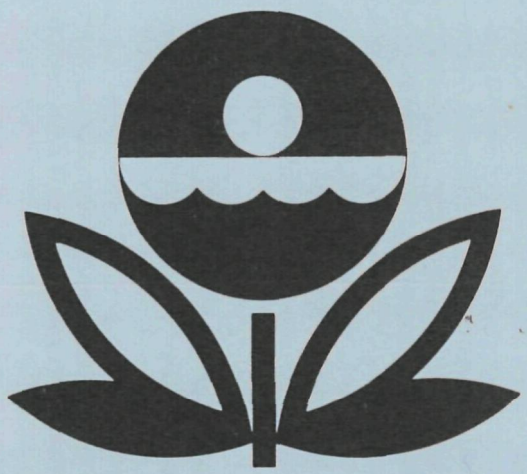
U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



REPORT

ON

LAKE HOWELL

SEMINOLE COUNTY

FLORIDA

EPA REGION IV

WORKING PAPER No. 257

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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REPORT
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WITH THE COOPERATION OF THE
FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
AND THE
FLORIDA NATIONAL GUARD
DECEMBER, 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.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Florida Department of Environmental Regulation for professional involvement and to the Florida National Guard for conducting the tributary sampling phase of the Survey.

Joseph W. Landers, Jr., Secretary of the Department of Environmental Regulation; John A Redmond, former Director of the Division of Planning, Technical Assistance, and Grants; and Dr. Tim S. Stuart, Chief of the Bureau of Water Quality, 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.

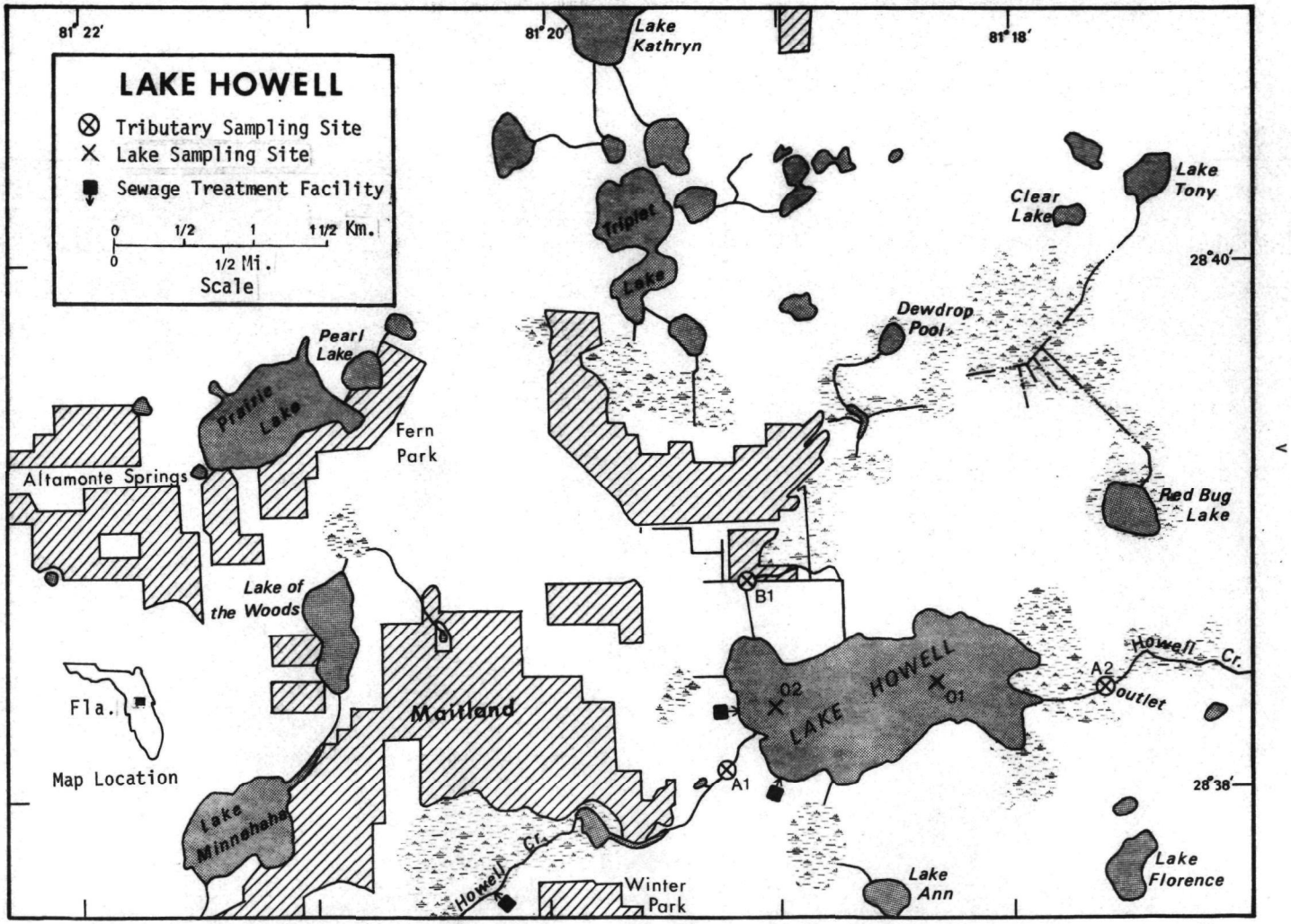
Major General Henry W. McMillan (Retired), then the Adjutant General of Florida, and Project Officer Colonel Hugo F. Windham, who directed the volunteer efforts of the Florida National Guard, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF FLORIDA

LAKE NAME	COUNTY
Alligator	Columbia
Apopka	Lake, Orange
Banana	Polk
Crescent	Flagler, Putnam
Doctors	Clay
Dora	Lake
East Tohopekaliga	Osceola
Effie	Polk
Eloise	Polk
George	Putnam, Volusia
Gibson	Polk
Glenada	Highlands
Griffin	Lake
Haines	Polk
Hancock	Polk
Horseshoe	Seminole
Howell	Orange, Seminole
Istokpoga	Highlands
Jessie	Polk
Jessup	Seminole
Kissimmee	Osceola
Lawne	Orange
Lulu	Polk
Marion	Polk
Minnehaha	Orange
Minneola	Lake
Monroe	Seminole, Volusia
Munson	Leon
Okeechobee	Glades, Hendry, Martin, Okeechobee, Palm Beach
Poinsett	Brevard, Orange, Osceola
Reedy	Polk
Seminole	Jackson, FL; Decatur, Seminole, GA
Seminole	Pinellas
South	Brevard
Talquin	Gadsden, Leon
Tarpon	Pinellas
Thonotosassa	Hillsborough
Tohopekaliga	Osceola
Trout	Lake
Weohyakapka	Polk
Yale	Lake


LAKE HOWELL
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1/2 1 1 1/2 Km.
0 1/2 Mi.
Scale
81° 22'
81° 20'
81° 18'
28°40'
28°38'
Lake Kathryn
Triplet Lake
Clear Lake
Lake Tony
Dewdrop Pool
Pearl Lake
Prairie Lake
Fern Park
Altamonte Springs
Red Bug Lake
B1
Lake of the Woods
Howell Cr.
A2
Outlet
LAKE HOWELL
O2
O1
Fla.
Map Location
Maitland
A1
Lake Minnehaha
Howell Cr.
Winter Park
Lake Ann
Lake Florence

LAKE HOWELL

STORET NO. 1220

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Howell is highly eutrophic. It ranked 33rd in overall trophic quality when the 41 Florida lakes sampled in 1973 were compared using a combination of six parameters*. Thirty-five of the lakes had less and one had the same median total phosphorus, 39 had less median orthophosphorus, 31 had less median inorganic nitrogen, 26 had less mean chlorophyll a, and 12 had greater and one had the same mean Secchi disc transparency.

Survey limnologists did not report any algal blooms but observed rooted aquatic vegetation in the shoreline shallows.

B. Rate-Limiting Nutrient:

The results of the algal assay indicate that the primary productivity of Lake Howell was limited by nitrogen at the time the sample was collected (03/15/73). The high inorganic nitrogen and orthophosphorus levels in the lake at all sampling times suggest in situ limitation by factors other than those two nutrients, but the ratios of inorganic N to inorganic P, which were considerably below 1 to 1 at all sampling times, confirm potential

* See Appendix A.

nitrogen limitation in the lake

C. Nutrient Controllability:

1. Point sources--It is estimated that known point sources accounted for 38.1% and 58.2% of the total phosphorus and total nitrogen loads, respectively, to Lake Howell during the sampling year. The City of Winter Park contributed 26.5% of the phosphorus load and 40.6% of the nitrogen load; the City of Maitland contributed 10.9% and 16.7% of the total phosphorus and total nitrogen loads, respectively; and Howell Park and septic tanks serving lakeshore dwellings collectively contributed an estimated 0.7% and 1.3% of the phosphorus and nitrogen loads, respectively.

The sampling year phosphorus loading of 58.51 g/m^2 is 56 times the eutrophic loading proposed by Vollenweider (Vollenweider and Dillon, 1974). Although Vollenweider's model may not be applicable to lakes with short hydraulic retention times, the level of primary productivity and the abundance of macrophytes in the lake indicate the loading is excessive.

Lake Howell was markedly nitrogen-limited during Survey sampling primarily as a result of very high orthophosphorus levels (median concentration = 1.175 mg/l) which indicates nitrogen control might reduce the rate of eutrophication of the lake. However, emphasis during the Survey was on the controllability of phosphorus, and a more intensive study of the nitrogen budget of Lake Howell is needed to assess the probable effects of point-source nitrogen control.

2. Non-point sources--It is estimated that non-point sources contributed 59.1% of the total phosphorus input and 32.6% of the total nitrogen input to Lake Howell, with Howell Creek accounting for 58.9% of the phosphorus load and 32.1% of the nitrogen load.

The nutrient export rates of Howell Creek and Unnamed Creek B-1 were very high during the sampling year (see page 12). The 1970 photorevised U.S.G.S. Casselberry quadrangle map indicates there are extensive urban areas in both drainages which likely accounts for the excessive nutrient exports of the two streams.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 1.60 kilometers^2.
2. Mean depth: 2.5 meters.
3. Maximum depth: 4.0 meters.
4. Volume: 4.000×10^6 m^3.
5. Mean hydraulic retention time: 30 days.

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

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Howell Creek	57.2	1.29
Unnamed Creek B-1	0.8	0.02
Minor tributaries & immediate drainage -	12.1	0.22
Totals	70.1	1.53**

2. Outlet -

Howell Creek	71.7***	1.53

C. Precipitation****:

1. Year of sampling: 123.5 centimeters.
2. Mean annual: 130.5 centimeters.

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† Table of metric conversions--Appendix B.
†† Surface area obtained from Brezonik et al. (1976); depths estimated from soundings reported in Appendix D.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Sum of inflows adjusted to equal outflow.
*** Includes area of lake.
**** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Lake Howell was sampled three times during 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from one or more depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (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 3.4 meters at station 1 and 1.8 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 LAKE HOWELL
STORET CODE 1220

PARAMETER	1ST SAMPLING (3/15/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (9/ 5/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (11/ 5/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	24.3 - 25.0	24.6	24.5	28.3 - 29.7	29.1	29.2	22.3 - 23.7	23.2	23.4
DISS OXY (MG/L)	11.4 - 11.6	11.5	11.6	6.8 - 10.2	8.5	8.5	6.0 - 11.2	8.8	9.2
CNDCTVY (MCROMO)	240. - 260.	250.	250.	260. - 265.	262.	260.	243. - 250.	245.	244.
PH (STAND UNITS)	10.0 - 10.2	10.1	10.1	7.6 - 8.7	8.3	8.7	7.5 - 8.7	8.2	8.3
TOT ALK (MG/L)	65. - 73.	70.	71.	59. - 61.	60.	59.	66. - 72.	68.	67.
TOT P (MG/L)	1.120 - 1.240	1.157	1.135	1.220 - 1.290	1.250	1.240	1.280 - 1.470	1.368	1.320
ORTHO P (MG/L)	0.915 - 1.120	0.990	0.962	1.170 - 1.210	1.187	1.180	1.140 - 1.390	1.240	1.190
NO2+NO3 (MG/L)	0.050 - 0.070	0.057	0.055	0.150 - 0.230	0.187	0.180	0.350 - 0.510	0.402	0.370
AMMONIA (MG/L)	0.050 - 0.080	0.065	0.065	0.060 - 0.090	0.073	0.070	0.050 - 0.260	0.108	0.070
KJEL N (MG/L)	1.100 - 1.400	1.225	1.200	1.600 - 1.800	1.700	1.700	1.200 - 1.600	1.420	1.500
INORG N (MG/L)	0.100 - 0.150	0.122	0.120	0.210 - 0.320	0.260	0.250	0.410 - 0.770	0.510	0.470
TOTAL N (MG/L)	1.150 - 1.470	1.282	1.255	1.830 - 1.980	1.887	1.850	1.570 - 2.020	1.822	1.850
CHLRPYL A (UG/L)	37.7 - 47.8	42.7	42.7	65.4 - 90.5	77.9	77.9	39.5 - 43.8	41.6	41.6
SECCHI (METERS)	1.0 - 1.2	1.1	1.1	0.7 - 0.8	0.7	0.7	0.9 - 0.9	0.9	0.9

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/15/73	1. Lyngbya sp.	8,043
	2. Golenkinia sp.	7,754
	3. Raphidiopsis sp.	7,681
	4. Anabaena sp.	2,681
	5. Cryptomonas sp.	1,884
	Other genera	6,812
	Total	34,855
09/05/73	1. Dactylococcopsis sp.	8,470
	2. Synedra sp.	7,957
	3. Cyclotella sp.	5,133
	4. Golenkinia sp.	3,080
	5. Scenedesmus sp.	1,440
	Other genera	10,108
	Total	36,188
11/05/73	1. Flagellates	21,560
	2. Cyclotella sp.	4,004
	3. Scenedesmus sp.	2,772
	4. Merismopedia sp.	1,848
	5. Dactylococcopsis sp.	1,540
	Other genera	8,624
	Total	40,348

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/15/73	1	47.8
	2	37.7
09/05/73	1	65.4
	2	90.5
11/05/73	1	39.5
	2	43.8

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	0.680	0.406	15.0
0.050 P	0.730	0.406	16.1
0.050 P + 1.0 N	0.730	1.406	22.2
1.0 N	0.680	1.406	35.5

2. Filtered and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.750	0.407	12.7
0.050 P	0.800	0.407	11.9
0.050 P + 1.0 N	0.800	1.407	40.3
1.0 N	0.750	1.407	36.5

3. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Howell was very high at the time the sample was collected (03/15/75). Also, both assays indicate nitrogen was limiting at that time. Increased levels of orthophosphorus did not result in increased yields, but inorganic nitrogen alone and in combination with orthophosphorus resulted in large increases in yields.

The lake data also indicate nitrogen limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios were less than 1/1 at all sampling times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Florida National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the month of December when two samples were collected. Sampling was begun in March, 1973, and was completed in February, 1974.

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

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. 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 nutrient loads, in $kg/km^2/year$, at station B-1 and multiplying by the ZZ area in km^2.

The operators of the Maitland, Winter Park, and Howell Park wastewater treatment plants did not participate in the Survey; nutrient loads for these sources were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Maitland*	9,000	act. sludge	3,406.5	Lake Howell
Winter Park**	21,895	act. sludge	8,287.3	Howell Creek
Howell Park**	550	stab. pond	208.2	Lake Howell

2. Known industrial - None

* Treatment plant questionnaire.
** Anonymous, 1971; population shown is 1970 Census.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Howell Creek	55,110	58.9
Unnamed Creek B-1	170	0.2
b. Minor tributaries & immediate drainage (non-point load) -	2,585	2.8
c. Known municipal STP's -		
Maitland	10,205	10.9
Winter Park	24,830	26.5
Howell Park	625	0.7
d. Septic tanks* -	15	< 0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	70	< 0.1
Total	93,610	100.0

2. Outputs -

Lake outlet - Howell Creek 66,375

3. Net annual P accumulation - 27,235 kg.

* Estimate based on 48 shoreline dwellings; see Working Paper No. 175.
** Brezonik and Shannon, 1971.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Howell Creek	58,885	32.1
Unnamed Creek	1,005	0.5
b. Minor tributaries & immediate drainage (non-point load) -	15,325	8.3
c. Known municipal STP's -		
Maitland	30,610	16.7
Winter Park	74,465	40.6
Howell Park	1,870	1.0
d. Septic tanks* -	510	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	930	0.5
Total	183,600	100.0

2. Outputs -

Lake outlet - Howell Creek 92,470

3. Net annual N accumulation - 91,130 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Howell Creek	963	1,029
Unnamed Creek B-1	212	1,256

* Estimate based on 48 shoreline dwellings; see Working Paper No. 175.
** Brezonik and Shannon, 1971.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Note, however, that Florida lakes may be able to assimilate phosphorus at a somewhat higher level than that suggested by Vollenweider (Shannon and Brezonik, 1972).

Essentially, Vollenweider's "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".

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	58.51	17.02	114.8	57.0

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

"Dangerous" (eutrophic loading)	1.04
"Permissible" (oligotrophic loading)	0.52

V. LITERATURE REVIEWED

Brezonik, Patrick L. and Earl E. Shannon, 1971. Trophic state of lakes in north central Florida. Publ. No. 13, FL Water Resources Res. Ctr., U. of FL, Gainesville.

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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
1201	ALLIGATOR LAKE	0.620	0.260	474.000	87.733	13.100	0.386
1202	LAKE APOPKA	0.102	0.230	484.176	46.611	8.200	0.019
1203	LAKE BANANA	0.660	0.260	482.667	208.600	3.600	0.293
1206	LAKE CRESCENT	0.065	0.130	473.889	10.211	10.200	0.033
1207	DOCTORS LAKE	0.084	0.120	465.555	27.100	10.600	0.028
1208	LAKE DORA	0.102	0.240	482.889	59.978	7.400	0.022
1209	LAKE EFFIE	1.480	0.410	489.000	261.433	15.000	0.950
1210	LAKE GEORGE	0.129	0.165	469.308	35.000	11.000	0.063
1211	LAKE GIBSON	0.167	0.115	470.000	19.675	10.200	0.069
1212	GLENADA LAKE	0.134	0.165	454.167	27.667	14.700	0.072
1214	LAKE GRIFFIN	0.119	0.260	481.333	66.855	6.600	0.038
1215	LAKE HAINES	0.063	0.115	462.667	26.567	10.600	0.014
1217	LAKE HANCOCK	0.772	0.195	483.500	97.900	5.600	0.158
1219	LAKE HORSESHOE	0.034	0.130	459.000	12.067	11.500	0.023
1220	LAKE HOWELL	1.260	0.285	464.000	54.117	9.000	1.175
1221	LAKE ISTOKPOGA	0.039	0.120	464.222	6.594	8.600	0.010
1223	LAKE JESSUP	0.492	0.290	487.000	76.550	7.600	0.288
1224	LAKE KISSIMMEE	0.034	0.145	463.667	24.142	8.800	0.007
1227	LAKE LULU	1.490	1.065	483.000	276.566	14.300	1.030
1228	LAKE MARION	0.044	0.260	468.833	29.967	7.600	0.016
1229	LAKE MINNEHAHA	0.038	0.080	435.000	8.733	7.700	0.012
1230	LAKE MINNEOLA	0.018	0.070	406.333	3.333	7.400	0.009
1231	LAKE MONROE	0.188	0.300	474.555	14.225	10.800	0.128
1232	LAKE OKEECHOBEE	0.063	0.185	472.366	14.524	9.800	0.010
1234	LAKE POINSETT	0.085	0.150	469.000	6.500	10.600	0.051
1236	LAKE PEEDY	0.033	0.330	468.500	34.837	10.600	0.008
1238	LAKE SOUTH	0.074	0.130	464.000	23.167	9.000	0.028
1239	LAKE TALQUIN	0.085	0.290	462.167	9.483	14.400	0.031

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
1240	LAKE THONOTOSASSA	0.695	0.095	466.167	37.700	10.200	0.565
1241	LAKE TOHOPEKALIGA	0.246	0.200	472.917	30.633	10.500	0.152
1242	TROUT LAKE	1.110	0.650	472.000	76.967	12.900	0.970
1243	LAKE WEOHYAKAPKA	0.047	0.080	458.667	7.767	8.200	0.011
1246	LAKE YALE	0.027	0.160	441.000	25.367	7.600	0.014
1247	LAKE MUNSON	1.475	0.925	486.667	140.317	12.200	0.852
1248	LAKE SEMINOLE	0.234	0.175	473.833	102.000	8.600	0.026
1249	LAKE LAWNE	2.560	1.350	494.667	84.900	10.400	0.117
1250	LAKE TARPON	0.041	0.070	400.889	6.867	9.000	0.027
1252	LAKE ELOISE	0.486	0.170	465.333	70.233	12.200	0.339
1258	LAKE JESSIE	0.051	0.090	452.667	26.300	10.800	0.011
1261	EAST LAKE TOHOPEKALIGA	0.042	0.070	440.833	5.167	9.400	0.007
1264	PAYNE'S PRAIRIE LAKE (NO	1.260	0.140	476.000	88.200	7.400	1.210

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
1201	ALLIGATOR LAKE	25 (10)	29 (10)	30 (12)	18 (7)	10 (4)	18 (7)	130
1202	LAKE APOPKA	50 (20)	38 (15)	10 (4)	38 (15)	74 (29)	70 (28)	280
1203	LAKE BANANA	23 (9)	29 (10)	20 (8)	5 (2)	100 (40)	23 (9)	200
1206	LAKE CRESCENT	65 (26)	70 (27)	33 (13)	80 (32)	48 (18)	50 (20)	346
1207	DOCTORS LAKE	60 (24)	76 (30)	60 (24)	55 (22)	34 (12)	56 (22)	341
1208	LAKE DORA	53 (21)	35 (14)	18 (7)	33 (13)	90 (35)	68 (27)	297
1209	LAKE EFFIE	5 (2)	10 (4)	3 (1)	3 (1)	0 (0)	10 (4)	31
1210	LAKE GEORGE	45 (18)	54 (21)	48 (19)	43 (17)	23 (9)	43 (17)	256
1211	LAKE GIBSON	40 (16)	81 (32)	45 (18)	70 (28)	48 (18)	40 (16)	324
1212	GLENADA LAKE	43 (17)	54 (21)	85 (34)	53 (21)	3 (1)	38 (15)	276
1214	LAKE GRIFFIN	48 (19)	29 (10)	23 (9)	30 (12)	95 (38)	48 (19)	273
1215	LAKE HAINES	70 (28)	81 (32)	75 (30)	58 (23)	34 (12)	78 (31)	396
1217	LAKE HANCOCK	18 (7)	43 (17)	13 (5)	13 (5)	98 (39)	28 (11)	213
1219	LAKE HORSESHOE	93 (37)	70 (27)	80 (32)	78 (31)	20 (8)	65 (26)	406
1220	LAKE HOWELL	11 (4)	23 (9)	69 (27)	35 (14)	60 (23)	3 (1)	201
1221	LAKE ISTOKPOGA	85 (34)	76 (30)	65 (26)	93 (37)	69 (27)	89 (35)	477
1223	LAKE JESSUP	28 (11)	18 (7)	5 (2)	25 (10)	83 (32)	25 (10)	184
1224	LAKE KISSIMMEE	90 (36)	63 (25)	73 (29)	65 (26)	65 (26)	99 (39)	455
1227	LAKE LULU	3 (1)	3 (1)	15 (6)	0 (0)	8 (3)	5 (2)	34
1228	LAKE MARION	78 (31)	29 (10)	53 (21)	50 (20)	83 (32)	73 (29)	366
1229	LAKE MINNEHAHA	88 (35)	91 (36)	95 (38)	85 (34)	78 (31)	80 (32)	517
1230	LAKE MINNEOLA	100 (40)	98 (38)	98 (39)	100 (40)	90 (35)	93 (37)	579
1231	LAKE MONROE	38 (15)	15 (6)	28 (11)	75 (30)	26 (10)	33 (13)	215
1232	LAKE OKEECHOBEE	68 (27)	45 (18)	40 (16)	73 (29)	53 (21)	89 (35)	368
1234	LAKE POINSETT	58 (23)	60 (24)	50 (20)	95 (38)	34 (12)	45 (18)	342
1236	LAKE REEDY	95 (38)	13 (5)	55 (22)	45 (18)	34 (12)	95 (38)	337
1238	LAKE SOUTH	63 (25)	70 (27)	69 (27)	68 (27)	60 (23)	56 (22)	386
1239	LAKE TALQUIN	55 (22)	20 (8)	78 (31)	83 (33)	5 (2)	53 (21)	294

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
1240	LAKE THONOTOSASSA	20 (8)	85 (34)	58 (23)	40 (16)	48 (18)	15 (6)	266
1241	LAKE TOHOPEKALIGA	33 (13)	40 (16)	38 (15)	48 (19)	40 (16)	30 (12)	229
1242	TROUT LAKE	15 (6)	8 (3)	43 (17)	23 (9)	13 (5)	8 (3)	110
1243	LAKE WEOHYAKAPKA	75 (30)	91 (36)	83 (33)	88 (35)	74 (29)	84 (33)	495
1246	LAKE YALE	98 (39)	58 (23)	90 (36)	63 (25)	83 (32)	75 (30)	467
1247	LAKE MUNSON	8 (3)	5 (2)	8 (3)	8 (3)	16 (6)	13 (5)	58
1248	LAKE SEMINOLE	35 (14)	48 (19)	35 (14)	10 (4)	69 (27)	63 (25)	260
1249	LAKE LAWNE	0 (0)	0 (0)	0 (0)	20 (8)	43 (17)	35 (14)	98
1250	LAKE TARPON	83 (33)	98 (38)	100 (40)	90 (36)	60 (23)	60 (24)	491
1252	LAKE ELOISE	30 (12)	50 (20)	63 (25)	28 (11)	16 (6)	20 (8)	207
1258	LAKE JESSIE	73 (29)	88 (35)	88 (35)	60 (24)	26 (10)	84 (33)	419
1261	EAST LAKE TOHOPEKALIGA	80 (32)	98 (38)	93 (37)	98 (39)	55 (22)	99 (39)	523
1264	PAYNE'S PRAIRIE LAKE (NO	11 (4)	65 (26)	25 (10)	15 (6)	90 (35)	0 (0)	206

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1230	LAKE MINNEOLA	579
2	1261	EAST LAKE TOHOPEKALIGA	523
3	1229	LAKE MINNEHAHA	517
4	1243	LAKE WEOHYAKAPKA	495
5	1250	LAKE TARPON	491
6	1221	LAKE ISTOKPOGA	477
7	1246	LAKE YALE	467
8	1224	LAKE KISSIMMEE	455
9	1258	LAKE JESSIE	419
10	1219	LAKE HORSESHOE	406
11	1215	LAKE HAINES	396
12	1238	LAKE SOUTH	386
13	1232	LAKE OKEECHOBEE	368
14	1228	LAKE MARION	366
15	1206	LAKE CRESCENT	346
16	1234	LAKE POINSETT	342
17	1207	DOCTORS LAKE	341
18	1236	LAKE REEDY	337
19	1211	LAKE GIBSON	324
20	1208	LAKE DORA	297
21	1239	LAKE TALQUIN	294
22	1202	LAKE APOPKA	280
23	1212	GLENADA LAKE	276
24	1214	LAKE GRIFFIN	273
25	1240	LAKE THONOTOSASSA	266
26	1248	LAKE SEMINOLE	260
27	1210	LAKE GEORGE	256
28	1241	LAKE TOHOPEKALIGA	229

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	1231	LAKE MONROE	215
30	1217	LAKE HANCOCK	213
31	1252	LAKE ELOISE	207
32	1264	PAYNE'S PRAIRIE LAKE (NO	206
33	1220	LAKE HOWELL	201
34	1203	LAKE BANANA	200
35	1223	LAKE JESSUP	184
36	1201	ALLIGATOR LAKE	130
37	1242	TROUT LAKE	110
38	1249	LAKE LAWNE	98
39	1247	LAKE MUNSON	58
40	1227	LAKE LULU	34
41	1209	LAKE EFFIE	31

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 FLORIDA 8/25/75

LAKE CODE 1220 LAKE HOWELL

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 71.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1220A1	57.2	1.56	1.53	1.39	0.71	0.31	0.40	1.33	1.53	1.95	1.87	1.50	1.36	1.29
1220A2	71.7	1.84	1.81	1.64	0.85	0.40	0.48	1.59	1.81	2.32	2.21	1.78	1.61	1.53
1220B1	0.8	0.02	0.02	0.02	0.01	0.00	0.00	0.02	0.02	0.03	0.03	0.02	0.02	0.02
1220ZZ	12.2	0.03	0.03	0.03	0.01	0.01	0.01	0.03	0.03	0.04	0.04	0.03	0.03	0.03

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 71.7
SUM OF SUB-DRAINAGE AREAS = 70.2
TOTAL FLOW IN = 15.94
TOTAL FLOW OUT = 18.35

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1220A1	3	73	0.34	17	0.34				
	4	73	0.42	7	0.45				
	5	73	0.22	13	0.24				
	6	73	0.34	17	0.40				
	7	73	1.13	7	0.71				
	8	73	0.88	4	0.96				
	9	73	1.08	8	0.99				
	10	73	0.93						
	11	73	0.34	3	0.34				
	12	73	0.19	8	0.16	15	0.16		
	1	74	0.27	12	0.31				
	2	74	0.14	2	0.20	15	0.14		
1220A2	3	73	0.59	17	0.59				
	4	73	0.74	7	0.79				
	5	73	0.40	13	0.42				
	6	73	0.59	17	0.68				
	7	73	1.84	7	1.13				
	8	73	1.50	4	1.70				
	9	73	2.01	8	1.76				
	10	73	1.53						
	11	73	0.62	3	0.62				
	12	73	0.37	8	0.34	15	0.34		
	1	74	0.51	12	0.57				
	2	74	0.34	15	0.31	2	0.40		

TRIBUTARY FLOW INFORMATION FOR FLORIDA 8/25/75

LAKE CODE 1220 LAKE HOWELL

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1220B1	3	73	0.03	17	0.02				
	4	73	0.03	7	0.03				
	5	73	0.01	13	0.01				
	6	73	0.02	17	0.01				
	7	73	0.08	7	0.01				
	8	73	0.09	4	0.15				
	9	73	0.22	8	0.14				
	10	73	0.07						
	11	73	0.01	3	0.02				
	12	73	0.02	8	0.02	15	0.02		
	1	74	0.02	12	0.02				
	2	74	0.03	15	0.01	2	0.01		
1220ZZ	3	73	0.19	17	0.19				
	4	73	0.24	7	0.25				
	5	73	0.13	13	0.13				
	6	73	0.18	17	0.21				
	7	73	0.57	7	0.34				
	8	73	0.48	4	0.54				
	9	73	0.62	8	0.54				
	10	73	0.48						
	11	73	0.19	3	0.20				
	12	73	0.12	8	0.11	15	0.11		
	1	74	0.16	12	0.18				
	2	74	0.10	15	0.10	2	0.12		

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/08/25

122001
28 38 25.0 081 18 15.0
LAKE HOWELL
12117 FLORIDA

11EPALES
3

2111202
0012 FEET DEPTH

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
73/03/15	13 45	0000	24.7		48	250	10.10	72	0.070	1.300	0.060	0.985
	13 45	0004	24.4	11.4		250	10.10	70	0.050	1.100	0.050	0.915
	13 45	0008	24.3	11.6		240	10.00	65	0.060	1.100	0.050	0.940
73/09/05	14 35	0000	29.2		29	260	8.70	59	0.060	1.700	0.150	1.180
	14 35	0010	28.3	6.8		260	7.60	59	0.090	1.600	0.230	1.170
73/11/05	12 15	0000	23.5		35	244	7.50	66	0.060	1.500	0.350	1.140
	12 15	0005	23.4	9.2		244	8.40	66	0.050	1.300	0.360	1.190
	12 15	0011	22.9	11.2		245	8.30	67	0.100	1.200	0.370	1.190

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/15	13 45	0000	1.120	47.8
	13 45	0004	1.130	
	13 45	0008	1.140	
73/09/05	14 35	0000	1.240	65.4
	14 35	0010	1.220	
73/11/05	12 15	0000	1.320	39.5
	12 15	0005	1.320	
	12 15	0011	1.280	

STORET RETRIEVAL DATE 75/08/25

122002
28 38 20.0 081 18 56.0
LAKE HOWELL
12117 FLORIDA

11EPALES 2111202
3 0005 FEET DEPTH

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
73/03/15	14 15	0000	25.0	11.6	40	260	10.20	73	0.080	1.400	0.070	1.120
73/09/05	14 45	0000	29.7	10.2	30	265	8.70	61	0.070	1.800	0.180	1.210
73/11/05	12 35	0000	23.7		34	250	8.70	69	0.070	1.600	0.420	1.290
	12 35	0006	22.3	6.0		243	8.30	72	0.260	1.500	0.510	1.390

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/15	14 15	0000	1.240	37.7
73/09/05	14 45	0000	1.290	90.5
73/11/05	12 35	0000	1.470	43.8
	12 35	0006	1.450	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/08/25

-1220A1
28 38 00.0 081 19 00.0
HOWELL CREEK
12117 7.5 CASSELRERRY
I/HOWELL LAKE
ST HWY 436 BRDG DOWNSTREAM MAITLAND STP
11EPALES 2111204
4 0000 FEET DEPTH

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
73/03/17	14	50	1.720	1.600	0.240	3.300	3.400
73/04/07	11	20	2.900	1.200	0.510	1.700	1.800
73/05/13	10	20	0.980	1.760	0.305	4.700	4.980
73/06/17	09	30	1.020	1.700	0.370	2.400	2.500
73/07/07	10	00	0.900	1.150	0.160	1.100	1.100
73/08/04			0.590	0.960	0.115	0.680	0.730
73/09/08	15	15	0.510	3.780	0.430	0.600	0.660
73/11/03	14	30	2.500	1.400	0.132	3.100	3.150
73/12/08	09	45	2.640	2.600	1.500	1.140	1.300
73/12/15	09	50	2.640	2.600	1.560	1.160	1.250
74/01/12	11	00	0.336	1.600	0.520	0.616	0.660
74/02/02	11	05	0.252	1.000	0.085	1.350	1.500

STORET RETRIEVAL DATE 75/08/25

1220A2
28 18 30.0 081 17 30.0
HOWELL CREEK
12 7.5 CASSELBERRY
O/HOWELL LAKE
BANK FROM RD .25 MI NE OF CAMP SAN PEDRO
11EPALES 2111204
4 0000 FEET DEPTH

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
73/03/17	15	15	0.036	3.150	0.091	1.400	1.450
73/04/07	11	00	0.020	7.200	0.140	1.500	1.710
73/05/13	10	00	0.074	2.100	0.073	0.340	0.525
73/06/17	09	10	0.056	2.400	0.100	1.020	1.250
73/07/07	09	45	0.076	1.540	0.132	1.580	1.720
73/08/04	10	30	0.120	1.680	0.078	1.280	1.590
73/09/08	14	45	0.071	1.260	0.198	1.050	1.150
73/11/03	15	00	0.390	1.650	0.100	1.080	1.275
73/12/08	10	10	0.450	1.300	0.080	1.560	1.800
73/12/15	10	00	0.440	0.800	0.088	1.560	1.700
74/01/12	11	30	0.168	1.800	0.100	1.600	2.000
74/02/15	10	40	0.008	1.100	0.010	0.015	0.040

STORET RETRIEVAL DATE 75/08/25

122081
28 39 00.0 081 19 00.0
UNNAMED CREEK
12 7.5 CASSELBERRY
T/HOWELL LAKE
RED BUG LK RD BRDG .25 E JCT ST HWY 436
11EPALES 2111204
4 0000 FEET DEPTH

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
73/03/17	15	00	0.150	3.900	0.430	0.029	0.100
73/04/07	10	55	0.154	4.300	0.390	0.030	0.070
73/05/13	10	10	0.015	0.670	0.050	0.021	0.040
73/06/17	09	25	0.084	0.930	0.093	0.048	0.090
73/08/04	10	20	0.270	0.980	0.115	0.008	0.140
73/09/08	14	15	0.168	3.100	0.054	1.000	1.150
73/11/03	14	45	0.510	1.150	0.108	1.010	1.050
73/12/08	10	10	0.216	1.300	0.120	0.064	0.115
73/12/15	18	45	0.192	0.500	0.092	0.052	0.085
74/01/12	11	15	0.080	0.900	0.156	0.075	0.677
74/02/15	11	10	0.004	1.500	0.010	0.005K	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED