PRELIMINARY EVALUATION

PHOSPHORUS LOADING

to

WESTCHESTER COUNTY LAKES

Submitted by

CARPENTER ENVIRONMENTAL ASSOCIATES INC.

406 Paulding Avenue
Northvale, New Jersey 07647
October 1984

Background

Carpenter Environmental Associates Inc. were retained by the Soap and Detergent Association on 3/26/84 to determine phosphorus loadings to Lakes in Westchester County, New York. The objective of this investigation was to carry out a first order evaluation of the total yearly loading of phosphorus to the lakes and the percentage of the phosphorus contributed from each source. Using this information, the relative impact of wastewater phosphorus loadings to Westchester County Lakes can be determined.

For the purposes of this investigation, the following sources were considered to be significant: surface runoff, septic tank leachate, and wastewater treatment plant discharges. The loading study was performed using existing information. Field investigations and analysis were not performed.

Methods/Assumptions

The scope of this investigation is directly dependent on the number of lakes which are potentially affected by wastewater phosphorus loading.

The lakes considered in this study include those listed in "Characteristics of New York Lakes Part 1- Gazetteer of Lakes, Ponds, and Reservoirs" Greeson, P.E., Robison F.L., U.S. Geological Survey Bulletin 68 1970. This listing was augmented with lakes that are not listed in the Gazetter but were visible on the USGS maps and pertinent to the study, that being they had homes surrounding the lake.

Lakes were eliminated from the study if investigations indicated that the lake is sewered, and does not receive a wastewater treatment plant discharge. Local authorities, i.e., Town Engineer, Board of Health, and NYDEC were contacted and questioned regarding the presence of sewers in these subject areas.

Utilitzing the assumptions presented above, 58 of the 89 lakes located in Westchester County are potentially affected by wastewater phosphorous loadings.

Surface Runoff

Estimation of surface runoff phosphorus loadings to the lakes required the definition of drainage basins. The most recent photorevised USGS maps were utilized in the definition of the basins.

The drainage area was defined as the land extending radially from each lake terminating at the points of highest elevation in closest proximity. The drainage basin was not extended to include the various drainage basins associated with the streams which feed the lake. Therefore, the drainage basin obtained represents a sub-basin specific to the subject lake.

Drainage basin areas were measured using a planimeter. The "Gazetteer" provided the surface area of the lake. This value is subtracted from the total drainage area to obtain the actual drainage basin area for runoff calculations. Direct precipitation phosphorus input to the lake surface was considered insignificant. Table 1 presents the measured drainage basin area for each lake.

Surface runoff phosphorus export from each basin was calculated on the basis of area land use. Omernik 1976,(1) presented information concerning land use vs. phosphorus export. This information was correlated with the general land use classifications provided for in the USGS maps. The following relationships were utilized in the calculation of phosphorus export:

(a) (Pink Area) assume Urban 0.2686 LBS/Acre/YR
(b) (White Area) assume Mixed 0.1642 LBS/Acre/YR
(c) (Green Area) assume Mostly Forest 0.1553 LBS/Acre/YR

The surface runoff phosphorus loadings to the lakes were estimated by establishing the percentage of the drainage basin under each of the land use classifications listed above and calculating phosphorus export. Table 1 presents the information regarding land use in each drainage basin. Table 2 presents the calculated surface runoff phosphorus loading to each lake.

Septic Tank Loadings

The calculation of septic tank phosphorus loadings to the lakes was based on a number of assumptions. The rationale behind the assumptions will be addressed individually.

One of the major assumptions utilized in the calculation of septic tank loading regarded the establishment of a boundary of potential input. A boundary was required to define the number of septic systems around each lake which potentially could result in phosphorus input to the Lake. A number of literature sources indicate that septic systems should be placed 100 feet from a lake to insure that septic phosphorus does not enter the lake.(2,3,4) Information concerning the number of septic systems within 100 feet was not considered for two basic reasons. The USGS maps indicate housing units within 100 feet, however, this does not accurately represent the number of septic systems which may be located in this zone. In addition, the scale of the USGS maps precludes accurate measurement within 100 feet. For the purposes of this investigation, a 500 foot radius was defined as the boundary of potential input. All homes within 500 feet of the lake perimeter as indicated on the USGS maps were assumed to be potential dischargers of septic leachate phosphorus to the lake. In some cases a USGS map house count was not possible due to the presence of pink (urban) area adjacent to the Lake. When this occurred, the local Planning Board or the Town Engineer was questioned regarding the number of homes in these areas and/or the type of wastewater treatment in use. In all of the cases where this situation occurred, the area was found to be sewered.

The phosphorus loading calculations are based on 2.116 lbs P/capita/yr. This value was presented in Clesceri, N.L. 1983 (8), and represents the phosphorus loading rate corrected to eliminate detergent phosphorus. The number of capita per house was established using the 1980 census data and is presented in Table 1.(11)

Septic tank treatment systems have a documented ability to remove phosphorus from the effluent. Removal occurs by interactions of the leachate with the soils surrounding the units. The literature indicates that 90-99% removal can occur from fifty to one hundred fifty feet from the septic tank. (2,3,4,5,6,10) For the purposes of this investigation, a removal of 95% was assumed. This value is highly conservative in light of the fact that the area of concern has been extended to include a 500 foot perimeter.

The 95% percent removal assumed above represents the operational characteristics associated with a correctly functioning system. In order to represent overall removal in an area, a failure rate must be assumed. Review of the literature indicated that system failure rate has not been related to phosphorus removal. However, there have been studies which relate septic system failure to sytem age. Hill, D.E., Frink, C.R. 1980, (9) conducted a survey in Connecticut which correlated system failure with age. Failure in this survey was defined as replacement or enlargement of the septic system. No reference to phosphorus removal was made. The failure rates presented in Hill and Frink´s work were applied to the Westchester Area. The septic system age distribution around each lake was established using the 1980 census. Table 3 presents information concerning the age distribution of homes in Westchester vs the failure rate for each system age group.

As noted above, the failure rate information provided in the literature lacked data concerning phosphorus removal. Data presented by Gilliom, R.J. and Patmont, C.R., (7) indicate that a 30% phosphorus removal corresponds to a 0.0 probability of exceedence. This literature source implies, therefore, that the "worst case" septic system will remove 30% of the phosphorus. For the purposes of this investigation, the "worst case" removal rate will correspond to system failure, i.e., 30% removal.

The per capita loading value, failure rate data, and percent removals were combined to calculate septic loading using the following equation:

[TC x AG x FR x 2.116 lbsP/yr x .30] + [TC x AG x (1-FR) x 2.116 x .05]

Where:
- TC : Total capitia surrounding lake
- AG : Fraction of homes in age group Table 3
- FR : Failure rate for homes in age group

The equation presented above was repeated for each age group listed in Table 3 and the sum of these iterations represents the total septic tank Phosphorus loading to each lake. The results of the septic tank loading calculations are presented in Table 2.

Wastewater Treatment Plant Phosphorus Loading

The third type of phosphorus loading cosidered in this study is wastewater treatment plant discharges. Discharge SPEDES permits for Municipal/domestic wastewater treatment plants were obtained from the regional New York Department of Environmental Conservation office in White Plains. These permits were utilized to identify discharge directly to the lake and/or to a stream which feeds the lake. As per the request of the Soap and Detergent Association, treatment plant discharges were eliminated from the calculations if they represented industrial or commercial sources. In the event that phosphorus concentration information was not available from the permit, a discharge phosphorus concentration of 4.5 mg/l was assumed. The discharge concentration was extrapolated from the loading information presented in the work of Clesceri 1983, (7). The basic assumption used in the discharge loading calculations is that the concentration remains constant during stream transport to the Lakes.

Wastewater treatment plant discharge phosphorus calculations are presented in Table 4. Table 2 incorporates the loading values in the calculation of total phosphorus loading to each Lake.

Total Lake Phosphorus Loading

The total phosphorus loading to each lake is the summation of the phosphorus loading due to runoff, septic tank effluent and wastewater treatment plant effluent, Table 2. It should be understood that these loading calculations are not based on actual analysis of the Lakes. In addition, the loading calculations are based on discharge concentrations without the presence of detergent phosphorus.

Reference

1. Omernik,J.M. "The Influence of Land Use on Stream Nutrient Levels" EPA-600/3-76-014,U.S.EPA.,1976

2. "National Euthrophication Survey Methods For Lakes Samples in 1972." Pacific Northwest Environmental Research Laboratory (1974).

3. Jones, R.A., and Lee, G.F., "Septic Tank Wastewater Systems as Phosphorus sources for Surface Waters" Colorado State Univ. (1979).

4. Ellis, B.G., "Gull Lake Investigations: Nutrient Input Studies", W.K. Kellogg Biological Station and Department of Crop and Soil Sciences, (1971).

5. Chan, Ph.D.,H.T., "Contamination of the Great Lakes by Private Wastes (Part 1- Field Investigations of Private Waste Disposal Systems)", Ministry of Environment, Ontario, (1978).

6. "Summary of Data Relative to Travel of Phosphorus in Sandy Soils", State of New York Department of Health, (1969).

7. Gilliom, R.J., and Patmont, C.R., "Lake Phosphorus Loading from Septic Systems by Seasonally Perched Ground Water, "Puget Sound Region, Washington, U.S. Geological Survey 82-907.

8. Clesceri, Ph.D., N.L., "An Analysis of the Implications of Wastewater Derived Phosphorus Loadings to Wisconsin Inland Lakes", The Soap and Detergent Association, (1983).

9. Hill, D.E., and Frink, C.R., "Septic System Longevity Increased by Improved Design"., The Connecticut Agricultural Experimental Station, New Haven, Conn., (1980).

10. Ellis, B.G., Hook, J.E., Jacobs, L.W., and Mokma, D.L., "Nutrient Movement throught Soils from Septic Systems", Department of Crops and Soil Sciences, Michigan State Univ.,(1978).

11. "1980 Census of Population and Housing", U.S. Department of Commerce, Bureau of the Census, (1983).

Table 1
Westchester Lake Phosphorus Loadings
Characteristics of Lake and Surrounding Area

Lake Name	Drainage Basin Area (acres)	Lake Surface Area (acres)	# Homes Within 500 Feet	Land Use %Mixed	Land Use %Urban	Land Use %Mostly Forest	# Persons/ Household
Amawalk Reservoir	12224	608	133	50	0	50	3.12
Blue Heron Lake	640	44.8	29	20	0	80	2.74
Blue Lake	153.6	6.4	10	0	0	100	3.27
Campfire Lake	294.4	64	32	5	0	95	2.72
Cobamong Pond	294.4	6.4	12	30	0	70	2.83
Cockrene Pond	172.8	12.8	8	10	0	90	3.27
Collabaugh Lake	320	38.4	9	5	0	95	3.27
Cortlandt Lake	659.2	19.2	87	5	0	95	2.74
Cross River Reservoir	19072	915.2	69	50	0	50	2.74
Dream Lake 1	326.4	6.4	9	0	0	100	3.27
Dream Lake 2	128	6.4	3	10	0	90	3.27
Echo Lake	102.4	6.4	2	10	0	90	2.72
Forest Lake	358.4	12.8	2	20	0	80	2.72
Frankcrest Lake	166.4	6.4	7	50	0	50	3.27
Furnace Brook Lake	2067	25.6	9	5	0	95	2.79
Gilmore Pond	787.2	6.4	4	10	0	90	2.74
Glendale Lake	249.6	44.8	4	5	0	95	3.27
Heaptaugua Lake	198.4	6.4	8	10	0	90	2.72
Highland Lake	172.8	6.4	16	90	0	10	2.74
Howland Lake	876.8	89.6	15	10	0	90	2.72
Indian Brook Reservoir	236.8	19.2	13	25	0	75	3.27
Journeys End Lake	147.2	6.4	11	10	0	90	3.27
Katonah Lake	147.2	19.2	48	20	0	80	2.72
Kitchawan Lake	851.2	89.6	59	20	0	80	2.74
Lincolndale Lake	492.8	19.2	95	40	0	60	3.12
Little Lake	134.4	6.4	6	5	0	95	3.27
Long Pond	147.2	12.8	36	0	0	100	2.83

Table 1
(continued)
Westchester Lake Phosphorus Loadings
Characteristics of Lake and Surrounding Area

Lake Name	Drainage Basin Area (acres)	Lake Surface Area (acres)	# Homes Within 500 Feet	Land Use %Mixed	Land Use %Urban	Land Use %Mostly Forest	# Persons/ Household
Mallard Lake	198.4	19.2	5	5	0	95	2.74
Mill Pond	4160	6.4	29	30	0	70	2.72
Mohegan Lake	1005	102.4	181	10	0	90	3.27
Muscoot Res.	2.0e5	1011.2	67	50	0	50	2.72
New Croton Res.	9939.	2182.4	77	20	0	80	3.27
North Lake	319.2	19.2	37	15	0	85	2.83
Oceola Lake	537.6	38.4	38	15	0	85	3.27
Oscaleta Lake	300.8	57.6	8	50	0	50	2.74
Pea Pond	492.8	6.4	9	50	0	50	2.74
Potantico Lake	684.8	51.2	22	10	0	90	2.94
Rippowam Lake	320	32	21	5	0	95	2.74
Robin Hood Lake	83.2	6.4	28	10	0	90	2.74
Scotts Res.	1062	12.8	12	50	0	50	2.74
Shadow Lake	166.4	6.4	3	35	0	65	3.27
Shenorock Lake	281.6	12.8	70	40	0	60	3.12
Siscowit Reservoir	1850.	38.4	2	10	0	90	2.74
Sparkle Lake	313.6	19.2	108	40	0	60	3.27
Still Lake	358.4	23.04	24	25	0	75	3.27
Teatown Lake	230.4	38.4	5	5	0	95	3.27
Titicus Res.	14912	665.6	62	50	0	50	3.12
Trinity Lake	832	76.8	7	50	0	50	2.74
Truesdale Lake	448	83.2	130	50	0	50	2.74
Twin Lake 1	364.8	12.8	3	0	0	100	3.27
Twin Lake 2	870.4	12.8	12	10	0	90	3.27
Twin Lake	320	12.8	9	50	10	40	2.74
Vernay Lake	102.4	6.4	3	5	0	95	3.27
Waccubuc Lake	678.4	12.8	112	40	0	60	2.74
Wallace Pond	230.4	19.2	28	10	0	90	2.74
Wampus Lake Res.	467.2	38.4	6	20	0	80	2.72
Whippoorwill Lake	377.6	12.8	1	15	0	85	2.72
Windmill Lake	25.6	12.8	17	15	0	85	2.83

Table 2
Westchester Lake Phosphorus Loadings

Lake Name	Runoff Phosphorus Loading LBS/YR	Septic Phosphorus Loading LBS/YR	POTW Phosphorus Loading LBS/YR	Total Phosphorus Loading LBS/YR	Phosphorus Surface Loading LBS/ACRE/YR	Wastewater Phosphorus Orgin %
Amawalk Reservoir	1855.7	124.	0	2020.	3.32	8.13
Blue Heron Lake	93.494	23.7	0	117.2	2.62	20.2
Blue Lake	22.860	7.32	0	30.18	4.72	24.3
Campfire Lake	35.884	26.0	0	61.85	.966	42.0
Cobamong Pond	45.495	10.1	0	55.63	8.69	18.2
Cockrene Pond	24.990	7.81	0	32.80	2.56	23.8
Collabaugh Lake	43.86	8.78	0	52.63	1.37	16.7
Cortlandt Lake	99.677	71.1	0	170.8	8.90	41.6
Cross River Reservoir	2900.5	56.4	0	3162.	3.45	8.25
Dream Lake 1	49.7	8.78	0	58.47	9.14	15.0
Dream Lake 2	18.993	2.93	0	31.78	4.97	40.2
Echo Lake	14.994	1.62	0	16.62	2.60	9.77
Forest Lake	54.287	1.62	0	55.91	4.37	2.90
Frankcrest Lake	25.56	6.83	0	32.39	5.06	21.1
Furnace Brook Lake	317.94	7.49	4986.2	5312.	207.	94.0
Gilmore Pond	121.95	3.27	0	125.2	19.6	2.61
Glendale Lake	31.9	3.9	0	35.8	.799	10.9
Heaptaugua Lake	29.988	6.49	0	36.48	5.70	17.8
Highland Lake	27.175	13.1	0	40.26	6.29	32.5
Howland Lake	122.95	12.2	0	135.1	1.51	9.01
Indian Brook Reservoir	34.277	12.7	0	46.96	2.45	27.0
Journeys End Lake	21.992	10.7	0	32.72	5.11	32.8
Katonah Lake	20.106	39.0	0	59.06	3.08	66.0
Kitchawan Lake	119.63	48.2	0	167.9	1.87	28.7
Lincolndale Lake	75.236	88.4	0	163.7	8.52	54.0
Little Lake	19.935	5.85	0	25.79	4.03	22.7
Long Pond	20.872	30.4	0	51.27	4.01	59.3

Table 2
(continued)
Westchester Lake Phosphorus Loadings

Lake Name	Runoff Phosphorus Loading LBS/YR	Septic Phosphorus Loading LBS/YR	POTW Phosphorus Loading LBS/YR	Total Phosphorus Loading LBS/YR	Phosphorus Surface Loading LBS/ACRE/YR	Wastewater Phosphorus Orgin %
Mallard Lake	27.910	4.09	0	32.00	1.67	12.8
Mill Pond	656.14	23.5	0	679.7	106.	3.46
Mohegan Lake	140.98	177.	0	317.6	3.10	55.6
Muscoot Res.	32116.	54.4	827.4	32997	32.6	2.67
New Croton Res.	1218.4	75.1	16694	17988	8.24	93.2
North Lake	46.991	31.2	0	78.23	4.07	39.9
Oceola Lake	78.192	37.1	0	115.3	3.00	32.2
Oscaleta Lake	38.851	6.54	0	45.39	.788	14.4
Pea Pond	77.702	7.36	0	85.06	13.3	8.65
Potantico Lake	98.962	19.3	0	118.3	2.31	16.3
Rippowam Lake	44.855	17.2	0	62.02	1.94	27.7
Robin Hood Lake	11.995	22.9	0	34.89	5.45	65.6
Scotts Res.	167.61	9.81	0	177.4	13.9	5.53
Shadow Lake	25.346	2.93	0	28.27	4.42	10.4
Shenorock Lake	42.702	65.2	0	107.9	8.43	60.4
Siscowit Reservoir	282.89	1.64	121.7	406.2	10.6	30.4
Sparkle Lake	46.768	105.	0	152.1	7.92	69.3
Still Lake	52.828	23.4	0	76.24	3.31	30.7
Teatown Lake	29.903	4.88	0	34.78	.906	14.0
Titicus Res.	2275.9	57.7	438.4	2772.	4.16	17.9
Trinity Lake	120.64	5.72	0	126.4	1.65	4.53
Truesdale Lake	58.277	106.	0	164.6	1.98	64.6
Twin Lake 1	54.666	2.93	0	57.59	4.50	5.08
Twin Lake 2	133.95	11.7	0	145.7	11.4	8.04
Twin Lake	52.556	7.36	0	59.91	4.68	12.3
Vernay Lake	14.952	2.93	0	17.88	2.79	16.4
Waccubuc Lake	105.74	91.6	0	197.3	15.4	46.4
Wallace Pond	32.987	22.9	0	55.88	2.91	41.0
Wampus Lake Res.	67.356	4.87	0	72.23	1.88	6.74
Whippoorwill Lake	57.140	.812	0	57.95	4.53	1.40
Windmill Lake	2.0049	14.4	0	16.36	1.28	87.7

TABLE 3

WESTCHESTER COUNTY LAKES

PHOSPHORUS LOADING STUDY

SEPTIC TANK AGE vs. FAILURE RATE

Age of Systems	Percent of Systems In Subject Age Group[1]	Failure Rate[2] %
X < 5 years	14.8	4.3
5 < X < 9 years	27.4	5.6
9 < X < 15 years	17.4	10.0
15 years < X	40.4	25.0

Notes:

1. Percentage of systems in each age group obtained from 1980 Census data (11)

2. Failure rate information obtained from (Hill, D.E., and Frink, C.R., 1980) (8)

TABLE 4
PHOSPHORUS LOADING CALCULATIONS
WASTEWATER TREATMENT PLANT DISCHARGES
WESCHESTER COUNTY LAKES

LAKE NAME	WASTEWATER TREATMENT PLANT	WWTP TRIBUTARY DISCHARGE MGD	DISCHARE PHOSPHORUS CONCENTRATION MG/L	PHOSPHORUS LOADING FROM WWTP LBS/YR	TOTAL PHOSPHOROUS WWTP LOADING LBS/YR
RYE LAKE	North Castle	.38	4.5	5205	5205
FURNACE BROOK LAKE	Baltic Estates	.25	4.5	3425.	4986.2
	Dickerson Pond Assoc	.014	4.5	191.8	
	Springvale	.1	4.5	1370.	
MUSCOOT RES.	Lincoln Hall	.05	4.5	684.9	827.39
	Bedford Park Apt.	.0195	2.4	142.5	
NEW CROTON RES.	Heritage Hills	.468	.5	712.3	16694.
	Mt.Kisco	1.14	4.5	15616	
	Somers Manor NH	.06	1	182.6	
	Wild Oaks	.06	1	182.6	
MILL POND	Lakeside Village	.1	1	304.4	304.4
SISCOUIT RES.	Oakridge	.08	.5	121.8	121.76
TITICUS RES.	Waterview Hills	.032	4.5	438.4	438.4
CROM POND	Yorktown Heights	1.5	4.5	20548	20548.

NOTE: A discharge concentration of 4.5 mg/l was assumed when actual data was unavailable.