	1.529	4	1.699	15	1.642		
	9	75	1.557	11	1.812				
	10	75	0.566						
0625A2	11	74	0.249	15	0.252				
	12	74	0.215	13	0.235				
	1	75	0.178	15	0.176				
	2	75	0.193						
	3	75	0.241	14	0.218	15	0.218		
	4	75	0.269	27	0.311				
	5	75	2.237	12	1.869	30	3.568		
	6	75	3.766	6	4.870				
	7	75	2.294	7	3.087	24	1.756		
	8	75	0.793	4	1.019	15	0.765		
	9	75	0.467	11	0.623				
	10	75	0.425						
0625ZZ	11	74	0.113						
	12	74	0.102						
	1	75	0.093						
	2	75	0.096						
	3	75	0.110						
	4	75	0.119						
	5	75	0.736						
	6	75	1.303						
	7	75	0.765						
	8	75	0.269						
	9	75	0.173						
	10	75	0.161						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/09/24

062501
38 09 10.0 119 21 15.0 3
UPPER TWIN LAKES
06051 CALIFORNIA

150193

11EPALES 2111202
0078 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
75/07/01	13 30	0000	10.1	8.8	204	48	7.90	20	0.030	0.300	0.020K	0.003
	13 30	0005	10.3	8.6		35	7.80	23	0.020	0.300	0.020K	0.002K
	13 30	0015	10.3	8.6		35	7.80	26	0.020	0.200	0.020K	0.002K
	13 30	0030	10.2	8.8		37	7.90	25	0.020K	0.300	0.020K	0.002K
	13 30	0050	9.3	8.4		43	7.70	24	0.020	0.200	0.020K	0.002
	13 30	0074	8.1	8.2		42	7.60	22	0.020	0.200	0.020K	0.002K
75/11/06	14 15	0000	10.5	8.4	228	17	7.45	37	0.020K	0.200K	0.020K	0.006
	14 15	0005	10.6	8.4		17	7.45	25	0.020K	0.200K	0.020K	0.004
	14 15	0025	10.5	8.2		17	7.45	22	0.020K	0.200K	0.020K	0.004
	14 15	0055	10.4	7.8		17	7.40	21	0.020K	0.200K	0.020K	0.007
	14 15	0094	10.3	7.8		17	7.40	32	0.020K	0.200K	0.020K	0.004

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/07/01	13 30	0000	0.015	2.5	
	13 30	0005	0.013		
	13 30	0015	0.014		
	13 30	0030	0.014		
	13 30	0050	0.015		
	13 30	0074	0.029		
75/11/06	14 15	0000	0.016	4.5	
	14 15	0005	0.013		
	14 15	0025	0.018		
	14 15	0055	0.016		
	14 15	0094	0.018		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

062502
38 08 52.0 119 21 52.0 3
UPPER TWIN LAKES
06051 CALIFORNIA

11EPALES 751126 2111202
0107 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
75/06/10	12 00	0000	10.6	8.8	135	35	7.60	21	0.030	0.200K	0.020K	0.005
	12 00	0005	10.8	9.0		34	7.90	20	0.030	0.200K	0.020K	0.011
	12 00	0020	8.0	9.2		30	8.10	21	0.030	0.200K	0.020K	0.012
	12 00	0041	5.7	9.0		35	7.60	24	0.030	0.200K	0.020K	0.011
	12 00	0071	4.3	8.2		37	7.50	27	0.030	0.200K	0.020K	0.013
	12 00	0103	4.1	7.6		39	7.90	29	0.040	0.200K	0.020K	0.014
75/07/01	13 50	0000	9.6	8.6	204	32	8.20	26	0.020	0.400	0.020K	0.002K
	13 50	0005	9.6	8.6		29	7.90	25	0.020K	0.200K	0.020K	0.002
	13 50	0021	9.5	8.6		31	7.80	25	0.020	0.200K	0.020K	0.002K
	13 50	0045	8.7	8.6		32	7.70	25	0.020	0.200K	0.020K	0.002
	13 50	0065	7.6	8.0		32	7.60	27	0.020	0.200K	0.020K	0.002
	13 50	0092	6.7	7.6		32	7.40	29	0.020	0.200K	0.020K	0.003
75/11/06	13 50	0000	10.6	7.8	228	17	7.40	35	0.020K	0.200K	0.020K	0.007
	13 50	0005	10.6	8.0		17	7.45	37	0.020K	0.200K	0.020K	0.006
	13 50	0015	10.6	8.4		17	7.40	33	0.020K	0.200	0.020K	0.010
	13 50	0030	10.6	8.0		17	7.40	47	0.020K	0.200K	0.020K	0.007
	13 50	0064	10.5	7.8		17	7.40	43	0.020K	0.200K	0.020K	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/06/10	12 00	0000	0.013	2.5	
	12 00	0005	0.010		
	12 00	0020	0.009		
	12 00	0041	0.011		
	12 00	0071	0.010		
	12 00	0103	0.023		
75/07/01	13 50	0000	0.015	3.1	
	13 50	0005	0.017		
	13 50	0021	0.015		
	13 50	0045	0.015		
	13 50	0065	0.016		
	13 50	0092	0.027		
75/11/06	13 50	0000	0.013	4.1	
	13 50	0005	0.018		
	13 50	0015	0.018		
	13 50	0030	0.018		
	13 50	0064	0.029		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/09/24

0625A1
38 09 15.0 119 20 55.0 4
ROBINSON CREEK
06 15 MATTERHORN PK
0/UPPER TWIN LAKES 150193
UNPVD RD BRDG .6 M SW TWIN LKS CAMPGRND
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
74/11/15	11 50		0.008	0.400	0.040	0.005K	0.010
75/01/15	10 52		0.012	0.400	0.012	0.005K	0.010K
75/03/14	11 30		0.005	1.700	0.045	0.005K	0.010K
75/03/15	11 00		0.008	0.100K	0.008K	0.008K	0.010K
75/04/27	09 14		0.005	0.150	0.010	0.005K	0.010K
75/05/12	13 00		0.005	1.450	0.010	0.005K	
75/05/30	09 35		0.015	2.500	0.080	0.005	0.020
75/06/06	09 55		0.095	2.500	0.080	0.005K	0.010
75/07/07	14 35		0.005	0.400	0.025	0.005K	0.025
75/07/24	12 15		0.015	0.300	0.005	0.010	0.010
75/08/04	14 10		0.015	0.050K	0.005	0.005	0.030
75/08/15	10 50		0.005	0.100	0.005K	0.005K	0.010K
75/09/11	16 40		0.005	1.200	0.315	0.005K	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

0625A2
38 08 45.0 119 22 30.0 4
ROBINSON CREEK
06 15 MATTERHORN PK
T/UPPER TWIN LAKES 150193
BNK .5 MI S OF MONO VILLAGE
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
74/11/15	11 10		0.024	0.100	0.020	0.005K	0.020
74/12/13	10 00		0.048	0.400	0.015	0.006	0.020
75/01/15	10 30		0.072	0.400	0.016	0.005K	0.010K
75/03/14	11 15		0.055	0.300	0.030	0.005K	0.010K
75/03/15	10 45		0.056	0.100K	0.008K	0.008K	0.010K
75/05/12	12 45		0.030	0.700	0.005	0.005	0.040
75/05/30	09 30		0.020	1.500	0.025	0.005	0.020
75/07/07	14 05		0.020	3.700	0.135	0.005	0.020
75/07/24	13 50		0.020	0.050	0.005K	0.010	0.010
75/08/04	13 55		0.020	0.050	0.010	0.005	0.040
75/08/15	11 10		0.005	0.800	0.010	0.005K	0.020
75/09/11	16 10		0.030	0.700	0.210	0.005K	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED