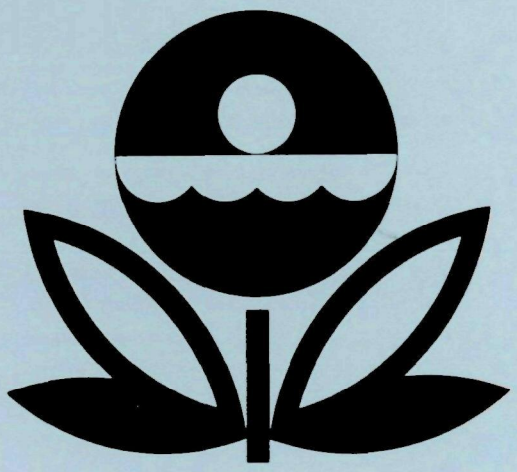
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT
ON
MINERSVILLE RESERVOIR
BEAVER COUNTY
UTAH
EPA REGION VIII
WORKING PAPER No. 846

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

REPORT

ON

MINERSVILLE RESERVOIR

BEAVER COUNTY

UTAH

EPA REGION VIII

WORKING PAPER No. 846

WITH THE COOPERATION OF THE

UTAH STATE DIVISION OF HEALTH

AND THE

UTAH NATIONAL GUARD

NOVEMBER, 1977

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 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 and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Utah Department of Social Services and the Utah Department of Natural Resources for professional involvement, to the Utah National Guard for conducting the tributary sampling phase of the Survey, and to those Utah wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staffs of the Bureau of Water Quality of the Division of Health and the Division of Wildlife Resources 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.

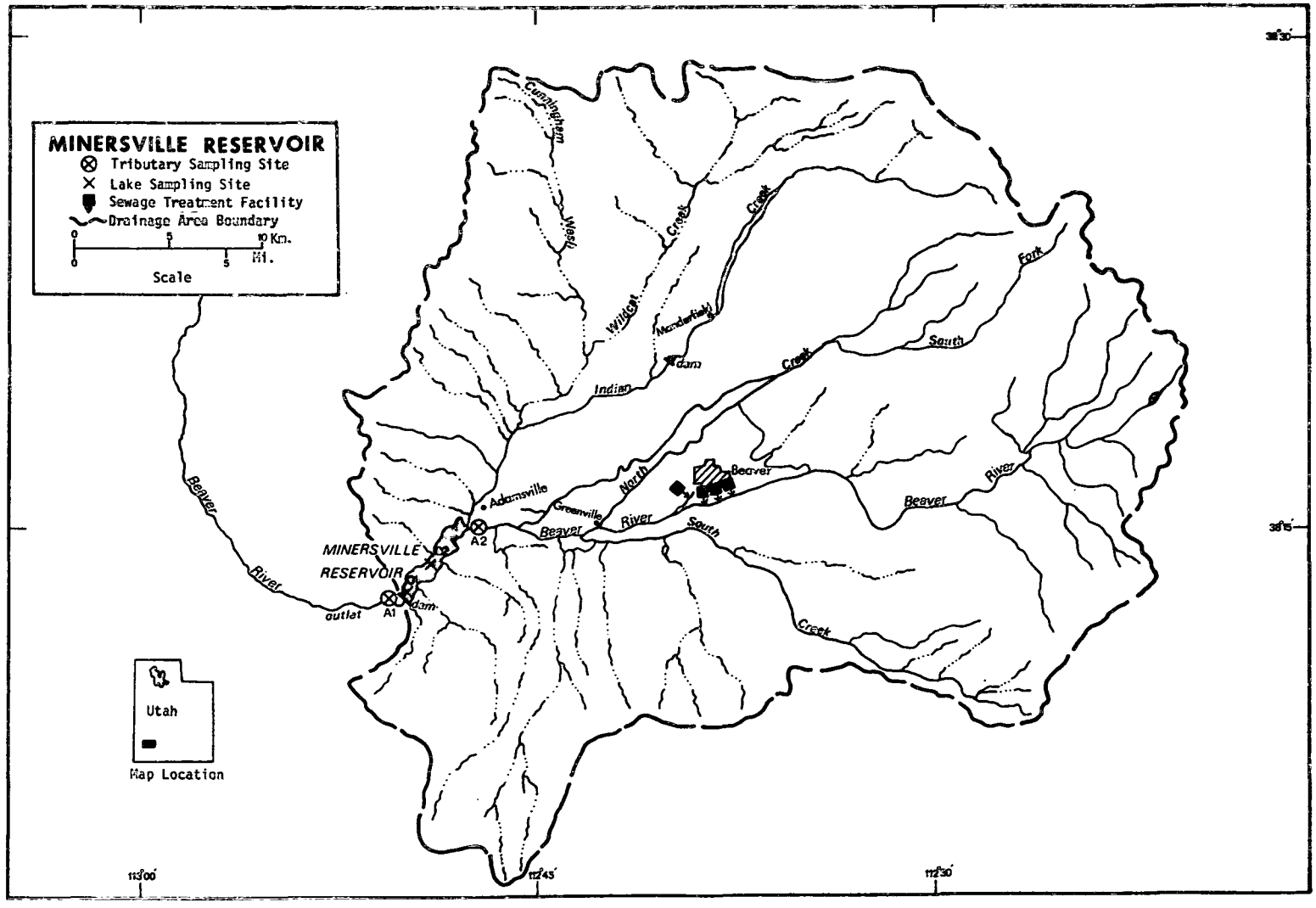
Major General Maurice L. Watts, the Adjutant General of Utah, and Project Officer Lt. Colonel T. Ray Kingston, who directed the volunteer efforts of the Utah National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES AND RESERVOIRS

STATE OF UTAH

NAME	COUNTY
Bear	Rich, UT; Bear Lake, ID
Deer Creek	Wasatch
Echo	Summit
Fish	Sevier
Flaming Gorge	Daggett, UT; Sweetwater, WY
Huntington	Emery
Joes Valley	Emery
Lower Bowns	Garfield
Lynn	Box Elder
Minersville	Beaver
Moon	Duchesne
Navajo	Kane
Newcastle	Iron
Otter Creek	Piute
Panguich	Garfield
Pelican	Uintah
Pineview	Weber
Piute	Piute
Porcupine	Cache
Powell	Garfield, Kane, San Juan, UT; Coconino, AZ
Pruess	Millard
Sevier Bridge	Juab, Sanpete
Starvation	Duchesne
Steinaker	Uintah
Tropic	Garfield
Utah	Utah
Willard Bay	Box Elder


MINERSVILLE RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
0 5 10 Km.
0 5 Mi.
Scale
Utah
Map Location
Cunningham
West
Creek
Willow
Creek
Middle Fork
Indian
Creek
dam
South
Fork
Beaver
River
North
Fork
Beaver
River
Adamsville
Greenville
Beaver
River
South
Fork
Beaver
River
MINERSVILLE
RESERVOIR
A2
A1
dam
outlet
River
Creek
38°30'
38°15'
113°00'
112°45'
112°30'

MINERSVILLE RESERVOIR

STORET NO. 4909

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Minersville Reservoir is eutrophic. It ranked twenty-second in overall trophic quality among the 27 Utah lakes and reservoirs sampled in 1975 when compared using a combination of six water quality parameters*. All of the other water bodies had less median total phosphorus and dissolved orthophosphorus, 14 had less and one had the same median inorganic nitrogen, 23 had less mean chlorophyll a, and 19 had greater mean Secchi disc transparency. No significant depression of dissolved oxygen occurred at any of the three sampling times; however, the reservoir is relatively shallow and was not thermally stratified at any of the sampling times.

Survey limnologists observed algal blooms in progress in August and September.

B. Rate-Limiting Nutrient:

The algal assay results indicate nitrogen was limiting at the time the sample was collected (05/08/75). The reservoir data indicate nitrogen limitation at the other sampling times as well.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--During the sampling year, known point sources accounted for an estimated 59.4% of the total phosphorus input to Minersville Reservoir. The Beaver municipal wastewater treatment plant contributed 17.5% during seven months of discharge, and the Valley Packing Company added 3.8%. The Beaver Fish Hatchery apparently added 24.4% of the total load; however, the phosphorus load in the hatchery water supply was not determined, so the contribution attributable to the operation of the hatchery probably was less than indicated.

In addition, it is conservatively estimated that the Hiland Dairy contributed 13.7% of the total phosphorus load during seven months of intermittent discharge in the Survey sampling year (see page 10).

The phosphorus loading of 1.45 g/m^2 measured during the sampling year is nearly three times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 15). It is calculated that the conversion of the Beaver municipal and the Hiland Dairy systems to land disposal in June, 1975 has reduced the loading by 0.45 $g/m^2/yr$ (or more if the prior dairy load was greater than that estimated). To reduce the remaining loading to the eutrophic level would require a 46% reduction of the current inputs, but this would necessitate at least some control of non-point contributions since even complete phosphorus removal at the remaining point sources would only reduce the loading by 41%.

2. Non-point sources--Non-point sources, including precipitation, contributed 40.6% of the total phosphorus load during the sampling year. The Beaver River contributed 33.4% of the total, and the ungaged minor tributaries and immediate drainage contributed an estimated 6.0%.

Land use in the reservoir drainage basin is predominantly agricultural. The U.S. Geological Survey reports that several ditches above Adamsville divert practically the entire Beaver River flow to supply the Adamsville and Beaver districts during the irrigation season (Anonymous, 1975). Further investigation is needed to determine the contribution and controllability of nutrients resulting from irrigation practices.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 4.01 kilometers^2.
2. Mean depth: 5.6 meters.
3. Maximum depth: 15.5 meters.
4. Volume: 22.487 x 10^6 m^3.
5. Mean hydraulic retention time: 266 days (based on outflow).

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Beaver River	704.5	0.910
Minor tributaries & immediate drainage -	612.4	0.127
Totals	1,316.9	1.037

2. Outlet -

Beaver River	1,320.9**	0.980

C. Precipitation***:

1. Year of sampling: 29.4 centimeters.
2. Mean annual: 28.8 centimeters.

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† Table of metric conversions--Appendix B.
†† Sudweeks, 1975; maximum depth from Ikner (1975).
* For limits of accuracy, see Working Paper No. 175, "... Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Minersville Reservoir 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 two or more depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 7.6 meters at station 1 and 3.7 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 MINERSVILLE RESERVOIR
STORET CODE 4909

	1ST SAMPLING (5/ 8/75) 2 SITES			2ND SAMPLING (8/12/75) 2 SITES			3RD SAMPLING (9/25/75) 2 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	9.7 - 10.8	10.1	9.9	20.4 - 22.6	21.2	21.0	17.0 - 17.5	17.1	17.0
DISS OXY (MG/L)	8.2 - 8.6	8.3	8.2	6.4 - 7.6	7.1	7.3	10.2 - 13.6	11.2	10.6
CNDCTVY (MCROMO)	543. - 560.	549.	547.	678. - 688.	681.	680.	496. - 538.	506.	499.
PH (STAND UNITS)	8.2 - 8.5	8.4	8.4	8.8 - 8.9	8.8	8.8	8.9 - 9.1	9.0	9.0
TOT ALK (MG/L)	252. - 325.	276.	260.	258. - 364.	298.	300.	193. - 330.	264.	296.
TOT P (MG/L)	0.137 - 0.233	0.170	0.145	0.374 - 0.393	0.383	0.381	0.140 - 0.191	0.170	0.171
ORTHO P (MG/L)	0.092 - 0.125	0.107	0.097	0.307 - 0.317	0.312	0.312	0.022 - 0.032	0.026	0.022
NO2+NO3 (MG/L)	0.020 - 0.050	0.024	0.020	0.020 - 0.030	0.022	0.020	0.020 - 0.020	0.020	0.020
AMMONIA (MG/L)	0.020 - 0.040	0.029	0.030	0.090 - 0.160	0.122	0.120	0.030 - 0.040	0.034	0.030
KJEL N (MG/L)	0.500 - 0.900	0.643	0.600	0.900 - 1.100	1.050	1.100	1.200 - 1.700	1.440	1.400
INORG N (MG/L)	0.040 - 0.070	0.053	0.050	0.110 - 0.180	0.143	0.145	0.050 - 0.060	0.054	0.050
TOTAL N (MG/L)	0.550 - 0.920	0.667	0.620	0.920 - 1.130	1.072	1.120	1.220 - 1.720	1.460	1.420
CHLRPYL A (UG/L)	4.1 - 5.3	4.7	4.7	13.8 - 25.8	19.8	19.8	67.3 - 85.2	76.2	76.2
SECCHI (METERS)	1.5 - 2.5	2.0	2.0	1.4 - 2.0	1.7	1.7	0.5 - 0.6	0.5	0.5

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/08/75	1. Synura (?) sp.	3,728
	2. Stephanodiscus sp.	270
	3. Asterionella sp.	90
	4. Eunotia sp.	45
	5. Cryptomonas sp.	45
	Other genera	45
	Total	4,223
08/12/75	1. Phormidium sp.	3,118
	2. Aphanizomenon sp.	432
	3. Gloeotrichia sp.	432
	4. Chroomonas (?) sp.	192
	5. Cryptomonas sp.	192
	Other genera	238
	Total	4,604
09/25/75	1. Aphanizomenon sp.	11,379
	2. Stephanodiscus sp.	646
	3. Trachelomonas sp.	50
	Total	12,075

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/08/75	1	5.3
	2	4.1
08/12/75	1	25.8
	2	13.8
09/25/75	1	85.2
	2	67.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.140	0.070	2.9
0.050 P	0.190	0.070	2.8
0.050 P + 1.0 N	0.190	1.070	31.8
1.0 N	0.140	1.070	31.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Minersville Reservoir was moderately high at the time the sample was collected (05/08/75). Also, the lack of increase in yield with the addition of phosphorus, until nitrogen was also added, indicates the reservoir was nitrogen limited at that time. Note that the addition of nitrogen alone resulted in a yield far greater than that of the control.

The reservoir data also indicate nitrogen limitation. The mean inorganic nitrogen/orthophosphorus ratios were 2/1 or less at all sampling times, and nitrogen limitation would be expected.

Nitrogen limitation, as indicated by the algal assay or by in-reservoir nitrogen to phosphorus ratios, does not necessarily mean that the trophic condition of the reservoir can be improved by controlling nitrogen inputs. In many

cases, the apparent condition of nitrogen limitation results from excessive phosphorus input from point sources and is often accompanied by a corresponding increase in primary production. In such cases, the reversal of the enriched condition depends upon phosphorus control, not nitrogen control.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

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

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

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the adjusted mean concentrations in the Beaver River at station A-2 (point source loads subtracted) and the mean annual ZZ flow.

The operators of the Valley Packing Company and the Beaver Fish Hatchery and the operator of the Beaver wastewater treatment plant provided monthly effluent samples and corresponding flow data (the Beaver municipal loads shown are for the seven months of discharge to the Beaver River during the sampling year).

The operator of the Hiland Dairy provided only four effluent samples during seven months of intermittent discharge in the sampling year. The nutrient loads attributed to this source are based on the mean concentrations and mean flow with the assumption that

discharges were continuous at the flow rates given on the days the samples were collected. However, only once-a-month samples were requested of the operator, and it seems likely that discharges occurred more than four times in the seven months. If so, the indicated nutrient loads are too low.

A. Waste Sources*:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Beaver	290	septic tank	454.2	Beaver River**

2. Known industrial -

Name	Type Waste	Treatment	Mean Flow (m^3/d)	Receiving Water
Beaver Fish Hatchery	fish propagation	none	13,176.7	Big Slough/ Beaver R.
Hiland Dairy Co.	milk processing	none	212.0 (intermittent)	Beaver River**
Valley Packing Co.	meat processing	none	2,384.9	Beaver River

* Hinshaw, 1975.
** Land disposal after June, 1975.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Beaver River	1,940	33.4
b. Minor tributaries & immediate drainage (non-point load) -	350	6.0
c. Known municipal STP's -		
Beaver	1,020	17.5
d. Septic tanks* -	< 5	< 0.1
e. Known industrial -		
Beaver Fish Hatchery	1,420	24.4
Hiland Dairy Co.	795**	13.7
Valley Packing Co.	220	3.8
f. Direct precipitation*** -	70	1.2
Total	5,815	100.0

2. Outputs -

Reservoir outlet - Beaver River 4,450

3. Net annual P accumulation - 1,365 kg.

* Estimate based on one lakeshore park; see Working Paper No. 175.
** Estimated 4-day discharge load.
*** 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) -		
Beaver River	9,940	23.7
b. Minor tributaries & immediate drainage (non-point load) -	1,700	4.0
c. Known municipal STP's -		
Beaver	2,400	5.7
d. Septic tanks* -	35	0.1
e. Known industrial -		
Beaver Fish Hatchery	17,860	42.5
Hiland Dairy Co.	3,135**	7.5
Valley Packing Co.	2,590	6.2
f. Direct precipitation*** -	4,330	10.3
Total	41,990	100.0

2. Outputs -

Reservoir outlet - Beaver River 36,375

3. Net annual N accumulation - 5,615 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Beaver River	3	14

* Estimate based on one lakeshore park; see Working Paper No. 175.
** Estimated 4-day discharge load.
*** See Working Paper No. 175.

E. Yearly Loads:

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

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

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.45	0.34	10.5	1.4

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

"Dangerous" (eutrophic loading)	0.54
"Permissible" (oligotrophic loading)	0.27

V. LITERATURE REVIEWED

Anonymous, 1975. Water resources data for Utah. Part 1: Surface water records. U.S. Geol. Surv., Salt Lake City.

Hinshaw, Russ, 1975. Treatment plant questionnaires. UT Bur. of Env. Health, Salt Lake City.

Ikner, James, 1975. Personal communication (maximum depth of reservoir). U.S. Geol. Surv., Salt Lake City.

Sudweeks, Calvin K., 1975. Personal communication (reservoir morphometry). UT Bur. of Env. Health, Salt Lake City.

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
4900	LAKE POWELL	0.010	0.410	339.830	3.081	13.800	0.007
4901	BEAR LAKE	0.011	0.040	253.167	0.945	9.200	0.003
4902	LOWER BOWN'S RESERVOIR	0.031	0.040	336.000	5.567	9.400	0.006
4903	DEER CREEK RESERVOIR	0.038	0.215	430.333	9.078	14.800	0.006
4904	ECHO RESERVOIR	0.047	0.170	450.333	6.967	14.000	0.012
4905	LYNN RESERVOIR	0.121	0.200	417.667	39.600	10.400	0.052
4906	FISH LAKE	0.023	0.040	152.000	12.483	10.400	0.004
4907	HUNTINGTON NORTH RESERVO	0.013	0.040	392.000	1.900	7.800	0.005
4908	JOE'S VALLEY RESERVOIR	0.012	0.045	400.000	2.483	11.200	0.003
4909	MINERSVILLE RESERVOIR	0.192	0.060	445.000	33.583	8.600	0.107
4910	MOON LAKE	0.008	0.040	381.000	2.700	9.600	0.002
4911	NAVAJO LAKE	0.016	0.040	368.000	2.000	6.000	0.003
4912	NEWCASTLE RESERVOIR	0.051	0.040	428.667	12.467	13.600	0.009
4913	OTTER CREEK RESERVOIR	0.067	0.040	453.667	11.767	10.600	0.033
4914	PANGUITCH LAKE	0.071	0.040	426.500	45.950	14.200	0.010
4915	PELICAN LAKE	0.044	0.050	438.500	6.350	8.400	0.004
4916	PINEVIEW RESERVOIR	0.028	0.300	435.083	5.692	14.600	0.006
4917	PIUTE RESERVOIR	0.047	0.150	482.625	25.329	11.600	0.007
4918	PORCUPINE RESERVOIR	0.025	0.110	440.000	7.860	12.400	0.011
4919	PROJECT RESERVOIR (GARRIS	0.057	0.140	491.000	4.533	8.800	0.008
4920	SEVIER BRIDGE RESERVOIR	0.026	0.355	449.778	18.222	12.400	0.008
4921	STARVATION RESERVOIR	0.016	0.040	394.583	5.675	13.200	0.004
4922	STEINAKER RESERVOIR	0.011	0.040	316.750	1.844	12.600	0.005
4923	TROPIC RESERVOIR	0.021	0.050	425.000	7.200	8.400	0.006
4924	UTAH LAKE	0.132	0.320	490.583	72.012	11.400	0.012
4925	WILLARD BAY RESERVOIR	0.044	0.060	457.182	7.567	11.000	0.009
5605	FLAMING GORGE RESERVOIR	0.011	0.690	285.636	2.500	10.400	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 NO
0403	LAKE POWELL	96 (25)	4 (1)	81 (21)	73 (19)	15 (4)	42 (11)	311
4901	BEAR LAKE	90 (23)	87 (19)	96 (25)	100 (26)	77 (20)	90 (23)	540
4902	LOWER BOWNS RESERVOIR	46 (12)	87 (19)	85 (22)	65 (17)	73 (19)	50 (13)	406
4903	DEER CREEK RESERVOIR	42 (11)	19 (5)	42 (11)	35 (9)	0 (0)	58 (14)	196
4904	ECHO RESERVOIR	31 (8)	27 (7)	19 (5)	50 (13)	12 (3)	13 (3)	152
4905	LYNN RESERVOIR	8 (2)	23 (6)	58 (15)	8 (2)	62 (15)	4 (1)	163
4906	FISH LAKE	62 (16)	65 (16)	100 (26)	23 (6)	62 (15)	79 (20)	391
4907	HUNTINGTON NORTH RESERVO	77 (20)	65 (16)	69 (18)	92 (24)	96 (25)	69 (18)	468
4908	JOE'S VALLEY RESERVOIR	81 (21)	58 (15)	62 (16)	85 (22)	46 (12)	96 (25)	428
4909	MINERSVILLE RESERVOIR	0 (0)	44 (11)	27 (7)	12 (3)	85 (22)	0 (0)	168
4910	MOON LAKE	100 (26)	87 (19)	73 (19)	77 (20)	69 (18)	100 (26)	506
4911	NAVAJO LAKE	69 (18)	87 (19)	77 (20)	88 (23)	100 (26)	85 (22)	506
4912	NEWCASTLE RESERVOIR	23 (6)	87 (19)	46 (12)	27 (7)	19 (5)	27 (7)	229
4913	OTTER CREEK RESERVOIR	15 (4)	87 (19)	15 (4)	31 (8)	54 (14)	8 (2)	210
4914	PANGUITCH LAKE	12 (3)	65 (16)	50 (13)	4 (1)	8 (2)	23 (6)	162
4915	PELICAN LAKE	37 (9)	54 (14)	35 (9)	54 (14)	90 (23)	73 (19)	343
4916	PINEVIEW RESERVOIR	50 (13)	15 (4)	38 (10)	58 (15)	4 (1)	58 (14)	223
4917	PIUTE RESERVOIR	27 (7)	31 (8)	8 (2)	15 (4)	38 (10)	46 (12)	165
4918	PORCUPINE RESERVOIR	58 (15)	38 (10)	31 (8)	38 (10)	33 (8)	19 (5)	217
4919	PRUESS RESERVOIR (GARRIS	19 (5)	35 (9)	0 (0)	69 (18)	81 (21)	37 (9)	241
4920	SEVIER BRIDGE RESERVOIR	54 (14)	8 (2)	23 (6)	19 (5)	33 (8)	37 (9)	174
4921	STARVATION RESERVOIR	73 (19)	87 (19)	65 (17)	62 (16)	23 (6)	79 (20)	389
4922	STEINAKER RESERVOIR	85 (22)	87 (19)	88 (23)	96 (25)	27 (7)	65 (17)	448
4923	TROPIC RESERVOIR	65 (17)	50 (13)	54 (14)	46 (12)	90 (23)	58 (14)	363
4924	UTAH LAKE	4 (1)	12 (3)	4 (1)	0 (0)	42 (11)	13 (3)	75
4925	WILLARD BAY RESERVOIR	37 (9)	44 (11)	12 (3)	42 (11)	50 (13)	31 (8)	216
5605	FLAMING GORGE RESERVOIR	90 (23)	0 (0)	92 (24)	81 (21)	62 (15)	90 (23)	415

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4901	BEAR LAKE	540
2	4911	NAVAJO LAKE	506
3	4910	MOON LAKE	506
4	4907	HUNTINGTON NORTH RESERVO	468
5	4922	STEINAKER RESERVOIR	448
6	4906	JOE'S VALLEY RESERVOIR	428
7	5605	FLAMING GORGE RESERVOIR	415
8	4912	LOWER BOWN'S RESERVOIR	406
9	4916	FISH LAKE	391
10	4921	STARVATION RESERVOIR	389
11	4923	TROPIC RESERVOIR	363
12	4915	PELICAN LAKE	343
13	0498	LAKE POWELL	311
14	4919	PRUESS RESERVOIR (GARRIS	241
15	4912	NEWCASTLE RESERVOIR	229
16	4916	PINEVIEW RESERVOIR	223
17	4918	PORCUPINE RESERVOIR	217
18	4925	WILLARD BAY RESERVOIR	216
19	4913	OTTER CREEK RESERVOIR	210
20	4903	DEER CREEK RESERVOIR	196
21	4920	SEVIER BRIDGE RESERVOIR	174
22	4909	MINERSVILLE RESERVOIR	168
23	4917	PIUTE RESERVOIR	165
24	4905	LYNN RESERVOIR	163
25	4914	PANGUITCH LAKE	162
26	4904	ECHO RESERVOIR	152
27	4924	UTAH LAKE	75

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 UTAH 10/18/76

LAKE CODE 4909 MINERSVILLE RES.

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 1320.9

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
4909A1	1320.9	0.23	0.25	0.31	0.54	2.32	2.52	2.24	1.70	0.88	0.28	0.17	0.20	0.98
4909A2	704.5	1.08	1.22	1.19	0.65	1.47	1.70	0.31	0.34	0.23	0.45	1.16	1.16	0.91
4909ZZ	616.4	0.028	0.028	0.057	0.198	0.595	0.255	0.142	0.071	0.042	0.042	0.028	0.028	0.127

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1320.9
SUM OF SUB-DRAINAGE AREAS = 1320.9
TOTAL FLOW IN = 12.47
TOTAL FLOW OUT = 11.64

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4909A1	11	74	0.144	10	0.136				
	12	74	0.190	14	0.187				
	1	75	0.156	11	0.156				
	2	75	0.170	8	0.156				
	3	75	0.204	16	0.187				
	4	75	0.221	5	0.198				
	5	75	1.444	3	0.793	25	0.110		
	6	75	1.642	1	0.538	25	0.680		
	7	75	1.926	13	1.303				
	8	75	1.048	25	0.708				
	9	75	0.453	24	0.153				
	10	75	0.227	22	0.170				
4909A2	11	74	0.983	10	1.104				
	12	74	0.847	14	0.850				
	1	75	0.750	11	0.680				
	2	75	0.827	8	0.793				
	3	75	1.110	16	1.104				
	4	75	0.578	5	0.878	24	1.501		
	5	75	0.051	3	0.037	25	0.020		
	6	75	0.620	1	0.368	25	0.396		
	7	75	0.549	13	1.189				
	8	75	0.453	25	0.425				
	9	75	0.139	24	0.071				
	10	75	0.275	22	0.481				
4909ZZ	11	74	0.071						
	12	74	0.028						
	1	75	0.028						
	2	75	0.028						
	3	75	0.042						
	4	75	0.071						
	5	75	0.368						
	6	75	0.425						
	7	75	0.198						
	8	75	0.113						
	9	75	0.042						
	10	75	0.071						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/08/12

490901
38 13 03.0 112 49 58.0 3
MINERSVILLE RESERVOIR
49001 UTAH

150891

11EPALES 2111202
0029 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
75/05/08	11 15	0000	10.1	8.4	58	544	8.20	325	0.030	0.700	0.020K	0.092
	11 15	0005	9.9	8.2		543	8.30	310	0.020	0.600	0.020K	0.096
	11 15	0015	9.7	8.2		544	8.40	260	0.020	0.500	0.050	0.097
	11 15	0025	9.7	8.2		547	8.45	252	0.030	0.600	0.020K	0.097
75/08/12	19 00	0000	20.4	7.6	54	682	8.90	306	0.090	1.100	0.020K	0.307
	19 00	0005	20.5	7.6		678	8.90	310	0.100	0.900	0.020K	0.312
	19 00	0014	20.4	7.6		678	8.90	364	0.120	1.000	0.020K	0.309
75/09/25	07 30	0000	17.0	10.6	18	499	8.90	296	0.030	1.200	0.020K	0.022
	07 30	0005	17.0	10.2		496	9.00	308	0.040	1.300	0.020K	0.032
	07 30	0013	17.0	11.0		497	9.05	330	0.040	1.700	0.020K	0.031

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/08	11 15	0000	0.137	5.3	
	11 15	0005	0.144		
	11 15	0015	0.145		
	11 15	0025	0.141		
75/08/12	19 00	0000	0.393	25.8	
	19 00	0005	0.383		
	19 00	0014	0.374		
75/09/25	07 30	0000	0.140	85.2	
	07 30	0005	0.191		
	07 30	0013	0.171		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

490902
38 14 03.0 112 48 55.0 3
MINERSVILLE RESERVOIR
49001 UTAH

150891

11EPALES 2111202
0016 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
75/05/08	11 35	0000	10.8	8.6	97	554	8.50	258	0.040	0.600	0.020K	0.125
	11 35	0005	10.4	8.4		560	8.50	274	0.030	0.900	0.020K	0.125
	11 35	0012	9.9	8.2		553	8.50	256	0.030	0.600	0.020K	0.118
75/08/12	19 20	0000	21.5	6.6	78	681	8.80	294	0.120	1.100	0.030	0.312
	19 20	0005	22.6	6.4		679	8.80	258	0.140	1.100	0.020K	0.315
	19 20	0012	21.8	7.0		688	8.80	258	0.160	1.100	0.020K	0.317
75/09/25	07 50	0000	17.5	13.6	25	499	9.10	193	0.030	1.400	0.020K	0.022
	07 50	0005	17.2	10.4		538	9.15	193	0.030	1.600	0.020K	0.022

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/08	11 35	0000	0.194	4.1	
	11 35	0005	0.233		
	11 35	0012	0.193		
75/08/12	19 20	0000	0.392	13.8	
	19 20	0005	0.380		
	19 20	0012	0.378		
75/09/25	07 50	0000	0.184	67.3	
	07 50	0005	0.166		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/08/12

4909A1
38 13 05.0 112 50 05.0 4
BEAVER RIVER
49 15 MINERSVILLE
O/MINERSVILLE RESERVOIR 150891
BNK .3 MI W OF ROCKY FORD DAM
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
74/11/10	09 10		0.464	0.400	0.035	0.055	0.060
74/12/14	09 45		0.490	1.500	0.030	0.040	0.060
75/01/11	11 25		0.528	0.700	0.085	0.070	0.090
75/02/08	11 10		0.517	0.500	0.024	0.072	0.080
75/03/16	16 30		0.379	0.850	0.018	0.058	0.060
75/04/05	10 15		0.350	1.600	0.040	0.050	0.050
75/05/03	15 05		0.050	0.700	0.055	0.100	0.130
75/05/25	12 00		0.125	0.400	0.030	0.055	0.060
75/06/01	14 00		0.060	1.200	0.035	0.115	0.170
75/06/25	14 00		0.110	0.700	0.030	0.150	0.180
75/07/13	11 00		0.145	1.150	0.135	0.370	0.470
75/08/25	15 00		0.070	1.400	0.045	0.260	0.320
75/09/24	11 00		0.375	0.500	0.045	0.067	0.130
75/10/22	14 00		0.410	0.800	0.075	0.065	0.150

STORET RETRIEVAL DATE 76/08/12

4909A2
38 15 05.0 112 47 25.0 4
BEAVER RIVER
49 15 ADAMSVILLE
T/MINERSVILLE RESERVOIR 150891
HWY 21 BRDG .5 MI S OF ADAMSVILLE
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
74/11/10	09	40	0.176	0.600	0.025	0.090	0.130
74/12/14	10	00	0.312	1.000	0.030	0.135	0.210
75/01/11	11	40	0.384	1.300	0.070	0.150	0.310
75/02/08	11	35	0.316	2.250	0.056	0.124	0.360
75/03/16	16	45	0.175	1.400	0.030	0.113	0.270
75/04/24	12	45	0.175	1.400	0.200	0.035	0.060
75/05/03	14	15	0.015	0.950	0.215	0.220	0.290
75/05/25	12	30	0.065	1.150	0.020	0.080	0.130
75/06/01	14	30	0.015	0.950	0.040	0.085	0.130
75/06/25	14	00	0.010	0.775	0.020	0.065	0.100
75/07/13	11	10	0.230	1.050	0.075	0.135	0.259
75/08/25	15	15	0.005	0.700	0.025	0.125	0.140
75/09/24	11	15	0.010	1.100	0.050	0.115	0.130
75/10/22	14	20	0.230	0.800	0.025	0.065	0.110

STORET RETRIEVAL DATE 76/08/12

4909AA NO4909AA P *
38 16 00.0 112 38 00.0 4
HILAND DAIRY
49 15 BEAVER
T/MINERSVILLE 150891
BEAVER RIVER
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/01/21	11 30		0.320	1524.000			485.000	0.056	0.056
75/03/11	16 05		0.400		67.000	550.000			0.056
75/04/16	14 50		0.400	1200.000	60.000	200.000L	430.000	0.100	0.056
75/05/05	16 15		0.650	940.000	32.000		360.000	0.012	

L ACTUAL VALUE IS KNOWN TO BE
GREATER THAN VALUE GIVEN

STORET RETRIEVAL DATE 76/08/12

4909AB N04909AB P *
38 16 00.0 112 38 00.0 4
VALLEY PACKING
49 15 BEAVER
T/MINERSVILLE 150891
BEAVER RIVER
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/01/21	10	40	1.620	0.100K	0.080K	0.086	0.177	0.0003	0.0003
75/02/20	09	20	2.240	1.000K	0.140	0.124	0.190		0.0003
75/03/11	16	20	2.160	0.500K	0.400	0.203	0.210	0.672	0.679
75/04/16	15	10	2.200	1.400	0.050K	0.153	0.200	0.0004	0.0004
75/05/05	16	30	2.100	0.500K	0.159	0.169	0.250	0.0004	0.0004
75/06/30	18	00	2.100	0.250	0.025K	0.170	0.200	1.300	
75/07/23	11	00	2.200	0.940	0.025K	0.195	0.207	1.300	1.500
75/09/04	14	30	2.400	1.100	0.025K	0.190	0.410	1.100	1.150
75/09/16	14	15	2.300	0.560	0.025K	0.210	0.210	1.000	1.100
75/11/11	15	20	2.100	1.100	0.025	0.220	0.220	0.800	0.900
75/12/09	13	00	2.300	1.200	0.025K	0.190	0.370	0.320	0.300

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

4909AC PR4909AC P000290
38 16 00.0 112 38 00.0 4
BEAVER
49 15 BEAVER
T/MINERSVILLE 150891
BEAVER RIVER
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/01/21	11 10		0.481	24.000	1.500	4.900	13.000	0.029	0.100
75/02/20	09 45		0.880	29.000	0.960	4.100	6.300		0.100
75/03/11	16 15		0.560	29.000	2.560	3.750	10.500		0.100
75/04/16	15 00		0.650	22.000	0.920	5.000	17.500	0.150	0.150
75/05/05	16 20		0.900	20.000	0.150	2.500	6.050	0.150	0.150

STORET RETRIEVAL DATE 76/08/12

4909XA NO4909XA P *
38 16 30.0 112 39 00.0 4
BEAVER FISH HAT.
49 15 BEAVER
T/MINERSVILLE 150891
ADOBE YARD SLOUGH
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/01/21	10	30	1.840	4.000	0.080K	0.050K	0.740	1.630	1.600
75/02/20	09	30	1.680	1.000K	0.080	0.230	0.279	1.560	1.400
75/03/11	16	30	1.520	0.500K	0.220	0.280	0.390	2.200	2.100
75/04/16	15	20	1.400	1.400	0.089	0.215	0.330	2.400	3.700
75/05/05	16	40	1.500	8.700	0.100	0.050K	0.110	2.600	2.500
75/06/30	17	45	2.100	0.250	0.025K	0.130	0.182	5.290	5.890
75/07/23	11	05	1.720	2.300	0.025K	0.210	0.370	5.920	6.000
75/09/04	14	15	1.880	1.600	0.075	0.225	0.260	4.220	5.100
75/09/16	14	25	1.800	0.880	0.150	0.210	0.270	3.500	4.000
75/11/11	15	15	1.720	1.300	0.059	0.200	0.230	3.150	4.000
75/12/09	13	05	1.800	1.600	0.025K	0.250	0.330	2.160	2.000

K VALUE KNOWN TO BE
LESS THAN INDICATED