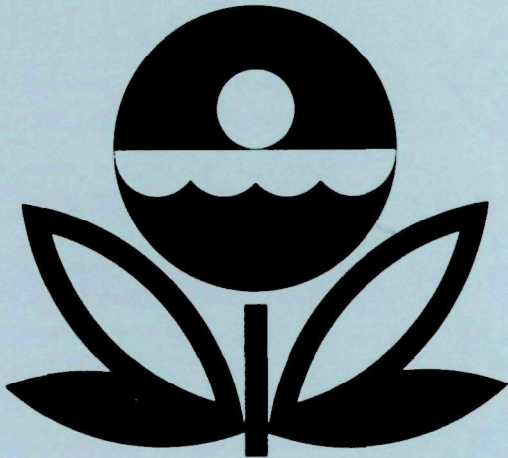


**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES**



REPORT
ON
LAKE WHATCOM
WHATCOM COUNTY
WASHINGTON
EPA REGION X
WORKING PAPER No. 875

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

REPORT
ON
LAKE WHATCOM
WHATCOM COUNTY
WASHINGTON
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WORKING PAPER No. 875

WITH THE COOPERATION OF THE
WASHINGTON DEPARTMENT OF ECOLOGY
AND THE
WASHINGTON NATIONAL GUARD
JULY, 1977

REPORT ON LAKE WHATCOM
WHATCOM COUNTY, WASHINGTON
EPA REGION X

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 875

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

July 1977

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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 nonpoint 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 the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

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

Ms. Barbara Blau, Lake Restoration Program, and the staff of the Washington Department of Ecology, Lake Restoration Program, 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 Howard S. McGee, Adjutant General of Washington, and Project Officer Colonel Clinton C. Johnson, who directed the volunteer efforts of the Washington National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WASHINGTONLAKE NAMECOUNTY

American Lake

Pierce

Banks Lake

Grant, Douglas

Chelan Lake

Chelan

Diamond Lake

Pend Oreille

Green Lake

King

Keechelus Lake

Kittitas

Mayfield Lake

Lewis

Medical Lake

Spokane

Moses Lake

Grant

Ozette Lake

Clallam

Sammamish Lake

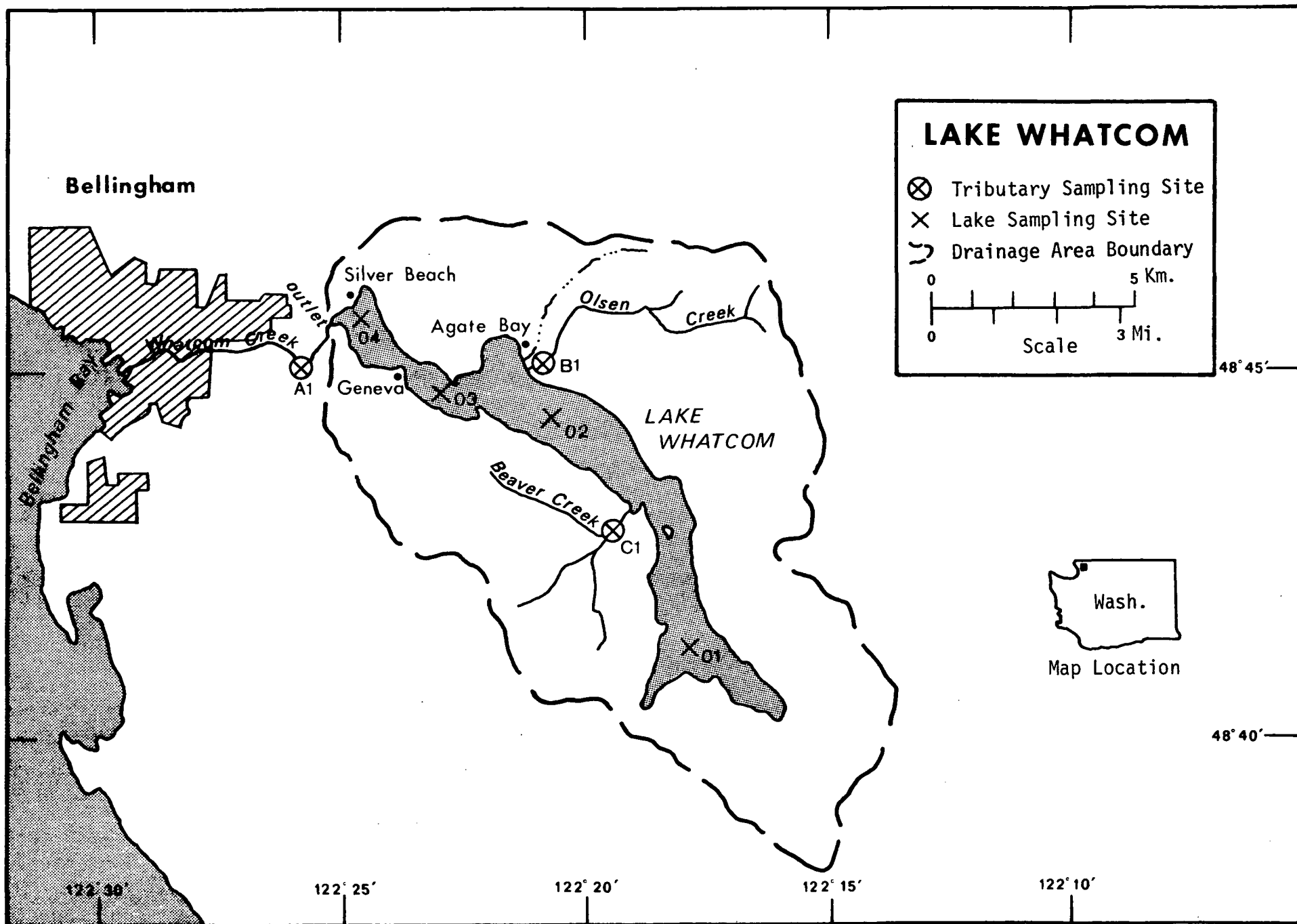
King

Lake Whatcom

Whatcom

Lower Granite Reservoir

Garfield, Whatcom



REPORT ON LAKE WHATCOM, WASHINGTON

STORET NO. 5312

I. CONCLUSIONS

A. Trophic Condition:*

Based upon Survey data Lake Whatcom is considered early mesotrophic. Chlorophyll a values in the lake ranged from 2.5 µg/l to 5.0 µg/l, with a mean of 3.4 µg/l. Secchi disc visibility remained high in the lake throughout the sampling year, and potential for primary production as measured by algal assay control yields was moderately low. Of the 13 Washington lakes sampled in 1975, 10 had greater median total phosphorus levels, none had greater median inorganic nitrogen values and 5 had greater median orthophosphorus levels than Lake Whatcom.

Survey limnologists did not observe any problem algal blooms or macrophyte growths in the lake during the sampling year. However, other studies (Ketelle and Uttormark, 1971; Kraft and Mason, 1970) indicate there is a tendency towards eutrophication in the western end of the lake as a result of septic tank seepage from lakeshore residences.

*See Appendix E.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Whatcom was primarily limited by phosphorus during both spring and fall sampling rounds. The lake data suggest phosphorus limitation on all three sampling occasions.

C. Nutrient Controllability:

1. Point sources -

There were no known municipal or industrial point sources contributing to Lake Whatcom during the sampling year. There are two known fish hatcheries located on the lake (Lake Whatcom Fish Hatchery, and a state trout hatchery on Brannian Creek); however, annual nutrient contributions from these sources are not known.

The present calculated annual phosphorus loading of $0.13 \text{ g P/m}^2/\text{yr}$ is less than Vollenweider's (1975) proposed oligotrophic level for a lake with such volume and hydraulic retention time. Additional study is needed to determine the actual number and significance of septic tanks contributing to the lake nutrient budget, however, since it appears there are localized water quality problems in Lake Whatcom due to septic tank discharges. Ketelle and Uttormark (1971) report that there has been some sewerage of lakeshore residences in an effort to control localized enrichment problems, but

it is not known at this time to what extent the sewerage has been accomplished.

2. Nonpoint sources -

Nonpoint sources provided the entire phosphorus load to Lake Whatcom during the sampling year. Olsen Creek contributed 6.6% of the total phosphorus load, Beaver Creek contributed 14.3%, and ungaged drainage areas were estimated to have contributed 62.5% of the total.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below.

Lake morphometry data were provided by E.E. Wolcott (1965). Tributary flow data were provided by the U.S. Geological Survey (USGS).

Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 20.25 km^2 .
2. Mean depth: 1.8 meters.
3. Maximum depth: 97.8 meters.
4. Volume: $37.005 \times 10^6 \text{ m}^3$.
5. Mean hydraulic retention time: 95 days.

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

1. Tributaries -

<u>Name</u>	<u>Drainage area (km²)</u>	<u>Mean Flow (m³/sec)</u>
B-1 Olsen Creek	9.8	0.30
C-1 Beaver Creek	20.0	0.58
Minor tributaries and immediate drainage	<u>95.2</u>	<u>3.89</u>
Totals	125.0	4.77

2. Outlet - A-1 Whatcom Creek 145.3 4.50

C. Precipitation:

1. Year of sampling: 108.6 cm.
2. Mean annual: 84.7 cm.

III. LAKE WATER QUALITY SUMMARY

Lake Whatcom 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 four stations on the lake (Station 03 was only sampled once and Station 04 was sampled twice) and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 67.0 meters at Station 01, 62.8 meters at Station 02, 17.1 meters at Station 03, and 18.3 meters at Station 04. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

WHATCOM LAKE
STOPEL CODE 5312

PHYSICAL AND CHEMICAL CHARACTERISTICS

(3/31/75)					(7/18/75)					(10/29/75)				
S*** = 3					S*** = 3					S*** = 3				
PARAMETER	N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)		
TEMPERATURE (DEG CENT)														
0.-1.5 M DEPTH	6	6.3- 7.0	6.5	0.0- 1.5	6	16.2- 18.7	17.7	0.0- 1.5	6	13.0- 13.8	13.6	0.0- 1.5		
MAX DEPTH**	3	6.2- 6.7	6.5	17.1- 59.4	3	5.2- 9.2	5.3	18.3- 67.1	3	9.3- 13.0	9.3	18.3- 53.3		
DISSOLVED OXYGEN (MG/L)														
0.-1.5 M DEPTH	6	11.6- 12.2	12.0	0.0- 1.5	6	9.2- 9.8	9.4	0.0- 1.5	6	9.8- 10.8	10.0	0.0- 1.5		
MAX DEPTH**	3	11.8- 12.0	11.8	17.1- 59.4	3	4.2- 10.4	9.8	18.3- 67.1	3	9.0- 10.0	9.2	18.3- 53.3		
CONDUCTIVITY (UMHOS)														
0.-1.5 M DEPTH	6	53.- 55.	54.	0.0- 1.5	6	23.- 58.	51.	0.0- 1.5	6	27.- 28.	28.	0.0- 1.5		
MAX DEPTH**	3	53.- 55.	54.	17.1- 59.4	3	36.- 41.	39.	18.3- 67.1	3	23.- 28.	23.	18.3- 53.3		
PH (STANDARD UNITS)														
0.-1.5 M DEPTH	6	7.1- 7.2	7.1	0.0- 1.5	6	7.8- 8.0	8.0	0.0- 1.5	6	7.1- 7.3	7.2	0.0- 1.5		
MAX DEPTH**	3	7.0- 7.1	7.0	17.1- 59.4	3	6.9- 7.2	7.2	18.3- 67.1	3	7.0- 7.3	7.0	18.3- 53.3		
TOTAL ALKALINITY (MG/L)														
0.-1.5 M DEPTH	6	10.- 17.	15.	0.0- 1.5	6	16.- 20.	19.	0.0- 1.5	6	15.- 19.	17.	0.0- 1.5		
MAX DEPTH**	3	10.- 17.	13.	17.1- 59.4	3	16.- 20.	19.	18.3- 67.1	3	16.- 18.	16.	18.3- 53.3		
TOTAL P (MG/L)														
0.-1.5 M DEPTH	6	0.008-0.015	0.010	0.0- 1.5	6	0.008-0.014	0.010	0.0- 1.5	6	0.008-0.016	0.009	0.0- 1.5		
MAX DEPTH**	3	0.008-0.013	0.011	17.1- 59.4	3	0.007-0.011	0.008	18.3- 67.1	3	0.008-0.016	0.009	18.3- 53.3		
DISSOLVED ORTHO P (MG/L)														
0.-1.5 M DEPTH	6	0.003-0.015	0.006	0.0- 1.5	6	0.010-0.030	0.013	0.0- 1.5	6	0.002-0.004	0.002	0.0- 1.5		
MAX DEPTH**	3	0.009-0.013	0.012	17.1- 59.4	3	0.009-0.017	0.012	18.3- 67.1	3	0.004-0.008	0.005	18.3- 53.3		
NO2+NO3 (MG/L)														
0.-1.5 M DEPTH	6	0.290-0.310	0.300	0.0- 1.5	6	0.120-0.180	0.165	0.0- 1.5	6	0.050-0.150	0.140	0.0- 1.5		
MAX DEPTH**	3	0.300-0.310	0.310	17.1- 59.4	3	0.200-0.330	0.330	18.3- 67.1	3	0.050-0.320	0.300	18.3- 53.3		
AMMONIA (MG/L)														
0.-1.5 M DEPTH	6	0.020-0.040	0.030	0.0- 1.5	6	0.020-0.050	0.025	0.0- 1.5	6	0.020-0.020	0.020	0.0- 1.5		
MAX DEPTH**	3	0.020-0.030	0.020	17.1- 59.4	3	0.020-0.080	0.020	18.3- 67.1	3	0.020-0.020	0.020	18.3- 53.3		
KJELDAHL N (MG/L)														
0.-1.5 M DEPTH	6	0.200-0.400	0.300	0.0- 1.5	6	0.200-0.700	0.450	0.0- 1.5	6	0.200-0.200	0.200	0.0- 1.5		
MAX DEPTH**	3	0.200-0.300	0.300	17.1- 59.4	3	0.200-0.300	0.200	18.3- 67.1	3	0.200-0.200	0.200	18.3- 53.3		
SECCHI DISC (METERS)														
	3	7.3- 7.9	7.6		3	2.7- 4.3	3.0		3	4.0- 6.1	5.5			

* N = NO. OF SAMPLES

** MAXIMUM DEPTH SAMPLED AT EACH SITE

*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

<u>Sampling Date</u>	<u>Dominant Genera</u>	<u>Algal Units per ml</u>
03/31/75	1. <u>Melosira</u>	735
	2. <u>Asterionella</u>	331
	3. <u>Chroomonas</u>	257
	4. <u>Stephanodiscus</u>	184
	5. <u>Tabellaria</u>	110
	Other genera	---
	Total	1,617
07/18/75	1. <u>Tabellaria</u>	733
	2. <u>Synedra</u>	193
	3. <u>Cyclotella</u>	38
	4. <u>Mallomonas</u>	38
	Other genera	---
	Total	1,002
10/29/75	1. <u>Asterionella</u>	184
	2. <u>Fragilaria</u>	184
	3. <u>Spondylosium</u>	184
	4. <u>Chroomonas</u>	147
	5. <u>Aphanocapsa</u>	73
	Other genera	109
	Total	881

2. Chlorophyll a -

<u>Sampling Date</u>	<u>Station Number</u>	<u>Chlorophyll <u>a</u> (μg/l)</u>
03/31/75	01	3.6
	02	3.6
	03	5.0
	04	---
07/18/75	01	2.8
	02	2.9
	03	---
	04	2.6
10/29/75	01	2.5
	02	3.4
	03	---
	04	4.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 03/31/75

<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	0.008	0.294	0.4
0.05 P	0.058	0.294	9.6
0.05 P + 1.0 N	0.058	1.294	26.5
1.00 N	0.008	1.294	0.3

b. 10/29/75

<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	0.180	0.3
0.05 P	0.055	0.180	6.7
0.05 P + 1.0 N	0.055	1.180	29.9
1.00 N	0.005	1.180	0.4

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that potential for primary productivity as measured by algal assay control yield was moderate during both spring and fall sampling of Lake Whatcom. In both assays, there was a significant increase in yield over that of the control when phosphorus was added, indicating primary limitation by phosphorus. In both assays, the addition of nitrogen alone did not result in an increase in yield over that of the control, and the simultaneous addition of both nutrients resulted in maximum increase in yield.

The mean inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were approximately 36/1, 19/1 and 58/1 during spring, summer and fall visits to the lake, indicating phosphorus limitation (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS (See Appendix D for data)

For the determination of nutrient loadings, the Washington 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 month of March 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 Washington District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $\text{kg}/\text{km}^2/\text{year}$, in Olsen Creek at Station B-1 and multiplying the means by the ZZ area in km^2 .

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 (nonpoint load) -		
B-1 Olsen Creek	170	6.6
C-1 Beaver Creek	370	14.3
b. Minor tributaries and immediate drainage (nonpoint load) -	1,620	62.5
c. Known municipal STP's - None		
d. Septic tanks* -	75	2.9
e. Known industrial - None		
f. Direct precipitation** -	<u>355</u>	<u>13.7</u>
Totals	2,590	100.0
2. Output - A-1 Whatcom Creek	1,480	
3. Net annual P accumulation -	1,110	

*Estimate based on 258 lakeshore residences and 1 park.

**Estimated (See NES 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 (nonpoint load) -		
B-1 Olsen Creek	10,895	6.5
C-1 Beaver Creek	25,410	15.2
b. Minor tributaries and immediate drainage (nonpoint load) -	106,435	63.5
c. Known municipal STP's - None		
d. Septic tanks* -	2,785	1.7
e. Known industrial - None		
f. Direct precipitation** -	<u>21,860</u>	<u>13.1</u>
Totals	167,385	100.0
2. Output - A-1 Whatcom Creek	89,620	
3. Net annual N accumulation -	77,765	

*Estimate based on 253 lakeshore residences and 1 park.

**Estimated (See NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

<u>Tributary</u>	<u>kg P/km²/yr</u>	<u>kg N/km²/yr</u>
Olsen Creek	17	1118
Beaver Creek	18	1270

E. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" 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 "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

<u>Total Yearly Phosphorus Loading (g/m²/yr)</u>	
Estimated loading for Lake Whatcom	0.13
Vollenweider's "eutrophic" loading	0.52
Vollenweider's "oligotrophic" loading	0.26

V. LITERATURE REVIEWED

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U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R.A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

VI. APPENDICES

APPENDIX A 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 B
TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR WASHINGTON

11/16/76

LAKE CODE 5312 A--ETOOM LAKE

TOTAL DRAINAGE AREA OF LAKE (SQ KM) 145.3

TRIBUTARY	SUB-DRAINAGE AREA (SQ KM)	NORMALIZED FLOWS (CMS)												MEAN
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
5312A1	145.3	8.35	8.30	6.46	4.70	3.10	2.75	3.01	3.06	3.11	3.26	4.92	3.23	4.5
5312B1	9.5	0.595	0.623	0.481	0.368	0.147	0.110	0.057	0.042	0.074	0.173	0.396	0.566	0.30
5312C1	27.7	1.218	1.274	0.963	0.736	0.244	0.144	0.059	0.037	0.071	0.311	0.793	1.161	0.58
531277	115.5	5.95	5.95	4.53	3.68	1.98	3.40	2.69	2.69	1.84	2.83	4.81	6.51	3.8

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 145.3
SUM OF SUB-DRAINAGE AREAS = 145.3

TOTAL FLOW IN = 57.51
TOTAL FLOW OUT = 54.24

MEAN MONTHLY FLOWS AND DAILY FLOWS (CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5312A1	9	74	0.010	21	0.006				
	10	74	0.274	19	0.028				
	11	74	0.015	20	0.017				
	12	74	1.203	8	0.014				
	1	75	7.306	16	6.343				
	2	75	4.729						
	3	75	1.960	3	6.173	16	0.057		
	4	75	0.025	20	0.024				
	5	75	0.042	28	0.024				
	6	75	0.020	22	0.024				
	7	75	0.535						
	8	75	0.026	5	0.021				
5312B1	9	74	0.037	21	0.034				
	10	74	0.048	19	0.045				
	11	74	0.255	20	0.453				
	12	74	0.453	8	0.190				
	1	75	0.708	16	0.311				
	2	75	0.566						
	3	75	0.453	3	0.680	16	0.272		
	4	75	0.368	20	0.340				
	5	75	0.232	28	0.167				
	6	75	0.082	22	0.068				
	7	75	0.048						
	8	75	0.057	5	0.048				

TRIBUTARY FLOW INFORMATION FOR WASHINGTON

11/16/76

LAKE CODE 5312 WHATCOM LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
5312C1	9	74	0.031	21	0.028				
	10	74	0.045	19	0.042				
	11	74	0.425	20	0.850				
	12	74	0.991	8	0.368				
	1	75	1.416	16	0.963				
	2	75	1.133						
	3	75	0.906	3	1.388	16	0.906		
	4	75	0.708	20	0.311				
	5	75	0.425	28	0.215				
	6	75	0.093	22	0.071				
	7	75	0.042						
	8	75	0.054	5	0.042				
531277	9	74	0.850						
	10	74	0.283						
	11	74	1.699						
	12	74	4.531						
	1	75	8.212						
	2	75	5.947						
	3	75	3.964						
	4	75	4.248						
	5	75	5.097						
	6	75	3.398						
	7	75	3.823						
	8	75	3.681						

APPENDIX C
PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 74/11/16
 NATL EUTROPHICATION SURVEY
 EPA-LAS VEGAS

531201
 48 41 21.0 122 18 03.0 3
 WHATCOM LAKE
 53073 WASHINGTON

131191

11EPALES 2111202
 0092 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 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
75/03/31	10 00	0000	6.3	12.2	288	53	7.10	14	0.030	0.400	0.290	0.005
	10 00	0005	6.5	12.0		53	7.10	15	0.030	0.300	0.310	0.014K
	10 00	0025	6.4	12.0		53	7.10	15	0.020	0.200	0.300	0.004
	10 00	0050	6.4	11.8		54	7.10	15	0.020	0.200K	0.310	0.005
	10 00	0070	6.5	11.8		54	7.10	16	0.030	0.200K	0.310	0.003
75/07/18	10 00	0086	6.5	11.8		54	7.05	17	0.020	0.200K	0.310	0.009K
	09 35	0000	16.2	9.2	120	23	7.95	19	0.030	0.700	0.160	0.010J
	09 35	0005	16.4	9.8		50	7.95	16	0.020	0.200	0.170	0.013K
	09 35	0025	16.0	10.0		41	7.85	18	0.030	0.200K	0.170	0.010K
	09 35	0045	10.1	10.8		36	7.50	16	0.030	0.200K	0.240	0.010K
75/10/29	09 35	0070	6.5	10.6		29	7.40	18	0.020K	0.200K	0.320	0.010K
	09 35	0120	5.5	10.6		31	7.30	16	0.020	0.200K	0.330	0.009K
	09 35	0170	5.4	10.4		37	7.30	15	0.020K	0.200K	0.320	0.009K
	09 35	0220	5.2	10.4		36	7.20	16	0.020K	0.200K	0.330	0.009K
	08 50	0000	13.6	9.8	240	28	7.20	17	0.020K	0.200K	0.150	0.002
75/10/29	08 50	0005	13.6	9.8		27	7.25	18	0.020K	0.200K	0.150	0.002K
	08 50	0025	13.6	9.8		27	7.25	17	0.020K	0.200K	0.150	0.002K
	08 50	0050	13.6	10.2		27	7.20	15	0.020K	0.200K	0.150	0.002K
	08 50	0095	9.6	9.6		22	7.10	14	0.020K	0.200K	0.310	0.002
	08 50	0135	9.4	9.4		21	7.00	14	0.020K	0.200K	0.320	0.002
75/10/29	08 50	0175	9.3	9.0		23	7.00	16	0.020K	0.200K	0.300	0.008

K VALUE KNOWN TO BE LESS
 THAN INDICATED

J VALUE KNOWN TO BE ESTIMATED

STORET RETRIEVAL DATE 76/11/16
 NATL EUTROPHICATION SURVEY
 EPA-LAS VEGAS

531201
 48 41 21.0 122 18 03.0 3
 WATCOM LAKE
 53073 WASHINGTON

131191

11EPALES 2111202
 0092 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLPPHYL A UG/L	00031 INCDT LT PEMNING PERCENT
75/03/31	10 00	0000	0.014	3.6	
	10 00	0005	0.010		
	10 00	0025	0.008		
	10 00	0050	0.011		
	10 00	0070	0.007		
	10 00	0086	0.008		
	10 00	0086	0.008		
75/07/18	09 35	0000	0.011	2.8	
	09 35	0005	0.008		
	09 35	0025	0.009		
	09 35	0045	0.008		
	09 35	0070	0.006		
	09 35	0120	0.006		
	09 35	0170	0.006		
	09 35	0220	0.007		
	09 35	0220	0.007		
75/10/29	08 50	0000	0.009	2.5	
	08 50	0005	0.008		
	08 50	0025	0.008		
	08 50	0060	0.009		
	08 50	0095	0.007		
	08 50	0135	0.007		
	08 50	0175	0.009		

STORET RETRIEVAL DATE 76/11/16
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

531202
48 44 19.0 122 20 33.0 3
WHATCOM LAKE
53073 WASHINGTON

131191

11EPALES 2111202
0204 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
75/03/31	11 20	0000	6.3	11.8	300	54	7.20	16	0.020	0.200	0.310	0.006J
	11 20	0005	6.6	11.6		53	7.10	17	0.030	0.200	0.310	0.006J
	11 20	0055	6.3	11.6		54	7.10	18	0.020	0.200	0.310	0.003
	11 20	0100	6.3	11.8		53	7.05	18	0.020	0.300	0.310	0.002
	11 20	0150	6.3	11.8		54	7.15	17	0.020K	0.300	0.310	0.011K
	11 20	0195	6.2	11.8		55	7.10	13	0.030	0.300	0.310	0.013J
75/07/18	11 55	0000	17.7	9.4	108	58	7.85	20	0.040	0.700	0.180	0.030K
	11 55	0005	17.8	9.4		51	8.00	19	0.020	0.300	0.170	0.016K
	11 55	0030	17.4	8.8		45	7.95	18	0.030	0.300	0.170	0.013K
	11 55	0045	15.0	10.0		39	7.65	17	0.030	0.300	0.190	0.017K
	11 55	0080	6.4			34	7.30	21	0.020	0.300	0.300	0.013K
	11 55	0130	5.6	10.0		36	7.30	19	0.020K	0.200	0.330	0.010K
	11 55	0170	5.4	10.2		33	7.20	18	0.020K	0.200	0.330	0.012K
	11 55	0206	5.3	9.8		39	7.20	19	0.020	0.200	0.330	0.012K
75/10/29	09 25	0000	13.8	10.0	216	28	7.15	15	0.020K	0.200K	0.140	0.002K
	09 25	0005	13.8	10.8		28	7.20	15	0.020K	0.200K	0.140	0.002
	09 25	0025	13.8	9.8		28	7.30	15	0.020K	0.200K	0.130	0.002K
	09 25	0060	13.9	10.2		26	7.30	14	0.020K	0.200K	0.130	0.002K
	09 25	0095	13.8	9.8		24	7.30	17	0.020K	0.200K	0.140	0.002K
	09 25	0135	9.4			19	7.10	17	0.020K	0.200K	0.310	0.004
	09 25	0175	9.3	9.2		23	7.00	16	0.020K	0.200K	0.320	0.004

K VALUE KNOWN TO BE LESS
THAN INDICATED

J VALUE KNOWN TO BE ESTIMATED

STOWET PETRIEVAL DATE 76/11/16
 NATL EUTROPHICATION SURVEY
 EPA-LAS VEGAS

531202
 48 44 18.0 122 20 33.0 3
 WHATCOM LAKE
 53073 WASHINGTON

131191

11EPALES 2111202
 0204 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/31	11 20	0000	0.008	3.6	
	11 20	0005	0.010		
	11 20	0055	0.011		
	11 20	0100	0.010		
	11 20	0150	0.009		
	11 20	0195	0.013		
75/07/18	11 55	0000	0.012	2.9	
	11 55	0005	0.014		
	11 55	0030	0.009		
	11 55	0045	0.012		
	11 55	0080	0.007		
	11 55	0130	0.007		
	11 55	0170	0.007		
	11 55	0206	0.008		
75/10/29	09 25	0000	0.009	3.4	
	09 25	0005	0.008		
	09 25	0025	0.008		
	09 25	0060	0.009		
	09 25	0095	0.010		
	09 25	0135	0.007		
	09 25	0175	0.008		

STORET RETRIEVAL DATE 76/11/16
 NATL EUTROPHICATION SURVEY
 EPA-LAS VEGAS

531203
 48 44 57.0 122 23 20.0 3
 WHATCOM LAKE
 53073 WASHINGTON

131191

11EPALES 2111202
 0061 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
75/03/31	13 55	0000	7.0	12.2	312	54	7.15	12	0.040	0.400	0.290	0.015J
	13 55	0005	7.0	12.0		55	7.10	10	0.030	0.300	0.290	0.003
	13 55	0020	6.9	12.6		54	7.00	10	0.020	0.300	0.290	0.009K
	13 55	0040	6.8	12.0		54	7.10	10K	0.030	0.300	0.300	0.014K
	13 55	0056	6.7	12.0		53	7.00	10K	0.020	0.300	0.300	0.012K

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/31	13 55	0000	0.015	5.0	
	13 55	0005	0.008		
	13 55	0020	0.008		
	13 55	0040	0.011		
	13 55	0056	0.011		

K VALUE KNOWN TO BE LESS
 THAN INDICATED

J VALUE KNOWN TO BE ESTIMATED

STORET RETRIEVAL DATE 76/11/16
 NATL EUTROPHICATION SURVEY
 EPA-LAS VEGAS

531204
 48 45 38.0 122 24 30.0 3
 WATCOM LAKE
 53073 WASHINGTON

131191

11EPALES 2111202
 0064 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 00 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
75/07/18	11 25	0000	18.6	9.2	168	50	8.00	18	0.050	0.600	0.160	0.013K
	11 25	0005	18.7	9.4		56	8.00	18	0.020	0.300	0.120	0.010K
	11 25	0025	14.7	8.0		46	7.50	17	0.040	0.200	0.120	0.011K
	11 25	0040	10.4	7.4		44	6.90	18	0.050	0.200	0.160	0.016K
	11 25	0060	9.2	4.2		41	6.90	20	0.080	0.300	0.200	0.017K
75/11/04	10 05	0000	13.0	10.0	156	28	7.10	19	0.020	0.200K	0.080	0.004
	10 05	0005	13.0	10.0		28	7.20	17	0.020K	0.200K	0.050	0.002
	10 05	0020	13.0	10.0		28	7.20	20	0.020K	0.200K	0.050	0.003
	10 05	0047	13.0	10.2		28	7.30	19	0.020K	0.200K	0.050	0.005
	10 05	0060	13.0	10.0		28	7.25	18	0.020K	0.200K	0.050	0.005

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/07/18	11 25	0000	0.009	2.6	
	11 25	0005	0.008		
	11 25	0025	0.009		
	11 25	0040	0.009		
	11 25	0060	0.011		
75/11/04	10 05	0000	0.016	4.4	
	10 05	0005	0.013		
	10 05	0020	0.015		
	10 05	0047	0.015		
	10 05	0060	0.016		

K VALUE KNOWN TO BE LESS
 THAN INDICATED

APPENDIX D
TRIBUTARY AND WASTEWATER
TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/11/16
 NATL EUTROPHICATION SURVEY
 EPA- LAS VEGAS

5312A1
 48 45 00.0 122 25 45.0 4
 WHATCOM CREEK
 53 7.5 BELLINGHAM N
 O/LAKE WHATCOM 131191
 SMPL OFF DIRT RD .7 MI E OF WOODBURN ST
 11EPALES 2111204
 0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&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
74/09/21	09 30		0.064	0.200	0.020	0.015	
74/10/19	10 00		0.072	2.700	0.135	0.005K	0.020
74/11/20	13 00		0.088	0.300	0.040	0.016	0.025
74/12/08	11 00		0.096	0.400	0.030	0.010	0.020
75/01/16	14 00		0.980	0.100K	0.016	0.008	0.010K
75/03/03	13 00		0.264	0.100	0.008K	0.008K	0.010K
75/03/16	15 15		0.200	0.100	0.008K	0.008	0.010
75/04/20	10 15		0.135	0.200	0.035	0.010	0.020
75/05/28	14 00		0.140	0.250	0.045	0.010	0.040
75/06/22	14 30		0.135	0.250	0.025	0.010	0.010
75/08/05	13 15		0.065	0.400	0.037	0.005K	0.030

K VALUE KNOWN TO BE LESS
 THAN INDICATED

STORET RETRIEVAL DATE 76/11/16
 NATL EUTROPHICATION SURVEY
 EPA- LAS VEGAS

531281
 48 45 05.0 122 21 07.0 4
 OLSEN CREEK
 S3 7.5 LAWRENCE
 T/LAKE WHATCOM 131191
 NORTH SHORE RD BRDG .3 MI S OF AGATE RAY
 11EPALES 2111204
 0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2AN03 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
74/09/21	11 00		0.216	0.150	0.017		0.010
74/10/19	11 00		0.160	0.100	0.025	0.005	0.005
74/11/20	15 00		1.100	0.550	0.028	0.008K	0.060
74/12/06	09 45		1.060	0.300	0.020	0.005K	0.010K
75/01/16	13 30		0.176	0.300	0.008	0.008K	0.010K
75/03/03	13 30		0.830	0.100	0.008K	0.008K	0.010
75/03/16	13 25		1.250	0.100	0.008K	0.008K	0.010
75/04/20	09 00		0.430	0.300	0.025	0.005	0.030
75/05/28	14 30		0.630	0.100	0.015	0.005K	0.020
75/06/22	13 30		0.360	0.125	0.010	0.010	0.026
75/08/05	14 30		0.175	0.150	0.060	0.005	0.020

K VALUE KNOWN TO BE LESS
 THAN INDICATED

STORET RETRIEVAL DATE 74/11/16
 NATL EUTROPHICATION SURVEY
 EPA- LAS VEGAS

5312C1
 48 42 45.0 122 19 30.0 4
 REAVER CREEK
 53 7.5 LAKE WHATCOM
 T/LAKE WHATCOM 131121
 SEC RD BRDG 4 MI SE OF GENEVA
 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 OPHOS MG/L P	00665 PHOS-TOT MG/L P
74/09/21	10 00		0.052	0.100	0.010	0.010	0.020
74/10/19	10 30		0.036	0.200	0.020	0.005K	0.010
74/11/20	14 00		1.100	0.600	0.024	0.016	0.050
74/12/08	10 30		1.120	0.300	0.015	0.005K	0.010K
75/01/16	14 30		2.080	0.200	0.008K	0.008K	0.010K
75/03/03	11 00		0.640	0.100K	0.008K	0.008K	0.010K
75/03/16	13 25		0.672	0.100	0.008K	0.008K	0.010
75/04/20	09 45		0.400	0.350	0.035	0.005	0.020
75/05/28	15 50		0.360	0.100	0.010	0.005	0.040
75/06/22	14 20		0.210	0.300	0.015	0.005	0.020
75/08/05	13 30		0.100	0.100	0.045	0.005	0.040

K VALUE KNOWN TO BE LESS
 THAN INDICATED

APPENDIX E

PARAMETRIC RANKINGS OF LAKES
SAMPLED BY NES IN 1975

STATE OF WASHINGTON

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Washington lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in $\mu\text{g/l}$. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

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
5301	AMERICAN LAKE	0.027	0.105	343.000	4.822	15.000	0.007
5302	BANKS LAKE	0.021	0.040	364.533	7.373	10.800	0.007
5303	CHELAN LAKE	0.005	0.070	111.900	0.905	6.400	0.003
5304	DIAMOND LAKE	0.014	0.060	303.667	14.537	14.200	0.010
5305	GREEN LAKE	0.027	0.050	415.000	2.983	10.600	0.009
5306	KEECHELUS LAKE	0.007	0.040	280.250	1.400	9.200	0.002
5307	MAYFIELD LAKE	0.014	0.100	402.000	4.250	10.600	0.007
5308	MEDICAL LAKE	0.275	0.225	401.714	16.425	15.000	0.166
5309	MOSES LAKE	0.115	0.150	463.600	29.060	14.600	0.038
5310	OTETTE LAKE	0.010	0.110	403.333	1.225	7.200	0.009
5311	SAMMAMISH LAKE	0.015	0.210	374.000	7.290	14.600	0.006
5312	WHATCOM LAKE	0.009	0.320	288.000	3.422	10.800	0.009
5313	LOWER GRANITE RESERVOIR	0.033	0.150	435.500	4.875	7.200	0.022

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
5301	AMERICAN LAKE	29 (3)	50 (6)	67 (8)	50 (6)	4 (0)	58 (7)
5302	BANKS LAKE	42 (5)	100 (12)	58 (7)	25 (3)	46 (5)	71 (8)
5303	CHELAN LAKE	100 (12)	67 (8)	100 (12)	100 (12)	100 (12)	92 (11)
5304	DIAMOND LAKE	62 (7)	75 (9)	75 (9)	17 (2)	33 (4)	25 (3)
5305	GREEN LAKE	29 (3)	83 (10)	17 (2)	75 (9)	62 (7)	46 (5)
5306	KEECHELUS LAKE	92 (11)	92 (11)	92 (11)	83 (10)	75 (9)	100 (12)
5307	MAYFIELD LAKE	62 (7)	58 (7)	33 (4)	58 (7)	62 (7)	71 (8)
5308	MEDICAL LAKE	0 (0)	8 (1)	42 (5)	8 (1)	4 (0)	0 (0)
5309	MOSES LAKE	8 (1)	29 (3)	0 (0)	0 (0)	21 (2)	8 (1)
5310	OZETTE LAKE	75 (9)	42 (5)	25 (3)	92 (11)	87 (10)	33 (4)
5311	SAMMAMISH LAKE	50 (6)	17 (2)	50 (6)	33 (4)	21 (2)	83 (10)
5312	WHATCOM LAKE	83 (10)	0 (0)	83 (10)	67 (8)	46 (5)	46 (5)
5313	LOWER GRANITE RESERVOIR	17 (2)	29 (3)	8 (1)	42 (5)	87 (10)	17 (2)