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A DIAGNOSTIC - FEASIBILITY STUDY FOR THE RESTORATION OF LAKE FAIRFAX, VIRGINIA

McLean, Virginia

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A DIAGNOSTIC - FEASIBILITY STUDY
FOR THE RESTORATION
OF LAKE FAIRFAX, VIRGINIA

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A Diagnostic - Feasibility Study for the Restoration of Lake Fairfax, Virginia

Executive Summary

A Diagnostic - Feasibility Study has been conducted on Lake Fairfax, Fairfax County, Virginia. The study was designed to ascertain the condition of the lake, factors underlying the condition, and to determine feasible solutions to the problems found. The study was conducted by NUSAC, Incorporated of McLean, Virginia in cooperation with Biospherics, Incorporated, Rockville, Maryland, which handled the water chemistries, and the Biology Department of George Mason University which provided assistance with field work and laboratory support.

The Diagnostic Study evaluated background information useful in assessing the condition of the lake and its recreational potential. This research analyzed local soils, public access to the lake, lake user population, and comparative recreational usage of the lake as opposed to other public lakes in the Washington, D.C. area. In addition to this baseline information, the Diagnostic Study also evaluated land usage in the Lake Fairfax watershed and quantified areas for all land uses in the suburban Reston catchment area.

Land use data was used to analyze nutrient and sediment inputs to Lake Fairfax; these inputs are called loadings. Phosphorus loading is a major concern in all lakes since phosphorus is an important fertilizing element for nuisance algae-and phosphorus loading to Lake Fairfax is very high at 808 kg per year. In the future, the figure may rise to 1007 kg as the watershed becomes fully suburbanized. Of this excessive phosphorus inflow, only about 15% is delivered under baseflow (non-storm) conditions, the remainder is caused by stormwater inflows. Analyses of storms during the study confirmed their importance and revealed that intense events can deliver more sediments and nutrients to the lake in one day than are brought in by baseflow over weeks or even months.

A depth or bathymetric study was conducted and determined that the lake averages 2.5 m (8 feet) in depth, has a surface area of 8.7 hectares (ha) (21 acres) and a volume of 220,431 m^3 (179 acre feet). Sediment appears to be accumulating at about 3,200 m^3 per year, so the lake should have sufficient depth for recreational use for 50 years or more. The watershed area is very large at 1111.4 ha which predisposes Lake Fairfax to water quality problems.

Data on water quality during the 1 year Diagnostic Study reveal no serious problems under non-storm conditions, except phosphorus levels are higher in the lake than the 25 mg/m^3 level considered healthy by the State Water Control Board standards. The water inflows to the lake are high, flushing it 23 times per year and making control of waterborne loading extremely difficult. Phosphorus in the lake is renewed every 11 days on the average, and the lakewater turns over every 16 days. A summary of all data collected on Lake Fairfax clearly depicts the lake as a eutrophic or highly fertile body of water and phosphorus inputs must be reduced to about 22% of current levels if any visible change in water quality is to be expected. This goal will be very difficult to attain.

A Feasibility Study was conducted to examine all possible ways of preserving and restoring Lake Fairfax. Restoration techniques for treating the pollution problems in the lake, in the tributaries, and in the entire watershed were studied. The only feasible means of improving Lake Fairfax were found to be in-lake methods. Tributary or watershed management approaches were determined to be ineffective and too costly to justify any further analysis.

There is one fundamental reason why it was found to be unrealistic to control pollution outside of the lake itself-- the watershed area is simply too great and pollution is totally nonpoint source (coming from the whole watershed). The 1111.4 ha (2700 acre) catchment produces a runoff volume equal to several times the volume of the lake with the rainfall of a moderate (5 cm/2 inch) storm. This vast volume would have to be held in detention basins for at least 24 hours and such large basins would be prohibitively expensive. Other means of reducing nutrient and sediment which were examined also turned out to be ineffective or not cost-effective because of the large area involved. It was concluded that handling the inputs within the lake itself is the only feasible approach to restoration.

The recommended approach to restoring Lake Fairfax involves dredging and installation of a bottom withdrawal mechanism. Using an hydraulic dredge, 20,000 m^3 of sediment should be removed from the Colvin and Cameron Run coves, and selected other shallow areas. This material will be deposited in a dewatering basin on the north shore of the lake. The dredging operation will increase fishing areas and access, expand boating areas, and increase aquatic habitats.

Either a drop inlet collar or a drain valve operating mechanism should be installed as the second part of the restoration process. These devices draw water from the pollutant-rich bottom region and thus improve the overall water quality by increasing the export of oxygen-poor water containing high nutrient and sediment concentrations.

Installation of a bottom withdrawal mechanism will have several major benefits at a very low cost. Bottom withdrawal will greatly expand the volume of water usable by fish, and will double the bottom area having benthic insects (important sources of fish food); besides removing nutrients from the lake faster than with surface overflow. Fish production and fishing success in Lake Fairfax can be expected to increase greatly after restoration. It is estimated that the restoration will cost $267,250 and take at least 15 months to implement. No serious environmental problems are expected in the restoration of Lake Fairfax, as is discussed in the final section of the Diagnostic-Feasibility Study.

A Diagnostic - Feasibility Study for the Restoration of Lake Fairfax, Virginia

I. Introduction

Lake Fairfax is a valuable asset to Fairfax County, Virginia, and the Washington, D.C. metropolitan area. In recent years the condition of the lake has deteriorated, bringing into question its long-term preservation as a regional asset. In response to this degradation, Fairfax County Park Authority (FCPA) and the Virginia State Water Control Board (SWCB)have applied for federal matching funds under the Clean Lakes Program directed by the U.S. Environmental Protection Agency (EPA) to conduct a study to begin restoration of the lake. The funds were granted in October, 1980, and a Phase 1, Diagnostic-Feasibility Study of the lake was begun. This report is the final phase of that study on Lake Fairfax.

A Diagnostic-Feasibility Study is designed to determine the condition of a lake, causative factors for that condition, and to develop feasible, cost-effective solutions to the problems found. The specific requirements for such studies are given in Appendix A of 40CFR35 Subpart H, and many details helpful in meeting the requirements are outlined in Appendix E of the Clean Lakes Program Guidance Manual (EPA440/5-81-003). The specifications of both these documents have been met in this Diagnostic-Feasibility Study of Lake Fairfax.

The investigation of Lake Fairfax involved many individuals and several corporations working together. The project was managed by the Lake Management Division of NUSAC, Incorporated in McLean, Virginia, under contract to FCPA. Biospherics, Incorporated of Rockville, Maryland conducted the analytical work for water quality testing. Enumeration of plankton, laboratory work on the growth of algae, and assistance with fieldwork was provided by George Mason University's Department of Biology. FCPA provided support in information gathering and project coordination, and the SWCB assisted by furnishing data and information throughout the study.

II. The Diagnostic Study of Lake Fairfax

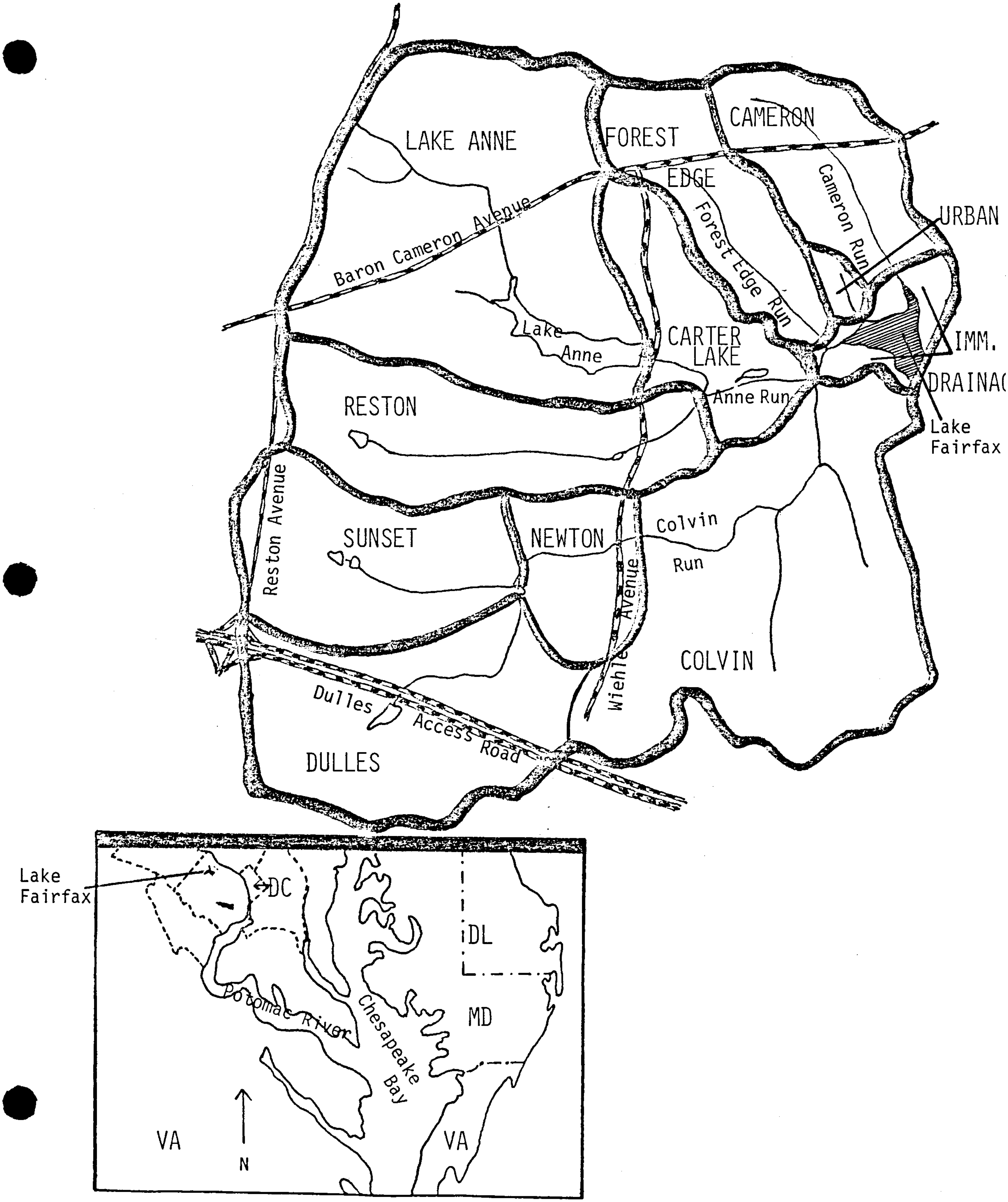
II.1. Lake Identification and Location.

Lake Fairfax is a small reservoir in Fairfax County, Virginia. The lake was impounded in 1956 and has been operated as a community park since acquisition by Fairfax County Park Authority in 1966. The general information on the lake is summarized as follows:

Name:	Lake Fairfax	
State:	Virginia	
County:	Fairfax	
Municipalities:	Fairfax, Herndon, Reston, and Vienna all lie within 10 km (7 miles) of the lake.	
Latitude/Longitude:	$38^{o}57'50''$ N / $77^{o}19'20''$ W	
EPA Region:	Mid-Atlantic, Region III.	
EPA Major Basin Name:	North Atlantic Unit	Code 02
EPA Minor Basis Name:	Potomac River	Code 1-4
Tributaries:	Colvin Run, major; Forest Edge Run and Cameron Run, minor.	
Receiving Water Body:	Outflow is to Colvin Run, which joins Difficult Run, draining into the Potomac River downstream from Great Falls.	
Water Quality Standards:	There does not appear to be any specific standards for the Fairfax system - Virginia SWCB should review.	

Lake Fairfax and its surroundings are shown in Figure II.1.a. The watershed, which is part of the larger Difficult Run watershed, is divided into 11 subwatersheds ranging in size from 8 to 232 hectares (17 to 494 acres). Lake Fairfax is supported by a total watershed covering 1,111.4 hectares (2367 acres) and the land is being utilized primarily as suburban development. Complete land use information is presented in Section II.9 and other watershed related details are given in Section II.10.

FIGURE II.1.a.
THE LAKE FAIRFAX WATERSHED



II.2. Geology and Soils of the Drainage Basin

Lake Fairfax and its watershed lie in the Piedmont Upland, a triassic region of weathered crystalline rocks. The overburden material is 10 to 100 feet thick within the watershed and no major trends in depth are evident moving through the watershed. A region of separation between the Triassic Lowland physiographic zone with a thin residium and the region of thick saprolite of the Piedmont crystalline rocks is found along the area close to Reston Avenue at the western boundary of the watershed.

The Fairfax drainage basin is largely biotite with and without garnet over about two-thirds of its area. A diagonal line of change follows Wiehle Avenue and the pipeline easement; to the west, biotite changes to chlorite.[1]

Groundwater in the Fairfax watershed is generally of good quantity, except where high iron levels, corrosiveness, and domestic contamination create local problems. The Wissahickon metamorphic schist, which underlies most of the Lake Fairfax basin, is a good source of groundwater, since weathering tends to decrease its soluble materials and increase porosity

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[1] These geological facts and further details are available from U.S.G.S. publications: Water-Supply Papers 1539-L and 1776, Quadrangle Maps of the Vienna surficial series OF75-520 and OF76-533 and the Preliminary Geologic Map of Fairfax County, OF79-398.

for movement and retention of water. Yields from Wissahickon wells average 12 gallons per minute at 130 feet of depth. In scattered Greenstone areas yields are less at about 6 gallons per minute. Water from the Wissahickon Schist is moderately soft containing less hardness than water from Greenstone formations. Groundwater quality is good in the Fairfax basin except for cases where iron concentrations are high. Areas where iron-laden groundwater surfaces can be seen are found in the Colvin Run flood plain and are numerous just upstream from where the stream enters the lake.

Two soil associations dominate in the Fairfax drainage basin: the Glenelg-Elioak-Manor and Manor-Glenelg-Elioak. The Glenelg-Elioak-Manor group is the most common and is a well-drained soil good for crops and pasture. The association is composed of undulating, rolling, hilly, and steep micaceous soils formed from the weathering of quartz sericite schist. The natural drainage system is well developed and allows medium to rapid surface runoff. Internal water movement is also rapid in the Glenelg-Elioak-Manor association, except in isolated areas in drainageways where alluvium has accumulated. These soils show moderate to severe erosion depending upon topography.

Along the lower tributaries of the drainage basin are areas of the Manor-Glenelg-Elioak soil series. This group is not good for crops, but rather is useful for forests and pastures. Runoff potentional and internal drainage are medium to rapid, while natural fertility and water-holding capacity are low. The erosion propensity of the soils is moderate to severe, depending upon the topography[2]. The soils of the Lake Fairfax watershed can be described briefly as Glenelg-Elioak-Manor silt loams with generally low fertility and high erosion potential.

The drainage basin of Lake Fairfax encompasses 1,111.4 hectares of the Piedment Upland in Fairfax County. This portion of the Piedmont Upland is well dissected. Interstream divides are fairly wide, undulating, and rolling, except in places along the lower tributaries of large streams. Entrenchment of the lower tributaries has been rapid along the major streams, causing formation of bluffs and V-shaped valleys with steep slopes that rise abruptly from the flood plain. The smooth upland is 107 to 137 m above sea level.

The drainage pattern in the Difficult Run watershed is generally dendritic and Colvin Run is the dominant stream in the Lake Fairfax drainage basin. The headwaters of Colvin Run reach an elevation of 134 m above sea level, with a streamfull of 53 m over its channel length above Lake Fairfax, which is 4.9 km long and has a moderate slope of 10.86 m/km.

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[2] Fairfax County Soil Survey Office: soil descriptions and communications from soil scientists; Soil Survey, Fairfax County, Virginia, series 1955 No. 11; and PBQ and D (1976), Difficult Run Environment Baseline.

II.3. Public Access to Lake Fairfax Park

The primary access to Lake Fairfax Park is Lake Fairfax Drive which runs approximately 1 mile from the lake to Baron Cameron Avenue (See Figure II.3.a.). Pedestrian access from surrounding neighborhoods is most directly from the single family homes on the northern park border and from the Carter Lake apartment complex to the west of the lake. A trail leads into the park from the Parkglen Court area, but where it crosses Colvin Run it has been washed out, making access more difficult.

Access through the main gate is controlled by the FCPA and is open during daylight hours on a year-round basis. Fairfax County residents enter without charge. Out-of-county user fees of $2.50 per vehicle are charged for cars without a County sticker entering the park between the months of May through September via Lake Fairfax Drive. An additional $.50 per person is charged to those vehicles with more than six people. A fee of $5.75 per night is charged to campers, plus a $1.50 for electricity. These fees are placed in the Fund 40 which is used by the FCPA to help offset operating costs. Specific usage of the fund is subject to change from year to year[3].

Vehicular access to Lake Fairfax Park from the Capital Beltway is not difficult and makes the facility readily available to the entire Washington metropolitan area (see Figure II.3.a.). The main

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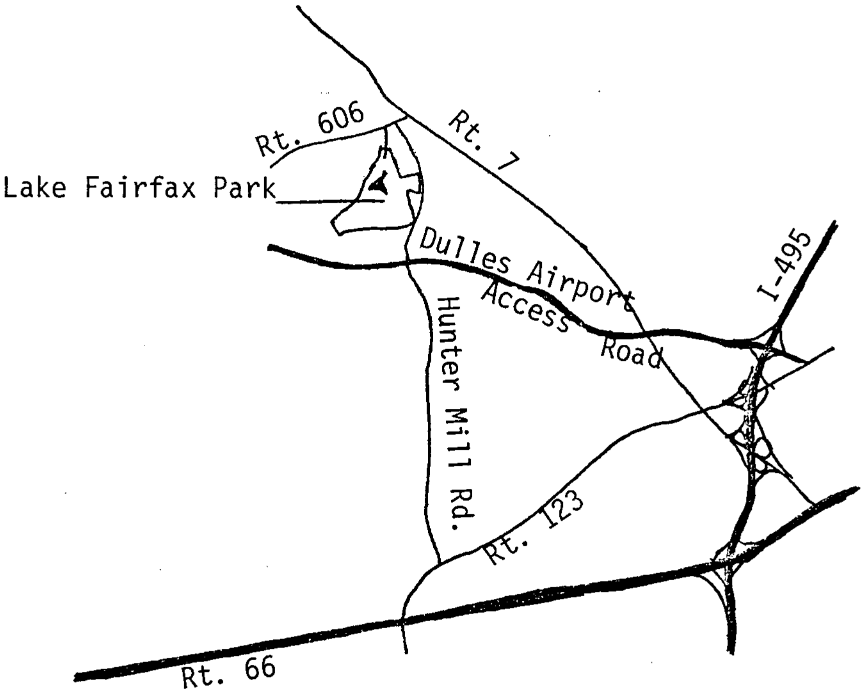
[3] This information was obtained from a personal communication with a Lake Fairfax Park Official.

FIGURE II.3.a.

PUBLIC ACCESS ROUTES TO LAKE FAIRFAX PARK



access route is Beltway Exit 10-W, Route 7 (Leesburg Pike), 6 1/2 miles west to Baron Cameron Avenue, and a left onto Lake Fairfax Drive which is the second left hand turn off Baron Cameron Avenue. Entry to the park is within a 45 minute drive from almost anywhere in the metropolitan area. Access is also possible from the I-66 corridor via Route 123 and Hunter Mill Road to Baron Cameron Avenue.

Access to Lake Fairfax by way of Metrobus is obtained by riding Bus #5S which leaves everyday at various hours from the Rossyln Metro Station, and returns to the Metro Station at various hours from the corner of Baron Cameron Avenue and Route 7.

II.4. The Size and Economic Structure of Potential User Population for Lake Fairfax

According to the Fairfax County Office of Comprehensive Planning - The Economic Demographic Section, there are approximately 612,600 people residing in Fairfax County, and about 3,375,000 people in the Washington Metropolitan area. Lake Fairfax Park is readily available to 2,700,000 of those residents.

This area also differs from the rest of the county in that it is a more family-oriented section of the county, with a very high proportion of married couples and a relatively high birth rate. There is a great number of out-of-state and out-of-Washington metropolitan area campers at Lake Fairfax because it is the only campground with electricity in the area. The number of non-regional visitors will no doubt continue to grow in the next couple of years because it is an inexpensive, back to nature means of vacationing.

The user population for Lake Fairfax is great and growing all the time. The communities surrounding Lake Fairfax have a population of 74,200, while the estimated population for 1985 is 87,456, a 17% increase in population in four years (1981-1985).

There are many groups that use Lake Fairfax park on a regular to semi-regular basis. These include school groups, camping clubs parks and recreation groups (e.g., Prince George's County, Maryland), a group holding dog shows (2 times/year), and soccer teams.

On a daily basis the user population is a group comprised of individuals from all over the Washington Metropolitan area, which includes the District of Columbia, Maryland, and Northern Virginia, and encompasses a wide range of economic classifications. The Fairfax County Office of Comprehensive Planning, The Economic Demographic Section provides evidence that the median family* income per year in 1979 within the Washington Metropolitan area is $29,086, for Washington, D.C. alone it was $6,852.30, and for Fairfax County the median income was $39,500 per year. As illustrated, the sections of the Washington area are widely divergent in income levels, creating a mixture of park users. The lower income level individuals may have a tendency to use the parks more because it is an inexpensive form of recreation not far from home.

Individuals living in the subdivisions surrounding Lake Fairfax within Fairfax County have a higher level of affluence and education than the Washington Metropolitan area average. The socioeconomic picture in Fairfax County as a whole is one of a general level of affluence and better education. Many Fairfax County residents are able to travel to other recreational locations because of higher income and awareness of recreational options.

* Median Family: Man 38 years of age, wife at home, boy 13 years of age, and girl of 8 years.

Although major corporations employ a high percentage of metropolitan area residents, the major source of employment is the United States Government. An extremely small percentage of metropolitan area residents are blue collar or factory workers. The unemployment rate for Fairfax County was 2.8% in 1980 as compared to Northern Virginia's 3.1%.

There is no significant relationship between Lake Fairfax and the local economy, except that the campgrounds and recreational facilities bring people out to the area to spend money locally on food and entertainment.

II.5 Historical Uses of Lake Fairfax

Lake Fairfax park was established in 1966. It has been a major revenue-producing facility catering to day use visitation and overnight camping. In the past, the use areas have been open four (4) months each year and the campgrounds from April through October. Recently, Lake Fairfax has seen restricted use because of its condition. In 1978, the lake was closed to swimming due to the steadily increasing turbidity of the water. It had been the last public open water swimming available in Fairfax County. Citizen requests for lake swimming have been increasing, as a "natural" swimming experience away from chlorine. A swimming pool is still available for public use at the lake.

Table II.5.a. provides quantitative background which clearly shows past use of the park facilities. Due to the increased use of Lake Fairfax, the activities offered as well as the concessions used for direct water related activities (Table II.5.b.) have shown an increase.

Figure II.5.a. shows the varying attendance per month. Total park usage for FY 1981 is greater than FY 1980 and FY 1979, yet in various months the graph shows that FY 1981 had less attendance. The cause of variation is weather: when the weather was conducive to outdoor activity, the park's attendance was up; when the weather was poor (i.e., rainy, cool or humid) the Park was virtually vacant.

TABLE II.5.a.
LAKE FAIRFAX PARK USAGE

	FY 79	FY 80	% Change	FY 81	% Change	% Change 1979/1981
Park	306,561	324,469	5% (+)	391,254	21% (+)	+28%
Carousel	18,327	20,450	12% (+)	22,661	11% (+)	+24%
River boat	5,789	8,166	41% (+)	15,205	86% (+)	+62%
Train	28,172	30,996	10% (+)	23,265	25% (-) (Train out of use)	-17%
Mini-golf	10,498	8,453	19% (-)	7,273	14% (-)	-31%
Campground	34,104	26,787	21% (-)	58,623	118% (+)	+72%
Boat rentals (pedal/canoes)	18,465	21,431	16% (+)	24,495	14% (+)	+33%
Misc. (soccer, large groups, special events)	105,200	97,378	7% (-)	132,416	36% (+)	+26%
Pool	44,705	53,049	19% (+)	57,557	8% (+)	+29%

TABLE II.5.b.
LAKE FAIRFAX REVENUES

* Fiscal Year 1980
** Fiscal Year 1981

	Tackle	Life Preservers	Pedal Boat	Canoe
July 1979*	$ 243.02	$ 1398.30	$ 1523.30	$ 814.64
July 1980**	68.17	1871.73	1918.53	1002.00
August 1979*	131.53	1017.72	1206.58	547.92
August 1980**	29.86	1331.96	1440.83	639.38
September 1979*	7.86	382.83	403.82	210.53
September 1980**	7.11	394.42	430.30	207.93
October 1979*	-0-	23.06	43.25	3.84
October 1980**	2.68	35.43	36.06	13.22
April 1980*	3.15	-0-	147.10	110.55
April 1981**	14.79	-0-	341.35	81.73
May 1980*	53.86	-0-	637.42	573.03
May 1981**	72.12	-0-	1641.26	747.68
June 1980*	86.93	-0-	1841.84	1004.00
June 1981**	67.71	-0-	2233.31	913.53
Total Fiscal Year 1980	$527.35	$2821.91	$5803.31	$3264.51
Total Fiscal Year 1981	262.44	3633.54	8041.64	3605.47
% Change	50% decrease	30% increase	40% increase	10% increase

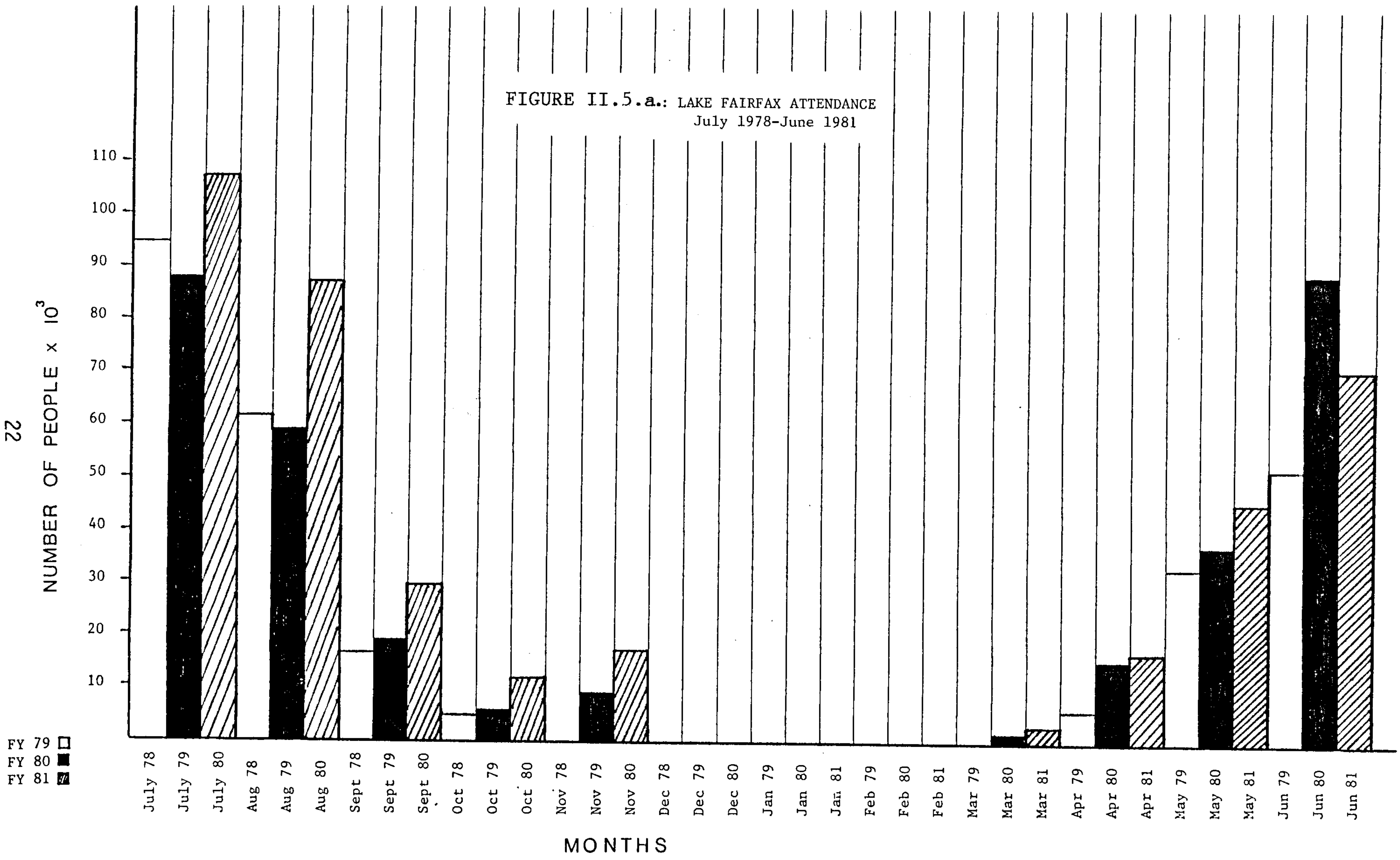


FIGURE II.5.a.: LAKE FAIRFAX ATTENDANCE
July 1978-June 1981

Clearly, Lake Fairfax is in need of and worthy of improvement; aesthetic enjoyment as well as direct water recreation are valued within the communities surrounding Fairfax County and the Washington metropolitan area. It is imperative that positive action be taken in the future to correct the condition of the lake.

II.6. Population Segments Adversely Affected by Further Degradation of Lake Fairfax

During the Phase 1 study, no particular group of persons was identified as being more adversely affected by degradation than any of the groups who enjoy Lake Fairfax Park. Serious degradation of Lake Fairfax would detract from the recreational opportunities of many persons in Fairfax County, especially those in the lower income groups with fewer recreational options. Fishermen, boaters, and those who come to Lake Fairfax for its aesthetic value (the scenery and natural landscape) would be the most directly affected by lake deterioration. The campers, hikers, joggers, children playing from the Reston-Herndon area whose primary summer recreation is associated with the lake, and those who use the lake and its park as an educational, interpretative experience, would all be less directly hurt by lake degradation.

Lake Fairfax Park is a valuable community asset for all the park users of the Metropolitan area. The lake is certainly important to those who choose to enjoy what it offers - inexpensive, outdoor activities close to home. Thus, lake deterioration is more a loss to the Fairfax County populus as a whole, than to any particular segment of the local population.

II.7. Comparison of Lake Fairfax Uses to Uses of Other Lakes in the Region

Table II.7.a. summarizes lake usage within a 80 km radius and contains 11 publicly operated lakes. The total number of lakes within the Maryland and Virginia area encompassed by the 80 km radius is far greater than this group of 11; the table contains all EPA required information on public lakes and their comparison to Lake Fairfax.

The major finding of this summary is that no lake in the area can be viewed as a replacement for Lake Fairfax. Although other lakes offer some of the same attractions, none can handle the large user population in the area alone, and none can begin to duplicate the unique features of Lake Fairfax, including its excellent location.

Table II.7.a. Comparative Lake Usage

Lake Name and Location	Type of Activities	Estimated User Population	Comparison to Lake Fairfax
Tridelphia Reservoir Brookville, MD Montgomery County, MD	Boating, fishing, picnic, area, and hunting (Bow and Shotgun) Recreation limited	500,000/year Increases by approximately 150,000/year	Recreation is limited at both Tridelphia and Rocky Duckett Reservoirs. Therefore neither has the type of recreation facilities that Lake Fairfax has. Also, they are approximately 25 miles from Lake Fairfax.
Rocky Duckett Reservoir Brookville, MD Montgomery County, MD	Picnic area, sailing, horsetrack, boating, hunting, and shore fishing (Natural atmosphere)	500,000/year	Recreation is limited at both Tridelphia and Rocky Duckett Reservoirs. Therefore, neither has the type of recreational facilities that Lake Fairfax has. They are approximately 25 miles from Lake Fairfax.
Greenbelt Lake Greenbelt, MD Prince Georges County, MD	Half-court basketball, picnic area, and playground well as a less natural setting.	1000/week	Greenbelt Lake is approximately 25 miles from Lake Fairfax and offers considerably fewer recreational activities as
Gilbert Run Park La Plata, MD Charles County, MD	Paddle boat, Canoe, and fishing (Natural atmosphere)	21,000/year	Gilbert Run Park is approximately 40 miles from Lake Fairfax and offers a natural atmosphere, with fewer recreational activities.
Culler Lake Frederick, MD Frederick County, MD	Fishing, ice skating, canoeing, sailing, strolling, jogging, and boat house	10,000/year	Culler Lake is located approximately 45 miles from Lake Fairfax and offers mostly natural activities, not as many recreational activities.

Table II.7.a. Comparative Lake Usage (Continued)

Lake Name and Location	Type of Activities	Estimated User Population	Comparison to Lake Fairfax
Lake Needwood North of Rockville, MD Montgomery County, MD	Recreational - picnic area, hiking, boating, archery, and fishing.	250,000/year	Lake Needwood is approximately 25 miles from Lake Fairfax and does not offer as great a variety of recreational activities; it is more of a natural atmosphere.
Lake Bernard Frank Derwood, MD Montgomery County, MD	Rustic - shore fishing only	50-75/day	Lake Bernard Frank is approximately 30 miles from Lake Fairfax and offers only fishing; it is underdeveloped and still very rustic.
Burke Lake Lorton, VA Fairfax County, VA	Recreational - picnic area, carrousel, rowboats mini-train, bike rental, golf, frisbee, par fitness course and fishing.	386,000/year	Burke Lake is approximately 10 miles from Lake Fairfax within Fairfax County. It serves a great number of people and offers more recreational activities than Lake Fairfax.
Seneca Creek State Park Gaithersburg, MD Montgomery County, MD	Picnic area, boating, and fishing (Natural atmosphere)	65,000+/year	Seneca Creek State Park is approximately 35 miles from Lake Fairfax and has less recreational facilities; it offers a natural setting.
Fishing Creek Reservior 4/5 miles North W. of Frederick, MD Frederick County, MD	Trails, picnic, fishing, and nature walking 8,000 acres	2,000/year	Fishing Creek Reservior is approximately 50 miles from Lake Fairfax and does not offer quite the variety of recreational facilities.

II.8. Inventory of Point Source Pollution Discharges Within the Watershed of Lake Fairfax

A review of the existing Virginia SWCB information on National Pollutant Discharge Elimination System Permits revealed only one current or past permit within the watershed of Lake Fairfax (Table II.8.a.). The A. Smith Bowman Distillery has an NPDES permit for discharge of water used for cooling. The distillery discharges into the upper reaches of Colvin Run, as shown on Figure II.8.a. This effluent has no significant effect on Colvin Run or on Lake Fairfax as far as our information to date indicates.

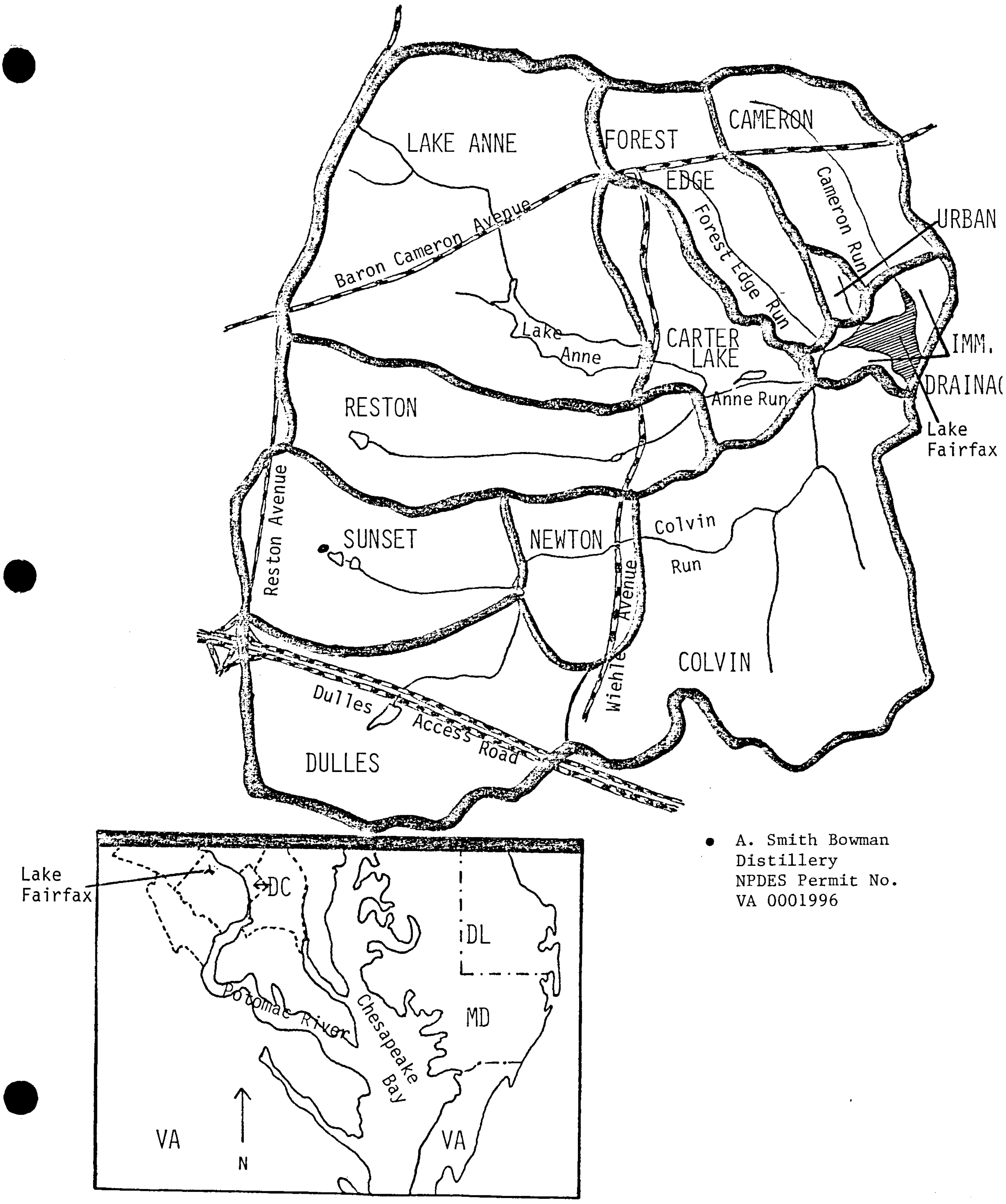
Table II.8.a.

Point Source Inventory

Name	NPDES Permit #	Receiving Water	S/C/I	Discharge Flow	Constituents	Limits	Abatement Actions
A. Smith Bowman Distillery	VA0001996	Colvin Run	C	No Restrictions	Temp pH	90°F 6.0-8.5	None Anticipated

S = Seasonal; C = Continuous; I = Intermittent

FIGURE II.8.a
THE LAKE FAIRFAX WATERSHED



● A. Smith Bowman
Distillery
NPDES Permit No.
VA 0001996

II.9. Land Use and Nonpoint Pollutant Loadings in the Lake Fairfax Watershed

a. Land Use Categories and Area Measurements

There are many definitions of land usages. In the Lake Fairfax study, land uses employed were as outlined in Table II.9.a, and were very close to those used by the Northern Virginia Regional Planning District Commission (NVRPDC) in their nonpoint pollution study. Since Fairfax County sectional maps were utilized for determining areas of each category within the subwatersheds, land uses had to agree with zoning criteria.

Areas were assigned to each land use using the following procedure:

1) Subwatersheds were traced onto county property maps.
2) Parcels, singly or as subdivisions, were assigned to land uses; questionable cases were either researched on other maps or clarified by site visits; uses not falling precisely into one of the land use categories were assigned to the category most closely reflecting the area's expected pollutant export, based primarily on estimated imperviousness.
3) Land use areas were determined by planimetry of the country property maps. A Hewlett Packard 98-25A keyboard system equipped with a 98-75A digitizer was used for areal measurements.
4) Future land uses were estimated from zoning and dominant uses in the vicinity of the developable area.

TABLE II.9.a.

COMPARISON OF LAND USE CATEGORIES

NUSAC Study	Northern Virginia Regional Planning District Commission	Fairfax County Zoning
Residential		
Estate Residential	Estate Single Family Residential	R1
Low Density Residential	Large-Lot Single Family Residential	R2
Medium Density Residential	Medium Density Single Family Residential	R3
Townhouse/Garden Apartment	Townhouse/Garden Apartment Residential	R5-R20
Highrise Residential	High-Rise Residential	R30
Commercial		
Low to Medium Density Retail	Suburban Shopping Center	C5-C6
Medium to High Density Retail	Central Business District	C6-C7
Industrial		
Low to Medium Industrial	Medium Imperviousness	C5-C6
Heavy Industrial	High Imperviousness	C6-C7
Institutions		Identified on zoning maps
Hospitals	Institutional	
Schools	Institutional	
Other	Institutional	
Parks - Open Space		Identified on zoning maps
Parkland-Recreational		Public Lands
Parkland-Forest	Forest	Public Lands
Planned Zoning, currently forest	Various	Various
Idle Land/Grassland/Pasture	Idle/Pasture	
Cemetaries	--	Identified on maps
Cropland	Cropland	
Water Retention Basins	--	Identified on maps
Transportation	--	Estimated from maps

TABLE [illegible].b Land use summary for the Lake Fairfax Watershed. Data are the areas in hectares being used in each category within the watersheds as of 1980 development.

	CURRENT LAND USE SUB-WATERSHEDS	Cameron	Carter Lake	Colvin	Dulles	Forest Edge	Immediate Drainage	Lake Anne	Newton	Reston	Sunset	Urban	TOTAL AREA: HECTARES	TOTAL AREA: %
RESIDENTIAL	R1 Estate Residential	3.1				2.12			1.6		24.8		31.62	2.8
	R2 Low Density	32.1	1.15	64.01	7.54	15.3		1.58	4.14	13.28	8.5	5.94	153.54	13.8
	R3 Medium Density	2.7	0.61		6.82	6.23		23.8	2.77	14.7	11.0		68.63	6.3
	R5 Townhouse/Apt R20RT	1.224	37.8	13.86	1.0	10.5		29.4	3.0	34.17			130.95	11.8
	R30 Highrise			0.72				42.2	0.7	2.45			46.07	4.2
COM.	C5/C6 Low to Medium Retail/Office							5.0	17.7		2.16		24.86	38.9% 2.2
	C7/C8 Medium to High Retail/Office													
INDUS.	I1-I4 Low to Medium Industrial			61.31	45.52						25.21		132.04	11.9
	I5/I6 Heavy Industrial													
INST.	Hospitals													
	Schools					5.22		2.63		1.4			9.25	0.8
	Other		1.51			1.0		2.95	0.72	2.95			9.13	0.8
PARKS	Recreational Parkland					7.5		14.1					21.60	15. 1.9
	Parkland Forest		7.19	76.6	2.7	0.86	17.82	2.6		4.0	1.44	2.7	115.91	10.4
	Planned Zoning, Still Forest	21.93	10.0	4.0	67.64	15.33		84.13*	11.9		20.8		235.73	21.2
	Idle Land/Grassland/Pasture (Crop Land)	(3.24)		4.0			9.76	3.24		37.9	1.1		59.24	5.3
	Water Retention		3.9				8.172	11.63					23.70	2.2
	Transportation	2.7	1.94	0.8	21.75	2.5		8.6	3.0	2.84	5.08		49.21	4.4
	TOTAL AREA	66.94	64.1	225.3	152.97	66.56	35.752	231.86	45.53	113.69	100.09	8.64	1111.4	45.4 20. 100.0

* Estimated

TABLE 9.c Land use summary for the Lake Fairfax W rshed. Data are the areas in hectares being us in each category within the watersheds estimated with complete development.

FUTURE LAND USE	SUB-WATERSHEDS	Cameron	Carter Lake	Colvin	Dulles	Forest Edge	Immediate Drainage	Lake Anne	Newton	Reston	Sunset	Urban	TOTAL AREA: HECTARES	TOTAL AREA:
RESIDENTIAL	R1 Estate Residential	3.1				2.12			1.6		24.8		31.62	2.8
	R2 Low Density	47.1	1.15	66.01	18.86	15.3		1.58	7.14	13.28	8.5	5.94	184.86	16.6
	R3 Medium Density	4.63	0.61		18.14	16.53		23.8	8.77	34.7	26.0		133.18	12.0
	R5 Townhouse/Apt R20RT	1.224	45.8	13.86	1.0	10.5		33.31	3.0	41.17			149.86	13.5
	R30 Highrise			0.72				42.2	0.7	2.45			46.07	4.1
COM.	C5/C6 Low to Medium Retail/Office							65.43*	17.7		2.16		85.29	7.7
	C7/C8 Medium to High Retail/Office													
INDUS.	I1-I4 Low to Medium Industrial			61.31	90.52						25.21		177.04	15.1
	I5/I6 Heavy Industrial													
INST.	Hospitals													
	Schools					5.22		2.63		1.4			9.25	0.8
	Other		1.51			1.0		2.95	0.72	2.95			9.13	0.8
PARKS	Recreational Parkland					7.5		14.1					21.60	1.9
	Parkland Forest		7.19	76.6	2.7	0.86	17.82	2.6		4.0	1.44	2.7	115.91	10.4
	Planned Zoning, Still Forest	5.0	2.0	2.0	10.64	5.0		21.03*	2.9		5.8		54.37	4.9
	Idle Land/Grassland/ Pasture(Crop Land)	3.24		4.0			9.76	2.0		10.9	1.1		31.0	2.8
	Water Retention		3.9				8.172	11.63					23.70	2.2
	Transportation	2.7	1.94	0.8	21.75	2.5		8.6	3.0	2.84	5.08		49.21	4.4
TOTAL AREA		66.94	64.1	225.3	152.97	66.56	35.752	231.86	45.53	113.69	100.09	8.64	1111.4	100.0

* Estimated

TABLE II.9.d.

RATES FOR UNCONTROLLED NONPOINT POLLUTION EXPORT*
(kg/ha/yr for Silt Loam Soils)

Land Use	Imperviousness		Total Nitrogen TN	Total Phosphorus TP	$\frac{TN}{TP}$ N:P	Sediment TSS
Estate Residential 0.1 - 1. DU/Ha	<9%		4.03	0.34	11.85	202
Low-Density Resid. 1 - 7 DU/ha	9-19%		7.40	1.01	7.33	291
Med- Density Resid. 7 - 15 DU/ha	20-35%		9.86	1.23	8.02	448
TH/APT Residential 15 - 50 DU/Ha	35-50%		13.90	1.79	7.77	740
High Rise Residential >50 DU/ha	50-75%		12.16	1.46	8.33	672
Industrial	60-80%		12.50	1.51	18.88	493
Shopping Center	90%		14.79	1.79	8.26	605
Central Bus. District	95%		27.57	3.03	9.10	628
Institutions	Variable	Imper.	15.58	1.87		583
		Perv.	4.03	0.46		112
Cropland - Conven.Tillage	1%		20.85	4.71		4528
- Min.Tillage	1%		10.76	1.68		1905
Cow Pasture			6.84	0.56		157
Forest			2.80	0.11		157
Idle Land			3.36	0.18		134

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* Values have been summarized and converted to metric units from Tables 5, 6, and 9 in MWCOG 1979.

TABLE II.9.e.

THE LAKE FAIRFAX WATERSHED: NUTRIENT AND SOLIDS EXPORT RATES
Phosphorus

		Annual Phosphorus Export			
		Current		Future	
Subwatershed	Area-hectares	Total kg/yr	Areal kg/ha/yr	Total kg/yr	Areal kg/ha/yr
Cameron	66.94	50.38	0.75	70.59	1.05
Carter Lake	64.10	106.0	1.65	120.32	1.88
Colvin	225.30	183.30	0.81	185.10	0.82
Dulles	152.97	115.02	0.75	194.41	1.27
Forest Edge	66.56	63.47	0.95	73.0	1.10
Immediate Drainage	35.75	17.45	0.49	17.45	0.49
Lake Anne	231.86	212.92	0.92	369.07	1.59
Newton	45.53	52.64	1.16	62.06	1.36
Reston	113.69	114.44	1.01	146.71	1.29
Sunset	100.09	77.49	0.77	94.29	0.92
Urban	8.64	6.30	0.73	6.30	0.73
Total Fairfax Watershed	1111.40	999.41	0.90	1339.3	1.21
*Adjusted Values		*807.78	0.73	1007.14	0.91

*Lake Anne's pollutant trapping is estimated to be 90% of sediment, and 50% of TP and TN. Correcting for this trapping provides the lower total export.

TABLE II.9.f.

THE LAKE FAIRFAX WATERSHED:
NUTRIENT AND SOLIDS EXPORT RATES
Nitrogen

		Annual Nitrogen Export			
		Current		Future	
Subwatershed	Area-hectares	Total kg/yr	Areal kg/ha/yr	Total kg/yr	Areal kg/ha/yr
Cameron	66.94	419.53	6.27	502.15	7.50
Carter Lake	64.10	835.87	13.04	947.07	14.77
Colvin	225.30	1617.0	7.18	1626.0	7.22
Dulles	152.97	1087.56	7.11	1632.74	10.67
Forest Edge	66.56	518.25	7.79	590.88	8.88
Immediate Drainage	35.75	210.17	5.88	210.17	5.88
Lake Anne	231.86	1905.66	8.22	2159.75	9.93
Newton	45.53	452.56	9.94	540.73	11.88
Reston	113.69	977.89	8.60	1181.67	10.39
Sunset	100.09	710.21	7.10	816.11	8.15
Urban	8.64	51.51	5.96	51.51	5.96
Total Fairfax Watershed	1111.40	8786.21	7.91	10,332.04	9.30
*Adjusted Values		*7071.12	6.36	8,388.27	7.55

*Lake Anne's pollutant trapping is estimated to be 90% of sediment, and 50% of TP and TN. Correcting for this trapping provides the lower total export.

TABLE II.9.g.

THE LAKE FAIRFAX WATERSHED: NUTRIENT AND SOLIDS EXPORT RATES

Solids

Subwatershed	Area-hectares	Annual Solids Export			
		Current		Future	
		Total kg/yr	Areal kg/ha/yr	Total kg/yr	Areal kg/ha/yr
Cameron	66.94	22,764	340	25,336	378
Carter Lake	64.10	45,306	707	51,226	799
Colvin	225.30	67,581	300	67,849	301
Dulles	152.97	43,969	287	61,520	402
Forest Edge	66.56	22,995	345	25,988	390
Immediate Drainage	35.75	8,870	240	8,870	240
Lake Anne	231.86	92,926	401	93,948	405
Newton	45.53	19,590	430	21,738	477
Reston	113.69	52,090	458	62,612	551
Sunset	100.09	29,523	293	33,888	339
Urban	8.64	2,152	249	2,152	249
Total Fairfax Watershed	1111.40	407,766	367	455,127	410
*Adjusted Values		* 324,133	292	370,574	333

*Lake Anne's pollutant trapping is estimated to be 90% sediment, and 50% of TP and TN. Correcting for this trapping provides the lower total export.

b. Area Within Each Land Use

The land use areas determined as described above are given in Table II.9.b. under current conditions, and II.9.c. for complete development.

The dominant land uses in the Lake Fairfax watershed are forest with planned development (21%); low density (14%) and townhouse residential (12%); and low to medium industrial (12%) which translates largely into office complexes in the Reston area. In the future, low, medium, and townhouse density residential will increase, as will commercial and industrial uses. Major changes can be expected in the Dulles and Lake Anne subwatersheds.

c. Nonpoint Source Loadings Derived from Land Use Data

The Northern Virginia Regional Planning District Commission (NVRPDC) report to Metropolitan Washington Council of Governments (1979) summarized a large, intensive modelling and data collection effort which generated pollutant export coefficients applicable to the Northern Virginia area. These coefficients were used to estimate nonpoint source pollutant loadings for the Lake Fairfax watershed. The NVRPDC values for silt loam soils (see section II.2.) were converted to metric units and averaged for the land use categories employed in this study. The resulting export rates are given in Table II.9.d. The calculated exports for each watershed (export rate X area) are presented in Tables II.9.e., f., and g. for phosphorus, nitrogen, and solids, respectively.

The Fairfax watershed exports a large quantity of phosphorus to the lake, although the overall rate per unit area of pollutant removal is less than that expected from low density residential neighborhoods. However, when this rate is applied to the 1111. hectare area, phosphorus loading is high at 808. kg P per year and translates to 9.26 $gP/m^2/yr$ as a lake loading rate. This figure will be used in trophic state analysis in the following section. At future development, the uncontrolled P loading from nonpoint sources will be 1007. kg, a 25% increase, and 11.54 $gP/m^2/yr$ areally at the lake. Increasing pollutant exports from the Dulles and Lake Anne subwatersheds are primarily responsible for this increase. The pollutant trapping by the new Reston lake north of Baron Cameron Avenue has not been included in these figures - its presence will undoubtedly lower pollutant loading from the Lake Anne watershed.

The export rates of nitrogen reflect the same patterns as noted above for phosphorus. However, nitrogen loading is not predicted to increase with future development as much as phosphorus; a +19% as opposed to a +25%. In turn, sediments will increase even less than nitrogen at only a +14% of current levels. The high trapping efficiency of Lake Anne is a major factor underlying this modest increase. Exports of solids and nitrogen occur at rates similar to those seen in low density residential housing (Table II.9.d.).

FIGURE II.9.a

Dynamics of daily loading rates for total phosphorus during the Phase I study of Lake Fairfax. Data are grams exported per day based on discharge and pollutant concentration data summarized in Appendix II.9.d.

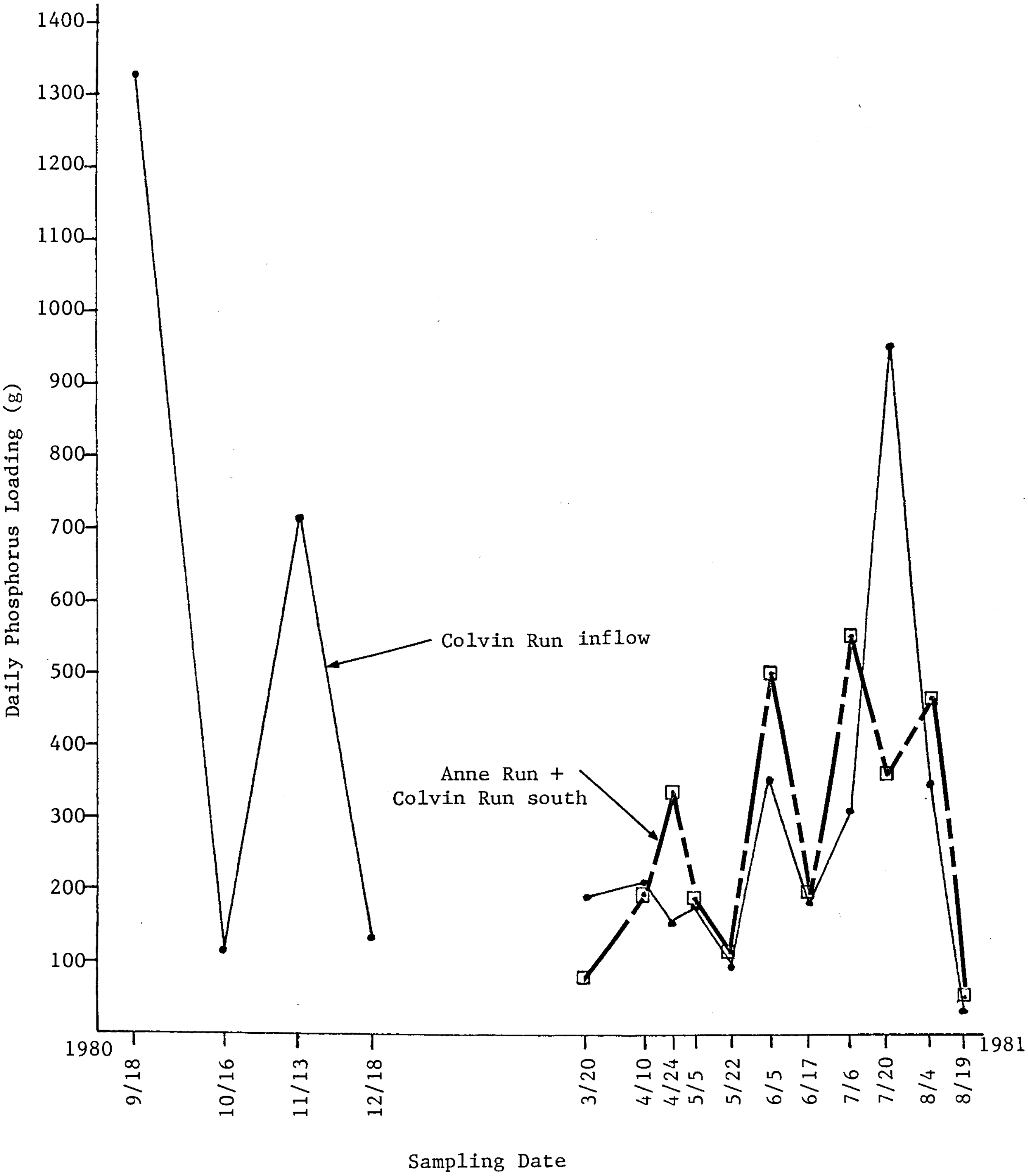


FIGURE II.9.b.

Dynamics of daily loading rates for total nitrogen during the Phase I study of Lake Fairfax. Data are grams exported per day based on discharge and pollutant concentration data summarized in Appendix II.9.d.

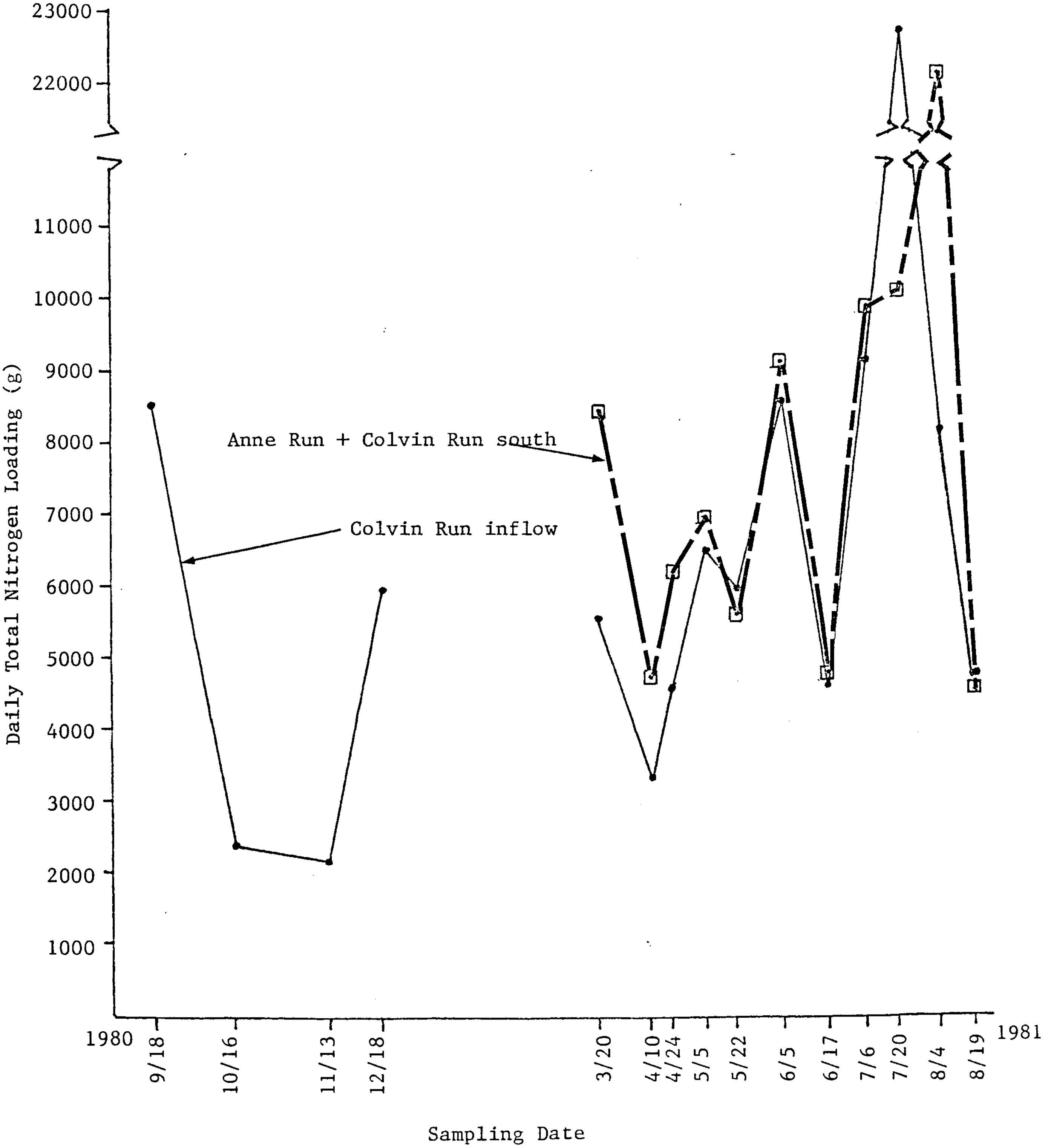
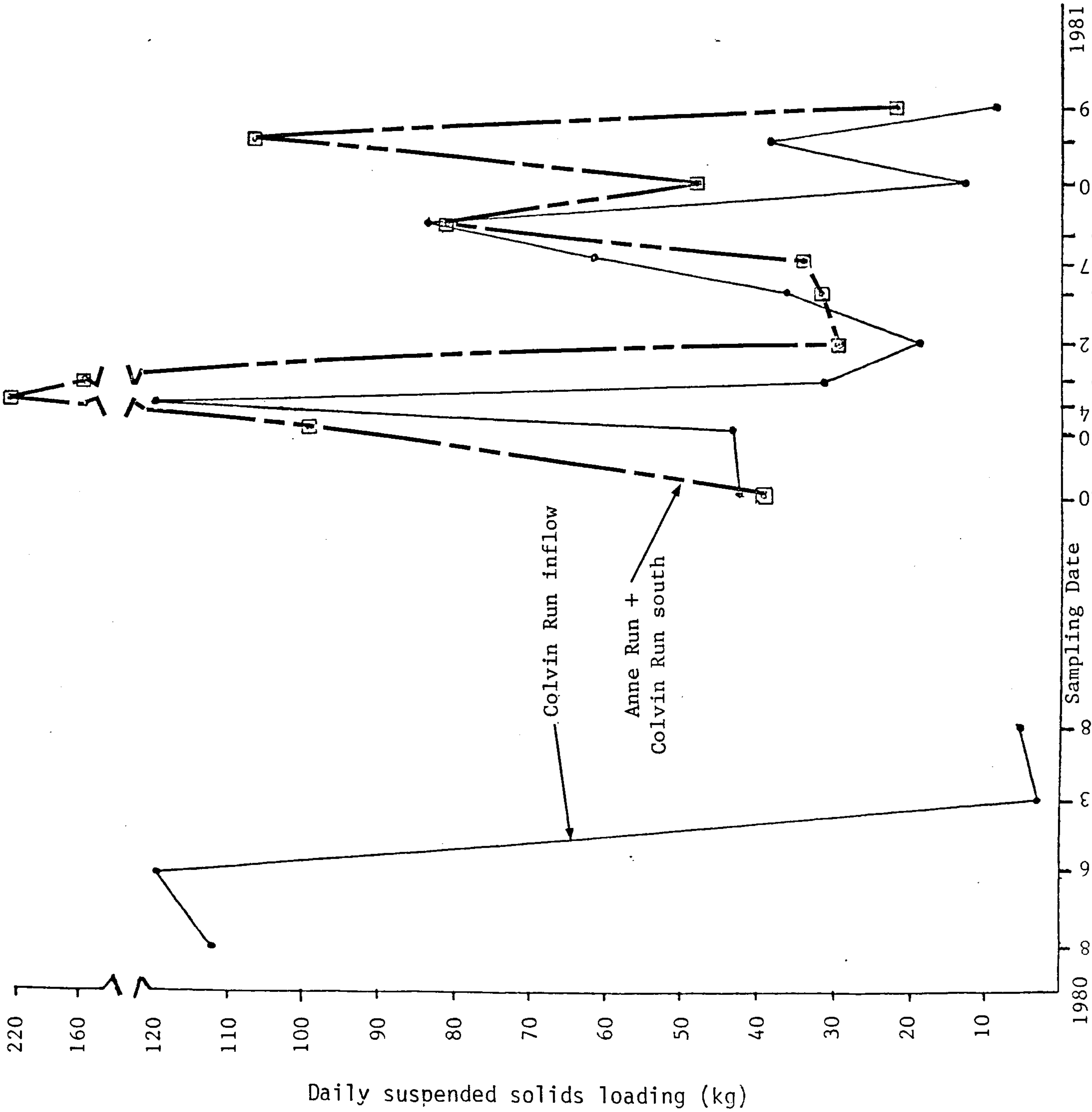


FIGURE II.9.c.

Dynamics of daily loading rates for suspended solids during the Phase I study of Lake Fairfax. Data are kilograms exported per day based on discharge and pollutant concentration data summarized in Appendix II.9.d.



d. Non-Storm Pollutant Loading to Lake Fairfax

The discharge measurements and water chemistry data taken on the tributaries to Lake Fairfax provide the basis for computing nutrient and solids input rates for non-storm conditions. Baseflow loading can then be compared to total imports estimated by export coefficients and to pollutant data collected during storm events.

The data on delayed flow pollutant loading is shown in figures II.9.a., b., and c. for phosphorus, nitrogen, and solids, and integrated values are summarized below:

	Stations	Colvin Run South*	Anne Run	Colvin Inflow as sum**	Colvin Inflow***	Colvin Outflow
	Parameters	(kg/yr)				
Total	9/80-8/81		36.56		123.19	176.48
Phosphorus	8/19/81	3/20/81- 25.03	19.12	44.15	43.00	
Total	9/80-8/81		898.20		2,255.85	2,427.10
Nitrogen	8/19/81	3-20-81- 661.85	637.35	1,299.20	1,172.35	
Suspended	9/80-8/81		6,393.10		13,208.40	25,254.40
Solids	3/20/81- 8/19/81	5,533.70	4,957.40	10,491.10	7,011.50	

* Station upstream from Anne Run confluence.

** As the sum of Colvin Run South and Anne Run.

***From direct measurement, rather than summing.

Several points emerge as significant regarding baseflow loadings. A relatively small proportion of yearly pollutant inputs (land-use based) are carried by delayed flow: 15% of TP, 32% of TN and only 4% of suspended solids. Thus, storms are clearly the major generators/transporters of nonpoint pollution of Lake Fairfax. Second, Colvin Run and Anne Run subdivisions of the watershed contribute nearly equal baseflow loads; Colvin ranges 53-57%. This same pattern holds for total yearly export until the pollutant trapping effect of Lake Anne is considered. With this removal included, the Anne Run area yield is reduced to about 40% of the Anne + Colvin Run total for TP, TN, and SS (43, 39, and 40%). Finally, the Colvin outflow export exceeds the Colvin import for all pollutants considered. This does not mean that the lake is a net exporter of substances. Instead, this difference reflects the detention of pollutants by the lake so that stormwater inputs not encompassed by routine tributary sampling are being measured, in part, by outflow sampling. Total yearly (storm and baseflow loading) far exceeds baseflow exports from the lake, and Lake Fairfax is clearly a sediment and nutrient trap based on its hydraulic residence time and known detention efficiencies.

e. Stormwater Pollutant Loading to Lake Fairfax

A total of four storm events were monitored in the Lake Fairfax watershed. This monitoring was undertaken to estimate stormwater pollutant loading which can then be compared to export coefficient based loadings. Also, the storm work can detect any sources of pollution not identified by the land use analysis, point source inventory, or baseflow monitoring effort.

Of the four storms, the first on May 1 generated by far the largest runoff. Storm #1 was sudden with 2 cm of rain falling between 0900 and 1000 hours, and another 2.3 cm falling through the later morning and early afternoon hours. The flashiness of this event made it impossible to sample the initial pulse of runoff and produced flood conditions which precluded accurate discharge measurement at most of the sampling stations. Due to these problems, only data for Colvin Run Inflow will be discussed; data are available for this station from early in the event to 72 hours later.

The original data for all storms are summarized in Appendix II.9.e. Storm 1 was the most significant of the events and deserves some separate discussion. Storm 1 generated phosphorus loading of 42 kg without the first two hours and 70 if the estimated initial inflow is included. These values translate to 924 and 1,532 kgP/yr, higher than the rate estimated by land use analysis in the previous section. This shows the major importance of this single event. Solids loading is 129,775 including the initial runoff. This value is used to estimate an annual accumulation of 986 m^3/yr. This value is only a rough estimate, but it is realistic in light of the analysis done on sediment accumulation in the following section.

Storm 1 had more intense runoff than any storm monitored later in the season and thus shows more dramatically the range of TP and SS concentrations in suburban runoff. At the peak runoff (1115 hours) suspended solids were 2660 mg/l which is over 500 fold the level on May 4 after the stormwater had passed. Similarly, phosphorus showed a 65 fold increase at peak flow. The mass transport rate (kg/min) was even greater in magnitude at peak flow, SS transport was over 20,000 times as rapid as baseflow rates (May 4), and TP inflows were over 2,000 as fast as post event levels. These data show clearly the crucial importance of stormwater in pollutant transport.

The major purpose of storm analysis is to generate annual pollutant yields for the watershed to assure that export coefficients do a reasonable job in predicting loading. Annual estimates were made by pooling the total mass loading from the storms and multiplying up to the long-term average rainfall of 105 cm per year (Dulles Airport). This analysis is summarized below:

Storm	Rain (cm)	TP Loading (kg)	Sus. Solids (kg)
1	4.3	70.	129,775
2	2.4	0.58	207
3	2.5	1.21	640
4	Insufficient Rainfall for Analysis		
5	1.0	1.13	1,391
TOTAL	10.2	73.	132,238.
ANNUAL	105.	751.	1,360,729

The four storms analyzed in the Lake Fairfax watershed reveal several important points: the vast majority of loading occurred during the Storm 1 event and most of the Storm 1 mass resulted from the 1 hour rain beginning at 0900. Thus, Storm 1 representing only about 4% of annual rain produced a mass load nearly as large as the total yearly estimate of export. These results are not intended to be quantitative for the year of the study since only four of many storms were analyzed, but they clearly show the relative magnitude of more intense events. Any restoration approach which cannot handle the more severe storms, will not be effective. In addition, the data summarized in Tables A.II.9.h., i, and j. in Appendix II.9.e. indicate no serious departures of loading expected for various subwatersheds. This result leads us to believe that no unidentified major pollutant sources exist in the Lake Fairfax watershed and that the land use-based estimates give reasonably accurate predictions of loading. The exception to this finding is storm-estimated sediment export which leads to very low annual accumulation rates. This difficulty will be dealt with in the following section as sediment accumulation is analyzed.

f. Sediment Accumulation in Lake Fairfax

Lake Fairfax appears to have had an original volume of 285,000 m^3, as listed in Table III-7 of PBQ and D (1978). Today, the lake has a volume of 220,431 m^3, giving a sediment accumulation of 65,000 m^3 over 25 years or 2,583 m^3per year. This is probably a very conservative estimate of accumulation since McHenry's rate of 7.38 m^3/ha would yield an accumulation of 205,000/ m^3 over the 25 years of the lake's life, and his 3.38 rate gives 94,000 m^3. We will assume that the average of the 65,000 and 94,000 yields a reasonable rate which is 79,500 or 3,200. m^3 per year.

Lake Fairfax currently has a predicted sediment retention efficiency of 76% based on Brune's 1953 figure. This trapping efficiency is bounded by extremes of 66 and 86%, encompassing median values for fine-grained (clays) and coarse-grained (sands) sediments, respectively. As the lake fills in it will retain less of inflowing sediments. For example, in 10 years, the lake will have a volume of about 188,000 m^3 and will retain about only 70% of inflowing sediment. It is tempting to speculate that the lake will last 68 years at a fill-in rate of 3,200 m^3 per year, but this involves many assumptions and is probably too long. McHenry's rate for small reservoirs (Table II.9.h.) would predict a life span of 27 years. The actual life expectancy for Lake Fairfax probably lies between these values at about 50 years.

The solids export rate of 324,133 kg/yr yields a very low sediment accumulation of 112. m^3 per year (assuming a bulk density of 2.2 and 76% retained). Values discussed above range from 2600 to

TABLE II.9.h.

A Summary of Sediment Accumulation Per Unit of Net Drainage Area.

Water Body	Drainage (sq.mi.)	Average Annual Sediment Accumulation (acre-ft/mi^2)	Average Annual Semiment Accumulation (m^3/ha)	Reference	Notes
	0-10	1.55	7.38	McHenry (1974)	Mean of 718 surveyed reservoirs
	10-100	0.71	3.38	McHenry (1974)	Mean of 189 surveyed reservoirs
Lake Fairfax	4.29	0.08	0.36	Examples based on Bull Run sediment export rates from Randall et.al.(1977)	Assumptions are: 1)76% efficienc in trapping 2)2.2kg/ℓ-bulk density 3)Total sedimen yield of 1054 kg/ha/yr
Lake Accotink	30.45	0.04	0.19	Examples based on Bull Run sediment export rates from Randall et.al.(1977)	Assumptions are: 1)40% efficienc in trapping 2)2.2kg/ℓ-bulk density 3)Total sedimen yield of 1054 kg/ha/yr
Lake Barcroft	14.50	a.0.26	3.47	Sediment Surveys reprinted in Tetra Tech(1981)	a.1915-1938
		b.0.73			b.1938-1957
Jackson Reservoir	337.00	0.14	0.67	"	Duration of loading - 7/1930 -8/1937
Greenbelt Lake	0.82	7.91	37.67	"	1936-1938
		2.27	10.81		1938-1957
		1.52	7.24		1957-1968

8,100 m^3 per year and 3,200, the compromise rate, is 28 fold higher than the export-based estimate. Clearly, sediment loading based on land use coefficients is far too low.

There are several possible reasons for this problem. Export coefficients do not measure erosion processes outside specific land-use categories, such as uncharted land disturbances and stream channel destabilization. Further, such coefficients do not necessarily estimate bedload (bottom-associated) movements. However, inclusion of these concerns does not bring the export-based loading 28 fold to those based on accumulation rates in the literature. Further research is needed on the subject, but for our purposes, 3,200 m^3 per year is a reasonable value for near-term sediment accumulation in Lake Fairfax.

II.10. Limnological Analyses of Lake Fairfax

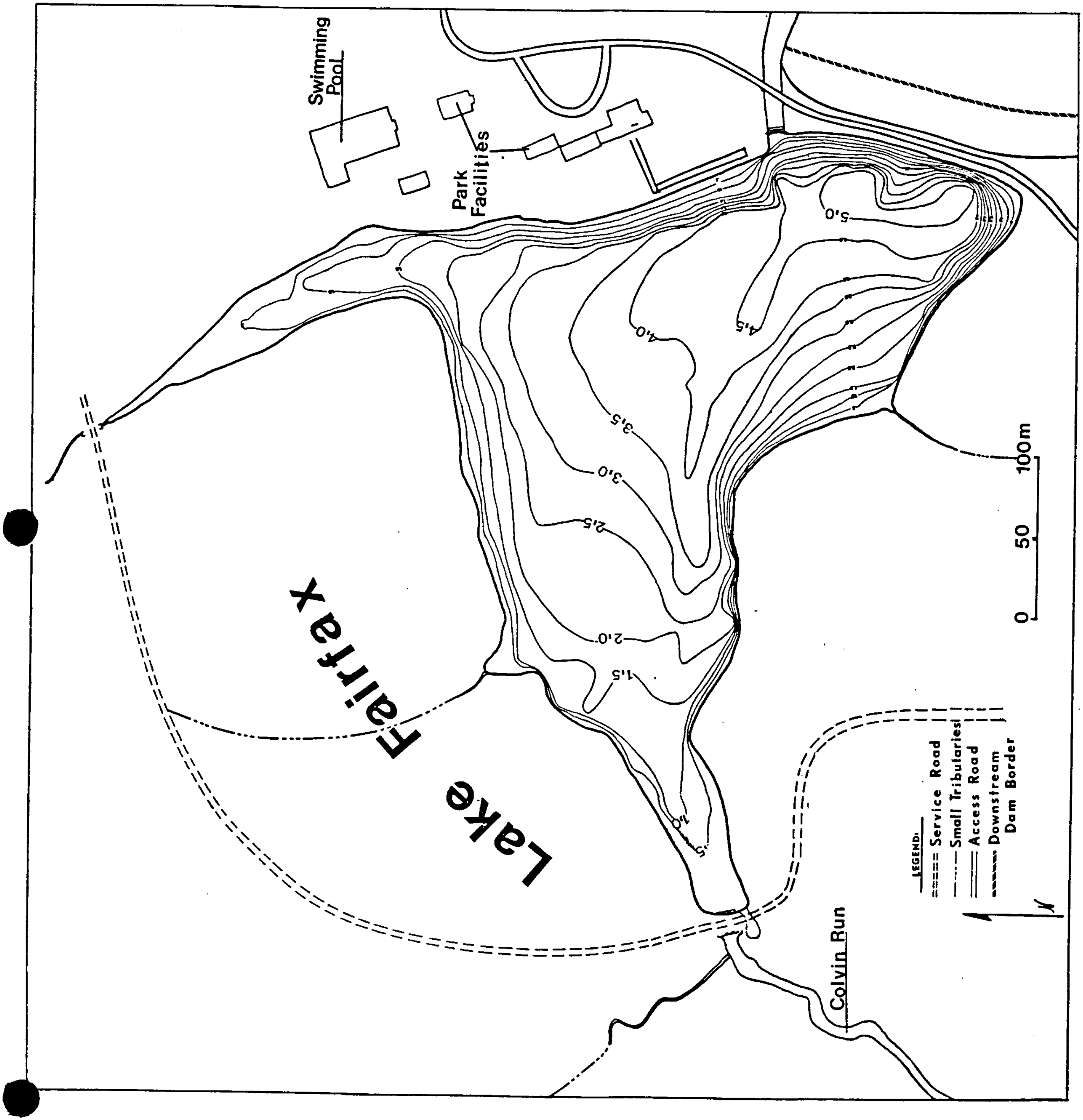
a. A Bathymetric Study of Lake Fairfax

A depth survey of Lake Fairfax was conducted to provide detailed and current information on depth and volume. Using alidade and plane table stations gave simultaneous angular readings on location while 133 depth soundings were made in multiple transects across the lake. Depths were then plotted on a map of the lake and 0.5 m contours drawn through points located by linear interpolation of depth data. The end result of this effort was the bathymetric map (Figure II.10.a.). A larger version of the map is inserted in the rear cover of this report and the original data are in Appendix II.10.a.

The map illustrates several noteworthy features of Lake Fairfax. The lake is primarily one basin without any portions isolated by submerged bars. Two coves are located at the inflow of Colvin Run to the west and Cameron Run to the north. These coves are important habitat for aquatic life and are in need of sediment removal; most of the cove areas are less than 1.0 m in depth. The small inlet cove on the north side of the lake receives the influent from the Urban subwatershed, a small area of homes near the northern park border. It can also be seen that most of the lake has ample depth for recreational and wildlife uses, being greater than 1.5 m.

FIGURE II.10.a.

A Bathymetric Map of Lake Fairfax. Depth contours are in 0.5 m intervals and are based upon soundings from March 1981.



The contour lines shown on the bathymetric map were analyzed to determine areas and volumes for various depth strata; these are presented in Table II.10.a. Of particular importance is the far right column giving volumes under various depths. These data have many immediate uses. For example, the bottom zone often extends from 2.0 m to the bottom. When the region is devoid of oxygen, 35.14% of the lake volume is not available to fish and severely limits biological productivity.

Similarly, using column 5 from the left, when the lake is without oxygen below 2.0 meters, 63.75% of the bottom surface may be uninhabitable by most benthic insects. These bathymetric statistics become valuable tools in determining the lake-wide effects of water quality measurements.

The following facts and figures are major findings of the bathymetric analysis of Lake Fairfax:

- Mean depth = 2.53 m, Maximum = 5.0 m
- Surface Area = 8.73 ha, Volume = 220,431 m^3
- Lake has a single, freely-communicating basin
- 73% of the lake area is greater than 1.5 m in depth, so that only selected coves deserve study for dredging to remove sediments
- Lake Fairfax has a high watershed area/lake area ratio of 126 which predisposes the system to high sediment and nutrient loading, and to a high rate of flushing.

BATHYMETRIC SUMMARY
TABLE II.10.a.
Lake Fairfax, Fairfax County, VA.

**Depths in Meters *Areas in Hectares		Mean Depth = 2.53 m Maximum Depth = 5.0 m			Surface Area = 8.725 ha Volume = 220,431 m^3			Volume Under Depth of Contour	
**Depth Contour	**Depth Interval	Areas* Trial 1	Areas* Trial 2	Area* Within Contour	Area* Within Contour as % Total	Comulative Volume m^3	Comulative Volume %	m^3	%
5.0	5.0	.164	.159	0.1615	0.13	8075.	3.67	0.	0.0
4.5	5.0-4.5	.551	.553	0.5520	6.33	26624.	10.26	1784	0.81
4.0	4.5-4.0	1.532	1.535	1.5335	17.58	68338.	31.00	6998	3.17
3.5	4.0-3.5	2.538	2.537	2.5375	29.08	105988.	48.08	17,176	7.79
3.0	3.5-3.0	3.555	3.554	3.5545	40.74	139041.	63.08	32,406	14.70
2.5	3.0-2.5	4.457	4.451	4.4540	51.05	163777.	74.30	52,427	23.78
2.0	2.5-2.0	5.562	5.562	5.5620	63.75	188707.	85.61	77,467	35.14
1.5	2.0-1.5	6.398	6.378	6.3880	73.21	203162.	92.17	107,342	48.70
1.0	1.5-1.0	7.247	7.247	7.2470	83.06	213900.	97.07	141,430	64.16
0.5	1.0-0.5	7.815	7.813	7.8140	89.56	218153.	98.97	179,083	81.24
0.0	0.5-0.0	8.7215	8.729	8.7253	100.00	220431.	100.00	220,431	100.00

b. Baseline Limnological Data on Lake Fairfax

There are not a lot of baseline data on Lake Fairfax before the sampling of the SWCB in 1980. The Fairfax County Health Department does not routinely sample Lake Fairfax or Colvin Run above the lake. The nearest station is Colvin Run where it joins Difficult Run, several miles below the lake. The data for 1979 are summarized below for this one station:

Fecal Coliform per 100 ml, % with			Dissolved Oxygen mg/l	Nitrate mg/l	pH	Phosphate
200	200-1000	1000				
47	47	6	10.	0.67	7.00	0.02

Water quality in Colvin Run below the lake is good without any apparent borderline concentrations. The dampening and pollutant trapping capability of Lake Fairfax is undoubtedly important in maintaining high quality.

In addition, Fairfax County Health Department has sampled Lake Fairfax over a four-year period for just solids and turbidity, as reviewed in PBQ and D (1975). The averages of these data are summarized below for the Lake:

	Range	1971	1972	1973	1974	(3 months) 1975
Turbidity Jackson Turb. Units	2.8-928	96	27	33	11	10
Total Suspended Solids	2.5-2420	221	124	38	10	10

These data are somewhat variable and do not give a very clear picture of Lake Fairfax. Without excessive storm inputs and active construction upstream, however, it is apparent that the lake has the potential for high quality water, as seen in the data from 1974 and 1975.

The Fairfax County Health Department tested the water quality in Colvin Run below Lake Fairfax where it joins Difficult Run. During the period from May to October, 1980, 79% of samples had coliforms less than 200/100 ml and none were found with 1000/100 ml or more. Also, data on nitrate and phosphate concentrations averaged 0.64 and 0.13 mg/l, respectively. Health Department work in 1980 thus indicates that Colvin Run below Lake Fairfax is satisfactory for use as water supply, contact recreation, and propagation of aquatic life.

As part of Fairfax County Task Order 10.5, sampling for water quality testing was conducted at 2 stations on Colvin Run; Wiehle Avenue above Lake Fairfax and Hunter Mill Road below. The data collected on the two dates of this sampling are summarized below:

Parameters in mg/l

Station	pH	Oxygen	TP	TN	Total Solids	Susp. Solids	Lead
Colvin Run -Wiehle Ave.							
5/7/75	6.45	11.0	0.04	0.54	70	3	-
6/6/75	6.60	7.5	0.01	1.03	78	29	0.0028
-Hunter Mill Road							
5/8/75	6.5	9.0	0.02	0.72	54	5	0.0028
5/23/75	6.5	7.4	0.16	0.75	106	13	0.0013

This body of observations shows no objectionable levels of important constituents. Good water quality (non-storm) was also found in other parts of the Difficult Run watershed.

Virginia SWCB personnel sampled Lake Fairfax on September 21, 1977. They found that oxygen declined by about 50% from 1 to 4 m and that Secchi transparency was 1.2 m. Total nitrogen to phosphorus ratio was 19 which is close to neutrality at 15, and chlorophyll 'a' was high at 23 mg/m^3. State workers noted that the lake was eutrophic with fertility and siltation derived from urbanization in the watershed.

More recent data were collected by the SWCB as part of their lake classification survey. This effort, which covers the period April-October 1980, is summarized in Table II.10.b. The key finding from this information is that Lake Fairfax is moderately eutrophic. Specifics include:

- phosphorus levels are modestly above the recommended .025 mg/l level.

- nitrogen is within normal range for a suburban watershed at 0.9 mg/l.

- suspended solids average within the range of common concentrations.

- oxygen is satisfactory at 85% saturation, but bottom region levels average much less at about 30% saturation.

Table II.10.b DATA SUMMARY: Va. SWCB STUDY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: All
Watershed: Difficult Run

Project: Lake Class Survey
Interval: Total Averages April-Oct. 1980
Other:

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3 mgN/l	N-NH3 mgN/l	N-TKN mgN/l
4/80-10/80	A_{123}	all	19.5	8.23	122.6	.031	.019	.01	.33	.38	.10	.57
4/80-10/80	I_1	surface	18.4	7.4	101	.013	.01	.01	.81		.10	.243
4/80-10/80	O_1	surface	23.6	8.5	106	.025	.0143	.01	.51	.34	.143	.386

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Notes
4/80-10/80	A_{123}	all		14.3		26.1	7.63	85.4	29.0	22.6	1.01 m	
4/80-10/80	I_1	surface		5.6		22.9	9.1	99.8	81.	91.		Inflow rate ave: 48.7 l/s
4/80-10/80	O_1	surface		8.3		24.1	8.64	104.1	35.4	45.6		Outflow rate ave 106.7 l/s

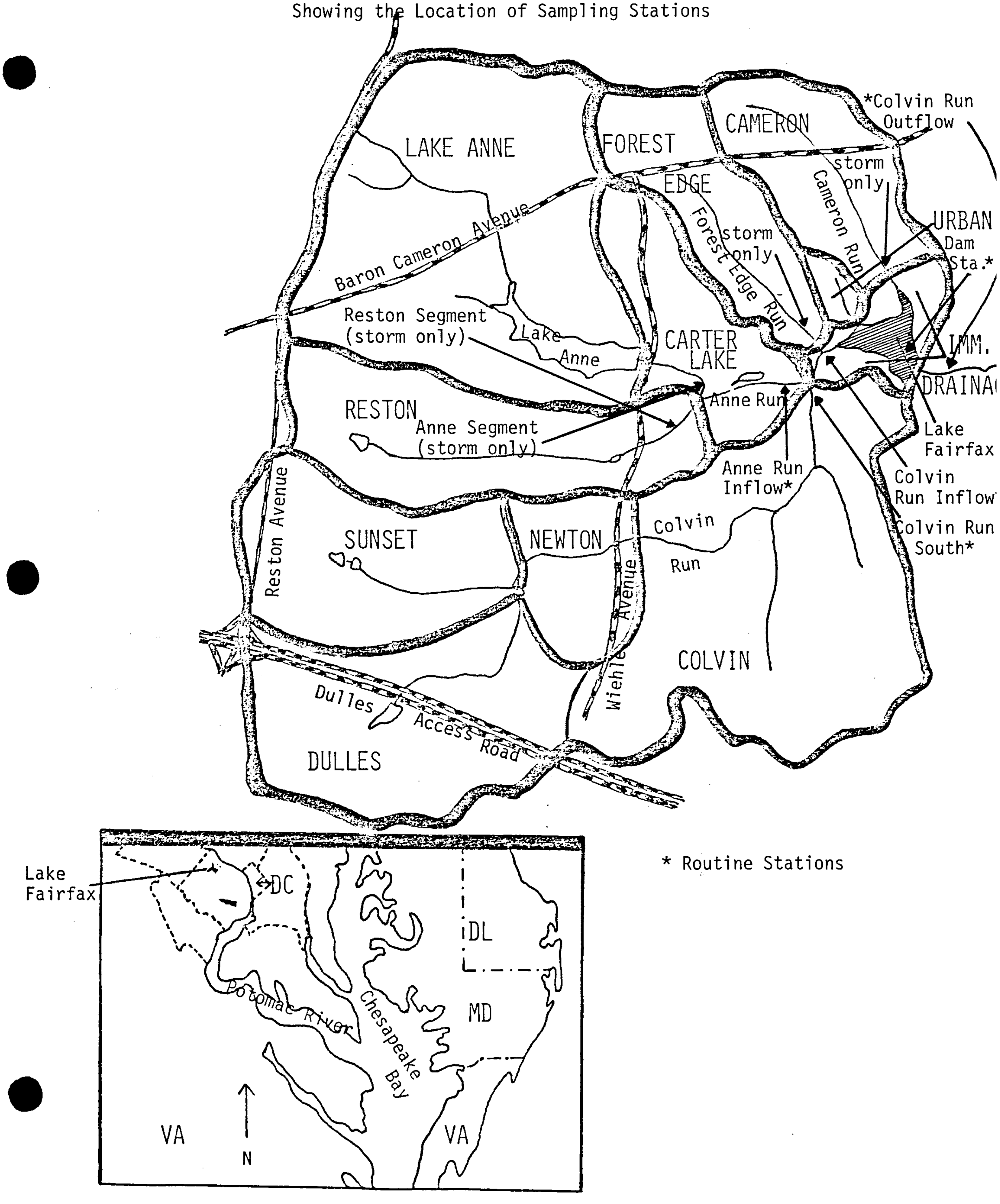
- the nitrogen:phosphorus ratio is significantly greater than 15, suggesting phosphorus as the most limiting element for algal growth.

c. Current Physical/Chemical Data on Lake Fairfax

Methods used in collecting current limnological data are all USEPA approved and the routine sampling regime follows the recommendations of Appendix A of 40 CFR 35, subpart H, while storm event sampling and quality assurance follow Appendix E of EPA (1980). The following specific methods and instruments were employed for the NUSAC field study in both routine and storm event sampling:

Parameter	Methods	EPA (1979) #
Temperature	YSI meter, Model 57	
Dissolved Oxygen	YSI meter, Model 57	360.1
Conductivity	YSI Water Quality Meter 33	120.1
pH	Hach, digital pH meter	150.1
Nitrogen		
Ammonia	Colorimetric	350.1
Nitrate-Nitrite	Colorimetric	353.2
Organic	Kjeldahl digestion	351.2
Phosphorus		
Total	Colorimetric	365.4
Soluble	Colorimetric	365.4
Total Solids	Gravemetric	160.3
Chlorophyll "a"	Spectrophotometric, acetone extraction	
Phytoplankon	Utermoeul chamber enumerations	
Sediment		
Metals	Extraction, Methods for the Chemical Analysis of Water and Wastes,	
Chlorinated pesticides	Methods for Organic Compounds in Municipal and Industrial Wastewater, Method 608, EPA, 1979.	

FIGURE II.10.a.a.
THE LAKE FAIRFAX WATERSHED
Showing the Location of Sampling Stations



On 15 dates spanning the period September 1980 through August 1981, water quality analyses were conducted of Lake Fairfax and its tributaries. Methods used for these determinations were all standard EPA approved, and results are given in Tables II.10.c, d, and e. on a quarterly basis; an overall summary is contained in Table II.10.f.

Key findings from these data are:

- Lake Fairfax and its tributaries show no unusual patterns in pH and are nearly neutral (pH= 7). The slightly acid conditions in the bottom zone is normal for a eutrophic lake.

- Electrical conductance mirrors dissolved solids levels, and is reasonably low (less than 100) in the lake and its tributaries. Higher levels in the hypolimnion or bottom zone are the result of biological degradation of organic matter and chemical solubilization. These elevated conductivities are associated with unwanted excessive fertility, but they do not directly cause any serious decline in water quality.

- Phosphorus levels tended to be highest in the fall of 1980 when they averaged well above the 0.101 mg/l concentration. Overall means were between 0.05 and 0.09 mg/l, and although lower, these levels are still of

Table II.10.c. DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: All Routine Stations
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: Sept.-Dec. 1980
Other: Fall Quarter Summary

Sample Date	Dates	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
Colvin	Outflow 4			7.18	102.1	0.154	0.190	0.016	0.306	0.291	0.556	0.974
Colvin	Inflow 4			6.79	81.73	0.178	0.090	0.009	0.790	0.780	0.406	0.626
Anne Run	4			2.13	91.2	0.103	0.092	0.008	0.46	0.452	0.425	0.367
Dam	4			6.97	116.5	0.143	0.058	0.0104	0.256	0.245	0.781	1.206

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Notes
Colvin Outflow			72.15	11.29	60.86	34.			8.31	4.54		
Colvin Inflow			61.93	9.49	52.44	34.			7.96	13.29		
Anne Run			58.5	5.8	52.7	34.			8.03	9.62		
Dam			76.3	10.84	65.46	34.	8.41	75.71	10.22	17.88	1.233	

Table II.10.d. DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: All Routine Stations
Watershed: Difficult Run

Project: Phase 1-Routine
Interval: March-May 1981
Other: Spring Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm At 25°C	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
Colvin Run	Outflow	surface	16.0	7.25	112.4	0.046	0.0146		0.496		0.12	0.494
Colvin Run	South	surface	14.4	7.01	94.8	0.0254	0.0154		0.548		0.154	0.472
Colvin Run	Inflow	surface	14.6	7.0	100	0.029	0.016		0.47		0.092	0.50
Anne Run	Inflow	surface	15.0	6.94	105	0.0260	0.0136		0.40		0.088	0.374
Lake:	Epilim	0-3	13.8	7.1	105	0.043	0.0192		0.55		0.144	0.437
Lake:	Hypolim	3-5	11.6	6.8	111.3	0.039	0.021		0.54		0.172	0.532
Lake:	$\overline{X}$	0 5	12.8	6.97	108.2							

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	$\frac{TN}{TP}$	$\frac{Inor\ N}{Sol\ P}$	Trans-parency	Discharge L/S
Colvin Run	Outflow		15.44						21.5	42.2		100.60
Colvin Run	South		13.0						40.2	45.6		48.35
Colvin Run	Inflow		10.5						33.5	35.13		159.1
Anne Run	Inflow		8.6						29.8	35.9		58.5
Lake:	Epilim		10.92				9.26	92.4	23.0	36.1		
Lake:	Hypolim		10.75				5.62	53.4	27.5	34.0		
Lake:	$\overline{X}$					22.0	7.67	75.0			0.75	

Table II.10.e. DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: All Routine Stations
Watershed: Difficult Run

Project: Phase 1-Routine
Interval: June-August 1981
Other: Summer Quarter Summary

Sample Date	Dates	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
olvin Outflow	6	Surface		7.58	95.37	0.0397	0.0252		0.394		0.151	0.78
olvin R. Inflow	5	Surface		6.94	94.40	0.0260	0.0212		0.680		0.120	0.60
olvin. R. South	6	Surface		7.038	94.62	0.0980	0.023		1.097		0.172	0.507
nne Run	6	Surface		7.04	97.75	0.0397	0.018		0.860		0.223	0.705
am Epilim	6	0-3		7.08	89.77	0.0827	0.0258	1.076	0.334	0.520	0.186	0.742
am Hypolim	6	3-5		6.743	178.32	0.0733	0.0188	1.989	0.252	1.272	1.02	1.737
am Total	6	0-5		6.912	127.66	0.0781	0.0208	1.553	0.293	0.923	0.630	1.260

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN/TP	Inor N/Sol P	Trans-parency	Notes
olvin Outflow			7.19			41.0						
olvin Inflow			7.54									
olvin R South			6.85									
nne Run			8.77									
am Epilim			7.395			30.5	7.48	92.15	13.01	20.155		
am Hypolim			19.097			45.5	0.292	3.361	27.135	67.660		
am Total			13.22			39.5	3.759	45.839	19.88	44.375	1.125	

Tables II.10.f. DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: All Routine Stations
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: Sept. 80 - August 81
Other: Overall Mean Concentrations

Sample Date	DATES	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
Colvin outflow	15			7.3	96.83	0.073	0.066		0.405		0.249	0.714
Colvin inflow	14			6.90	92.52	0.074	0.039		0.633		0.190	0.571
Colvin Run South	11			7.028	82.118	0.065	0.020		0.847		0.164	0.491
Anne Run	14			7.03	98.79	0.0484	0.0316		0.443		0.218	0.514
Dam (Epilim)	10			7.05	96.55	0.0756	0.0249	1.027	0.345	0.538	0.193	0.628
Dam (Hypolim)	10			6.65	141.86	0.0936	0.0236	1.885	0.290	1.265	0.975	1.595
Dam (Total)	15			6.95	118.2	0.0828	0.0305	1.354	0.366	0.879	0.513	0.988

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency S.D.	Notes
Colvin outflow				11.03								
Colvin inflow				9.146								
Colvin Run South				9.618								
Anne Run				8.071								
Dam (Epilim)				7.717			8.245	96.00	13.58	23.41		
Dam (Hypolim)				15.651			1.289	12.88	20.14	53.60		
Dam (Total)				11.84			6.30	63.12	16.35	28.82	1.00	

concern since 0.02 mg/l can sometimes cause algal blooms in lakes. Virginia water quality criteria are that no inflow should exceed 50 mg/l in mean concentration and reservoir waters should not be greater than 25 mg/l to ensure reasonable quality for general lake use. Lake Fairfax and its inflows are within these guidelines.

- Nitrogen forms occurred at levels within the range expected for a suburban watershed. In comparison, they are nearly equal to phosphorus. This is seen in the TN:TP ratios which are within the common range of 15-25.

- Suspended solids were not especially high averaging about 10 mg/l in the inflows and 12 mg/l in Lake Fairfax; these values are far below Virginia maximum standards.

- Alkalinities are quite normal at less than 50 mg/l and are a reflection of the local softwater.

- Dissolved oxygen in the lake averages only 63% saturated, 12% in the bottom zone during stratification. This level needs improvement. Ideally, oxygen should be raised to the 96% saturation found in the epilimnion.

- Transparencies in Lake Fairfax average about 1 m, which is a moderately low value. A lake with high quality water in Northern Virginia would have transparencies greater than 2 m.

It is important to remember that the majority of routine stream and lake sampling done for this diagnostic study was conducted during dry weather, baseflow conditions. Lake Fairfax has been observed to be highly turbid following storms of 2 cm rainfall or more. This sediment generated turbidity only lasts 2 - 3 days in the lake and less than 1 day typically in tributaries. Thus, stormwater inflow is easily missed by biweekly sampling and pollutant transport estimated under baseflow circumstances greatly underestimates pollutant burdens in the lake and its feeder streams. This bias in the data is important to keep in mind.

d. Analysis of Lake Fairfax Water and Fishes for Heavy Metals and Pesticides.

Lake Fairfax has a suburban watershed and contamination with heavy metals and pesticides is always possible. Since the lake's water should be suitable for primary contact recreation and its fishes suitable for consumption, the absence of potentially toxic heavy metals and pesticides was documented through fish flesh and water analysis.

Most heavy metals occurred below Virginia and EPA water quality standards in samples of Lake Fairfax water (Table II.10.g.). Only the mercury level at less than 0.005 mg/l was above the EPA drinking water standard, but this slight difference is not significant. Whole body digestion of Lake Fairfax bottom feeding fish and sunfishes found levels acceptable based on FDA and EPA standards for arsenic, cadmium, and mercury, but yielded mixed results for other metals. Fish flesh levels were above the Virginia water quality standards for copper, lead, and chromium. However, water standards are far below levels commonly accumulating in tissues and must therefore be viewed very conservatively.

Based upon evidence reviewed for this study, heavy metals are not harmful at levels found in the fish and water from Lake Fairfax. However, the levels of chromium, copper, and lead are

FISH FLESH AND WATER ANALYSIS
HEAVY METALS

TABLE II.10.g.
Analytical Results
Lake Fairfax

Metal	Bottom Feeders (μg/g)	Centrachids (μg/g)	Lake Water Composite (μg/g)	VA Water Quality Stds* (μg/g)
Arsenic	<0.05	<0.05	<0.005	0.05
Selenium	<0.05	<0.05	<0.005	0.01
Cadmium	<0.02	<0.02	<0.001	0.01
Chromium	6.73	0.99	<0.005	0.05
Copper	1.35	0.52	<0.005	1.00
Mercury	<0.05	<0.05	<0.005	0.002
Lead	0.94	<0.05	<0.005	0.05

* Virginia Water Quality Standards. Environmental Reporter 936:1001, 1975.

Note - FDA tolerance level for mercury in the edible portion of fish flesh is 1.0 ppm.

at levels which merit rechecking in future years, and careful analysis based upon recent EPA studies being published as proposed standards (Table II.10.h.). It must always be remembered that sampling and analytical errors in metals evaluations are high at these minute quantities so that single-sample values should be interpreted cautiously; see Table II.10.i.i. for data on error analysis.

Pesticide levels (Table II.10.i.) in Lake Fairfax water samples were far below Virginia water quality standards for all compounds tested. In addition, levels of Aldrin, Dieldrin, Endrin, Heptachlor, PCBs, HCB, DDD, DDT, OP-DDE, Methoxychlor, and Chlordane in fish tissue were at concentrations so low as to be at or beyond the ability of our instruments to detect. Trace amounts of DDE were found in bottom feeding fishes, but at levels below the FDA tolerance level of 5 ppm for DDT in fish tissue (Table II.10.h.h.). Alpha-BHC levels of 0.03 mg/l were recorded in both bottom feeding and centrarchid fish samples. No standard for alpha-BHC is available at this time. However, for most chlorinated hydrocarbons 0.3 ppm is an acceptable tolerance level, and is not expected to be of any potential harm (see Table II.10.h.h.). Finally, the 0.01 mg/kg of Lindane is not significant since this level is far below the FDA tolerance level 0.3 ppm, approximately 0.3 mg/kg.

TABLE II.10.h.

EPA WATER QUALITY CRITERIA FOR THE REASONABLE PROTECTION OF AQUATIC LIFE AND HUMAN HEALTH

Compound or Element	Criterion for Aquatic Life µg/l	Criterion for Human Health µg/l
Heavy Metals		
Arsenic	2. 440	A. 0.022 B. 0.175
Cadmium	1. 0.012 2. *1.5	B. 10 (existing drinking water std.)
Chromium -hexavalent-	1. 0.29 2. 21.0	B. 50 (drinking water std.)
Chromium -trivalent-	1. 2. 2,200	A. 1.70×10^5 B. 3.433×10^6
Copper	1. 5.6×10^3 2. *12	B. 1×10^3 -organoleptic-based
Lead	1. *0.75 2. *74	B. 50 (drinking water std.)
Mercury	1. 0.00057 2. 0.0017	A. 1.44×10^{-5} B. 1.46×10^{-5}
Nickel	1. *56 2. *1,100	A. 13.4 B. 100
Selenium	1. 35 2. 260	B. 10 (drinking water std.)
Zinc	1. 47 2. *180	B. 5×10^3 -organoleptic only

* Based on a hardness of 50 mg/l as $CaCO_3$.

---

1. For aquatic life = 24 hr. mean conc.
2. For aquatic life = maximum level.

A. For health = total consumption
B. For health = consumption of organisms only.

TABLE II.10.h. (Continued)

EPA WATER QUALITY CRITERIA FOR THE REASONABLE PROTECTION OF AQUATIC LIFE AND HUMAN HEALTH

Compound or Element	Criterion for Aquatic Life µg/l	Criterion for Human Health ng/l
Pesticides		
Aldrin	2. 3.0	A. 0.74 B. 0.79
Dieldrin	1. 0.0019 2. 2.5	A. 0.71 B. 0.76
Chlordane	1. 0.0043 2. 2.4	A. 4.6 B. 4.8
DDT	1. 0.0010 2. 1.10	A. 0.24 B. 0.24
TDE	2. <<0.6	
DDE	2. <<1.050	
Endrin	1. 0.0023 2. 0.18	1 (drinking water standard)
PCBs	1. 0.014 2. 2.0	A. 0.79 B. 0.79

---

1. For aquatic life = 24 hr. mean conc.
2. For aquatic life = maximum level

A. For health = total consumption
B. For health = consumption of organisms only.

TABLE II.10.h.h.- FDA Tolerance Limits for Toxic Substances in Fish Tissues (Source: 40CFR180)

COMPOUND OR ELEMENT	TOLERANCE LEVELS IN FISH Parts Per Million
Heptachlor Epoxide	0.3
Methoxychlor	1.25 (in milk fat)
Endrin	0.3
Lindane	0.3 (in shellfish)
Aldrin	0.3
Dieldrin	0.3
DDT	5.0 (1.5 ppm in fat)
Chlorodane	0.3
PCB	5.0 (edible portion)
Mercury	1.0 (edible portion)

FISH FLESH AND WATER ANALYSIS

PESTICIDES

TABLE II.10.i.

Analytical Results
Lake Fairfax May 13, 1981

Pesticides	Quantitative Detection Limits(25g sample) (μg/g)	Bottom Feeders (μg/g)	Centrachids (μg/g)	Lake Water Composite (μg/g)	VA Water Quality Stds** (μg/g)	FDA Stds. ppm
Aldrin	.05	ND	ND	ND	0.017	0.3
DDD-op	.01	ND	ND	ND	NI	
DDE-pp	.01	ND	ND	ND	NI	
Dieldrin	.01	ND	ND	ND	0.017	0.3
Endrin	.01	ND	ND	ND	0.0002*	0.3
HCB	.05	ND	ND	ND	NI	
Heptachlor epoxide	.01	ND	ND	ND	0.018	0.3
Lindane	.01	.01	ND	ND	0.004*	0.3
p-p'-DDT	.01	ND	ND	ND	NI	5.0*
Methoxychlor	.05	ND	ND	ND	0.1*	1.25
o,p-DDT	.01	ND	ND	ND	NI	5.0*
Chlordane	.05	ND	ND	ND	0.003	0.3
alpha-BHC	.01	.03	.03	ND	NI	
op-DDE	.01	ND	ND	ND	NI	
pp-DDE	.01	T	ND	ND	NI	
Trans-non	.05	ND	ND	ND	NI	
PCB	.10	ND	ND	ND	NI	5.0

Key:

T means less than the quantitative detection limit (Trace present)
ND means less than the qualitative detection limit (None detected)
NI means not available in cited reference
** Virginia Water Quality Standards. Environmental Reporter 936:1001, 1975
* Virginia Water Quality Standards. State Water Control Board No. RB-1-80.

* Std. for DDT

TABLE II.10.i.i.

QUALITY CONTROL DATA FOR MAY 13, 1981 FISH AND WATER COLLECTIONS

Heavy Metals Analysis

Metal	Conc. µg/g	Dupl.Conc. µg/g	Digested Spike Recovery %	Post Digested Spike Recovery %	Digested Reagent Recovery %
Arsenic	<0.05	<0.05	67	42	98
Selenium	<0.05	<0.05	72	78	94
Cadmium	<0.02	<0.02	90	94	90
Chromium	3.46	3.33	63	80	97
Copper	0.94	0.93	81	130	121
Lead	0.43	0.36	68	81	95
Mercury	*0.19	*0.09	48	—	95

Duplication and analysis of sample #5304(*5305) of Lake Accotink bottom feeding fishes.

Pesticides Analysis

Recovery % Processed Standard		Standard Value	Determined Value
HCB	84.4	1.3 ng	1.10 ng
Lindane	100.0	.256 ng	.256 ng
Hept.	95.9	.256 ng	.245 ng
Aldrin	81.7	.256 ng	.209 ng
Hept. Epox.	81.4	.256 ng	.208 ng
Transnon	77.8	.5 ng	.387 ng
pp-DDE	68.9	.256 ng	.176 ng
Endrin	84.5	.5 ng	.422 ng
pp-DDD	71.7	.5 ng	.359 ng
pp-DDT	95.2	.5 ng	.476 ng

Recovery % Spiked Fish		Standard Value	Determined Value
HCB	100.0	1.3 ng	1.3 ng
Lindane	100.0	.256 ng	.256 ng
Hept.	84.5	.256 ng	.216 ng
Aldrin	66.7	.256 ng	.171 ng
Hept. Epox.	92.7	.256 ng	.237 ng
pp-DDE	89.0	.256 ng	.228 ng
pp-DDD	97.6	.5 ng	.488 ng

e. The Plankton of Lake Fairfax

The Phytoplankton

Total phytoplankton biomass (as fresh weight) was at or above 0.5 mg/l for the entire period of April through November (Figures II.10.b. and c.). Data on species densities underlying this biomass are in Tables II.10.j. and k. Methods for counting phytoplankton are described in Appendix II.10.e.Chrysophytes dominated in spring, early summer, and late fall. Important species were the flagellates *Dinobryon bavaricum*, *Dinobryon divergens*, *Mallomonas pseudocornata*, and the diatoms *Asterionella formosa* and *Cyclotella meneghiniana*. Green algae dominating during the summer included *Coelastrum microporum* and *Sphaerocystis schroeteri*.

A succession of five blooms was noted during the summer in the following sequence: April, *Dinobryon divergens*; May, *Mallomonas pseudocornata* and *Asterionella formosa*; June - July, *Coelastrum reticulatum*; August, *Anabaena limnetica*; September - October, *Sphaerocystis schroeteri* and *Dinobryon divergans*. Winter populations were sparce, overwhelmingly dominated by cryptophytes, notably *Cryptomonas erosa*.

The relatively minor importance of blue-green algae is significant since this group is commonly regarded as causing the greatest eutrophication problems. Massive blooms of these organisms can form surface scums which can decay, releasing foul odors into the air and consuming large amounts of oxygen. Blue-greens were important only in late summer when a bloom of *Anabaena limitica* made up about 13% of total algal weight.

FIGURE II.10.b.

The Dynamics of Algal Biomass in Lake Fairfax. Data are total freshweight of algae in mg/l from samples taken as composites of the mixed layer near the dam.

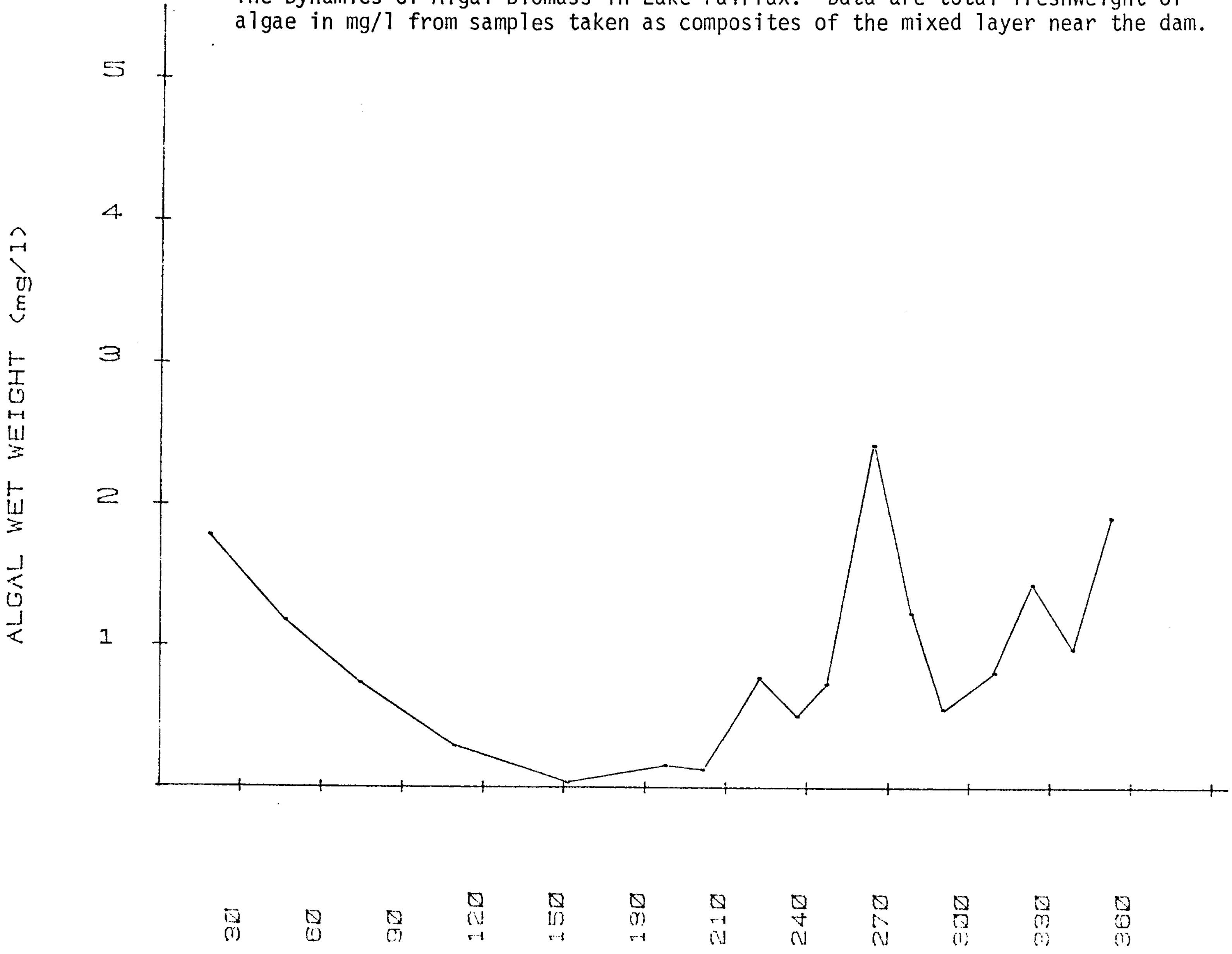
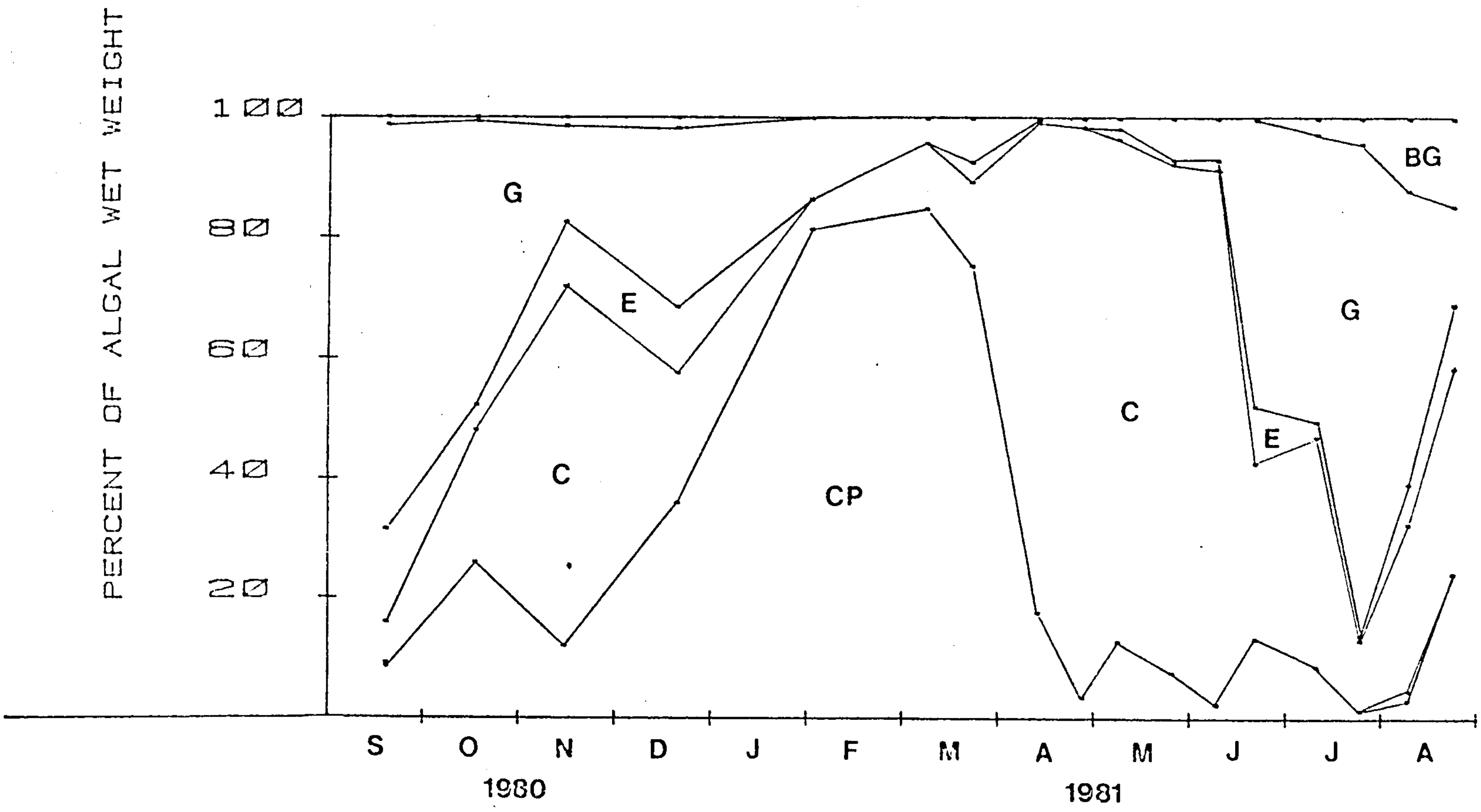


FIGURE II.10.c.

Algal composition in Lake Fairfax. Data are the percent of freshweight for the major algal groups in biweekly samples from the dam station.



Key to Groups of Algae:
BG = Blue-green algae = Cyanochloronta
C = Chrysophycophyta = golden-brown aglae
CP = Cryptophycophyta = Cryptophytes
E = Euglenoids = Euglenophycophyta
G = Chlorophycophyta = Green algae
D = Diatoms

TABL I.10.j.

THE PHYTOPLANKTON OF LAKE FAIRFAX

Biomass as wet weight (thousands of (um)^3/ml)

	SIZE (um)^3	9/18/80	10/16/80	11/13/80	12/18/80	1/29/81	3/6/81	3/20/81	4/10/81	4/23/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/81	8/5/81	8/19/81
CYANOCHLORONTA (Blue-green algae)																		
Anabaena limnetica	98.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	261.7
Anabaena wisconsinense	14.1	0.6	0.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphanocapsa elachista	24.7	1.7	0	1.4	0	0	0	0	0	0	0	0	0	4.9	2.8	2.7	0	6.2
Chroococcus limnetica	83.8	20.7	0	6.5	4.8	0	0	0	0	0	0	0.7	0	0	2.0	16.7	92.5	5.1
Chroococcus dispersus	14.1	0.9	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coelosphaerium dubium	3828.8	0	0	0	0	0	0	0	0	0	0	0	0	0	15.6	31.2	0	0
Merismopoedia glauca	1.8	0	5.5	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merismopoedia tenuissima	10.5	0.7	0	0	0	0	0	0	0	0	0	0	0	0.2	0.6	7.9	23.4	7.1
Total Cyanochloronta		24.6	6.7	8.9	4.8	0	0	0	0	0	0	0.7	0	5.1	21.0	58.5	117.5	280.1
CHLOROPHYCOPHYTA (Green algae)																		
Ankistrodesmus falcatus	67.0	15.5	28.4	19.4	29.8	1.2	3.0	7.9	0.6	2.7	4.1	10.7	13.1	18.6	8.2	10.9	8.5	9.0
Ankistrodesmus nannoselene	33.5	0	0	0	0	0	0	0	0	0	0	3.0	0.5	0.8	0.1	0	0	0
Arthrodesmus octocornis	84.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0
Chlamydomonas angulosa	130.7	4.3	11.7	1.6	5.9	0	0	0	0	0	0	0	0	0	0	0	0.5	3.2
Closteriopsis longissima	192.0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0
Closterium praelongum	3182.9	0	0	0	0	0	0	0	0	0	0	64.9	0	0	0	0	0	0
Closterium leibleinii	461.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0	1.9
Coelastrum microporum	4849.3	79.0	79.0	0	0	0	0	0	0	0	0	0	0	98.8	158.1	39.5	39.5	79.0
Coelastrum reticulatum	3591.5	0	0	0	0	0	0	0	0	0	0	0	43.9	0	0	892.7	190.2	0
Cosmarium regnelli	153.2	1.7	1.9	0	0	0	0	0	0	0	0	0	0	0	4.4	48.7	20.0	10.6
Crucigenia apiculata	72.0	0	9.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crucigenia quadrata	77.0	22.4	33.6	16.0	0.3	0	0	0	0	0	0	0	0	0.6	9.4	2.2	6.0	6.3
Elakatothrix viridis	83.8	4.8	2.0	0.7	0	0	0	0	0	0	0	1.7	0	1.0	0	0	0	0
Eudorina elegans	6100.7	0	0	0	0	0	0	0	0	0	0	24.9	0	0	24.9	0	0	74.6
Franceia ovalis	102.1	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kirchneriella obesa	58.9	4.8	4.3	1.4	0.2	0	0	0	0	0	0	3.4	0	0	0	0	1.4	0
Kirchneriella subsolitaria	75.4	9.6	14.1	15.4	3.7	0.6	0	0	0	0	0	1.2	3.7	1.2	0	1.2	4.9	12.9
Oocystis solitaria	75.5	19.1	21.2	3.4	0.9	0	0.3	0	0	0	1.2	10.1	3.4	14.8	11.4	16.9	15.4	16.0
Pediastrum duplex	1131.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.8
Scenedesmus bijuga	55.1	7.0	3.8	0	0.2	0	0.4	0	0.4	0	0	0	0	0	4.3	1.3	0	0
Scenedesmus quadricauda	55.1	1.5	0.5	0.2	0	0	0	0.2	0	0.9	0.9	0	0	5.6	7.4	15.5	24.7	13.3
Selenastrum capricornutum	70.7	23.5	0	0	0	0	0.6	0	0	0	0	0	0	0	0.3	1.2	20.1	11.5

THE PHYTOPLANKTON OF LAKE FAIRFAX - 2 -	SIZE (um)^3	9/18/80	10/16/80	11/13/80	12/18/80	1/29/81	3/6/81	3/20/81	4/10/81	4/23/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/8	8/5/81	8/19/81
Sphaerocystis schroeteri	79.1	951.3	326.4	45.7	44.8	2.7	1.9	1.0	1.0	3.9	6.8	49.3	20.9	86.7	136.3	98.6	102.8	61.2
Staurastrum manfeldtii	2079.0	50.8	8.5	0	0	0	0	0	0	0	0	0	0	33.9	16.9	42.4	42.4	0
Quadrigula closterioides	192.0	0	11.7	14.1	0	0	0	0	0	0	0	0	0	0	1.6	7.0	0.8	0
Tetraedron gracile	1944.0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.9	0	0	0
Tetraedron regulare	144.0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0
Tetraedron setigera	73.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0.9
Total Chlorophycophyta		1197.0	556.3	117.9	85.8	4.5	6.2	9.1	2.0	7.5	13.0	169.2	85.5	262.0	391.2	1182.8	478.9	314.2
EUGLENOPHYCOPHYTA (Euglenoids)																		
Euglena proxima	4135.1	134.8	0	0	0	0	0	0	0	0	0	0	0	16.9	0	0	50.6	134.
Phacus suecicus	3435.3	65.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trachelomonas hispida	1021.0	16.6	0	37.4	0	0	0	4.2	0	0	12.5	16.6	16.6	0	20.8	12.4	16.6	62.
Trachelomonas volvocina	867.9	58.9	49.6	42.4	31.8	0	0	0	3.5	0	0	0	3.5	35.4	0	0	0	3.
Total Euglenoids		275.6	49.6	79.8	31.8	0	0	4.2	3.5	0	12.5	16.6	20.1	52.3	20.8	12.4	67.2	200.
CHRYSOPHYCOPHYTA (Chrysophytes)																		
Non-diatoms																		
Dinobryon bavaricum	350.2	0.9	129.8	0	0	0	0	0	0	118.9	2.8	0	0	0	0	0	0	0
Dinobryon divergens	220.5	0	104.2	0	0	0	0	0	577.8	301.6	99.7	0	0	0	0	0	0	5.
Mallomonas pseudocornata	744.3	0	0	0	27.3	0	6.1	0	0	3.0	12.1	643.0	27.3	9.1	9.1	12.1	24.3	33.
Tribonema bombycinum	70.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	2.9	0.
Vacuolaria viridis	2688.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	514.
Diatoms																		
Asterionella formosa	162.0	0	0	31.7	0	0	0	0	0	0	429.1	1385.6	1048.3	5.9	0	0	0	0
Cyclotella meneghiniana	374.1	90.4	24.4	263.7	19.8	0.8	10.7	15.5	50.3	50.3	68.6	21.3	27.4	41.2	274.3	140.2	47.2	100.
Cyclotella stelligera	942.5	23.1	0	0	0	0	0	0	0	0	0	0	0	69.2	30.7	15.4	0	3.
Cymbella sp.	188.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.
Melosira granulata	377.0	0	0	139.8	13.8	0	0	1.5	7.7	3.1	0	1.5	0	0	0	0	0	0
Navicula sp.	33.5	0.6	0.1	0.8	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Rhizoselinium logiseta	350.0	0	0	0	0	0	0	0	0	0	0	0	0	34.2	0	0	29.9	0
Synedra sp.	40.8	0	0.2	0.8	0	0	0.2	0.3	0.2	0	0	0	0	0	0	0	0.2	0
Tabellaria fenestrata	162.0	0	0	0	0	0	0	0	0	0	0	0	0	4.0	0	0	0	0
Stephanodiscus sp.	150.8	5.3	1.2	3.1	1.8	0	0	0	0	4.9	2.4	3.1	0	0	0	0	0	0
Total Chrysophytes		120.3	259.9	439.9	62.7	1.2	17.0	17.3	636.0	481.8	614.7	2054.5	1103.0	163.6	314.1	170.0	274.5	658.

THE PHYTOPLANKTON OF LAKE FAIRFAX - 3 -	SIZE (um)^3	9/18/80	10/16/80	11/13/80	12/18/80	1/29/81	3/6/81	3/20/81	4/10/81	4/23/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/8	8/5/81	8/19/81
PYRRHOPHYCOPHYTA (Dinoflagellates)																		
Ceratium hirundinella	3797.5	10.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.5	0
Total Dinoflagellates		10.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.5	0
CRYPTOPHYCOPHYTA (Cryptophytes)																		
Chroomonas nordstedtii	91.9	5.7	0	0	1.2	17.2	52.8	44.2	19.1	0	0	0	13.1	6.7	6.4	0	1.5	0
Cryptomonas erosa	433.9	144.9	305.8	88.4	102.6	7.9	77.8	49.5	118.5	17.7	93.7	183.9	15.9	67.2	63.6	19.4	28.3	76.0
Cryptomonas ovata	1323.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	388.2
Total Cryptophytes		150.6	305.8	88.4	103.8	25.1	130.6	93.7	137.6	17.7	93.7	183.9	29.0	73.9	70.0	19.4	29.8	464.2
TOTAL ALGAE		1778.4	1178.3	734.9	288.9	30.8	153.8	124.3	779.1	507.0	733.9	2424.9	1237.6	556.9	817.1	1443.1	983.4	1917.6
% OF TOTAL IN EACH GROUP:																		
CYANOCHLORONTA		1.4	0.6	1.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.6	4.0	11.9	14.6
CHLOROPHYCOPHYTA		67.3	47.2	16.0	29.7	14.6	4.0	7.3	0.3	1.5	1.8	7.0	6.9	47.0	47.9	82.0	48.7	16.4
EUGLENOPHYCOPHYTA		15.5	4.2	10.8	11.0	0.0	0.0	3.4	0.4	0.0	1.7	0.7	1.6	9.4	2.5	0.8	6.8	10.5
CHRYSOPHYCOPHYTA		6.8	22.0	59.8	21.7	4.9	11.0	13.9	81.6	95.0	83.7	84.7	89.1	29.4	38.4	11.8	27.9	34.3
PYRRHOPHYCOPHYTA		0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0
CRYPTOPHYCOPHYTA		8.5	25.9	12.0	35.9	81.5	84.9	75.4	17.7	3.5	12.8	7.6	2.3	13.3	8.6	1.3	3.0	24.2

TABLE II.10.k.

THE PHYTOPLANKTON OF LAKE FAIRFAX

(numbers/ml)

	9/18/80	10/16/80	11/13/80	12/18/80	1/29/81	3/6/81	3/20/81	4/10/81	4/23/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/81	8/5/81	8/19/81
CYANOCHLORONTA																	
Anabaena limnetica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.30	2665.04
Anabaena wisconsinense	40.75	24.40	24.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aphanocapsa elachista	67.92	0	57.10	0	0	0	0	0	0	0	0	0	199.67	114.10	110.02	0	248.57
Chroococcus limnetica	247.22	0	77.40	57.05	0	0	0	0	0	0	8.15	0	0	24.45	199.67	1104.32	61.12
Chroococcus dispersus	62.48	61.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coelospherium dubium (colonies)	0	0	0	0	0	0	0	0	0	0	0	0	0	4.08	8.15	0	0
Merismopedia glauca	0	3076.6	366.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merismopedia tenvissima	70.63	0	0	0	0	0	0	0	0	0	0	0	20.38	57.05	749.80	2237.16	676.45
SUBTOTALS	489.00	3162.10	525.60	57.05	0	0	0	0	0	0	8.15	0	220.05	199.68	1067.64	1120.62	3651.18
CHLOROPHYCOPHYTA																	
Ankistro desmus falcatus	230.92	423.80	289.30	444.67	18.33	44.83	118.17	8.15	40.75	61.12	158.92	195.60	277.10	122.25	163.00	126.32	134.47
Ankistro desmus nannoselene	0	0	0	0	0	0	0	0	0	0	89.65	16.30	24.45	4.08	0	0	0
Arthrodesmus octocornis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.38	0
Chlamydomonas angulosa	32.60	89.60	12.2	44.83	0	0	0	0	0	0	0	0	0	0	0	4.08	24.45
Closteriopsis longissima	5.43	0	0	0	0	0	0	0	0	0	0	0	0	0	8.15	0	0
Closterium praelongum	0	0	0	0	0	0	0	0	0	0	20.38	0	0	0	0	0	0
Closterium leibleinii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.07	0	4.08
Coelastrum microsporum(colonies)	16.30	16.30	0	0	0	0	0	0	0	0	0	0	20.38	32.60	8.15	8.15	16.30
Coelastrum reticulatum (colonies)	0	0	0	0	0	0	0	0	0	0	0	12.22	0	0	248.57	52.97	0
Cosmarium regnellii	10.87	12.20	0	0	0	0	0	0	0	0	0	0	0	28.53	317.85	130.40	69.28
Crucigenia apiculata	0	126.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crucigenia quadrata	290.68	436.00	207.80	4.08	0	0	0	0	0	0	0	0	8.15	122.25	28.53	77.43	81.50
Elakatothrix viridis	57.05	24.40	8.20	0	0	0	0	0	0	0	20.38	0	12.22	0	0	0	0
Eudorina elegans (colonies)	0	0	0	0	0	0	0	0	0	0	4.08	0	0	4.08	0	0	12.23
Franceia ovalis	2.72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kirchneriella Obesa	81.50	73.30	24.50	4.08	0	0	0	0	0	0	57.05	0	0	0	0	24.45	0
Kirchneriella subsolitaria	127.68	187.45	203.73	48.90	8.15	0	0	0	0	0	16.30	48.90	16.30	0	16.30	65.20	171.15
Oocystis solitaria	252.65	281.20	44.80	12.22	0	4.08	0	0	0	16.30	134.47	44.82	195.60	150.77	224.12	203.75	211.90
Pediastrum duplex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.23
Scenedesmus bijuga	127.69	69.30	0	4.08	0	8.15	0	8.15	0	0	0	0	0	77.42	24.45	0	0
Scenedesmus quadricauda	27.17	8.20	4.10	0	0	0	4.08	0	16.30	16.30	0	0	101.88	134.48	281.17	448.25	240.42
Selanastrum capricomutum	331.43	0	0	0	0	8.15	0	0	0	0	0	0	0	4.08	16.30	285.25	163.00
Sphaerocystis schroeteri	12032.06	4127.90	578.60	566.42	34.62	24.45	12.22	12.22	48.90	211.90	623.47	264.87	1096.17	1723.72	3777.51	1299.92	774.25

THE PHYTOPLAN[illegible] OF
LAKE FAIRFAX

	9/18/80	10/16/80	11/13/81	12/18/80	1/29/81	3/6/81	3/20/81	4/10/81	4/23/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/81	8/5/81	8/19/81
Staurastrum manfeldtii	24.45	4.10	0	0	0	0	0	0	0	0	0	0	16.30	8.15	20.38	20.38	0
Quadrigula closteriodes	0	61.10	73.30	0	0	0	0	0	0	0	0	0	0	8.15	36.68	4.08	0
Tetraedron graciie	0	0	0	0	0	0	0	0	0	0	0	0	0	4.08	0	0	0
Tetraedron regulare	2.72	0	0	0	0	0	0	0	0	0	0	0	0	0	4.07	0	0
Treubaria setigera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.15	0	12.23
SUBTOTALS	13653.92	5941.15	1446.53	1129.28	61.10	89.66	134.47	28.52	105.95	305.62	1124.70	582.71	1768.55	2424.64	5187.45	2771.01	1927.49
EUGLENOPHYTA																	
Euglena proxima	32.60	0	0	0	0	0	0	0	0	0	0	0	4.08	0	0	12.23	32.60
Phacus suecicus	19.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trachelomonas hispida	16.30	0	36.70	0	0	0	4.08	0	0	12.22	16.30	16.30	0	20.38	12.23	16.30	61.13
Trachelomonas volvocina	67.92	57.10	48.90	36.68	0	0	0	4.08	0	0	0	4.08	40.75	0	0	0	4.08
SUBTOTALS	135.84	57.10	85.60	36.68	0	0	4.08	4.08	0	12.22	16.30	20.38	44.83	20.38	12.23	28.53	97.81
CHRYSOPHYCOPHYTA																	
Dinobryon barvaricum	2.72	370.80	0	0	0	0	0	0	339.42	8.15	0	0	0	0	0	0	0
Dinobryon divergens	0	472.70	0	0	0	0	0	2620.21	1367.99	452.32	0	0	0	0	0	0	24.45
Mallomonus pseudocornata	0	0	0	36.68	0	8.15	0	0	4.08	16.30	863.90	36.67	12.22	12.22	16.30	32.60	44.83
Tribonema bombycinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32.60	40.75	4.08
Vacuolgria viridis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190.52
(Diatoms)																	
Asterionella Formosa	0	0	195.60	0	0	0	0	0	0	264.87	8553.38	6471.07	36.68	0	0	0	0
Cyclotella meneghiniana	241.78	65.20	705.0	52.98	2.04	28.53		134.47	134.47	183.37	57.05	73.35	110.02	73.34	374.90	126.32	268.95
Cyclotella stelligena	24.45	0	0	0	0	0	40.75	0	0	0	0	0	73.35	32.60	16.30	0	4.08
Cymbella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.08
Melosira guanulata	0	0	370.80	36.68	0	0	4.08	20.37	8.15	0	4.08	0	0	0	0	0	0
Navicula	19.02	4.10	24.50	0	12.22	0	4.08	0	0	0	0	0	0	0	0	0	0
Rhizoselinium longiseta	0	0	0	0	0	0	0	0	0	0	0	0	97.80	0	0	85.58	0
Stephanodiscus	35.32	8.20	20.24	12.22	0	0	0	0	32.60	16.30	20.37	0	0	0	0	0	0
Synedra	0	4.10	20.40	0	0	4.08	8.15	4.08	0	0	0	0	0	0	0	4.08	0
Tabillaria fenestrata	0	0	0	0	0	0	0	0	0	0	0	0	24.45	0	0	0	0
SUBTOTALS	323.29	925.10	1336.70	138.56	14.26	40.76	57.06	2779.13	1886.71	941.31	9498.78	6581.09	354.52	118.16	440.10	289.33	350.47
PYRRHOPHYCOPHYTA																	
Ceratium hirundinella	2.72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.08	0
SUBTOTALS	2.72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.08	0

THE PHYTOPLANKTON OF LAKE FAIRFAX - 3 -	9/18/80	10/16/80	11/13/80	12/18/80	1/29/81	3/06/81	3/20/81	4/10/81	4/23/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/81	8/5/81	8/19/81
CRYPTOPHYCOPHYTA																	
Chroomonas nordstedtii	62.48	0	0	207.82	187.37	574.57	480.85	207.82	0	0	0	142.62	73.35	69.28	0	16.30	0
Cryptomonas erosa	334.15	704.90	203.7	236.35	18.33	179.30	114.10	273.02	40.75	215.97	423.80	36.68	154.85	146.70	44.83	65.20	175.22
Cryptomonas ovata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	293.40
SUBTOTALS	396.63	704.90	203.70	444.17	205.70	735.87	594.95	480.84	40.75	215.97	423.80	179.30	228.20	215.98	44.83	81.50	468.62

Chlorophyll levels in Lake Fairfax as measured by routine sampling data (Figure II.10.d.) were highest during the summer months, peaking at 15-20 mg/m^3, except on August 19 when a record high level of 44 mg/m^3 was reached. Summer lows following storm-induced flushing were 5-10 mg/l. Chlorophyll was relatively constant during the cooler months at 3-7 mg/l. Additional chlorophyll measurements were made during the summer of 1981 by George Mason University (Figure II.10.e.). Peaks represent algal blooms following stormwater pulsing of nutrients. Declines represent nutrient depletion which is often followed by washout. Duplicate samples analyzed by Biospherics, Inc. (routine analyses) show variable degrees of agreement with GMU values, but are by and large in the same general range.

Primary production (see method in Appendix II.10.d.) by Lake Fairfax phytoplankton was measured on 11 occasions during June, July, and August (Table II.10.1.). Measurements were centered around storm events. Primary production was highest on July 16 at 1.4 g C/m^2/day and lowest on June 14 at 0.3 g C/m^2/day in the wake of a large storm. Primary production was generally greatest a few days after a storm when sediments had settled, but nutrients were still plentiful. Lowest production was found immediately following a storm when algal biomass was low and turbidity from sediments was high. Photosynthesis per unit chlorophyll showed a stimulation in photosynthetic rate in the days following a storm which slowly tapered off as nutrients were depleted.

FIGURE II.10.d.

Chlorophyll 'a' levels in Lake Fairfax during the September 1980-1981 study. Values are the mean of duplicate analyses of composite samples from the dam station.

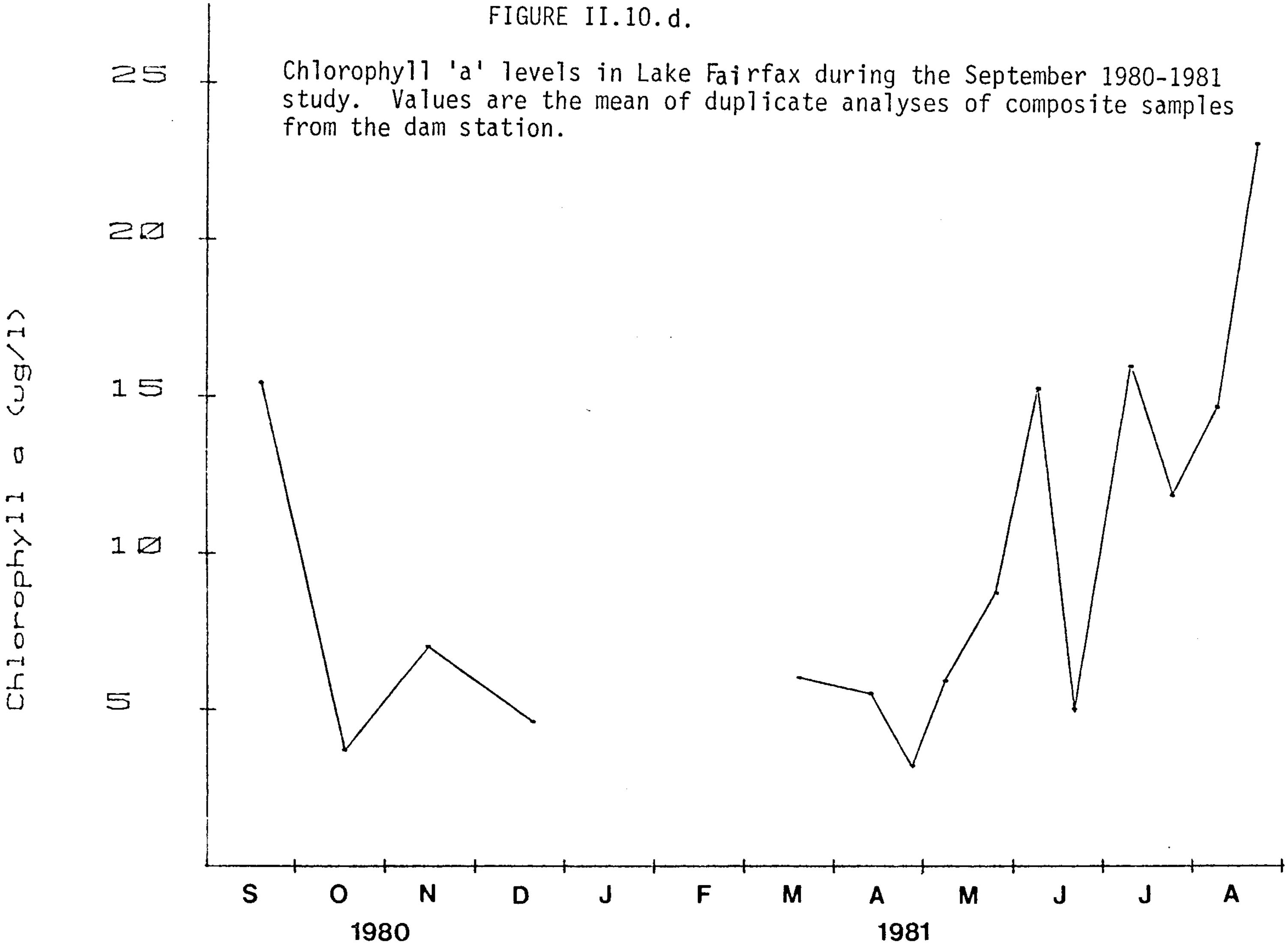


FIGURE II.10.e.

Additional chlorophyll 'a' values for Lake Fairfax determined by George Mason University. Values represent the mean of duplicate analyses of either composite samples or surface grab samples in the dam area.

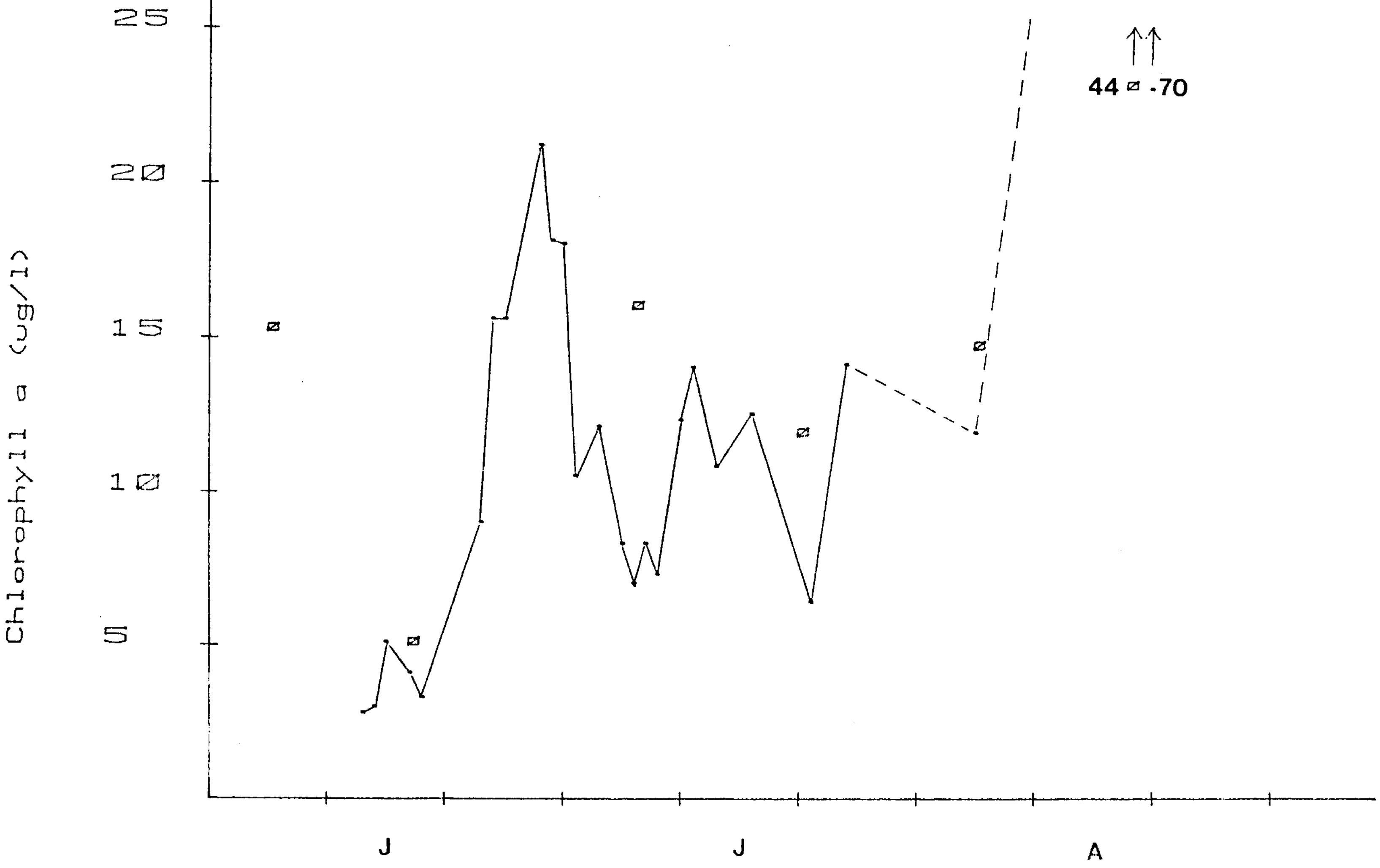


Table II.10.1. Primary Productivity Measurements in Lake Fairfax

Date	Daily Primary Production gC/m2/day	Photosynthesis At 915uE/m2/sec	Chlorophyll per unit At 65uE/m2/sec
6/13/81	0.682	12.25	5.18
6/14/81	0.343	10.07	3.79
6/15/81	0.473	7.82	3.02
6/17/81	0.520	6.68	2.38
7/6/81	0.370	7.44	2.54
7/8/81	0.698	10.14	3.57
7/10/81	1.191	6.21	3.10
7/13/81	0.990	6.99	2.38
7/16/81	1.434	6.71	2.85
7/20/81	0.678	6.34	2.08
8/14/81	0.747	6.34	2.01

Phytoplankton data indicate that Lake Fairfax should be classified as moderately eutrophic. Algal wet weight values of 0.5 to 3.0 mg/l found during the warmer months are actually in the mesotrophic range as reported by Wetzel (1975). The chlorophyll 'a' levels of 5-25 ug/l found during the same period are indicative of mild eutrophic conditions (Wetzel 1975; Carlson 1977). Primary production levels of 0.5-1.5 $gC/m^2/day$, which were common during the summer of 1981, overlap the mesotrophic and eutrophic ranges (Wetzel 1975).

f. Nutrient Limitation of Algal Growth in Lake Fairfax

Algal assays show Lake Fairfax to be limited by phosphorus (Table II.10.m.). On each of eight occasions tested, the P effect was most significant. On several occasions, the N effect and the N-P interaction were also significant indicating that N became limiting in those cultures which were spiked with P. On two occasions EDTA-spiked cultures showed a significant effect indicating heavy metal inhibition. These two occasions were associated with a storm occurring on June 13. It is interesting to note that the large storm of July 4 produced no detectable toxic effects on assays of July 6 water. Such an effect was found on July 6 at Lake Accotink.

Chemical analysis of lake waters can be used to predict yields of algae (Table II.10.n.) using the factors of 430 g dry weight/gP and 38 g dry weight/gN available in the lake water (Miller et. al., 1978). Predicted yields based on SRP are much lower than those based on inorganic nitrogen bolstering the conclusion that P would run short before N. Actual yields are somewhat greater than theoretical yields based on SRP levels suggesting the availability of some total P as found by other researchers (Cowen and Lee 1976, Dorich et. al. 1980). Inhibition is not indicated by these data. Methods used for algal assays for nutrient limitation and heavy metal inhibition are found in Appendix II.10.f.

Table II.10.m. Lake Fairfax Algal Assay Results.

Data are F values showing the significance of effects and interactions.

Date	5/5/81	6/13/81	6/14/81	6/15/81	6/17/81	7/5/81	7/6/81	8/4/81
Source of Variation								
N	11.882**	0.381	0.285	5.761*	0.347	30.849***	46.703***	29.43
P	1261.660***	605.506***	467.718***	433.388***	137.788***	184.659***	274.524***	214.98
EDTA	0.073	11.392**	7.364*	4.352	0.096	0.085	1.796	35.31
N-P	19.415**	0.381	0.632	5.270*	0.336	33.173***	55.162***	33.16
N-EDTA	0.324	0.082	2.131	0.006	0.001	0.188	4.668	17.69
P-EDTA	0.863	6.985*	8.004*	2.863	0.431	0.020	3.048	29.76
N-P-EDTA	0.655	0.003	2.481	0.051	0.082	1.132	2.894	16.19
Cell Yield in Lake Water	0.530	0.059	0.080	0.103	0.0625	0.234	0.230	0.076

Levels of significance:
* .05
** .01
*** .001

Table II.10.n. Lake Fairfax Chemistry Data

Data are from routine analysis series useful in interpreting algal assay results.

	Date			
Parameter	5/5/81	6/17/81	7/6/81	8/4/81
Total P (mgP/l)	0.054	0.03	0.21	0.04
Soluble RP (mgP/l)	0.024	0.01	0.02	0.01
NO3-N (mgN/l)	0.57	0.32	0.30	0.23
NH4-N (mgN/l)	0.20	0.21	0.11	0.16
TKN (mgN/l)	0.64	0.30	0.91	0.83
Predicted Yield				
SRP	10.32	4.3	8.6	4.3
TP	23.22	12.9	90.3	17.2
NO_3-N + NH_4-N	29.3	20.1	15.6	14.8
Actual Yield				
Total	13.56	8.74	10.47	8.88

g. The Zooplankton

The animal plankton are a vital link in the food chain of lakes and provide a valuable index of their biological condition. The planktonic animals residing in Lake Fairfax resemble a community which would be expected in a eutrophic lake in a warm, humid area. The genera living in the lake are listed, along with the data on abundance, in Table II.10.o. Crustacean identification is limited to the genus level except for the species *Daphnia parvula* and, *Bosmina longirostris*. The rotifers found in Lake Accotink are: *Asplanchna*, *Branchionus havanaensis*, B. *plicatilus*, B.*quadridentats*, *Conochilus*, *Rellicottia bostoniensis*, *Keratalla cochlearis*, R.*valga*, *Polyarthra*, *Tetramastix* and *Trichocera*.

All of the animals recorded in the lake have several common properties:

- they have high growth rates
- they are widely distributed in North America
- they are frequently found in lakes with high turbidity
- they are found where water temperatures are often 28°C or more in the summer
- they are abundant where predation by fish is intense
- they are relatively small for planktonic animals, almost all less than 1 mm in body length.

Table II. 10.o. The zooplankton of Lake Fairfax. Data are the number of animals per m^2 of lake surface based upon duplicate vertical tows encompassing the entire water column.

		9/18/80	10/16/80	11/13/80	12/18/80	3/6/81	3/20/81	4/10/81	4/23/81	4/29/81	5/5/81	5/22/81	6/5/81	6/17/81	7/6/81	7/20/81	8/5/81	8/19/81
CLADOCERA	Daphnia	3.697E5	4.749E4	5.456E4	2.182E5	2.547E5	8.232E5	1.843E6	1.873E5	2.882E5	2.060E5	4.428E4	1.823E5	6.740E4	1.204E5	2.022E5	4.493E4	3.787E4
	Ceriodaphnia	4.111E5	8.408E4	4.300E4	1.829E4	1.605E3	0	0	4.180E2	3.21E2	6.42E2	4.493E3	2.246E4	6.419E4	1.473E5	5.950E5	1.049E5	5.327E4
	Diaphanosoma	1.457E5	3.209E3	3.530E3	6.42E2	0	0	0	7.700E2	9.63E2	6.42E2	3.209E4	3.594E4	1.316E5	4.621E4	1.502E5	9.628E3	7.702E3
	Bosmina	5.189E5	4.171E3	3.177E5	5.584E5	2.113E5	3.803E5	1.829E4	1.033E5	2.317E5	7.112E3	1.906E5	3.042E5	2.561E5	3.145E4	5.392E4	1.406E5	0
	Chydorids	1.926E3	0	2.246E3	1.604E3	2.047E3	4.493E3	4.814E3	1.444E3	6.418E3	3.851E3	7.060E3	6.42E2	6.41E2	0	6.42E2	0	0
	TOTAL CLADOCERA	1.447E6	1.390E5	4.210E5	7.971E5	4.670E5	1.208E6	1.866E6	2.933E5	5.276E5	2.182E5	2.785E5	6.091E5	5.199E5	3.454E5	1.002E6	3.000E5	9.884E4
COPEPODA	Diaptomus	2.484E5	3.369E4	2.211E5	1.601E5	3.158E4	3.883E4	8.810E4	1.662E5	1.175E5	1.264E5	2.131E5	1.078E5	5.841E4	2.246E4	2.195E5	5.007E4	8.986E3
	Cyclops	2.513E5	2.452E5	3.883E5	2.304E5	3.402E4	5.744E4	2.580E5	5.488E4	9.050E4	1.194E5	1.207E5	1.213E5	1.200E5	6.996E4	1.156E5	7.767E4	1.669E4
	Nauplii	2.176E5	2.397E5	2.677E5	2.782E5	1.540E5	3.736E5	1.061E6	5.969E4	7.452E5	3.498E5	5.623E5	3.543E5	9.667E5	2.163E5	1.618E5	4.044E5	7.831E4
	Colanoid	0	0	9.660E4	0	0	0	0	6.561E5	0	0	0	0	0	2.054E4	1.476E5	1.155E5	2.503E4
	TOTAL COPEPOD	7.173E5	5.186E5	9.737E5	6.687E5	2.196E5	4.699E5	1.407E6	9.369E5	9.532E5	5.956E5	8.961E5	5.834E5	1.145E6	3.293E5	6.445E5	6.476E5	1.240E5
	TOTAL ROTIFERS	8.107E5	1.174E6	1.624E6	4.281E5	4.332E5	1.380E4	3.707E4	2.888E4	1.130E5	3.620E5	5.809E5	1.228E6	1.423E6	7.439E5	1.021E6	1.651E6	1.160E6
	TOTAL OSTRACODS	3.434E4	3.851E3	4.81E2	1.60E2	3.20E2	0	3.370E3	6.42E2	1.155E4	8.986E3	5.134E3	1.283E3	3.209E3	8.344E3	8.344E3	1.669E4	7.061E3
	COPEPOD W/O NAUPLII	4.997E5	2.789E5	8.771E5	3.905E5	6.560E4	9.627E4	3.460E5	8.772E5	2.080E5	2.458E5	3.338E5	2.291E5	1.783E5	1.130E5	4.827E5	2.432E5	5.069E4

FIGURE II.10.f.

Dynamics of crustaceans in Lake Fairfax. Data are the sum of species counts for cladocerans and copepods in duplicate vertical haul samples taken near the dam.

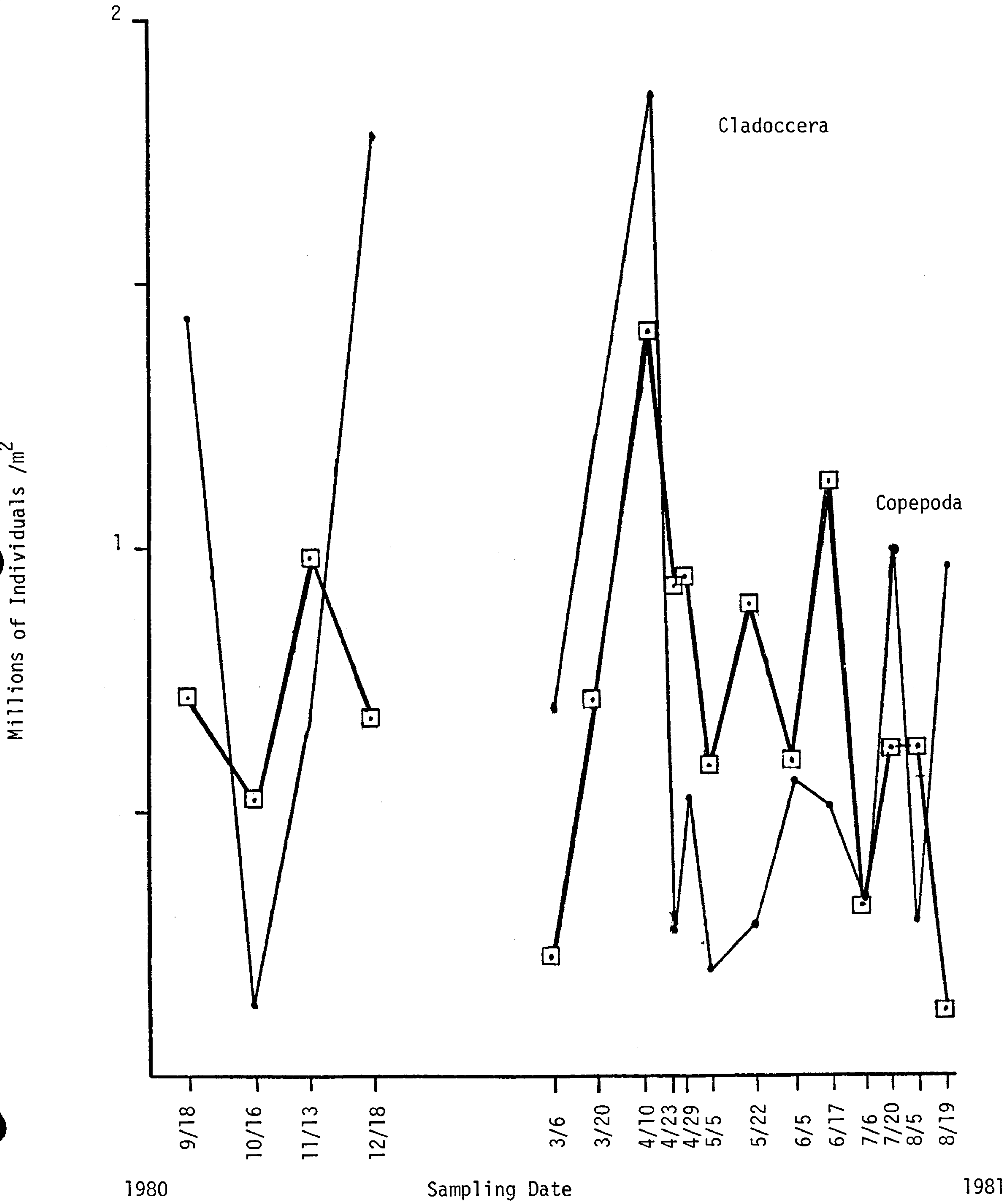
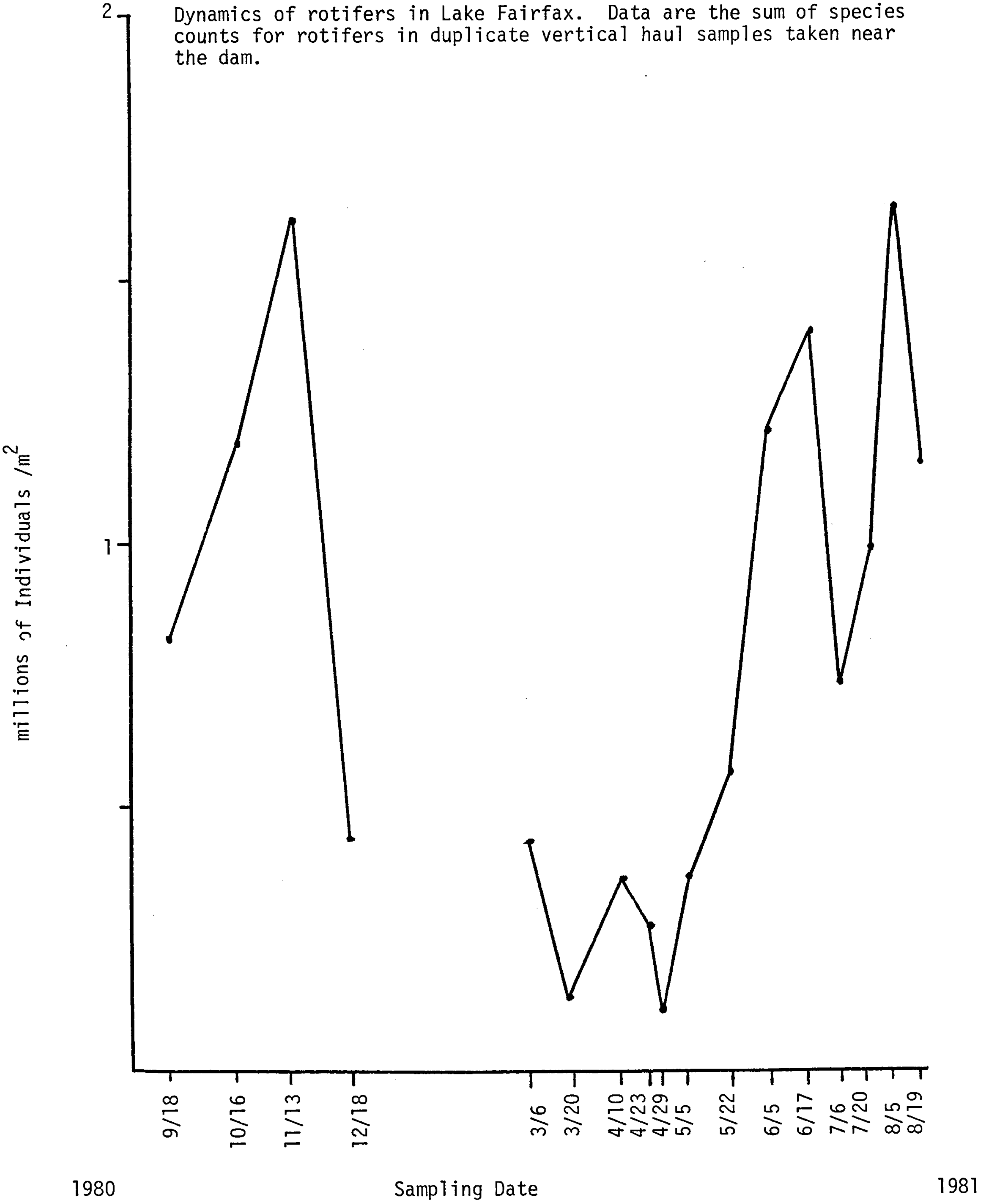


FIGURE II.10.g.

Dynamics of rotifers in Lake Fairfax. Data are the sum of species counts for rotifers in duplicate vertical haul samples taken near the dam.



The species data in Table II.10.o. are pooled by class and graphed in Figures II.10.f. and g. Except for a high peak on the 9th of April, the rotifers oscillated between 2 and 5 million specimens per m^2 (this means that there are trillions of rotifers in Lake Fairfax), and the average abundance was 3.29 E6. The crustaceans also displayed high numbers, averaging 1.01 x 10^6, but they did not follow the same pattern as the rotifers. The cladocerans and copepods were abundant in the fall and summer, with lower densities from December to June.

The biomass of zooplankton, assuming an average mass of 0.004 mg/animal, ranges from about 1 to 4 grams per m^2. This does not include rotifers, but is still high even for a productive lake. Lake Fairfax thus appears to be very productive in plankton animals which are important as food for fish, waterfowl, and insects. It does not appear that any manipulation of the animal community is necessary during the restoration of Lake Fairfax. The existing animals should merely be protected during the restoration process since they not only provide food, but also help to clear the water of algae.

h. Hydraulic Budget of Lake Fairfax

o Analysis of Delayed Flow Inputs

The discharge measurements conducted on the tributaries to Lake Fairfax have been used to construct a baseflow (delayed flow) analysis for the lake. This portion of the hydraulic evaluation is most useful in assessing the significance of groundwater. The model used in developing the baseflow budget is that inflow volumes (measured and indirectly estimated) less evaporation are equal to the outflow plus or minus the groundwater influence. Notes on the approach to specifics for this hydraulic analysis are given in Appendix II.10.

The results of this analysis are in Table II.10.p. About 3% of the inflow to Lake Fairfax evaporates, while 80% is estimated to leave via the surface outflow. The fate of the remaining 17% is less certain. This remainder is the difference between input and known water loss, and it indicates that input exceeds measured losses. This difference is designated as the influence of groundwater and is our approach to the hydraulic budget. A positive (+) 17% thus suggests that the lake has a net loss to the groundwater. However, errors inherent in these estimates preclude a firm conclusion on this apparent recharge.

TABLE II.10.p THE DELAYED FLOW [illegible]RAULIC BUDGET FOR LAKE FAIRFAX
(All Values are m^3 /dy)

DATE	COLVIN RUN SOUTH	ANNE RUN	COLVIN RUN INFLOW	*CAMERON RUN INFLOW	*FOREST EDGE INFLOW	TOTAL INFLOW	COLVIN RUN OUTFLOW	EVAPORATION	TOTAL WATER LOSS	INFLOW MINUS LOSS
9/18/80			4690.8	235.9	290.8	5217.5	1542.6	244.3	1786.9	3430.6
10/16/80			1697.5	85.4	105.6	1888.5	2977.4	87.3	3064.7	-1176.2
11/13/80			2155.5	108.4	134.1	2398.0	1958.9	69.8	2028.7	369.3
12/18/80			4002.7	201.3	249.0	4453.0	3728.2	69.8	3798.0	655.0
3/20/81	5137.3	2634.3	7771.6	390.9	483.4	8645.9	6308.9	113.4	6422.3	2223.6
4/10/81	3777.4	3824.1	7601.5	382.4	472.8	8456.7	11759.0	200.7	11959.7	-3503.0
4/24/81	3827.5	6373.7	10201.2	513.1	634.5	11348.8	10946.0	200.7	11146.7	202.1
5/5/81	4187.8	3100.9	7115.9	357.9	442.6	7916.4	7539.3	287.9	7827.2	89.2
5/22/81	4147.2	1728.0	5875.2	295.5	365.4	6536.1	6912.0	287.9	7199.9	- 663.8
6/5/81	3332.4	2987.7	6320.2	317.9	393.1	7031.2	7453.7	314.1	7767.8	- 736.6
6/17/81	2952.3	1581.1	4518.7	227.3	281.1	5027.1	4879.9	314.1	5194.0	- 166.9
7/6/81	3421.4	4225.0	7646.4	384.6	475.6	8506.6	8933.8	314.1	9247.9	- 741.3
7/20/81	4147.2	1296.0	5443.2	273.8	338.6	6055.6	3456.0	314.1	3770.1	2285.5
8/4/81	1738.4	6782.4	8520.8	428.6	530.0	9479.4	2505.6	**244.3	2749.9	6729.5
8/19/81	1613.1	921.9	2535.0	127.5	157.7	2820.2	1139.6	**244.3	1383.9	1436.3
Integrated Totals										
ᴼ Total for the study period						2,096,895	1,740,586	57,837	1,798,423	298,472
ᴼ Total Yearly 9/1/80 - 8/31/81						2,216,438	1,779,978	64,922	1,844,903	371,535

Notes:

* Inflows based on proportions to Colvin Run delayed flow. Proportions developed from runoff estimates and their proportions.

** Evaporation estimated from long term August averages for temperature, wind speed, and dew point at Dulles Int'l. Airport.

ᴼ Totals include 51,719 m^3/yr delayed flow calculated from the Immediate Drainage subwatershed.

Based upon the lake volume of 220,431 m^3 and the annual inflow during the study period, it is estimated that delayed flow (non-storm) alone is sufficient to flush the lake 10 times per year or once every 5 weeks. With a volume of 87,000 m^3, the bottom zone could be flushed biweekly. In addition, although the fate of the surplus inflow cannot be certain, it can be concluded that major hydraulic inputs from groundwater are highly unlikely and that nutrient loading is entirely by surface inflows to Lake Fairfax.

o Analysis of Total Water Inflows

The second component of the Lake Fairfax hydraulic budget is total yearly inflow to the lake. In the absence of continuous gauging, annual tributary volumes were estimated using the land use data, and modified runoff coefficients, most developed by Whipple, et al. (1981), and others assigned based on imperviousness. Table II.10.q. presents the runoff coefficients used in this evaluation, and these factors were applied to the land use areas in Table II.9.a. to arrive at the land use weighted, subwatershed runoff coefficients in Table II.10.r. Annual runoff, current and future, is given by subwatershed in Table II.10.s. based upon 1.05 m of rain, the long-term Dulles International Airport average.

The delayed flow found during the September 1980 to September 1981 study period represents 45% of total watershed discharge using the long-term rainfall average (1.05 m) and <u>58%</u> of

TABLE II.10.q.

RUNOFF COEFFICIENTS FOR THE RATIONAL FORMULA AND RUNOFF CURVE NUMBERS

The values of runoff coefficients are based on the modified factors given by Whipple et al. (1981). Since both soil types B and C occur in the watersheds, the high values for soil B were selected as most representative. Curve Numbers are from SCS (1975) for various land uses, soil types, and antecedent condition II. Values have been selected as most reasonable for Fairfax County and do not necessarily match the originals exactly.

LAND USE	RUNOFF COEFFICIENT	CURVE NUMBER
Residential		
Estate Residential	0.33	68
Low Density	0.40	72
Medium Density	0.50	75
Townhouse/Apartment	0.60	80
Highrise	0.68	85
Commercial		
Low/Medium Office or Retail	0.70	92
Medium/High Office or Retail	0.82	95
Industrial		
Low to Medium Industrial	0.65	85
Heavy Industrial	0.75	90
Institutions	0.75	90
Transportation (Corridor)	0.75	90
Cropland	0.20	81
Water Retention	0.98	98
Cemetary	0.28	69
Idle Land	0.20	66
Parkland		
Recreational (Low Imperviousness)	0.28	69
Forest (No imperviousness) including that zoned for future development	0.15	55

TABLE II.10.r.

THE LAKE FAIRFAX WATERSHED: WEIGHTED RUNOFF COEFFICIENTS

Subwatershed	Area-hectares	Runoff Coef.'C'	
		Current	Future
Cameron	66.94	.33	.39
Carter Lake	64.10	.66	.74
Colvin	225.30	.39	.39
Dulles	152.97	.415	.62
Forest Edge	66.56	.41	.46
Immediate Drainage	35.75	.35	.35
Lake Anne	231.86	.44	.62
Newton	45.53	.50	.67
Reston	113.69	.43	.44
Sunset	100.09	.42	.48
Urban	8.64	.32	.32
Total Fairfax Watershed	1111.40	.43	.52

Table II.10.s. Annual Runoff Estimated for the Lake Fairfax Watershed.

Subwatershed	Area (ha)	*Annual Runoff (m3) -Current	*Annual Runoff (m^3) -Future
Cameron	66.94	231,947.	274,119.
Carter Lake	64.10	444,213.	498,057.
Colvin	225.30	922,604.	922,604.
Dulles	152.97	666,567.	995,835.
Forest Edge	66.56	286,541.	321,485.
Immediate Drainage	35.75	131,381.	131,381.
Lake Anne	231.86	1,071,193.	1,509,409.
Newton	45.53	239,033.	320,304.
Reston	113.69	513,310.	525,248.
Sunset	100.09	441,397.	504,454.
Urban	8.64	29,030.	29,030.
	1111.4		
Total Fairfax Watershed	Long term =	4,977,216.	6,031,926.
	Study Period =	3,851,890.	4,658,100.

* Runoff coefficients and 105 cm of average rainfall (Dulles data) are used for these estimates.

study period rainfall data from several Fairfax County stations (10.806 m). Runoff can be expected to increase by 21% as the Reston area moves towards complete development. The lake volume is replaced about 23 times per year at current development and will be replaced 27 times at full development. This translates to an hydraulic residence time of 0.044 years currently and 0.037 years in the future. The 'qs' factor or hydraulic loading, which is mean depth divided by residence time, is thus <u>57.</u> in the current average rainfall year and <u>69.</u> at full development. Furthermore, hydraulic loading can be expected to be highest in the summer, less in the spring, and lowest in the fall and winter. However, this distribution of flushing over the seasons is subject to large year to year variations.

The increase in annual runoff is primarily attributable to construction expected in the Lake Anne and Dulles subwatersheds. The estimated increase in discharge from these two districts alone accounts for 73% of the total. Additional office buildings and industrial expansion are the prime factors in the Dulles watershed, while both shopping/commercial development and residential increases underlie the changes in the Lake Anne area. The peak flow reduction and pollutant trapping capacity of Lake Anne and the new lake being constructed north of Baron Cameron Avenue will moderate both hydraulic and nutrient loading from the developing Lake Anne watershed. However, the only planned buffering of pollutant export from the Dulles watershed will come from the stormwater management basins required under Fairfax County ordinances.

Key points regarding the water budget for Lake Fairfax are:

- 3% of baseflow inputs evaporate while 80% leave as surface outflow.
- the remainder of inflow-outflow difference may represent groundwater outflows, but this is not certain.
- delayed flow flushes the lake once every 5 weeks, or 10 times per year.
- about 1/2 inflow occurs as baseflow; the rest is stormwater runoff.
- runoff from the watershed will increase by 21% with full development.
- the lake flushes 23 times per average year and will do so 27 times in the future.
- hydraulic loading based on average inflows and a mean depth of 2.53 m is 57 currently, 69 finally.

This is moderately high hydraulic loading, and suggests that inflows are a major factor affecting water quality.

i. Phosphorus Budget for Lake Fairfax

The fate of phosphorus transported into Lake Fairfax is an important area for consideration since restoration often involves limiting P inputs and thereby improving water quality in a predictable manner. A first step in evaluating the P budget is to apply P models to the lake to assess the accuracy of their predictions and the meaning of any irregularities found. Using a Qs = 57, z = 2.53 m and L = 9.26g/m^2/yr = annual P loading, the following results were obtained from models used to predict P concentrations in lakes:

Model Source	Predicted P Concentration mg P/m3	% Diff. w. Lake Conc. of 83 mg P/m3
Vollendweider(1969)	138 (V_s = 10 m)	+66
	106 (V_s = 30 m)	+28
Dillion (1975)	106	+28
Walker (1977)	133	+ 7
Reckhow (1977)	115	+39
Reckhow	130	+57
Jones & Bachman (1976)	130	+57
	123	+48

(Please note that ug/liter = mg/m^3 = parts per billion)

These predicted P levels are all above the actual 1980-81 observed value of 83 mgP/m^3. A large loss of P to the sediments is one possible reason for this difference since the loss of P by sinking in turbid lakes is greatly underestimated by existing models. However, if we account for the fact that rainfall was about 76% of normal during the study period and loading is estimated by long-term normal rainfall, then the P predictions would improve greatly. For example, Reckhow's general model predicts 89 mg P/m^3 when L is lowered to 0.76 of long-term, and this estimate is only 7% above the average of 83 recorded during the Phase 1 study of Lake Fairfax. Therefore, we find no large discrepancy in the behavior of P in Lake Fairfax and loading based upon land use coefficients yields reasonable predicted P levels.

Next, the phosphorus concentrations in the inflow need attention. The data from Colvin Run inflow produce an average of 74 mg P/m^3 total and 39 mg P soluble. Using long-term loading divided by runoff volume yields 162 mg P/m^3, over 2X baseflow levels. This difference is due to stormwater inflows which have high P concentrations. About 20% of phosphorus inputs to Lake Fairfax occur as delayed flow, over 58% of hydraulic input is baseflow. Thus, stormwater carries 80% of nutrient loading but only about 40% water inputs, so that the high P concentration estimated for storm flows is by no means unreasonable and is in the range recorded for stormwater in this study (section II.9.e.).

The long-term, annual loading to Lake Fairfax is 807.8 kg P after a correction is applied for the trapping capability of Lake Anne. This figure is based upon the detailed land use and export rate analysis presented in section II.9.c. From the information provided through the land use study, sources of P loading can be broken down into small watershed segments, extending the division by subwatersheds done in Section 9.c. However, it does not appear necessary to backtrack in such a detailed manner since it is clear that P sources are diffuse and evenly distributed across the suburban Lake Fairfax watershed.

Outflow P levels and export of P are important. Assuming that outflow equals inflow volume, and outflow concentration equals that in the lake, P export from Lake Fairfax would equal 413. kg P/yr, 51% of long-term estimated loading, 47% if the surface concentration is used for the estimation. This indirect estimate of export and retention (by difference) yields a far higher level of P retained in the lake (about 50%) than is predicted by the retention coefficient for P which is 0.33 (Kirchner and Dillion, 1975). High entrapment of P absorbed onto sediments probably underlies this difference when it is remembered that about 76% of all inflowing sediments are retained in Lake Fairfax and P is strongly associated with sediment particles.

Phosphorus is found in particulate and dissolved states in lake water. Total phosphorus averages 83 mg P/m^3 in Lake Fairfax and soluble P represents 31 mg or 37% of the total. The difference of 52 mg reflects particulate P contained in algae, zooplankton, bacteria, and detritus. The P mass held in the algae of Lake Fairfax is estimated by dividing the average freshweight of algae (0.9929 mg/l) by 500, the P = biomass coefficient. This value is 1.85 mgP/l which is a very small value, about 4% of particulate phosphorus and 2% of total. If chlorophyll 'a' is assumed to equal 1% of algal biomass, then we can check algal biomass estimations. This approach predicts algal freshweight of 1.2 mg/l (close to the 0.9 level found) and algal-P of about 24 mg P/m^3. Thus, the low algal-P concentrations are confirmed by chlorophyll data. Planktonic animals equal 25.9 mg/l on the average and dividing by 798 (Baudouin and Ravera, 1972) gives 32.4 mg/m^3 in zooplankton, 62% of particulate phosphorus. The relatively high phosphorus pool in the animals is the result of their densities and P retention capabilities. Zooplankton forage upon algae and when the animals are dense, they transfer P from plant tissue to their flesh rapidly.

The phosphorus budget of Lake Fairfax is internally consistent and reveals no large stores of P not accounted for in the calculations. This balance is very important since P control is often central to improving water quality and unknown sources of the element can hamper restoration efforts.

The phosphorus budget of Lake Fairfax is summarized below on an annual basis:

	Total Yearly		Baseflow
P Input =	807.78 kg	=	123.19 kg
=	9.26 g/m^2/yr	=	1.41 g/m^2/yr
	@ 162 mgP/m^3		@ 74 mgP/m^3

Correcting for rainfall in the study period, 20% of P loading is in delayed flow.

Phosphorus Budget - Continued

Water Column Phosphorus = 83 mg/m^3 total
= 31 mg/m^3 soluble
= 18.28 kg P in lake
1.85 mgP/m^3 in algae
32.4 mgP/m^3 in zooplankton

In-lake turnover of P equals 11 days, as compared to 16 days for water. ?

	Total	Baseflow
P Output =	413. kg P/yr	176.48

Baseflow export is greater than apparent import due to the hold-over of stormwater by the lake.

Lake Fairfax retains about 50% of yearly loading.

P Lost to Sediments = 395. kg = 4.53 $g/m^2/yr$

h. The Trophic State of Lake Fairfax.

The trophic state of a lake is basically its fertility level and manifestations of that level. Trophic states are in a continuum between lakes low in fertility called oligotrophic lakes and those very well fertilized called eutrophic; mesotrophic lakes lie between these two states. In general, eutrophic lakes are less desired for man's uses, while oligotrophic ones are highly prized. Other differences include:

Levels in Oligo- or Eutrophic Lakes

Characteristic	Oligotrophic	Eutrophic
Total Phosphorus	Low, below 10 mg/m^3	High, above 20
Chlorophyll'a'	Low, less than 4 mg/m^3	High, greater than 10
Secchi Transparency	High, 5m or more	Low, below 2m
Algal Growth Rate	Low, less than 0.3 $gC/m^2/dy$	High, more than 1.0
Algal Biomass	Low, below 100 mgC/m^3	High, above 300

Lake Fairfax is a moderately eutrophic lake.

The lake displays many characteristics associated with eutrophy:

- Transparency is poor due to both algae and sediment-related turbidity; Secchi depth averages only 1.0 m.
- Populations of planktonic algae are fairly dense; mean of 0.9 mg/l algal biomass and 12.4 mg/m^3 of chlorophyll'a'.
- Oxygen depletion occurs rapidly during the period of thermal stratification.
- Total phosphorus levels are high at more than 80 mg/m^3 (20 or more is eutrophic), and P loading is over 16 fold eutrophic levels (to be discussed further along).
- Levels of plant growth are in the range of eutrophic lakes at over 1 g $C/m^2/dy$.
- Dominant species of algae are commonly found in eutrophic environments.

This evidence leads to the conclusion that Lake Fairfax is moderately eutrophic. However, we must look closely at quantitative measures of eutrophy for the lake since these allow us to see how much "oligotrophication" can be expected when various improvements are made in water quality. Three functions used for the quantitative analysis are listed in Table II.10.t. Using phosphorus loading of 9.26 $gP/m^2/yr$, hydraulic loading of 58 and mean depth of 2.53 m, the functions of Table II.10.t. yield important results. (All references to literature can be located in Reckhow, 1977.)

The Ciecka et al. index predicts that the probability of Lake Fairfax being eutrophic is 0.988 - this says that lakes being fertilized at rates similar to those recorded for Fairfax will be eutrophic 99% of the time. At baseflow rates, the prediction is 68% which suggests that if all stormwater inputs were eliminated, Lake Fairfax would still have about a 7:3 chance of being overly fertile.

Walker's index predicts that Lake Fairfax will be eutrophic with 100% certainty at current loading, and that with only baseflow loading the lake will be oligotrophic 4% of the time, mesotrophic 69%, and eutrophic 27%.

TABLE II 10. t.

FUNCTIONS USED IN ASSESSING THE LIKELIHOOD OF EUTROPHIC STATUS

1. Ciecka et al. (1979)

$$P = 1 - \frac{1}{10^{1.8285}\ L^{1.9212}\ Q_s^{-.7078}\ e\left[-.0739(\ln Q_s)^2\right] + 1}$$

A 0.10 probability lies within Vollenweider's oligotrophic band and a $P = 0.5$ denotes eutrophic status.

2. Walker (1977)

$$X = L\left[Q_s\ (1 + .824\ \tau^{.454})\right]^{-.815}$$

X is then located on a graph from which the probability of an oligotrophic classification is read.

3. Reckhow (1978)

$$P_{oxic} = \frac{1}{10^5\ z^{-2.49}\ L^{2.00}\ Q_s^{-1.78} + 1}$$

P_{oxic} expresses the probability that the hypolimnion will become devoid of oxygen - a useful transition point indicating eutrophication.

Reckhow's function predicts that oxic conditions in the bottom zone are highly unlikely; lake being loaded at current P loading, oxic conditions will only be present 0.12% of the time, rising to 7.0% for baseflow levels.

Vollenweider's (1976) equation predicts a P loading of 0.70 $gP/m^2/yr$ as critical (transitional), and one of 1.40 g as clearly producing eutrophic conditions. Notice that even the higher loading is only about 15% of current inputs. In addition, Reckhow's (1977) uncertainty analysis can not be applied to Lake Fairfax since the predicted P concentration at current loading is too high to be included in his figures. This means that the chances of eutrophic classification for Lake Fairfax are 100% regardless of uncertainty assigned to loading estimates. Finally, Carlson's (1977) trophic state index yields 60, 55, and 68 for transparency, chlorophyll, and total phosphorus concentrations. These values also indicate eutrophic status for the lake (chlorophyll is lower due to turbidity and flushing).

The most important purpose of the foregoing trophic analysis is to set reasonable goals for water quality improvements which will bring Lake Fairfax into a meso/oligotrophic classification. One problem is that each index or equation predicts a different level of phosphorus for a given improvement in trophic state. Using the evidence given above, it is justified to set the desired phosphorus inputs to the restored lake at three levels: 1, 2, and 4 $g/m^2/yr$.

The 2 g/m^2/yr level would produce in-lake P levels of about 24 mg/m^3 corresponding to a trophic index of 50 (Carlson, 1977). However, this 2 g level would still leave the lake with a high probability of an eutrophic status despite expected improvements in overall water quality. The 1 g/m^2/yr level would produce lake P concentrations of only about 12 mg/m^3 which gives a Carlson index of 40, a good level for the lake. Walker's index predicts that the 2 g level would give a 60:40 chance of eutrophic and mestrophic classification, respectively, and at the 1 g level lakes would be oligotrophic 11% of the time, mesotrophic 82% and eutrophic 7%. The 4 g level would give eutrophic classification 95% of the time.

In summary, Lake Fairfax is a mildly eutrophic lake with a Carlson index of more than 60 and with a P concentration greater than 80 mg/m^3. After reviewing the prediction of various trophic state models, it is reasonable to set the following objectives:

- Reduce P loading to <u>1 g/m2/yr</u> or less. This low level is about 11% of current P loading and although it will be extremely difficult to attain, this input will <u>dramatically improve</u> the water quality of Lake Fairfax. The lake bottom would probably be visible down to 2 m at all times. Assuming a loading uncertainty of 0.5, Reckhow's (1977) method predicts non-eutrophic condition 65% of the time with this loading.

- Reduce P loading to 2 $g/m^2/yr$ or less. This loading is about 22% of current levels and has a good chance of substantially improving water quality so that there will be no significant impairment of lake usage. Reckhow's method yields a probability of .33 for non-eutrophic status.
- Reduce P loading to 4 $g/m^2/yr$ or less. This level is considered a minimal goal and will produce a eutrophic classification despite some improvement in water quality.

Above the 4 g level, P concentrations will be more than 50 mg/m^3 and there is no assurance that water quality in Lake Fairfax will improve visibly or that lake-use impairment will not continue. If restoration can not reduce loading to significantly less than 4 g in an average year (43% of current), then it must be viewed as totally ineffective and should not be implemented.

II.11. The Biological Resources of Lake Fairfax

a. The Major Habitats

The lake and its immediate surroundings contain a diverse array of habitats. Most areas are biologically sound and these assets should be augmented and protected as part of the overall restoration of Lake Fairfax. The following habitat summary is organized around the classification hierarchy of Cowardin, et. al., (1979):

- Lacustrine (Lake) Habitats
  - Limnetic Zone

    The open water area of Lake Fairfax is underlain primarily by an unconsolidated bottom, most of which is subjected to summertime anaerobic (without oxygen) conditions. This stress severely limits benthic life in this zone and limits its productivity. All in all, the limnetic habitat of Lake Fairfax needs improvement, but it does currently play a valuable role in supporting the lake fish and plankton communities.
  - Littoral Zone

    The shore area or littoral zone is a valuable habitat in Lake Fairfax. The bottom is somewhat variable; rock, submerged aquatic plants, and unconsolidated mud are all found in different areas of the littoral. Pondweed (Potomageton) and water weed (Elodea) occur in patches throughout the littoral. Sedimentation is generally harmful to both animals and plants in this zone, and water quality improvement should prove very beneficial.

- Riverine (Stream-Associated) Habitats

  Forested and Scrub Wetland

  Upstream from the lake along Colvin Run are forests which are flooded several times each year, primarily as a result of urbanization in the Reston area. This is a conservation area and an excellent wildlife habitat. The forests are predominantly hardwoods with species of oak (Quercus), hickory (Carya) and maple common in the area. Scrub pine (P. virginiana) and red cedar (Juniperus virginiana) are scattered throughout the flood plain forest. The area is not a permanent wetland and can be expected to show no change as the lake water quality is improved. It should be preserved during the restoration process.

b. The Fish Populations

The fish assemblage in Lake Fairfax has reasonable species diversity with a good Centrarchid (Sunfish) to bottom feeder balance. There are good populations of at least four species of sunfish (Bluegill, Lepomis macrochirus, pumpkinseeds, L. gibbosus, green sunfish, L. cyanellus, and warmouth, L. gulosus). Largemouth bass (Micropterus salmoides), and white crappie (Pomixis annalaris) are common and are the major targets of fishermen. The bottom feeders are not nearly as prevalent and the brown bullhead, Iclaturus nebulosus, seems to be dominant to carp, Cyprinus carpio. Notes and a summary of fish collections in Lake Fairfax are given in Table II.11.a.

The water quality of the lake allows for good-sized beds of submerged aquatic vegetation (especially in the coves), and is a major factor promoting the health and abundance of the fish populations in Lake Fairfax. The aquatic vegetation is a major nesting area, gives protection to larval and juvenile fish, and is habitat for invertebrate food items. An increased sediment load would damage the submerged vegetation and also have a detrimental effect on fish eggs by increasing the chances of fungal attack and making oxygen uptake by the eggs difficult. Dredging the coves and decreasing anaerobic conditions in the bottom area will improve the fish production of the lake.

Table II.11.a.

SAMPLING FISH POPULATIONS IN LAKE FAIRFAX

May 13, 1981

Five locations were sampled by shore seining in Lake Fairfax. seining hauls 1, 2, and 3 near the inflow of the small creek feeding from the picnic/campground area yielded similar catches:

1. Many (100-200) juvenile bluegills (*Lepomis macrochirus*) of 4 to 7 cm in length;
2. Few (1-10) shiners (*Notropis* sp.);
3. Many (10-50) pumpkinseeds (*Lepomis gibbosus*);
4. Few (1-7) adult bluegill sunfish (*Lepomis macrochirus*);
5. Few (1-3) warmouth sunfish (*L. gulosus*);
6. Few (1-5) largemouth bass (*Micropterus salmoides*), 2, 20-30 cm, and 5 smaller than 15 cm in fork length.

The fourth seining near the mouth of the Cameron Run cove (north of the park buildings) produced a catch similar to the first three with 3 white crappie (*Pomoxis annularis*) captured along with several turtles. The final collection, further north in the cove, yielded 2 brown bullheads (*Ictalurus nebulosus*) and many pumpkinseeds, apparently nesting in the cove.

c. Bird Populations Associated with Lake Fairfax

The lake has several resident families of mallard ducks, with an increased winter population. Geese, ducks, and sandpipers use the lake during migration in small numbers. Several species of gulls and terns occasionally visit the lake, but rarely stay long. A few kingfishers and green herons are resident around the lake, and there is a good-sized population of barn swallows near the lake. Gnat-catchers, warblers, and flyeaters are summer residents in the low trees along the shores. Water quality is important to the resident and migratory populations. Increased benthic insect populations, expansion of aquatic plant beds, and higher fish populations can only improve the outlook for bird populations; these changes should accompany improved water quality.

d. Mammals of the Lake Fairfax Area

Mammals of the Lake Fairfax area are for the most part associated with the surrounding habitat rather than the lake itself. Starnosed moles (Condylora cristata) can be expected on the flood plains along Colvin and Anne Runs, and below the dam. There does not seem to be a resident beaver (Castor canadensis) or muskrat (Ondatra zebithica) population, but the lake is often visited by wandering individuals of both species. Improving water quality will not significantly affect the mammal populations.

e. Reptiles and Amphibians of Lake Fairfax

Lake Fairfax has a large population of painted turtles (*Chrysemys picta*) centered mainly in and around Cameron Run cove. Snapping turtles (*Chelydra serpentina*) are present, but probably few in number due to the small size of the lake and the large area of the turtle's home range. The northern water snake (*Nerodia sepidon*) is common, both around the lake and in the tributory streams and outflow. Several species of ranid frogs (bull frog, *Rana catesbiana*; green frog, *R. clamitans*; pickeral frog, *R. palustris*; leopard frog, *R. pipians*; and the wood frog, *R. sylvatica*) are common around the lake and feeder streams. The beds of submerged vegetation are breeding areas for these frogs and the spotted salamander (*Ambystoma maculatum*). The egg, juvenile, and adult stages of the red spotted newt (*Natothalmus viridecens*) also live in the aquatic vegetation.

A decreased sediment load would improve survivorship for the amphibian eggs in much the same way as was described for the fish eggs. Generally, diversified communities which would result from restoration of the lake will help support and expand current reptile and amphibian populations.

III. The Feasibility Study for Restoring Lake Fairfax

III.1 Alternatives for Restoring Lake Fairfax

The water quality of Lake Fairfax can be improved by treating the lake itself, by purifying the inflows, and by implementing various management practices within the watershed. A number of methods under each of these approaches have been studied for restoring and protecting Lake Fairfax, and these are summarized below, along with reasons for rejection or more detailed analysis. Some of the restoration techniques are classified under two headings when they fall under more than one approach or fulfill several objectives.

a. Lake Restoration Methodologies Applied Directly to the Lake Environment: In-Lake Techniques

- Dredging to Remove Sediments

  Sediment accumulation reduces the storage volume of a lake and its assimilation capacity for pollutants, limits habitats available for fish and other aquatic life, and contributes directly to internal stores and supplies of nutrients or other contaminants. To date, sedimentation has seriously damaged only the Cameron Run and Colvin Run coves of Lake Fairfax, as discussed in Section II.9. Dredging to remove sediments from these areas has been studied as part of the restoration process.

With a depth of 1.5 m considered as adequate for recreation and aquatic habitat, removing sediment from Colvin and Cameron Coves, and allowing for some additional 'targets of opportunity' such as the two small tributary inflow areas in the middle of the north and south shores, leads to a sediment volume of about 20,000. m^3; areas needing dredging are shown in Figure II.1.a. Removing this quantity would greatly improve the breeding grounds for fish and other aquatic vertebrates, and would substantially increase shoreline area suitable for fishing, boating, and tour boat trips.

Three basic approaches can be used to remove the 20,000 m^3 of sediment from Lake Fairfax.

- Sediment Removal by Draining and Excavation

With the water withdrawn from the lake, excavation can be used to transport sediment. A possible drawback to this method is the strength of the lake bottom to hold earth-moving equipment. Also, the lake would be out of use during the work, and access roads and hauling vehicles would detract from terrestrial-based uses of the park. Conversely, the method has the added benefit of increasing the lake volume through sediment compaction when the lake is drained; a 5% increase in average depth is possible at no added cost.

As noted in the engineering reports given in Appendix III.1, the major difficulty with excavation is the uncertainty of whether or not the bottom will support machinery. This problem can be solved in Fall, 1981, when Lake Fairfax will be drained for dam repairs. The contractors handling the dam work can readily find out if the cove areas will be suitable for earth-moving gear. If they are not stable, then other options can be utilized for the dredging, as discussed further along. In terms of costs, excavation is not significantly more costly that other methods, as is illustrated in Table III.1.a.

- Sediment Removal By Barge-Mounted Dragline

Sediment can be moved by a crane-mounted clam shell or dragline and pumped onto a land disposal area as a slurry. The dragline is slower than using an hydraulic dredge and is somewhat more costly. However, it does not require complete cessation of lake use as with excavation. On the other hand, if two casts are necessary to move the spoils to an ultimate disposal site, then the costs calculated for the dragline alternative could exceed those listed in Table III.1.a. Using a dragline is feasible in Lake Fairfax, but is the most costly method of dredging.

TABLE III.1.a.

COST DATA
DREDGING ALTERNATIVES FOR LAKE FAIRFAX

Volume of sediment to be removed - 20,000 cubic meters

Alternatives	Sediment Disposal	Total Dollars	$\$/m^3$
1. Drain & excavate	Hauled	$380,000	19.00
	On-site	$210,000	10.50
2. Dragline	Hauled	$415,000	20.75
	On-site	$230,000	11.50
3. Contractor Dredge	Hauled	$375,000	18.75
	On-site	$190,000	9.50

- Sediment Dredging with an Hydraulic Dredge

Hydraulic dredging consists of breaking materials free from the lake bottom with a rotating cutter and pumping a slurry to a disposal area on shore. With a shield over the cutter, the slurry can carry 20 to 25 percent solids and is thus quite efficient. Costs for hydraulic dredging compare favorably to those of other methods (Table III.1.a). Costs have been estimated for contracting the dredging, and for a County owned and operated dredge with the machine being kept or sold after the project. Table III.1.b. shows costs calculated for a combined effort in which both Lake Accotink and Lake Fairfax are dredged.

Hydraulic dredging seems to be the most practical approach to dredging Lake Fairfax and there is <u>not</u> a significant increase in cost-effectiveness if the County owns the dredge and undertakes the Lake Accotink work with that needed in Lake Fairfax. The most reasonable disposal site is actually within the lake itself, extending the northern shore slightly in the area adjacent to Cameron Cove. This area may need to be extended modestly over that shown in Figure III.1.a, but it will be very desirable as an area for day use activities, especially open water fishing.

TABLE III.1.b. Cost Data for Sediment Removal from Lakes Fairfax and Accotink

Alternatives	Sediment Disposal	Lake Fairfax/Lake Accotink	Total m^3	Lake Fairfax	Lake Accotink	Total $	Total $/$m^3$
County buys and keeps dredge*	Hauled	20,000/76,500	96,500	360,100	1,550,000	1,910,100	19.80
		20,000/100,000	120,100	360,100	1,965,000	2,325,100	19.35
		20,000/153,000	172,900	360,100	2,923,000	3,283,100	18.99
	On-site	20,000/76,500	96,500	173,300	837,000	1,010,300	10.47
		20,000/100,000	120,100	173,300	1,031,000	1,204,300	10.02
		20,000/153,000	172,900	173,300	1,497,000	1,670,300	9.66
County buys and sells dredge*	Hauled	20,000/76,500	96,500	360,100	1,460,000	1,820,100	18.87
		20,000/100,000	120,100	360,100	1,875,000	2,235,100	18.60
		20,000/153,000	172,900	360,100	2,833,000	3,193,100	18.47
	On-site	20,000/76,500	96,500	173,300	747,000	920,300	9.54
		20,000/100,000	120,100	173,300	941,000	1,114,300	9.27
		20,000/153,000	172,900	173,300	1,407,000	1,580,300	9.14

*Costs for purchasing & selling dredge are included in Lake Accotink costs.

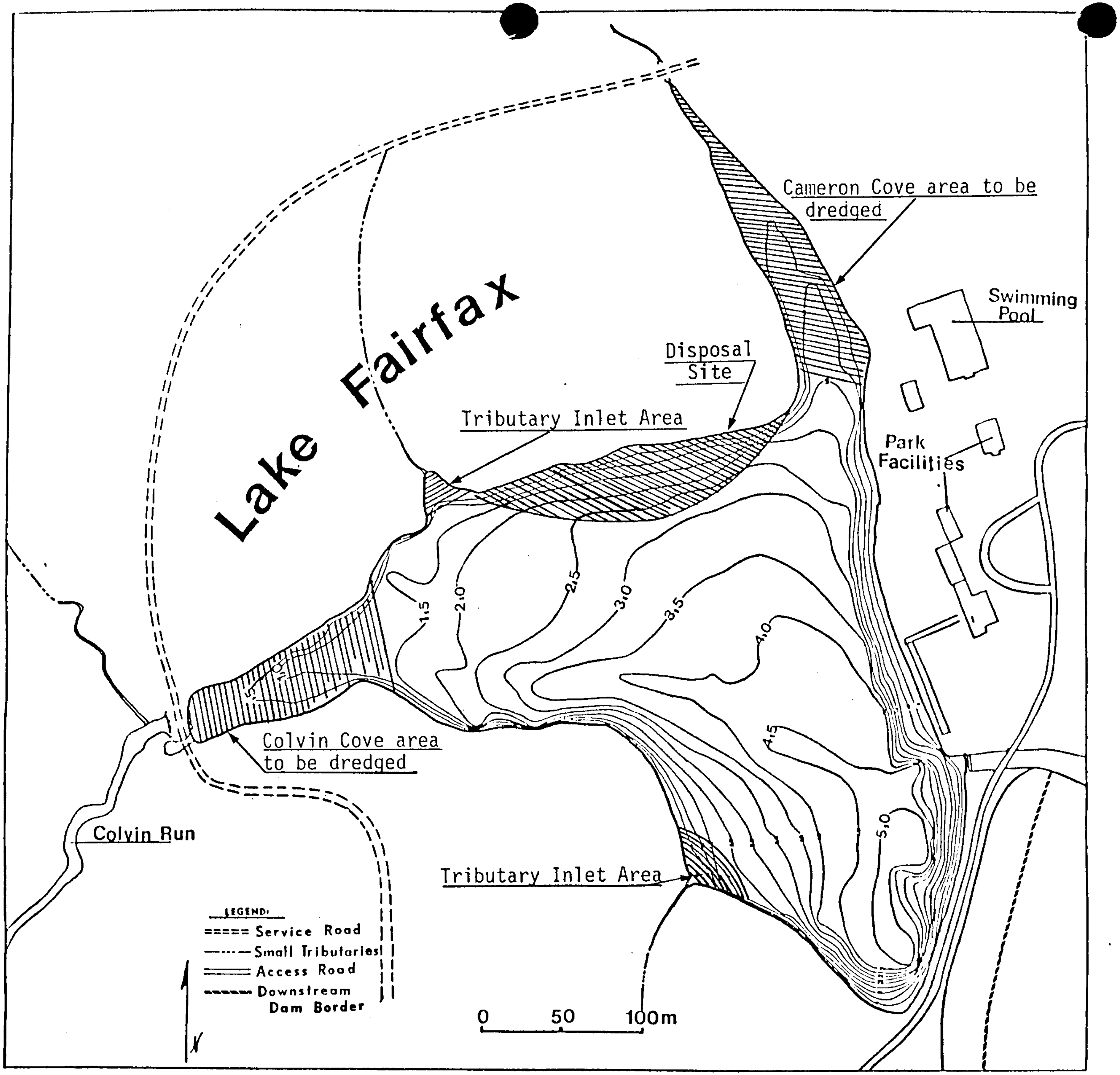


FIGURE III-1 - Sites for sediment removal and dispositioning are shown

- Nutrient Inactivation; Chemical Precipitation

Nutrients and other contaminants can be removed from lake water through precipitation with chemical additives; aluminum sulfate or sodium aluminate are the most common chemical agents. An absolute requirement for using this method of water purification is that nutrients coming from outside the lake be largely eliminated and that internal stores be the primary nutrient source. Even with a dramatic reduction in P loading, this method would <u>not</u> work in Lake Fairfax because the turnover of the lake is too rapid; phosphorus in the lake is replaced every 8 days (See II.10.g.).

- Dilution/Flushing of Lake Water

Relatively pure water can be diverted into a lake diluting nutrients and improving water quality. This process requires huge quantities of clean water which are unavailable to Lake Fairfax. In a similar manner, water can be put into a lake to act as a physical cleanser, flushing materials, especially algal scums, from the water. With an average hydraulic residence time of 15 days (Section II.10.f.), Lake Fairfax is already being flushed quite rapidly and would be little altered by increasing water turnover. Dilution and flushing are therefore <u>not</u> useful in this case.

o Selective Withdrawal of Lake Water

Drawing the lake outflow from the bottom region increases nutrient and sediment export. This is especially true during periods of thermal stratification and the process is called selective withdrawal because it involves a pipe and valve device which is operated at will. Withdrawal of nutrient and sediment-rich bottom water can be accomplished by a pipe device and by the operation of existing drain valves associated with the drop inlet.

It appears most practical and efficient to use the existing drop inlet valve, being rebuilt in Fall, 1981. A motorized operator for the valve can be designed which will be linked to the level of the lake in the fashion of a thermostat. As the lake level drops and rises with respect to the elevation of the spillway, the bottom valve will automatically be closed or opened in compensation. Using stilling wells, a very accurate level indicator can be built so that the valve operator can be activated by level changes as small as a centimeter (1/2").

Another important side-benefit of the motorized valve approach, as opposed to piping, is that during stormwater inflows the valve can open wide, flushing out bottom water most laden with sediment and its associated contaminants. Also, the level compensator can easily be adju permit various amounts of surface outflows over the spillway, and can be overridden manually should complete surface outflow ever be needed to flushout scums from the surface. Further, a safety shut-off override and a warning system for malfunction can easily be developed so that danger of draining the lake accidentally can be minimized.

Information available currently indicates that such an automatic valve system has not been used to date in improving the water quality of the lake. Various piping arrangements have been used successfully and we can see no reason whatsoever why the drop inlet valve can not be similarly applied. As noted in the engineer's report in Appendix III.1., using the existing outlet structure avoids aesthetic problems and reduces costs to about $10,000 above drop inlet replacement costs. However, we should add a note of caution that additional research costs on the operating control device may be needed on engineering and prototype construction.

A reasonable value for average baseflow input to Lake Fairfax is 100 liters per second or 8600 m^3 per day. Referring to Table II.10.a. on bathymetrics, it can be seen that 77,467 m^3 occurs in the bottom zone below 2 m which constitutes the area without oxygen over most of the summer season (the hypolimnion) and overlies about 64% of the lake bottom. Using bottom withdrawal as 75% of the total outflow (keeping some surface overflow for flushing), the bottom zone will be replaced every 12 days. This turnover rate is sufficient to have major affects on Lake Fairfax.

A bottom withdrawal regime for Lake Fairfax will have several major consequences:

- It will eliminate anaerobic conditions which now affect 35% of the lake's volume and 64% of its bottom area.
- It will increase the outflow of sediments and their associated contaminants especially during and immediately following storms when most of the outflow can be shunted through the bottom valve.
- It will prevent the formation of thermal stratification and thus avoid the attendant oxygen depletion and nutrient release.
- It will improve the food base for the lake's fish and will greatly increase the usable volume of water. It should therefore have a substantial benefit on fish yield.
- It will cause some increase in phosphorus and nitrogen export, although this may be limited to a 15% increase based on depth-related difference in nutrient levels.

- Sediment Compaction

Sediment dewatering by draining the lake can cause the bottom to consolidate, increasing the lake's depth sometimes a meter or more. This compaction has been little researched as a lake renewal method, and its success would depend upon the consolidation properties of the sediments, (density, solids content, porosity) and upon the feasibility of lowering the water table 1 or 2 meters below the sediment surface for about 2 months to fully dewater the deposited stratum. The relative shallowness of Lake Fairfax sediments and the uncertainty of complete dewatering in a reasonable time period make sediment consolidation doubtful as a separate restoration technique. However, some sediment compaction could be a valuable side effect of draining the lake for dam repairs or excavation dredging.

- Sediment Sealing

Sediments have been covered with chemical blanket in some lakes which successfully isolates nutrients and other contaminants from the water column above, and improves water quality. The success of sediment sealing as a renovation technique depends upon the importance of sediment-released substances to lake fertility and quality. In cases such as Lake Fairfax, where nutrients are rapidly replaced in the lake, sediment sealing would not be effective in improving water quality.

- Lake Aeration/Mixing

Large air pumps can be used to aerate and circulate lake water. This usually breaks thermal layering of the lake and reduces internal release of nutrients. As with sediment sealing, this process can only be effective when in-lake nutrient stores are very important. Lake Fairfax would not be improved significantly more by aeration than by the bottom withdrawal scheme discussed above which will accomplish the same objectives at greatly reduced cost.

b. Restoration Methodologies Applied to the Inflows for Control of Nutrient and Sediment Loading.

- Inflow Treatment with Detention Basins

When stormwater is held for over 24 hours in detention ponds, much of the sediments and associated contaminants settle out of suspension and are trapped in the basin.

Detention basins reduce peak flow rates and provide recreation and aesthetic values as well. Such multipurpose basins are being widely used for control of nonpoint source pollution, and have potential in restoring Lake Fairfax.

Capital costs of detention basins on tributary streams is a major consideration, but operating and maintenance costs (O & M) are also important. Sedimentation ponds need to be dredged periodically at substantial cost, already reviewed earlier in this section for the lake itself. Detention basins also need maintenance such as outlet cleaning, shore stabilizations, dam inspections, and miscellaneous repairs. These items become increasingly significant as multiple basins are placed around a large watershed, such as that feeding Lake Fairfax.

The multipurpose detention basin approach to improving the inflow water quality of Lake Fairfax can be undertaken either by a single large basin just upstream from the lake or by multiple smaller detention basins on the tributaries. The advantages of these options are outlined below:

	Single Large Basin	Multiple Tributary Basins
Maintenance	Lower cost by a single location for dredging and one set of structures to maintain.	Higher cost due to travel, many structural features to be maintained and multiple dredging sites.
Pollutant Trapping, assuming same design capacity	Higher trapping efficiency for total load due to holding inflow from all the watershed except the immediate drainage	Lower overall removal runoff from unponded areas will be missed.
Land Acquisition	Probably, none would be needed	Land would need to be purchased by FCPA
Capital Cost	Lower because of efficiency of scale and lower miscellaneous costs from less mobilization	Higher cost with multiple mobilizations, site analyses and possible land acquisition.

The fundamental requirement of a nonpoint source control basin is that it hold the volume of a 2-year frequency storm for 24 hours (NVRPDC, 1979). For the Fairfax watershed near the lake, such a storm yields a huge quantity of runoff equalling 1 to 2 times the current lake volume, depending upon rainfall characteristics and antecedent conditions. A new lake could be constructed upstream from the existing lake, but it is clearly impractical to do so since it would be as valuable as Lake Fairfax. A large detention basin would cost $350,000 at a minimum and would not restore Lake Fairfax; it would merely create another reservoir with environmental problems of its own.

Applying multiple basins to the tributaries is also fraught with problems. Several smaller basins greatly exceed the cost of a single one, and would require land acquisition and maintenance in remote areas around the watershed. It does not appear feasible to improve the quality of inflowing water to Lake Fairfax in any sort of a cost-effective way using detention basins. Additional information on this approach is presented in the engineering report in Appendix III.1.

- Inflow Purification with the Dunkers' Stormwater Balancing and Treating System

A water holding system in combination with a treatment plant has been used successfully to restore several lakes in Sweden. This system was developed by Karl Dunkers who kindly developed plans for a model applicable to Lake Fairfax; his drawings and narrative are included in Appendix III.1.

The Dunkers system holds great promise under a variety of circumstances. However, the sytem proposed for use in Lake Fairfax has several serious drawbacks. Approximately 400 m^3/hr is the overall inflow rate to Lake Fairfax and most of the time it exceeds 180 m^3/hr. The 80 m^3/hr treatment rate is thus too small to make a substantial reduction in nutrient and sediment loading. Further, even if the plant were quadrupled in capacity, the loading of larger storms could still not be handled, and, more importantly, O and M costs would be very high. Mr. Dunkers estimated approximately $50,000 for all operational expenses, but this would at least double with a expanded plant.

A Dunkers' system which would make a real contribution to restoring Lake Fairfax could cost approximately $100,000, much more than originally estimated and could demand this much for yearly O and M. For these reasons, we cannot recommend installation of the system in Lake Fairfax; the benefits cannot justify the costs. In lakes with much lower watershed to lake area ratios than Fairfax (at 100), the system could work well. The substantial effort expended by Mr. Dunkers in preparing a proposal for evaluation during this study is gratefully acknowledged.

- Inflow Diversion

Consideration has been given to techniques by which pollutant-rich stormwater can be diverted around the lake to reduce both sediment and nutrient loading. It would be prohibitively expensive to build a bypass channel around the lake, so the investigation focused on an in-lake bypass channel. Bypassing is a difficult means of reducing inputs to Lake Fairfax, but it does have the potential of handling the huge volumes of polluted water entering the lake with each runoff event, and is capable of greatly reducing loading to the lake.

The preliminary cost of a concrete pipe (60 inch) 2000 feet long across Lake Fairfax is $236,000 (Appendix III.1.) and in order to handle larger storms the bypass would have to be installed <u>in addition</u> to a stormwater detention basin upstream from the lake at $350,000. This investment of about $600,000 is probably conservative since the costs of many construction activities have not been included. The bypass would drastically reduce pollutant loading to about 20% of current levels and would greatly improve the water quality of Lake Fairfax. However, the prospective phosphorus loading is still on the order of 2 $g/m^2/yr$ which is within the eutrophic range and would maintain transparency at only about 1.7-1.9 m.

The bypassing of water through the lake will thus improve the water quality of Lake Fairfax moderately, and would reduce sediment and nutrient loading to around 20% of current levels. However, the cost is high at about $750,000 allowing a 25% contingency for unaccounted costs. Because of this expenditure we can <u>not</u> recommend the bypass approach for the Lake Fairfax restoration.

c. Lake Restoration Methodologies Involving the Control of Pollution within the Watershed.

- Street Sweeping to Decrease Pollution.

  Pollutants can be removed by vacuum street sweepers before they are transported to a lake. The NVRPDC (1979) report provides valuable information for assessing the usefulness of sweeping. Based upon their data, it would take four sweepers to cover the 2000 acres of the Lake Fairfax watershed not being fed through Lake Anne. At $27,518 per year, it would cost $110,000. per year for one pass per week which would remove about 25% of loading from Lake Fairfax. This is a high yearly expense and is not adequate in pollutant reduction to justify the cost. Visible improvement in the lake would be minor if sweeping were fully implemented.

- Detention Basins.

  Earlier in this section, detention ponds were studied regarding their possible use for pollutant trapping. Multipurpose detention basins were found to be inefficient for use in restoring Lake Fairfax (See III.1.).

o Public Education Programs.

A good-public education program can help reduce nonpoint source pollution. Using the information provided by NVRPDC (1979), reasonable compliance with a voluntary fertilizer management program, for example, could remove about 5-20% of phosphorus loading from residential areas.

Also, soil erosion, and garden litter and oil dumping, can be reduced by education and community action programs. However, these efforts individually cannot be considered adequate to have a substantial effect on Lake Fairfax. They are important, nonetheless, as agents furthering public involvement and awareness.

We recommend that a public education program, possibly in conjunction with ordinance, be developed during the restoration of Lake Fairfax. The program will serve to inform the population about FCPA restoration efforts, and would involve citizens in saving a regional asset. Key elements which should be considered for educational purposes include:

- understanding nonpoint source pollution and stormwater runoff
- reducing fertilizer runoff by careful application
- controlling organic and debris accumulation
- using street sweeping to reduce pollution.

d. Recommended Approach for Restoring Lake Fairfax

In light of the Feasibility Study summarized throughout Section III of this report and the Diagnostic Study presented in Section II, NUSAC has arrived at a combination of restoration activities for improving Lake Fairfax. The recommendations given below have been selected recognizing the impracticality of efficiently controlling nonpoint source pollution in the 1000 hectare watershed; it is far more realistic to manage the consequences. For example, two years of street sweeping could possibly avoid about 1600 m^3 of sediment accumulation in Lake Fairfax (3200 m^3/yr x 25% reduction x years). This reduction will cost about $60. per m^3 saved in the lake ($220,144/1600 m^3), while dredging the accumulated sediment costs about $9.50 m^3. This line of evidence should not be construed as an argument against pollution control at the source, but rather as an example of developing solutions to the problems generated by pollution in a cost-effective manner.

- Dredging to remove sediments

  A hydraulic dredge should be utilized to remove about 20,000 m^3 of sediment from the two major coves and selected additional areas shown in Figure III.1.a. The sediment dewatering and disposal site can be constructed on the north shore. After dredging, this area can be stabilized and used as a prime fishing site and for general daily activities. Using the data of Table III.1.a., and that given in detail in the engineering analysis (Appendix III.1), the dredging should cost about $190,000 in 1981 dollars or about $220,000, making a 15% correction for inflation.

- Installing a selective withdrawal mechanism

We recommend that an automated operating system be installed on the drop inlet drain valve, which is being rebuilt in Fall, 1981. This valve system has been discussed thoroughly in III.1.d. The motorized valve control will act as a regulator of lake level allowing varying amounts of nutrient-rich bottom water to be released from the lake depending upon the inflow rate. If the system can be installed without modifying the drop inlet valve extensively, the cost could be as low as $10,000. However, allowing at least $5,000 for research costs on the lake-level regulatory mechanism, and a 25% contingency which seem prudent, $18,750 is an approximate cost estimate for planning purposes. The bottom withdrawal system will substantially improve the biological production in the lake and help to improve overall water quality.

We thus recommend that $238,750 be allocated for the dredging operation and for a valve operating device. These restoration projects will have many positive benefits:

- Increase the habitat for fishes, especially as regards nesting areas, and provide a stronger food base for fish.
- Increase shore access to good fishing areas, and expand shore areas for day-use activities.
- Improve the overall water quality of the lake, and remove the stress and nutrient release associated with oxygen depletion.

III.2. Benefits Expected from the Restoration of Lake Fairfax

The major areas of benefit from the recommended restoration projects will be in the visible water quality of the lake and in the production of its sport fisheries. These and other benefits are detailed below.

o Improving fishing in the lake

The bottom withdrawal regime to be installed in Lake Fairfax will greatly improve the benthic food resources and water volume available to fish, and the dredging effort will expand nursery grounds and habitat area for fish. These changes can be expected to greatly improve the fish yield from Lake Fairfax;

much better catch per unit effort can be anticipated for bass, crappie, and catfish. Quantitative estimates of improvement cannot be made, but since 35% of the lake's volume is currently unusable by fish for over 6 months each year, and since oxygen depletion degrades the benthic environment of about 65% of the lake's bottom, removing these inhibiting factors can only have a major positive benefit on the sport fisheries. Also, the dredging operation will increase shoreline fishing area about 40% due to both cover deepening and the disposal area access to deep water. The user population of the lake should also increase with these positive changes in fishing, and revenues from bait and tackle sales will improve.

- Increases in rental boating

Making the main coves deeper and dredging some additional area around the shore will improve the opportunities for enjoying paddle boats and canoes on Lake Fairfax. The improved clarity of the water and increased fishing success should also serve to expand the fees generated by the boat and canoe rental operation on Lake Fairfax.

- Increases in tour boat cruises

With more deep areas near shore and navigable coves, the tour boat cruises can be more interesting. Thus, both special trips and routine cruises can be expected to increase with the restoration projects on Lake Fairfax.

- Overall increase in park usage

  Restoration-related improvement in fishing, boating, and general aesthetic appeal will expand the user population of Lake Fairfax Park. Expansion of the recreational value of the lake will draw additional users, who in turn will bring non-lake oriented accompanying persons into the park. The restoration of Lake Fairfax will avoid any drop in use which would have occurred without the projects, and will cause a moderate expansion in the current user population.

III.3. Monitoring Program for the Restoration Phase

With the careful use of a deflector shield on the hydraulic dredge, the turbidity stress generated by dredging should not seriously affect Lake Fairfax on the long-term basis. For this reason and the fact that the phosphorus loading into the lake is not being attacked, we do not see any need to monitor Lake Fairfax during the dredging or valve installation operations.

Following project completion, however, monthly monitoring from April through October should be done for the following: conductivity, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, chlorophyll 'a' and phytoplankton. Samples should be analyzed from 0.5, 1.5, 3.0, and 4.5 m at the dam station of the lake. The efficiency of the bottom withdrawal valve should also be measured during at least three storm events. On these occasions, Colvin Run inflow and outflow, and the drop inlet effluent should be sampled. These data can also be used to assess the relative increase in the export rate from bottom withdrawal as compared to the surface outflow.

III.4 Preliminary Schedule and Budget for the Restoration of Lake Fairfax

Cost factors used in computing the cost of alternatives are given in the engineering report in Appendix III.1. The dollar values are realistic but should not be viewed as final estimates; final costs will be made during contracting negotiations and further engineering analyses during restoration. Similarly, the schedule allotments are only approximate, although they do reflect a reasonable time span for handling the particular project area. The preliminary budget and schedule allotments are given in Tables III.4.a. and b., respectively. Final budgets and schedules can only be formulated after the Park Authority has committed funds to proceed.

Table III.4.a.

A Preliminary Budget for the Restoration of Lake Fairfax

	1981 Value	With a 15% Inflation Added
Dredging:		
Engineering	$ 1,900	
Construction and Dredging Operations	$190,000.	
@9.50/m^3; 20,000m^3		
	$191,900.	$220,685
Bottom Withdrawal Mechanism		
Engineering	5,000	
Construction	10,000	
25% Contingency	3,750.	
	$ 18,750	$ 21,560

This estimate is for the valve operating mechanism. This same amount should prove adequate to install a drop inlet collar should that approach be selected after further engineering and analysis.

Monitoring and Research Studies		$ 25,000.
TOTAL ESTIMATED COST		$267,245.

Table III.4.b.

Preliminary Schedule Allotments for the Restoration Project of Lake Fairfax

Project Area	Time Allotted, Months
Dredging	
- contracting preparations, bidding	3
- engineering	1
- dewatering basin construction	2
- set-up of dredge	0.5
- dredging operation	3.5
*@300m^3/day; 20,000 m^3	
	10
Withdrawal Mechanism Installation	
- contracting preparations, bidding	2
- engineering/research	3 - 6**
- construction/installation	1
	6 - 9
Lake Monitoring	8 following completion of above

*Estimates of dredging speed vary from 115 m^3/day as a communication from an operator at Royal Lake, to 400 m^3/day estimated by Mudcat sales representative. At a down-time of 25%, 300 m^3/day was used here as a reasonable figure.

**Research time may be needed for valve operating mechanism.

III.5 Sources of Matching Funds for the Restoration of Lake Fairfax

Inflation, the overall poor condition of the economy, and the current wave of fiscal conservatism, combine to produce an atmosphere in which restoration of lakes is considered a luxury, and funding for such projects is difficult to obtain. Due to President Reagan's economic cuts, federal monies are improbable, and yet some sources of possible federal funding worthy of FCPA research are:

- HUD's Community Development Block Grants
- Department of Interior's Heritage Conservation and Recreation Service
- Department of Interior's U.S. Fish and Wildlife Service.

Besides local governments, divisions of State government, such as the Virginia Commission of Outdoor Recreation, are possible grantors of funds for the Clean Lakes restoration of Lake Fairfax.

Another source for funds the Park Authority can explore are private sector funds, especially those known to sponsor environmental projects. Some examples are:

- Virginia Environment Endowment
  700 East Main Street
  P.O. Box 790
  Richmond, Virginia 23206

- Atlantic Richfield Foundation
  515 South Flower Street
  Los Angeles, California 90071

- Kalamazoo Foundation
  332 ISB Building
  151 South Rose Street
  Kalamazoo, Michigan 49006

- Lily Endowment
  2801 North Meridian Street
  P.O. Box 88068
  Indianapolis, Indiana 46208

Companies within the private sector to consider for funding are listed in the Foundation Directory, published by the Foundations of the United States. Companies who are known to have funded a variety of park and community projects are as follows:

- Bank America Foundation
  BankAmerica Center
  P.O. Box 37000
  San Francisco, California 94137

- The Robert G. III and Maude Morgan Cabell Foundation
  P.O. Box 1377
  Richmond, Virginia 23211

- Camp Foundation
  c/o John C. Parker
  Franklin, Virginia 23851

- Cole (Quincy) Trust
  c/o First and Merchants National Bank
  Richmond, Virginia 23261

- The Flager Foundation
  510 United Virginia Bank Building
  Richmond, Virginia 23219

- Ford Motor Company Fund
  The American Road
  Dearborn, Michigan 48121

- General Motors
  3044 West Grand Boulevard Rm 13-145
  Detroit, Michigan 48202

- Massy Foundation
  The Massy Building
  P.O. Box 26765
  Richmond, Virginia 23261

- Mobil Foundation
  150 East 42nd Street
  New York, New York 10017

- The Ohrstrom Foundation, Inc.
  P.O. Box 325
  Middleburg, Virginia 22117

- Perry Foundation, Inc.
  240 Court Square
  Charlottesville, Virginia 22901

- Richmond Corporation Foundation
  First and Merchants National Bank
  Twelfth and Main Streets
  Richmond, Virginia 23261

- Xerox Fund
  High Ridge Park
  Stamford, Connecticut 06904

Please note that the requirements for and availability of each funding program is subject to change from year to year, depending upon the administration, as well as the competitive climate. Also, the Fairfax County Park Authority cannot search for funds effectively until they have committed funds to the restoration project.

III.6. Relationship With Other Pollution Control Programs

At this time, no programs for pollution control have been located which will be affected by and affect the in-lake restoration activities for Lake Fairfax. Relationships may be appropriate, however, if matching funds can be located through any of the programs given in section III.5. Coordination plans can be developed for any relationship which evolves in the implementation phase.

III.7. Public Participation Summary

A summary of public participation will included as part of the final report.

III.8 Operation and Maintenance Plan for Restoration Projects at Lake Fairfax

The restoration projects which were determined to be feasible are in-lake treatments, and require no maintenance beyond that expected for any structure, or facility in the park. Thus, the park operations and management personnel can be used to oversee any operation and maintenance requirements. Operating and maintenance needs should be detailed as part of the restoration engineering, and these specifications will then be incorporated into the general facilities management for Lake Fairfax Park.

III.9. Permit Applications

Fairfax County Park Authority will include all required permits when applying for Phase 2 implementation funding. The Phase 1 analysis and data should provide all necessary information for dredging permits or other required State or Federal permits.

IV. Environmental Evaluation for the Restoration of Lake Fairfax

1. Displacement of People

No persons will be displaced by the restoration project.

2. Defacement of Residential Areas

No residential lands will be used for the spoils disposal area for sediment dredging and no residential area will be otherwise damaged.

3. Changes in Land Use Patterns

No changes in land use are proposed as part of the restoration project.

4. Impacts on Prime Agricultural Land

No agricultural land will be lost as a result of the project.

5. Impacts on Parkland, Other Public Land, and Scenic Resources

The restoration cost in land and scenic attributes is very minor. Only the small north shore disposal area represents any change in the lake-associated lands and, after stabilization, this area will become an asset to the park and its recreational potential.

6. Impacts on Historic, Architectural, Archaeological, and Cultural Resources

The restoration project is planned for an area within the boundaries of the existing lake so that no cultural resources should be affected.

7. Long Range Increases in Energy Demand

The restoration project will have no effect on energy demand for the long-term. Energy will be used only during the dredging and should not be required on a continuing basis.

8. Changes in Ambient Air Quality or Noise Levels

The construction and dredging activities will produce some unavoidable noise and aesthetic pollution on a short-term basis. These problems will be minimized to the greatest practical extent as part of the contract requirements for the work. Longer-term air or noise problems are not expected, since increased park use will make a minute contribution to the noise and air quality problems of the Reston-Herndon area.

9. Adverse Effects of Chemical Treatment

Chemical treatment is not proposed for this lake restoration.

10. Compliance with Executive Order 11988 on Floodplain Management

All dredging and construction activities for Lake Fairfax are located within the Colvin Run floodplain. However, major changes in flow routing have intentionally been avoided and no impact is expected for the floodplain or its beneficial uses.

11. Dredging and Other Channel, Bed, or Shoreline Modifications

Dredging can cause environmental problems beyond the area being worked. In the Lake Fairfax environment, these effects are not considered a serious problem since the lake is currently suffering high turbidity and has been so affected for at least a decade. The direct impact of sediment resuspension is therefore not anticipated to be serious. Indirect toxic effects will be examined when chemical testing of Lake Fairfax sediments is completed.

12. Adverse Effects on Wetlands and Related Resources

No wetland areas will be affected by the restoration projects at Lake Fairfax.

13. Feasible Alternative to the Proposed Project

The restoration of Lake Fairfax is highly cost-effective. No park-lake in the D.C. area has the unique properties of Lake Fairfax and the cost for improving the lake does not even approach a partial replacement cost for the lake. The evidence discussed in the Diagnostic Study, particularly regarding the user population, comparative lake uses, and biological resources strongly support the restoration effort. Considering also the ideas of Sections III.1 and 2, Lake Fairfax is certainly <u>not</u> worthy of a 'no action' alternative.

14. Other Necessary Mitigative Measures or Requirements

No mitigative measures appear to be appropriate at this time. Measures to mitigate environmental impact will be reassessed in the detailed implementation plan to be developed during restoration.

V. References Cited

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APPENDICES

Appendix I Unit Conversion Factors

To Convert from:	To:	Multiply by:
Acres	Square Feet	43,560
Acres	Square Meters	4047
Cubic Feet	Acre-Feet	2.2957×10^{-5}
Cubic Feet	Gallons	7.45
Cubic Feet	Liters	28.32
Gallons	Cubic Feet	0.1337
Gallons	Liters	3.785
Grams	Pounds	0.00221
Hectares	Acres	2.471
Hectares	Square Kilometers	10,000
Kilograms	Pounds	2.205
Kilometers	Miles	0.6214
Liters	Cubic Feet	0.03532
Liters	Gallons	0.2642
Meters	Feet	3.281
Miles	Kilometers	1.609
Pounds	Grams	454
Pounds	Milligrams	454,000
Square Kilometers	Acres	247.1054
Square Kilometers	Square Miles	0.386
Square Miles	Acres	640
Square Miles	Square Kilometers	2.59
Tons	Pounds	2,000
Tons	Kilograms	907.18
Tons	Metric Tons	0.907

Appendix II.9.e.

Storm Event Monitoring Data
for the Lake Fairfax Watershed

A summary table, station data summaries, and water chemistries, with quality control data are presented for 4 storms in the Spring and Summer of 1981. Storm number 4 was not analyzed due to insufficient runoff.

NUSAC

Date: 5/1 - 5/1981 Station: Colvin Run Inflow Storm #: 1 Lake Fairf

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow m^3/min.	25 C Cond	Total P mgP/ℓ	Susp. Solids (mg/ℓ)	
1	1130	79	259	65	1.18	2,660	
2	1315	74	247	77	0.22	722	
3	1420	68	186	78	0.35	54	
4	1530	61	158	83	0.25	288	
6	1700	60	199	79	0.22	262	
7	1800	41	78	81	0.20	189	
8	2040	14	28	87	0.14	106	
	5/2/81						
9	1045	9	7.1	103	0.04	15	
	5/3/81						
10	1245	.3	6.0	102	<0.01	11	
	5/4/81						
11	1000	2		96	0.02	5	

Notes:

Date: 5/1 - 5/81 Station: Colvin Run South Storm #: 1 Lake Fairf

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow m^3/min.	25 C Cond	Total P mgP/ℓ	Susp. Solids (mg/ℓ)	
6	1715	61	110 Revs at Sur.	70	0.30	344	
8	2050	45		78	0.21	162	
9	1045	25	129.37	95	0.05	13.4	
	5/3/81						
10	1230	20.5	59.80	94	0.03	4.1	
	5/4/81						
11	1100	19.2	52.09	89	0.03	2.7	

Notes:

Date: 5/1 - 5/81 Station: Colvin Run South Storm #: 1 Lake Fairfa

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow m^3/min.	25 C Cond	Total P mgP/ℓ	Susp. Solids (mg/ℓ)	
6	1715	61	110 Revs at Sur.	70	0.30	344	
8	2050	45		78	0.21	162	
9	1045	25	129.37	95	0.05	13.4	
	5/3/81						
10	1230	20.5	59.80	94	0.03	4.1	
	5/4/81						
11	1100	19.2	52.09	89	0.03	2.7	

Notes:

NUSAC

Date: 5/1 - 5/81 Station: Anne Run Storm #: 1 Lake Fairf

Observers: ______ ______

Sample No.	Time	Gauge(cm) Height	Estimated Flow m^3/min.	25 C Cond	Total P mgP/ℓ	Susp. Solids (mg/ℓ)	
6	1715	61		94	0.12	107	
8	2045	48.5		103	0.07	52.9	
9	1030	30.4	160.05	112	0.03	9.2	
	5/3/81						
10	1200-1300	21.5	59.21	110	0.02	6.1	
	5/4/81						
11	1100	19.2	47.3	105	<0.01	3.0	

Notes:

Date: 5/1 - 5/81 Station: Colvin Run Outflow Storm #: 1 Lake Fairf

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow m^3/min.	25 C Cond	Total P mgP/ℓ	Susp. Solids (mg/ℓ)	
1	1350	63		124	0.14	138	
2	1445	63		127	0.13	106	
3	1545	60		126	0.12	94.5	
4	1645	60		124	0.10	66.1	
5	1745	59		118	0.08	67.3	
6	2115	45.5		123	0.11	50	
	5/2/81						
7	1115	17	463.91	97	0.10	47.3	
	5/3/81						
8	1130	10	116.16	102	0.09	22.3	
	5/4/81						
9	0930	7.7	117.29	100	0.06	15.2	

Notes:

WATER CHEMISTRY ANALYSES FOR STORM #1
AT LAKE FAIRFAX ON MAY 1-2, 1981

Sample Designation	Bios #	Total Phosphorus (mg P/l)	Suspended Solids (mg/l)
Colvin Run Inflow 1	4950	1.18	2660
Colvin Run Inflow 2	4950	0.217	722
Colvin Run Inflow 3	4952	0.351	53.6
Colvin Run Inflow 4	4953	0.247	288
Colvin Run Inflow 6	4954	0.222	262
Colvin Run Inflow 7	4955	0.198	189
Colvin Run Inflow 8	4956	0.135	106
Colvin Run Inflow 9	4957	0.038	14.8
Colvin Run Inflow 10	4958	<0.010	10.6
Colvin Run Inflow 11	4959	0.018	5.1
Colvin Run Outflow 1	4960	0.137	138
Colvin Run Outflow 2	4961	0.132	106
Colvin Run Outflow 3	4962	0.118	94.5
Colvin Run Outflow 4	4963	0.096	66.1
Colvin Run Outflow 5	4964	0.084	67.3
Colvin Run Outflow 6	4965	0.108	50.0
Colvin Run Outflow 7	4966	0.101	47.3
Colvin Run Outflow 8	4967	0.086	22.3
Colvin Run Outflow 9	4968	0.057	15.2
Colvin Run South 6	4969	0.298	344
Colvin Run South 8	4970	0.208	162
Colvin Run South 9	4971	0.052	13.4
Colvin Run South 10	4972	0.025	4.1
Colvin Run South 11	4973	0.030	2.7
Anne Run Inflow 6	4974	0.123	107
Anne Run Inflow 8	4975	0.069	52.9
Anne Run Inflow 9	4976	0.025	9.2
Anne Run Inflow 10	4977	0.018	6.1
Anne Run Inflow 11	4978	<0.01	3.0

NUSAC

Date: 5/28/81 Station: Colvin Run (South) Storm #: 2 (Lake Fairfax)

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S			
1	0900	26	241			
2	1000	22	155			
3	1100	20	120			
4	1200	19	113			
5	1310	19.5				
6	1400	19.5				
7	1410	20				
8	1500	19.5				
9	1610	18.5				
10	1700	18.5				
11	1800	22				
12	1820	24	231			
13	2000	20				
1	0900	13.5				
	(5/29/81)					

Notes: Total discharge (m^3) - 5,543.17

	TP (mg/l)	TN (mg/l)	SS (mg/l)
Composite A	0.105	930.25	36.6
Composite B	0.102	630.25	38.2

Date: 5/28/81 Station: Anne Run Storm #: 2

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S				
1	0915	26	106				
2	1015	23.5	89				
3	1120	20	63				
4	1215	22					
5	1315	24					
6	1320	25	81				
7	1415	24					
8	1515	23					
9	1620	22					
10	1705	26					
11	1715	28					
12	1815	28	132				
13	2015	24					
1	0900	20					
	(5/29/81)						

Notes: Total discharge (m^3) - 3,044.39

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.044	520.25	13.4
Composite B	0.018	1420.25	15.0

Date: 5/28/81 Station: Colvin Run Outflow Storm #: 2

Observers: ______________________ ______________________

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S			
1	0830	6				
2	0930	8				
3	1030	9.5	135			
4	1130	10				
5	1230	10.5	163			
6	1335	12				
7	1435	12				
8	1535	11				
9	1635	12				
10	1735	14				
11	1850	13	320			
12	2030	13				
1	0900	8.8				
	(5/29/81)					

Notes: Total discharge (m^3) - 15,940.04

	TP (mg/l)	TN (mg/l)	SS (mg/l)
Composite A	0.019	610.39	9.3
Composite B	0.019	160.37	9.0

WATER CHEMISTRY ANALYSES FOR STORM #2 AT LAKE FAIRFAX, AND ROUTINE TESTING FOR LAKES ACCOTINK AND FAIRFAX ON JUNE 4-5, 1981

Sample Designation	Bios #	Total Phosphorus (mg P/1)	Soluble Phosphorus (mg P/1)	Nitrate-Nitrite (mg N/1)	Ammonia (mg N/1)	Total Kjeldahl Nitrogen (mg N/1)	Suspended Solids (mg/1)
Anne Run A 5/28/81	5754	0.044	<0.01	520*	0.25	<0.25	13.4
		.031	.01	970	.23	35	
Anne Run B 5/28/81	5755	0.018	<0.01	1420*	0.21	<0.25	15.0
Colvin Run Inflow A 5/28/81	5756	0.105	<0.01	930*	0.13	<0.25	36.6
		.1035	.01	780	.32	.37	37.4
Colvin Run Inflow B 5/28/81	5757	0.102	<0.01	630*	0.51	0.50	38.2
Outflow A 5/28/81	5758	0.019	<0.01	610*	<0.01	0.39	9.3
				385	.011	38	
Outflow B 5/28/81	5759	0.019	<0.01	160*	0.21	0.37	9.0
Lake Accotink Comp A 6/4/81	6015	0.056	0.051	0.30	0.25	1.18	28.5
Lake Accotink Comp B 6/4/81	6016	0.078	0.063	0.50	0.23	1.14	35.6
Flag Run 6/4/81	6017	0.058	0.041	0.27	0.17	1.02	1.8
Accotink Creek Inflow A 6/4/81	6018	0.073	0.058	0.49	0.14	0.83	18.6
Accotink Creek Inflow B 6/4/81	6019	0.068	0.043	0.46	0.20	0.72	22.6
Accotink Creek Outflow	6020	0.083	0.053	0.38	0.22	1.02	18.7
Accotink Creek North	6021	0.073	0.061	0.62	0.10	0.70	7.7
Lake Fairfax Epi A 6/5/81	6039	0.028	0.021	0.55	0.13	0.76	5.6
Lake Fairfax Epi B 6/5/81	6040	0.048	0.033	0.37	0.11	0.66	6.2
Hypo A 6/5/81	6041	0.032	<0.01	0.36	0.10	0.76	6.2
Hypo B 6/5/81	6042	0.052	0.041	0.31	0.18	0.90	6.8
Colvin Run Inflow 6/5/81	6043	0.056	0.036	0.62	0.08	0.74	5.7
Colvin Run South Inflow 6/5/81	6044	0.098	0.058	1.08	0.07	0.65	7.2
Colvin Run Outflow	6045	0.063	0.061	0.50	0.03	0.66	2.5
Anne Run Inflow	6046	0.058	0.048	0.49	0.04	0.60	2.4

* See QC comments.

Control Check		Total Phosphorus (mg/1)	Nitrite-Nitrate (mg N/1)	Ammonia (mg N/1)	TKN (mg N/1)	Total Suspended Solids (mg/1)
QC Standards	Determined	0.105	0.830	2.93	3.18	202
	Theoretical	0.100	0.950	3.00	3.00	200
	% Recovery	105	87	98	106	92
	Determined	0.096	0.88	2.93	3.18	187
	Theoretical	0.100	0.95	3.00	3.00	185
	% Recovery	96	95	97.7	106	101
Spike	Sample #	5755	6019	6019	6019	
	Orig. Conc.	0.018	0.46	0.20	0.72	
	Conc. Spike Added	0.200	1.17	1.15	2.50	
	Conc. Spike Recovered	0.175	1.06	1.22	2.87	
	% Recovery	87.5	109	106	115	
Duplicates	Sample #	5755	6019	6019	6019	5759
	Orig. Conc.	0.018	0.46	0.20	0.72	9.0
	Duplicate Conc.	0.017	0.43	0.21	0.72	9.2
	Duplicate Conc.	0.019	0.50	0.20	0.72	8.9

Comments

1. Problems encountered with NO_2/NO_3 for samples #5754-9. Extremely high results put data for this parameter in question for these samples only. QC samples worked well however, indicating no problems with analytical techniques. Contamination from some unknown source seems likely.

Date: 6/20/81 Station: Anne Run Storm #: 3

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S				
1	1250	15.5	30				
2	1320	32.0	173				
3	1350	28.5	136				
4	1430	27.8	128				
5	1510	23.5	85				
6	1545	21.5	65				
7	1620	20.0	50				
8	1815	18.5	40				

Notes: Total discharge (m^3) - 1624.0

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.42	3.21	190
Composite B	0.40	3.35	185

NUSAC

Date: 6/20/81 Station: Colvin Run (South) Storm #: 3

Observers: ______________ ______________

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S				
1	1251	13.0	22				
2	1322	16.5	82				
3	1350	21.5	168				
4	1432	24.5	220				
5	1515	20.0	142				
6	1550	18.6	118				
7	1615	18.0	108				
8	1820	17.0	91				

Notes: Total discharge (m^3) - 2,455

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.23	2.24	138
Composite B	0.21	2.28	135

Date: 6/20/81 Station: Cameron Run Storm #: 3

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S				
1	1245	14.5	75				
2	1320	11.0	40				
3	1350	9.8	25				
4	1420	9.0	15				
5	1450	8.8	13				
6	1520	8.5	10				
7	1550	8.5	10				

Notes: Total discharge (m^3) - 279.2

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.29	3.21	77.2
Composite B	0.32	3.27	74.5

Date: 6/20/81 Station: Colvin Run Outflow Storm #: 3

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S				
1	1230	6.8	92				
2	1330	8.4	124				
3	1430	9.5	148				
4	1530	10.5	173				
5	1630	11.0	190				
6	1830	10.9	186				

Notes: Total discharge (m^3) - 3,467

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.02	0.81	5.1
Composite B	0.04	0.60	3.8

Date: 6/20/81 Station: Forest Edge Run Storm #: 3

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S				
1	1238	0.0	80				
2	1308	+2.5	100				
3	1338	0.0	80				
4	1410	-2.5	40				
5	1445	-7.5	20				
6	1532	-10.0	10				

Notes: Total discharge (m^3) - 326.7

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.36	2.88	215
Composite B	0.32	2.45	211

WATER CHEMISTRY ANALYSES FOR STORM #3 AT LAKE FAIRFAX ON JUNE 22, 1981

Sample Designation				Bios #	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Total Suspended Solids (mg/l)
Colvin Run	South	A	6/20/81	7513	0.23	0.05	1.09	,08 0.09	1,10 1.15	138
Colvin Run	South	B	6/20/81	7514	0.21	0.05	1,17 1.24	0.07	1.04	135
Anne Run		A	6/20/81	7515	0.42	0.12	1.19	0.31	2.02	190
Anne Run		B	6/20/81	7516	0.40 .41	0.12 .12	1.15 1.17	0.22 .27	2.11 2.20	185
Forest Edge Run		A	6/20/81	7517	0.36	0.05	0.89	0.08	1.99	215
Forest Edge Run		B	6/20/81	7518	0.32 .34	0.04 .045	0.85 .87	0.03 .055	1.79 1.60	211
Cameron Run		A	6/20/81	7519	0.29	0.16	1.11	0.24	2.10	77.2
Cameron Run		B	6/20/81	7520	0.32 .305	0.14 .15	1.14 1.125	0.32 .28	2.13 2.115	74.5
Colvin Run	Outflow	A	6/20/81	7521	0.02	0.02	0.53	0.04	0.28	5.1
Colvin Run	Outflow	B	6/20/81	7522	0.04 .03	0.04 .03	0.40 .465	0.19 .115	0.20 .24	3.8

Comments: No Analytical Problems.

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)
QC Standards	Determined	0.094	0.95	3.03	3.20	
	Theoretical	0.100	0.95	3.00	3.00	
	% Recovery	94	100	101	107	
Spike	Sample #	27514	27513	27513	27516	
	Orig. Conc.	0.21	1.09	0.09	2.20	
	Theoretical Conc. Spike	0.200	1.18	1.15	12.5	
	Determined Conc. of Spike	0.206	1.01	1.23	11.9	
	% Recovery	103	85.6	107	95.2	
Duplicates	Sample #	27514	27513	27513	27516	27513
	Orig. Conc.	0.21	1.09	0.09	2.20	138
	Duplicate Conc.	0.21	1.10	0.10	2.24	135
	Duplicate Conc.	0.21	1.12	0.08	2.72	140

Date: 7/20/81 Station: Colvin Run (South) Storm #: 5

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S	25°C Cond.	pH	Turbidity % Trans.	
C5	1450	14.4	48	114.6	6.72	100.0	
6	1550	17.2		118.6	6.73	92.5	
-	1620	17.0					
7	1650	16.1		111.7	6.77	100.0	
-	1720	15.9					
8	1747	15.7	70	110.7	6.78	100.0	
9	1825	16.7	86	108.7	6.59	72.0	
10	1853	17.0	92	107.7	6.65	83.5	
11	1904	22.7	188	106.7	6.65	87.6	
12	1920	18.7	120	106.7	6.63	87.0	
13	1933	19.3	130	107.7	6.71	87.0	
1	1948	26.5	253	105.7	6.51	52.0	
2	2002	27.4	268	108.7	6.63	65.5	
3	2018	27.2	265	108.7	6.49	37.0	
4	2040	25.5	236	106.7	6.44	50.0	
C	2054	24.4	218	106.7	6.36	33.5	
52/53	2110	23.4	200	106.8	6.18	27.5	
56/57	2127	22.6	187	106.8	6.17	31.0	
2 Unlabeled Nalgene Bot.	2152	21.8	173	106.8	6.17	40.0	
FE13	2315	19.5	134	119.5	6.30	67.8	
FE16	0830	15.3	62	102.8	6.75	80.2	

(7/21/81)

Notes: Total discharge (m^3) - 3,381.15

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.06	3.06	1.51
Composite B	0.24	3.19	1.73

Date: 7/20/81 Station: Colvin Outflow Storm #: 5

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S	25°C Cond.	pH	Turbidity % Trans.	
C01	1030	3.0	40	100.3	7.44	94.4	
3	1818	3.0	40	123.3	7.47	96.0	
4	1848	9.8	156	149.1	6.60	63.0	
5	1918	7.0	96	179.8	6.56	41.2	
6	1948	7.0	96	113.6	7.05	90.5	
7	2018	8.0	115	101.8	7.25	92.5	
8	2048	8.7	132	99.8	7.30	92.8	
9	2118	9.3	143	98.8	7.35	92.6	
12	2330	9.2	142	98.8	7.48	95.0	
FE10	0830	6.2	83	203.0	7.63	97.0	

Notes: Total discharge (m^3) - 2,436.7

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.03	1.10	18.2
Composite B	0.04	1.16	7.9

NUSAC

Date: 7/20/81 Station: Anne Run Storm #: 5

Observers: ______________ ______________

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S	25°C Cond.	pH	Turbidity % Trans.	
AR5	1445	15.6		97.8	7.06	96.5	
AR6	1545	15.6		98.8	7.11	98.0	
AR7	1645	15.5		98.8	7.08	97.8	
AR8	1745	15.5	15	98.8	7.10	98.5	
AR9	1820	16.2	20	95.8	7.0	92.0	
AR10	1850	17.2	25	96.8	7.05	91.5	
AR11	1900	40.0	252	97.8	6.66	34.0	
AR12	1917	33.0	182	98.8	6.40	49.0	
AR13	1931	28.3	144	100.8	6.30	31.0	
AR1	1945	25.4	104	97.8	6.22	28.0	
AR2	2000	24.0	90	98.8	6.20	32.0	
AR3	2015	23.7	87	96.8	6.21	38.0	
AR4	2030	22.6	76	93.9	6.30	44.5	
D	2048	22.2	71	92.8	6.30	47.2	
50/51	2105	21.2	61	92.5	6.25	53.0	
54/55	2125	20.7	57	90.3	6.30	55.8	
58/59	2145	19.8	48	94.2	6.35	65.0	
FE11	2310	17.3	25	100.0	6.60	77.4	
FE15	0830	15.7	15	206.5	6.95	91.5	
	(7/21/81)						

Notes: Total discharge (m^3) - 2,000.46

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.32	2.82	1.95
Composite B	0.30	2.74	1.01

Date: 7/20/81 Station: Reston (Z) (Anne Run) Storm #: 5

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S	25°C Cond.	pH	Turbidity % Trans.	
Z1	1130	1-3 l/sec.					
Z2	1230	1-3 l/sec.					
Z3	1440	1-3 l/sec.		122	7.28	96.3	15.8mg/l .038 .041 .204
Z4	1740	1-3 l/sec.		122	7.35	96.0	
Z5	1830	1-3 l/sec.		113	7.13	81.5	
Z6	1845	6.0		95	6.29	52.0	184.0
Z7	1900	-0.4		90	6.15	53.0	
Z8	1930	-6.0		85	6.32	65.0	534.0
Z9	2000	-4.0		140	6.54	74.0	
Z10	2030	-5.0		230	6.36	59.0	401.0
Y11	2240	-7.0		110	6.22	56.0	

Notes: Total discharge (m^3) - 506.12

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite 3,4,5	0.07	3.23	15.8
Composite 6,7	0.33	3.67	184.0
Composite 8,9	0.27	3.72	534.0
Composite 10,11	0.70	5.47	401.0

NUSAC

Date: 7/20/81 Station: Lake Anne (Y) Storm #: 5

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S	25°C Cond.	pH	Turbidity % Trans.	
Y1	1135	31					
Y2	1235	31					
Y3	1445	31		98	6.10	97.0	3.0
Y4	1745	31		100	6.90	96.0	
Y5	1835	31		95	6.98	94.5	
Y6	1845	57		102	6.98	4.0	1056.0
Y7	1910	55		85	7.0	32.5	
Y8	1930	40		90	6.0	28.0	204.0
Y9	2000	39		94	6.10	42.5	
Y10	2030	38		94	6.12	48.5	66.6
Y12	2240	35		95	6.22	72.0	

Notes: Total discharge (m^3) - 1,494.34

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite 3,4,5	0.02	1.50	3.0
Composite 6,7	1.00	4.71	1050.0
Composite 8,9	0.45	3.50	204.0
Composite 10,12	0.28	4.07	66.6

Date: 7/20/81 Station: Cameron Run Storm #: 5

Observers:

Sample No.	Time	Gauge(cm) Height	Estimated Flow L/S	25°C Cond.	pH	Turbidity % Trans.	
FE1	1450	8.0	5.0	153.0	7.22	99.0	
FE2	1826	8.6	9.0	152.0	7.10	99.0	
FE3	1857	16.8	105.0	105.7	6.26	45.0	
FE4	1929	11.2	50.0	117.6	6.35	71.5	
FE6	1957	10.0	26.0	133.4	6.43	82.6	
FE7	2027	9.2	17.0	148.2	6.48	84.0	
FE8	2056	8.8	14.0	158.1	6.50	84.0	
FE9	2127	8.2	6.0	170.0	6.60	86.5	

Notes: Total discharge (m^3) - 414.03

	TP (mgP/l)	TN (mgN/l)	SS (mg/l)
Composite A	0.48	3.69	84.8
Composite B	0.45	4.03	1.74

WATER CHEMISTRY ANALYSES FOR STORM #5 AT LAKE FAIRFAX ON JULY 20, 1981

Sample Designation	Bios. #	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
Cameron Run A	8605	0.48	0.27	1.24	0.72	2.45	84.8
				1.31		2.55	
Cameron Run B	8606	0.45	0.27	1.38	0.72	2.65	1.74
Anne Run A	8607	0.32	0.04	1.20	0.40	1.62	1.95 •
Anne Run B	8608	0.30	0.02	1.14	0.41	1.60	1.01 •
Colvin Run South A	8609	0.06	0.04	1.41	0.51	1.65	1.51 •
				1.425	.535	1.70	
Colvin Run South B	8610	0.24	0.07	1.44	0.56	1.75	1.73 •
Colvin Run Outflow A	8611	0.03	0.01	0.45	0.30	0.65	18.2
				.38		.75	
Colvin Run Outflow B	8612	0.04	0.02	0.31	0.30	0.85	7.9
Reston Segment 345	8613	0.07	0.03	2.73	0.33	0.50	15.8
Reston Segment 67	8614	0.33	0.03	1.47	0.40	2.20	184
Reston Segment 89	8615	0.27	0.11	2.12	0.47	1.60	534
Reston Segment 1011	8616	0.70	0.50	3.87	1.40	1.60	401
Anne Segment 345	8617	0.02	0.01	0.85	0.34	0.65	3.0
Anne Segment 67	8618	1.00	0.02	0.86	0.40	3.85	1050
Anne Segment 89	8619	0.45	0.10	1.05	0.48	2.45	204
Anne Segment 1012	8620	0.28	0.07	1.12	0.70	2.95	66.6

• Assume

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)
QC Standards	Determined	0.096	0.88	2.93	3.18	120
	Theoretical	0.100	0.95	3.00	3.00	131
	% Recovery	96	93	98	106	92
Spike	Sample #	6042	6019	6019	6019	
	Orig. Conc.	0.052	0.46	0.20	0.72	
	Conc. Spike Added	0.200	1.154	1.15	2.50	
	Conc. Spike Recovered	0.210	1.037	1.22	2.89	
	% Recovery	105	90	106	115	
Duplicates	Sample #	6042	6019	6019	6019	6019
	Orig. Conc.	0.052	0.46	0.20	0.72	22.6
	Duplicate Conc.	0.051	0.43	0.21	0.72	22.1
	Duplicate Conc.	0.053	0.50	0.20	0.72	23.2
Comments	No Analytical Problems					

APPENDIX II.10. Water Budget Development

General. Water Budget Notes - Lake Fairfax.

Total yearly values for the Lake Fairfax water budget were based on total inflow (m^3/yr) minus total outflow (m^3/yr), which was calculated from yearly lake evaporation and Colvin Run outflow rates. All values were derived from actual lake station values with the exception of daily lake evaporation rates for the month of August and daily inflow rates from Forest Edge and Cameron Run subwatersheds. Daily lake evaporation rates for the month of August were based on long term (1963-81) August precipitation values provided by Dulles International Airport. Because daily data records for the inflow rates of Forest Edge and Cameron Run subwatersheds were sporadic, their inflow rates were based as proportions to the total Colvin watershed inflow, using weighed averages and runoff coefficients.

Actual data was inclusive from 9-17-80 to 8-18-81, but extrapolations were formulated for water budget values based on a yearly increment (9-1-80 to 8-31-81).

Notes on Evaporation Rate Calculations.

Evaporation rates for the study lakes were based on Penman's theoretical pan concept (Linsley, et. al., 1958), in which average temperature (^oF), dew points (^oF), wind speed (m.p.h.), and mean daily solar radiation (Lanpleys) values were used to compute daily evaporation rates. Values were read from nomographs in Linsley, et. al.

All average data values were taken from monthly Dulles International Airport local climatological data sheets, with the exception of the mean daily solar radiation values, which were taken from the Input Data for solar systems (1941-70), U.S. Department of Energy, No. E (49-76)-1041, Nov. 1978.

Long term monthly evaporation rates were based on average monthly temperature, dew point, wind speed, and mean daily solar radiation for the years 1963-81. However, some modifications had to be employed. Average monthly temperatures were available for the years 1963-81, but dew point and wind speed values ceased after 1978, and the mean daily solar radiation values were based on data taken between the years 1941-1970. To overcome these discrepancies, average monthly temperatures for the years 1963-81 were averaged to one monthly value and then compared to the average monthly temperature for the years 1978-81. The average monthly temperatures for the years 1963-81 were found to be very comparable to the average temperatures for the years 1978-81, which enabled us to use the 1978-81 average monthly dew points and wind speed values as the values for our long term (1963-81) monthly evaporation rates.

Selection of the Maryland Patuxent River Station for mean daily solar radiation values (in Langleys) was based on proximity to Fairfax County study sites.

Appendix II.10.a

Bathymetric data from Lake Fairfax, March, 1981

1 of 3

BATHYMETRIC DA :

LOCATION: *Lake Fairfax*

NUSAC LAKE MANAGEMENT STUDY

WATERSHED: *Difficult Run*

Survey March 1981 Table A II.10.a.

	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7		Station 8		Station 9	
	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth
1	-18°0'	1.5	+57°45'	1.5	-3°15'	1	36°0'	1.2	-3°0'	1	23°30'	2.1	1°15'	1.3	12°30'	.9	7°0'	.3
2	+11°0'	2.0	59°30'	2.25	+1°45'	1.5	33°0'	3.5	+2°15'	2.3	21°30'	2.5	4°15'	1.6	10°30'	1.4	8°30'	1
3	+37°15'	2.75	58°30'	2.8	11°15'	2.8	30°45'	4	11°45'	2.3	18°15'	2.5	10°15'	1.6	9°30'	1	10°0'	1
4	+53°15'	3	57°0'	3.3	20°0'	3.2	28°0'	3	17°15'	2.5	14°30'	2.2	13°15'	1.9	8°0'	1	11°30'	.75
5	64°30'	3.25	58°0'	4.6	38°30'	3.5	26°45'	3.2	22°0'	3	10°0'	2.1	15°30'	1.1	7°0'	.5	12°0'	.5
6	71°45'	3.5	56°15'	4.2	38°15'	3.8	22°18'	3.3	25°30'	3.9	7°0'	2.0						
7	74°15'	4.25	56°0'	4	43°15'	3.5	14°30'	3	27°0'	3	2°30'	1.9						
8	76°15'	4.25	53°15'	4.2	46°15'	4.2	6°15'	2.4	27°45'	2.3	-1°30'	1.1						
9	77°15'	4.5	48°15°	4	46°15'	3.6	0°0'	1.5			-2°0'	1.0						
10	76°15'	5	35°0'	3.5	46°30'	2.4	-5°0'	.2										
11	73°15'	4.5	22°30'	3	45°45'	1												
12	69°0'	4	12°0'	2.15														
13	65°15'	1.3	-0°30'	.2														
14			-3°45'	.2														

2 of 3

BATHYMETRIC DATA :

LOCATION: Lake Fairfax

WATERSHED: Difficult Run

	Station 10		Station 11		Station A		Station B		Station C		Station D		Station E		Station F		Station G	
	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth
1	7°45'	.5	8°45'	.5	53°45'	1.2	65°0'	2	71°0'	1.3	-10°45'	1.6	-60°45'	1.3	-60°0'	.9	-78°0'	.9
2	8°30'	1	9°30'	.4	59°0'	3	68°45'	4	73°45'	4.5	-13°45'	1.9	-60°0'	1.2	-64°30'	1.1	-73°45'	.8
3	9°45'	1	10°0'	.75	66°0'	4.1	75°15'	4.9	77°30'	5	-9°45'	1.9	-55°0'	1.3	-72°30'	1	-67°0'	1
4	11°0'	.8	11°45'	.4	72°0'	4.6	78°45'	5	80°0'	4.8	-9°45'	1.75	-47°30'	1	-79°45'	.9	-63°0'	.9
5	12°15'	.5			77°15'	4.5	82°0'	5	82°30'	2.1	-13°0'	1						
6					81°45'	4.5	84°15'	1.5										
7					85°45'	1.8												

3 of 3

BATHYMETRIC D[illegible] :

LOCATION: *Lake Fairfax*

WATERSHED: *Difficult Run*

	Station H		Station 0		Station		Station		Station		Station		Station		Station		Station	
	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth	Angle	Depth
1	-76°45'	.6	+76° 15'	1.2														
2	-72°45'	.25	79°0'	5														
3	-68°0'	.5	80°45	4.9														
4	-65°30'	.4	81°15'	4.9														
5			82° 15'	1.3														
6			78°45'	1.4														
7			75°0'	1.2														
8			68°45'	1.2														
9			57°30'	2.3														
10			33°45'	2.1														

Appendix II.10.b.

Routine water chemistry analyses for Phase 1 Study,
September 1980 to August 1981,
Quality Control data is presented on the page following each data set.

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES ACCOTINK AND FAIRFAX ON SEPTEMBER 17 and 18, 1980

Sample Designation	Bios#	pH	Conductivity (umhos/cm)	Total Phosphorus (mg P/L)	Soluble Phosphorus (mg P/L)	Nitrit (mg N/
North Accotink A	1385	7.17	160	0.10	0.07	0.019
North Accotink B	6	6.85	161	0.10	0.06	0.018
Accotink Outflow A	7	7.30	173	0.13	0.04	0.011
Accotink Outflow B	8	7.05	156	0.11	0.04	0.010
Accotink Inflow A	9	7.37	193	0.10	0.06	0.010
Accotink Inflow B	1390	7.40	187	0.11	0.03	0.010
Flag Run Inflow A	1	7.18	222	0.12	0.08	0.006
Flag Run Inflow B	2	7.14	221	0.11	0.09	0.038
Accotink 0.5M	3	7.07	160	0.13	0.04	0.011
Accotink 1.0M	4	7.08	156	0.10	0.04	0.010
Accotink 2.0M-A	5	6.86	176	0.21	0.04	0.010
Accotink 2.0M-B	6	7.02	134	0.18	0.04	0.010

9/17/80

Sample Designation	Bios#	pH	Conductivity (umhos/cm)	Total Phosphorus (mg P/L)	Soluble Phosphorus (mg P/L)	Nitrit (mg N/
Colvin Run Inflow A	1431	6.16	32	0.37	0.21	0.016
Colvin Run Inflow B	2	6.11	32	0.20	0.09	0.017
Colvin Run Outflow A	3	6.65	118	0.24	0.07	0.004
Colvin Run Outflow B	4	6.32	125	0.05	0.08	0.004
Lake Fairfax 2.0M A	5	6.42	118	0.26	0.08	0.002
Lake Fairfax 2.0M B	6	6.28	118	0.17	0.05	0.004
Fairfax 0.5M	7	6.44	32	0.07	0.06	0.003
Fairfax 1.0M	8	6.32	106	0.17	0.03	0.004
Fairfax 3.0M	9	6.40	140	0.06	0.01	0.010
Fairfax 4.0M	1440	5.95	220	0.77	0.14	<0.002

9/18/80

			Chlorophyll-a (mg/m^3)
Accotink Comp. A	9/17	1397	6.0
Accotink Comp. B		1398	6.7
Accotink Comp. C		1399	12.6
Fairfax Comp. A	9/18	1441	14.4
Fairfax Comp. B		1442	15.5
Fairfax Comp. C		1443	12.8

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKE ACCOTINK ON OCTOBER 15, 1980,
AND LAKE FAIRFAX ON OCTOBER 16, 198

	Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrite (mg N/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Total Solids (mg/l)	Suspended Solids (mg/l)
10/15/80	Flag Run A	1997	0.070	0.038	0.004	0.030	0.07	.21	227	18.4
	Accotink Inflow A	1998	0.046	0.023	0.006	0.240	0.05	.26	159	4.8
	Accotink Inflow B	1999	0.042	0.028	0.006	0.250	0.05	.26	167	5.0
	Accotink Outflow A	2000	0.108	0.040	0.013	0.190	0.20	1.08	138	26.8
	Accotink Outflow B	2001	0.112	0.050	0.015	0.190	0.29	1.73	156	28.2
	Accotink North A	2004	0.062	0.028	0.006	0.360	0.05	0.31	170	5.5
	Accotink North B	2005	0.074	0.074	0.005	0.360	0.05	.13	194	2.9
	Accotink 0.5 m	2006	0.150	0.034	0.013	0.190	0.23	1.47	153	35.0
	Accotink 1.0 m	2007	0.116	0.027	0.012	0.170	0.23	1.16	168	33.5
	Accotink 2.0 m A	2008	0.158	0.035	0.013	0.170	0.25	0.80	145	35.5
	Accotink 2.0 m B	2009	0.162	0.029	0.012	0.170	0.24	0.98	166	52.5
10/16/80	Ann Run A	2012	0.213	0.169	0.006	0.480	0.27	.26	83	1.4
	Ann Run B	2013	0.106	0.058	0.004	0.490	0.28	0.44	51	2.0
	Col in Run Inflow A	2014	0.044	0.040	0.003	0.890	0.27	0.38	75	9.1
	Col in Run Inflow B	2015	0.092	0.077	0.004	0.920	0.28	0.54	98	13.6
	Col in Run Outflow A	2016	0.230	0.098	0.012	0.200	0.77	1.60	100	13.7
	Col in Run Outflow B	2017	0.134	0.090	0.013	0.170	0.78	2.04	96	8.9
	L. Fairfax 0.5 m	2018	0.150	0.110	0.014	0.190	0.81	1.54	93	8.3
	L. Fairfax 1.0 m	2019	0.088	0.060	0.013	0.170	0.1	<0.25	90	7.4
	L. Fairfax 2.0 m A	2020	0.070	0.062	0.012	0.160	0.3	<0.25	92	7.2
	L. Fairfax 2.0 m B	2021	0.058	0.080	0.013	0.170	0.3	<0.25	106	7.5
	L. Fairfax 3.0 m	2022	0.100	0.060	0.012	0.160	0.3	<0.25	97	10.6
	L. Fairfax 4.0 m	2023	0.124	0.073	0.012	0.190	0.3	<0.25	114	23.4

			Chlorophyll-α (mg/m³)
10/15	Accotink Comp. A	2002	10.7
	Accotink Comp. B	2003	6.95
10/16	L. Fairfax Comp. A	2010	4.28
	L. Fairfax Comp. B	2011	3.21

10/15 Accotink
10/16 Fairfax

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Nitrite (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Solids (mg/l)	Total Suspended Solids (mg/l)	Chlorophyll-α (mg/m^3)
QC Standards	Determined	0.484	0.972	0.254	9.7	9.54	4.12 x 10^4	603.6	-
	Theoretical	0.500	1.00	0.250	10.0	10.0	4.25 x 10^4	622.2	-
	% Recovery	96.8	97.2	101.6	97.0	95.5	96.9	97.0	-
	Determined	0.360	0.758	0.242	7.9	7.77	4.11 x 10^4	570.0	-
	Theoretical	0.400	0.800	0.250	8.0	8.00	4.25 x 10^4	576.0	-
	% Recovery	90.0	94.8	96.8	98.8	97.1	96.7	98.9	-
Spike	Sample #	2021	2017	2017	2017	2006	-	-	-
	Orig. Concentration	0.058	0.170	0.013	0.78	1.47	-	-	-
	Spike Added	0.200	1.25	0.025	0.417	6.66	-	-	-
	Determined Concentration of Spiked Sample	0.264	1.26	0.033	1.21	5.63	-	-	-
	Recovered Spike	0.206	1.09	0.020	0.430	4.16	-	-	-
	% Recovered	103	87.2	80.0	103	62.5	-	-	-
Duplicates	Sample #	2007	1999	1999	1999	2006	1997	2006	2469
	Orig. Concentration	0.116	0.250	0.006	0.05	1.47	227	35.0	10.7
	Dup. Concentration	0.104	0.260	0.006	0.04	1.37	227	20.1	9.6
	Sample #	2021	2017	2017	2017	2006	2013	2013	
	Orig. Concentration	0.058	.170	0.013	0.78	1.47	51	2.0	-
	Dup. Concentration	0.058	.170	0.013	0.77	1.37	49	3.8	-

Comments

TKN spike of 2006 raised concentration out of working range. Future TKN samples will be spiked to lower levels. Suspended solids duplicates acceptable as values are near detection limit. In addition, future Total Solids QC Standards will be lower. Duplicate for chlorophyll-α analyses taken from sample designated Accotink Comp. B received November 12, 1980.

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKE ACCOTIN ON NOVEMBER 12, 1980 and LAKE FAIRFAX ON NOVEMBER 13, 1980

	Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrite (mg N/l)	Nitrate-Nitrite (mg N/l)	Ammonia[a] (mg N/l)	Total Kjeldahl Nitrogen[a] (mg N/l)	Total Solids (mg/l)	Suspended Solids (mg/l)
11/12/80	Accotink 0.5 m	2470	0.202	0.088	0.013	0.23	0.7	0.44	151	66.1
	Accotink 1.0 m	2471	0.565	0.048	0.011	0.22	0.9	0.53	153	61.5
	Accotink 2.0 m	2472	0.186	0.050	0.011	0.22	0.9	0.46	144	38.8
	Accotink Flag Run	2473	0.180	0.098	<0.01	0.06	0.7	0.26	171	8.5
	Accotink North	2474	0.135	0.046	<0.01	0.05	0.7	0.46	127	7.3
	Accotink Inflow A	2475	0.161	0.082	<0.01	0.08	0.7	0.45	161	8.8
	Accotink Inflow B	2476	0.161	0.038	<0.01	0.13	0.8	0.42	140	10.0
	Accotink Outflow A	2477	0.141	0.044	0.010	0.21	0.7	0.40	124	28.9
	Accotink Outflow B	2478	0.162	0.061	0.010	0.22	0.7	0.44	136	28.1
11/13/80	Fairfax 0.5 m	2490	0.106	0.083	0.018	0.31	0.9	1.40	74.6	12.4
	Fairfax 1.0 m	2491	0.137	0.039	0.015	0.36	1.0	1.30	88.4	13.8
	Fairfax 2.0 m	2492	0.102	0.088	0.014	0.31	1.0	1.28	91.8	13.5
	Fairfax 3.0 m	2493	0.119	0.058	0.014	0.31	0.9	1.17	69.1	13.4
	Fairfax 4.0 m	2494	0.170	0.055	0.014	0.31	1.0	1.16	77.6	13.5
	Fairfax Ann Run	2495	0.124	0.124	<0.01	0.40	0.8	0.43	70.1	7.4
	Fairfax Inflow A	2496	0.304	0.152	<0.01	0.66	0.8	0.28	54.4	1.7
	Fairfax Inflow B	2497	0.357	0.110	<0.01	0.67	0.8	0.38	58.4	1.4
	Fairfax Outflow A	2498	0.353	0.220	0.046	0.45	0.8	0.52	76.0	7.1
	Fairfax Outflow B	2499	0.083	0.078	0.027	0.42	0.9	<0.25	67.3	7.1
							↑	↑		

			Chlorophyll-α (corrected for phaeophitin) (mg/m³)
11/12	Accotink Comp A	2468	6.0
	Accotink Comp B	2469	10.7
11/13	Fairfax Comp A	2488	7.5
	Fairfax Comp B	2489	6.4

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[a] Please see comment A. (next page)

11/12-13/80

ontrol Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Nitrite (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Solids (mg/l)	Total Suspended Solids (mg/l)	Chlorophyll-a (mg/m^3)
C Standards	Determined	0.364	0.739	0.251	7.9	8.04	4.00 x 10^4	439	-
	Theoretical	0.350	0.800	0.250	8.0	8.00	4.25 x 10^4	458	-
	% Recovery	104	92.4	100	98.8	101	94.1	95.8	-
	Determined	0.424	0.663	0.257	7.0	6.22	4.03 x 10^4	633	-
	Theoretical	0.400	0.700	0.250	7.0	7.00	4.25 x 10^4	662	-
	% Recovery	106	94.7	103	100	88.8	94.8	95.6	-
Spike	Sample #	2490	2490	2490	2475	2493			
	Orig. Conc.	0.106	0.31	0.018	0.70	1.17	-	-	-
	Theoretical Conc. of Spiked Sample	0.200	1.15	0.023	1.15	5.00	-	-	-
	Determined Con. of Spiked Sample	0.146	1.07	0.0295	1.06	4.70	-	-	-
	% Recovery	73.0	92.9	128	92.0	94.0			
Duplicates	Sample #	2490	2490	2490	2490	2493	2476	2475	2469
	Orig. Conc.	0.106	0.31	0.018	0.9	1.17	140	7.3	10.7
	Dupl. Conc.	0.110	0.31	0.017	0.9	1.19	139	8.1	9.6
	Dupl. Conc.	0.101	0.31	0.018	0.9	1.15	140	9.6	-
	Sample #	2475	2475	2475	2475	2475	2497	2499	
	Orig. Conc.	0.161	0.078	<0.01	0.7	0.45	58.4	7.1	-
	Dupl. Conc.	0.141	0.080	<0.01	0.7	0.44	58.7	7.0	-
	Dupl. Conc.	0.181	0.080	<0.01	0.7	0.45	58.1	7.2	-

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKE ACCOTINK ON DECEMBER 17, 1980
and LAKE FAIRFAX ON DECEMBER 18, 1980

	Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrite (mg N/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Total Solids (mg/l)	Suspended Solids (mg/l)
12/17/80	Accotink 0.5 m	2978	0.082	0.070	0.011	0.25	0.2	0.74	159	18.6
	Accotink 1.0 m	2979	0.070	0.026	0.010	0.28	0.4	0.72	151	19.0
	Accotink 2.0 m	2980	0.070	0.044	0.010	0.26	0.3	0.87	*	19.0
	Accotink Flag Run	7981	0.054	0.048	<0.01	0.13	0.3	0.46	226	3.4
	Accotink Creek	2982	0.032	0.026	<0.01	0.43	0.3	0.56	136	< 0.2
	Accotink Inflow A	2983	0.070	0.048	<0.01	0.40	0.3	0.57	155	19.5
	Accotink Inflow B	2984	0.044	0.022	<0.01	0.40	0.3	0.68	160	20.6
	Accotink Outflow A	2985	0.076	0.033	0.010	0.29	0.3	0.80	143	18.6
	Accotink Outflow B	2986	0.078	0.038	0.010	0.28	0.3	0.67	162	19.0
12/18/80	Fairfax 0.5 m	3062	0.068	0.042	0.010	0.46	0.1	0.87	32.3	6.3
	Fairfax 1.0 m	3063	0.058	0.030	0.010	0.47	0.2	0.87	*	9.5
	Fairfax 4.0 m	3064	0.068	0.032	<0.01	0.46	0.3	0.51	*	9.8
	Fairfax 2.0 m	3065	0.072	0.030	<0.01	0.46	0.4	1.03	48.2	9.0
	Fairfax Inflow B	3066	0.025	0.024	<0.01	0.76	0.2	0.26	42.5	1.5
	Fairfax 3.0 m	3067	0.070	0.042	<0.01	0.47	0.2	0.75	*	9.0
	Fairfax Inflow A	3068	0.042	0.032	<0.01	0.73	0.2	0.27	21.4	1.1
	Fairfax Outflow A	3069	0.098	0.032	0.011	0.51	0.2	0.88	61.4	30.8
	Anne Run	3070	0.027	0.040	<0.01	0.51	0.2	0.32	31.0	2.2
	Fairfax Outflow B	3071	0.046	0.040	0.011	0.49	0.2	0.72	42.0	8.2

			Chlorophyll-α (mg/m^3) (corrected for phaeophitin)
12/17	Accotink Comp A	2976	6.9
	Accotink Comp B	2977	5.9
12/18	Fairfax Comp A	3072	4.3
	Fairfax Comp B	3073	4.8

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*Total Solids Analyses not performed due to insufficient sample volume

12/17-18, 1980

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Nitrite (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Solids (mg/l)	Total Suspended Solids (mg/l)	Chlorophyll-a (mg/m^3)
QC Standards	Determined	0.336	0.681	0.239	6.9	7.62	4.14	338	-
	Theoretical	0.350	0.700	0.250	7.0	7.0	4.25	358	-
	% Recovery	96.0	97.3	95.6	98.6	108.8	97.4	94.4	-
	Determined	0.460	0.884	0.226	8.3	14.8	4.06	366	-
	Theoretical	0.450	0.900	0.225	9.0	14.0	4.25	379	-
	% Recovery	102.2	98.2	100.4	92.2	105.7	95.5	96.6	-
Spike	Sample #	3070	3071	2980	3071	3068			
	Orig. Conc.	0.027	0.49	0.010	0.2	0.27	-	-	-
	Theoretical Conc. Spiked Sample	0.200	1.15	0.023	1.15	2.5	-	-	-
	Determined Conc. of Spiked Sample	0.185	0.753	0.019	0.83	2.53	-	-	-
	% Recovery	92.5	65.5	82.6	72.1	101.2	-	-	-
Duplicates	Sample #	2982	2980	2980	2980	2986	2981	2980	3072
	Orig. Conc.	0.032	0.26	0.010	0.3	0.67	226	19.0	4.3
	Dupl. Conc.	0.027	0.26	0.010	0.3	0.64	228	20.4	6.4
	Dupl. Conc.	0.037	0.25	0.010	0.3	0.70	226	17.5	-
	Sample #	3070	3071	3071	3071	3069	3066	3064	3073
	Orig. Conc.	0.27	0.49	0.011	0.2	0.88	42.5	9.8	4.3
	Dupl. Conc.	0.22	0.48	0.011	0.2	0.86	39.8	9.6	4.8
	Dupl. Conc.	0.32	0.48	0.011	0.2	0.91	45.2	10.1	-

Comments

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKE ACCOTINK ON MARCH 17, 1981
and LAKE FAIRFAX ON MARCH 20, 1981

	Sample Designation	Bios #	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
3/17/81	Accotink Cr. North	2228	0.069	0.017	0.86	0.10	0.58	15.4
	Accotink Cr. InflowA	2229	0.022	0.012	0.72	0.09	0.35	9.0
	Accotink Cr. InflowB	2230	0.046	0.012	0.65	0.11	0.34	11.3
	Accotink Cr. Outflow	2231	0.076	0.022	0.52	0.19	0.55	43.8
	Flag Run Inflow	2232	0.067	0.040	0.41	0.12	<0.25	3.7
	Lake Composite A	2233	0.081	<0.01	0.46	0.23	0.46	43.2
	Lake Composite B	2234	0.086	0.010	0.48	0.24	0.45	41.3
3/20/81	Fairfax Lake Comp. A	2288	0.049	0.042	0.97	0.12	0.53	8.3
	Fairfax Lake Comp. B	2290	0.059	0.017	0.65	0.06	0.60	9.8
	Colvin Run Outflow	2291	0.059	<0.01	0.53	0.12	0.64	10.5
	Anne Run	2292	0.030	0.027	0.36	0.09	0.67	3.9
	Colvin Run Inflow	2294	0.036	0.027	0.38	0.13	0.70	8.3
	Colvin Run South	2295	<0.01	<0.010	0.42	0.39	0.69	5.6

			Chlorophyll-α (corrected for phaeophytin) (mg/m³)
	Accotink:		
3/17	Lake Composite A	2235	4
	Lake Composite B	2236	10
3/20	Fairfax Lake Comp. A	2293	3
	Fairfax Lake Comp. B	2289	9

3/17-20/81

Control Check		Total Phosphorus (mg/l)	Nitrate (mg N/l)	Nitrite (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)
QC Standards	Determined	0.348	0.826	0.254	1.79	3.71	120
	Theoretical	0.350	0.900	0.250	2.00	3.50	125
	% Recovery	99.4	91.8	101.6	89.5	106.0	96.0
	Determined	0.086	1.11	0.257	2.93	2.97	523
	Theoretical	0.100	1.20	0.250	3.00	3.00	538
	% Recovery	86.0	92.8	102.8	97.7	99.0	97.2
Spike	Sample #	2230	2229	2229	2229	2232	
	Orig. Conc.	0.046	0.710	0.019	0.09	< 0.25	-
	Conc. Spike added	0.200	1.15	0.023	1.15	2.50	-
	Conc. Spike Recovered	0.198	0.930	0.020	0.963	2.69	-
	% Recovery	99.0	80.9	87.0	83.7	107.6	-
Duplicates	Sample #	2230	2229	2229	2291	2290	2230
	Orig. Conc.	0.046	0.710	0.019	0.12	0.60	11.3
	Dupl. Conc.	0.052	0.690	0.020	0.25	0.66	11.6
	Dupl. Conc.	0.040	-	-	0.27	0.64	11.0

Comments No Analytical Problems Encountered

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKE ACCOTINK ON APRIL 9, 1981 and LAKE FAIRFAX ON APRIL 10, 1981

Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)		Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
Lake Accotink Comp. A	2848	0.082	0.036	4/9/81	0.25	0.20	0.88	25.5
Lake Accotink Comp. B	2849	0.080	0.036		0.27	0.21	0.66	29.2
Flag Run Inflow	2850	0.072	0.032		0.18	0.14	0.28	6.3
Accotink Creek Inflow A	2851	0.034	0.029		0.15	0.11	0.42	14.5
Accotink Creek Inflow B	2852	0.042	0.019		0.15	0.12	0.42	12.6
Accotink Creek Outflow	2853	0.075	0.019		0.26	0.20	0.72	26.5
Accotink Creek North	2854	0.046	0.017		0.22	0.12	0.46	10.0
Colvin Run - Outflow	2917	0.036	<0.01	4/10/81	0.56	0.18	0.32	7.7
Colvin Run - Inflow	2918	0.027	0.013		0.43	0.12	<0.25	5.6
Colvin Run - South	2919	0.023	0.011		0.56	0.13	<0.25	18.9
Anne Run Inflow	2920	0.025	0.011		0.45	0.19	0.27	6.8
Lake Comp A (Epilimnion)	2921	0.036	0.016		0.50	0.22	<0.25	12.1
Lake Comp B (Epilimnion)	2922	0.036	<0.01		0.56	0.21	0.30	9.9
Lake Comp A (Hypolimnion)	2925	0.027	0.010		0.51	0.30	0.32	13.8
Lake Comp B (Hypolimnion)	2926	0.027	<0.01		0.51	0.30	0.34	

			Chlorophyll-α (corrected for phaeophytin) (mg/m^3)
Lake Accotink Comp a	2846	4/9/81	4.0
Lake Accotink Comp B	2847		5.1
Lake A - Fairfax	2923	4/10/81	6.4
Lake B - Fairfax	2924		4.5

4/9-10/81

Control Check		Total Phosphorus (mg/1)	Nitrate (mg N/1)	Nitrite (mg N/1)	Ammonia (mg N/1)	TKN (mg N/1)	Dissolved Phosphorus (mg/1)	Total Suspended Solids (mg/1)
QC Standards	Determined	0.145	0.905	0.255	1.99	2.14	0.126	177.0
	Theoretical	0.150	0.900	0.250	2.00	2.00	0.150	193.0
	% Recovery	96.7	100.6	102.0	99.5	107.0	84.0	91.7
	Determined	0.084	0.445	0.254	1.81	1.80	0.082	177.0
	Theoretical	0.100	0.500	0.250	2.00	2.00	0.100	193.0
	% Recovery	84.0	89.0	101.6	90.5	90.0	82.0	91.7
Spike	Sample Number	2852	2849	2849	2849	2918	2849	
	Original Conc.	0.042	0.252	0.018	0.21	<0.25	0.036	-
	Conc. Spike Added	0.200	1.154	0.023	1.15	2.50	0.200	-
	Conc. Spike Recov'd.	0.216	1.038	0.024	1.15	2.53	0.169	-
	% Recovery	108.0	89.9	104.3	100.0	101.2	84.5	-
Duplicates	Sample Number	2852	2849	2849	2849	2851	2925	2854
	Original Conc.	0.042	0.252	0.018	0.21	0.42	0.010	10.0
	Duplicate Conc.	0.041	0.252	0.018	0.22	0.40	0.011	10.0
	Duplicate Conc.	0.043	0.252	0.018	0.21	0.44	0.009	10.0

Comments No Analytical Problems Encountered

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES ACCOTINK ON APRIL 27, 1981 and
LAKE FAIRFAX ON APRIL 24, 1981

	Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
4/24/81	Colvin Run Inflow	4184	0.040	0.021	0.30	0.07	0.90	30.9
	Colvin Run South	4185	0.058	0.036	0.32	0.04	0.72	35.0
	Colvin Run Outflow	4186	0.036	0.028	0.39	0.11	0.34	44.2
	Forest Edge Run	4187	<0.01	<0.01	0.18	0.05	<0.25	9.6
	Anne Run	4188	0.017	<0.01	0.32	0.06	<0.25	13.8
	Cameron Run	4189	<0.01	0.014	0.72	0.08	0.26	7.4
	Lake Fairfax Epilimnion A	4190	0.025	<0.01	0.45	0.08	0.25	10.2
	Lake Fairfax Epilimnion B	4191	0.011	<0.01	0.39	0.10	0.28	11.0
	Lake Fairfax Hypolimnion A	4192	0.011	<0.01	0.38	0.11	0.44	18.0
	Lake Fairfax Hypolimnion B	4193	0.020	0.016	0.36	0.03	0.38	20.1
4/27/81	Flag Run Inflow	4383	0.048	0.015	0.13	<0.01	<0.25	4.4
	Accotink Creek Inflow A	4384	0.025	<0.01	0.18	0.01	<0.25	13.6
	Accotink Creek Inflow B	4385	0.032	<0.01	0.18	<0.01	<0.25	39.7
	Accotink Creek Outflow	4386	0.056	<0.01	0.10	<0.01	0.48	23.9
	Accotink Creek North	4387	0.029	<0.01	0.18	<0.01	<0.25	4.3
	Lake Accotink Comp. A	4388	0.052	<0.01	0.10	<0.01	0.41	9.6
	Lake Accotink Comp. B	4389	0.043	<0.01	0.08	0.01	0.46	10.2

			Chlorophyll-α (corrected for phaeophytin) (mg/m^3)
4/24	Lake Fairfax Chlorophyll A	4194	3.1
	Lake Fairfax Chlorophyll B	4195	3.2
4/27	Lake Accotink Composite A Chlor.	4381	11.5
	Lake Accotink Composite B	4382	14.0

4/24-27/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Nitrite (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Solids (mg/l)	Total Suspended Solids (mg/l)
	Determined	0.155	0.453	0.247	0.85	0.95	0.135	259
	Theoretical	0.150	0.500	0.250	1.00	1.00	0.150	289
	% Recovery	103.3	90.6	98.8	85.0	95.0	90.0	89.6
QC Standards	Determined	0.139	0.453	0.247	0.85	0.95	0.131	167
	Theoretical	0.150	0.500	0.250	1.00	1.00	0.150	185
	% Recovery	92.7	90.6	98.8	85.0	95.0	87.3	90.3
	Sample #	4386	4386	4386	4187	4384	4383	--
Spike	Orig. Conc.	0.057	0.070	0.025	0.027	<0.25	0.015	-
	Conc. Spike Added	0.200	1.154	0.023	1.15	2.50	0.200	-
	Conc. Spike Recov'd.	0.200	1.038	0.029	1.17	2.83	0.189	-
	% Recovery	100	89.9	126.1	101.7	113.2	94.5	-
Duplicates	Sample #	4188	4187	4187	4187	4389	4383	4193
	Orig. Conc.	0.017	0.162	0.018	0.27	0.46	0.015	20.1
	Duplicate Conc.	0.016	0.172	0.018	0.26	0.50	0.016	20.5
	Duplicate Conc.	0.018	0.152	0.018	0.28	0.42	0.014	19.7

Comments No Analytical Problems

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKE FAIRFAX ON MAY 5, 1981 and LAKE ACCOTINK ON MAY 6, 1981

Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
Colvin Run Inflow	4979	0.025	<0.010	0.56	0.03	0.32	4.4
Colvin Run Outflow	4980	0.050	0.015	0.55	0.13	0.74	10.8
Colvin Run South	4981	0.018	<0.010	0.68	0.06	0.29	3.6
Anne Run Inflow	4982	0.040	<0.010	0.53	0.04	0.43	4.7
Lake Composite Epi A	4983	0.056	0.023	0.50	0.20	0.60	13.2
Lake Composite Epi B	4984	0.052	0.025	0.64	0.21	0.69	13.8
Lake Composite Hypo A	4985	0.067	0.028	0.53	0.17	0.70	17.8

5/5/81

		Chlorophyll-α
Lake Composite Chloro.-α A	4986	6.0
Lake Composite Chloro.-α B	4987	5.8

Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
Accotink Creek Inflow A	4991	0.023	<0.010	0.55	0.03	0.44	10.8
Accotink Creek Inflow B	4992	0.025	0.012	0.52	0.06	0.54	11.2
Accotink Creek Outflow	4993	0.157	0.025	0.58	0.13	1.03	30.9
Lake Accotink Comp A	4994	0.091	0.025	0.54	0.23	1.03	32.0
Lake Accotink Comp B	4995	0.088	0.033	0.55	0.25	1.02	30.5
Flag Run Inflow	4996	0.040	<0.010	0.31	0.08	0.56	3.0
Accotink Creek North	4997	0.033	0.011	0.65	0.09	0.52	6.5

5/6/81

		Chlorophyll-α
Lake Accotink Comp. A Chloro.-α	4989	11.8
Lake Accotink Comp. B Chloro.-α	4990	15.5

5/5-6/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Nitrite (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Solids (mg/l)	Total Suspended Solids (mg/l)
	Determined	0.203	0.605	0.245	2.94	2.26	0.212	321
	Theoretical	0.200	0.700	0.250	3.00	2.00	0.200	323
	% Recovery	101.5	86.4	98.0	98.0	113.0	106.0	99.4
QC Standards	Determined	0.191	0.605	0.245	2.94	3.24	0.188	265
	Theoretical	0.200	0.700	0.250	3.00	3.00	0.200	289
	% Recovery	95.5	86.4	98.0	98.0	108.0	94.0	91.7
	Sample #	4995	4983	4983	4983	4997	4985	--
Spike	Orig. Conc.	0.088	0.484	0.013	0.20	0.52	0.028	-
	Conc. Spike Added	0.200	1.154	0.023	1.15	2.50	0.200	-
	Conc. Spike Recov'd.	0.207	0.935	0.024	1.11	2.94	0.201	-
	% Recovery	103.5	81.0	104.3	96.5	117.6	100.5	-
Duplicates	Sample #	4983	4983	4983	4983	4993	4985	4955
	Orig. Conc.	0.056	0.484	0.013	0.20	1.03	0.028	189
	Duplicate Conc.	0.054	0.457	0.013	0.20	1.04	0.025	194
	Duplicate Conc.	0.057	0.507	0.013	0.19	1.02	0.030	184

Comments No Analytical Problems

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES ACCOTINK AND FAIRFAX
ON MAY 21 and 22, 1981

	Sample Designation	Bios.#	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Suspended Solids (mg/l)
5/21/81	Lake Accotink Comp. A	5613	0.070	0.015	0.33	0.16	0.73	12.6
	Lake Accotink Comp. B	5614	0.048	0.018	0.36	0.17	0.66	11.4
	Inflow Flag Run	5615	0.057	0.035	0.30	0.11	0.30	1.9
	Accotink Creek Inflow A	5616	0.072	0.040	0.37	0.09	0.48	12.6
	Accotink Creek Inflow B	5617	0.057	0.033	0.40	0.07	0.38	10.6
	Accotink Creek Outflow	5618	0.060	0.026	0.43	0.10	0.50	18.2
	Accotink Creek North	5619	0.084	0.016	0.37	0.13	0.25	19.8
	Anne	5653	<0.01	<0.01	0.52	0.08	0.19	2.8
	Lake Fairfax Comp A Hypo	5654	0.040	0.031	0.48	0.22	0.79	7.8
	Lake Fairfax Comp B Epil	5655	0.028	0.025	0.43	0.10	0.32	5.4
5/22/81	Col Run Outflow	5656	0.050	<0.01	0.45	0.06	0.43	4.0
	Col Run South	5657	0.018	<0.01	0.76	0.15	0.41	1.6
	Col Run Inflow	5658	0.016	<0.01	0.67	0.11	0.32	3.2
	Lake Fairfax Comp B Hypo	5659	0.036	0.018	0.40	0.20	0.58	8.2
	Lake Fairfax Comp B Epil	5660	0.068	0.011	0.42	0.15	0.49	4.8

Chlorophyll-α (corrected for phaeophytin)
(mg/m^3)

Lake Accotink A	5611	5/21/81	4.5	(duplicate = 4.8)
Lake Accotink B	5612		4.8	
Lake Fairfax Comp B	5651	5/22/81	8.0	
Lake Fairfax Comp A	5652		9.4	

5/21/22/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)
	Determined	0.092	0.88	1.90	1.91	259
	Theoretical	0.100	1.05	2.00	2.00	289
	% Recovery	92	84	95	96	89
QC Standards	Determined	0.100	0.95	2.79	2.80	167
	Theoretical	0.093	1.05	3.00	3.00	185
	% Recovery	93	91	93	93	90.3
Spike	Sample #	5653	5653	5653	5653	-
	Orig. Conc.	<0.01	0.52	0.08	0.19	-
	Conc. Spike Added	0.200	1.18	1.15	2.50	-
	Conc. Spike Recov'd.	0.224	1.56	1.06	2.79	-
	% Recovery	112	91	92	90	-
Duplicates	Sample #	5653	5614	5614	5613	4185
	Orig. Conc.	<0.01	0.36	0.17	0.73	35.0
	Duplicate Conc.	<0.01	0.36	0.16	0.82	34.9
	Duplicate Conc.	<0.01	0.36	0.17	0.64	30.1

Comments No Analytical Problems

WATER CHEMISTRY ANALYSES FOR STORM #2 AT LAKES ACCOTINK AND FAIRFAX AND ROUTINE TESTING ON JUNE 4 and 5, 1981

Sample Designation	Bios #	Total Phosphorus (mg P/1)	Soluble Phosphorus (mg P/1)	Nitrate-Nitrite (mg N/1)	Ammonia (mg N/1)	Total Kjeldahl Nitrogen (mg N/1)	Suspended Solids (mg/1)
Anne Run A 5/28/81	5754	0.044	<0.01	520*	0.25	<0.25	13.4
Anne Run B 5/28/81	5755	0.018	<0.01	1420*	0.21	<0.25	15.0
Colvin Run Inflow A 5/28/81	5756	0.105	<0.01	930*	0.13	<0.25	36.6
Colvin Run Inflow B 5/28/81	5757	0.102	<0.01	630*	0.51	0.50	38.2
Outflow A 5/28/81	5758	0.019	<0.01	610*	<0.01	0.39	9.3
Outflow B 5/28/81	5759	0.019	<0.01	160*	0.21	0.37	9.0
Lake Accotink Comp A 6/4/81	6015	0.056	0.051	0.30	0.25	1.18	28.5
Lake Accotink Comp B 6/4/81	6016	0.078	0.063	0.50	0.23	1.14	35.6
Flag Run 6/4/81	6017	0.058	0.041	0.27	0.17	1.02	1.8
Accotink Creek Inflow A 6/4/81	6018	0.073	0.058	0.49	0.14	0.83	18.6
Accotink Creek Inflow B 6/4/81	6019	0.068	0.043	0.46	0.20	0.72	22.6
Accotink Creek Outflow	6020	0.083	0.053	0.38	0.22	1.02	18.7
Accotink Creek North	6021	0.073	0.061	0.62	0.10	0.70	7.7
Lake Fairfax Epi A 6/5/81	6039	0.028	0.021	0.55	0.13	0.76	5.6
Lake Fairfax Epi B 6/5/81	6040	0.048	0.033	0.37	0.11	0.66	6.2
Hypo A 6/5/81	6041	0.032	<0.01	0.36	0.10	0.76	6.2
Hypo B 6/5/81	6042	0.052	0.041	0.31	0.18	0.90	6.8
Colvin Run Inflow 6/5/81	6043	0.056	0.036	0.62	0.08	0.74	5.7
Colvin Run South Inflow 6/5/81	6044	0.098	0.058	1.08	0.07	0.65	7.2
Colvin Run Outflow	6045	0.063	0.061	0.50	0.03	0.66	2.5
Anne Run Inflow	6046	0.058	0.048	0.49	0.04	0.60	2.4

* See QC comments.

6/4-5/81

Control Check		Total Phosphorus (mg/1)	Nitrite-Nitrate (mg N/1)	Ammonia (mg N/1)	TKN (mg N/1)	Total Suspended Solids (mg/1)
QC Standards	Determined	0.096	0.88	2.93	3.18	120
	Theoretical	0.100	0.95	3.00	3.00	131
	% Recovery	96	93	98	106	92
Spike	Sample #	6042	6019	6019	6019	
	Orig. Conc.	0.052	0.46	0.20	0.72	
	Conc. Spike Added	0.200	1.154	1.15	2.50	
	Conc. Spike Recovered	0.210	1.037	1.22	2.89	
	% Recovery	105	90	106	115	
Duplicates	Sample #	6042	6019	6019	6019	6019
	Orig. Conc.	0.052	0.46	0.20	0.72	22.6
	Duplicate Conc.	0.051	0.43	0.21	0.72	22.1
	Duplicate Conc.	0.053	0.50	0.20	0.72	23.2
Comments	No Analytical Problems					

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES FAIRFAX AND ACCOTINK ON JUNE 17, 1981

Sample Designation				Bios #	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l)	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Total Suspended Solids (mg/l)
Lake Fairfax	Hypo	A	6/17/81	7430	0.05	<0.01	0.29	0.85	0.85	7.5
Lake Fairfax	Hypo	B	6/17/81	7431	0.04	<0.01	0.14	0.52	0.82	8.4
Lake Fairfax	Epi	A	6/17/81	7432	0.03	<0.01	0.31	0.33	0.38	3.5
Lake Fairfax	Epi	B	6/17/81	7433	0.03	<0.01	0.35	0.09	0.23	1.2
Lake Accotink	Comp	A	6/17/81	7434	0.10	0.03	0.28	0.42	0.78	13.0
Lake Accotink	Comp	B	6/17/81	7435	0.10	0.02	0.27	0.44	0.89	15.8
Anne Run	Inflow		6/17/81	7436	0.03	<0.01	0.37	0.15	0.23	3.2
Colvin Run	South		6/17/81	7437	0.05	0.02	0.78	0.42	0.48	7.9
Colvin Run	Inflow		6/17/81	7438	0.04	<0.01	0.64	0.31	0.38	13.5
Colvin Run	Outflow		6/17/81	7439	0.03	0.03	0.37	0.21	0.39	4.3
Flag Run	Inflow		6/17/81	7440	0.10	0.05	0.19	0.24	0.46	8.2
Accotink Creek	Inflow	A	6/17/81	7441	0.08	0.04	0.33	0.24	0.47	31.6
Accotink Creek	Inflow	B	6/17/81	7442	0.08	0.04	0.34	0.25	0.32	18.5
Accotink Creek	Outflow		6/17/81	7443	0.09	0.06	0.36	0.57	0.85	14.5
Accotink Creek	North		6/17/81	7444	0.10	0.07	0.38	0.63	0.64	17.0

				Chlorophyll-α (mg/m^3) (corrected for phaeophitin)
Lake Fairfax	A	6/17/81	7426	6.95
Lake Fairfax	B	6/17/81	7427	2.94
Lake Accotink	A	6/17/81	7428	17.1
Lake Accotink	B	6/17/81	7429	16.6

6/17/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)
QC Standards	Determined	0.106	0.95	3.03	3.20	
	Theoretical	0.100	0.95	3.00	3.00	
	% Recovery	106	100	101	107	
Spike	Sample #	27442	27442	27442	27516	
	Orig. Conc.	0.08	0.34	0.25	2.20	
	Conc. Spike Added	0.200	1.17	1.15	12.5	
	Conc. Spike Recovered	0.155	1.01	.99	11.9	
	% Recovery	77.5	86.0	86.1	95.2	
Duplicates	Sample #	27442	27442	27442	27516	27444
	Orig. Conc.	0.08	0.34	0.25	2.20	17.0
	Duplicate Conc.	0.07	0.34	0.24	2.24	17.6
	Duplicate Conc.	0.08	0.34	0.26	2.72	16.4
Comments	No Analytical Problems.					

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES ACCOTINK AND FAIRFAX
ON JULY 6, 1981

Sample Designation				Bios #	Total Phosphorus (mg P/1)	Soluble Phosphorus (mg P/1)	Nitrate-Nitrite (mg N/1)	Ammonia (mg N/1)	Total Kjeldahl Nitrogen (mg N/1)	Total Suspended Solids (mg/1)
Lake Accotink	Comp	A	7/6/81	7837	0.51	0.08	0.56	0.21	1.24	123
Lake Accotink	Comp	B	7/6/81	7838	0.42	0.07	0.70	0.19	1.32	122
Accotink Creek	North		7/6/81	7839	0.06	0.03	0.71	0.11	0.80	18.5
Flag Run	Inflow		7/6/81	7840	0.06	0.01	0.29	0.15	0.82	98.0
Accotink Creek	Inflow		7/6/81	7841	0.40	0.32	0.59	0.07	0.89	20.2
Accotink Creek	Outflow		7/6/81	7842	0.22	0.05	0.62	0.15	1.42	18.2
Accotink Creek	Braddock		7/6/81	7843	0.07	0.02	0.66	0.13	0.82	17.3
Long Branch			7/6/81	7844	0.32	0.12	0.56	0.15	0.77	9.4
Lake Fairfax	Comp A EPI		7/6/81	7845	0.19	0.03	0.36	0.07	0.88	16.7
Lake Fairfax	Comp B EPI		7/6/81	7846	0.23	0.01	0.24	0.14	0.94	17.1
Lake Fairfax	Comp A Hypo		7/6/81	7847	0.10	0.04	0.19	0.47	1.50	33.8
Lake Fairfax	Comp B Hypo		7/6/81	7848	0.09	0.01	0.22	0.56	1.44	39.0
Anne Run			7/6/81	7849	0.05	<0.01	0.36	0.04	0.80	11.1
C lvin Run	Inflow		7/6/81	7850	0.04	0.03	0.62	0.05	0.58	10.8
C lvin Run	South		7/6/81	7851	0.31	0.02	0.92	0.11	0.56	10.4
C lvin Run	Outflow		7/6/81	7852	0.06	<0.01	0.41	0.08	1.03	15.0

					Chlorophyll-α (mg/m^3) (corrected for phaeophitin)
Lake Fairfax	Comp	A	7/6/81	7833	13.4
Lake Fairfax	Comp	B	7/6/81	7834	18.4
Lake Accotink	Comp	A	7/6/81	7835	8.6
Lake Accotink	Comp	B	7/6/81	7836	8.8

7/6/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)
QC Standards	Determined	0.115	0.95	3.03	3.00	
	Theoretical	0.100	0.95	3.00	3.16	
	% Recovery	115	100	101	105	
Spike	Sample #	7846	7837	7837	7837	
	Orig. Conc.	0.231	0.56	0.21	1.24	
	Conc. Spike Added	0.200	1.15	*	*	
	Conc. Spike Recovered	0.176	1.05			
	% Recovery	88.0	90.4			
Duplicates	Sample #	7846	7837	7837	7837	7837
	Orig. Conc.	0.231	0.56	0.21	1.24	123
	Duplicate Conc.	0.220	0.530	0.21	1.22	132
	Duplicate Conc.	0.242	0.600	0.21	1.27	114

Comments: No Analytical Problems.

* Spikes performed on non-NUSAC samples. Adequate recoveries demonstrated.

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES ACCOTINK AND FAIRFAX
ON JULY 20, 1981

Sample Designation	Bios.#	Total Phosphorus (mg P/1)	Soluble Phosphorus (mg P/1)	Nitrate-Nitrite (mg N/1)	Ammonia (mg N/1)	Total Kjeldahl Nitrogen (mg N/1)	Suspended Solids (mg/1)
Long Branch Inflow 7/20/81	8590	0.02	0.02	0.30	0.30	0.40	< 1
Braddock Road Inflow 7/20	8591	0.04	0.02	0.38	0.40	0.50	3.6
Accotink Inflow 7/20/81	8592	0.04	0.02	0.37	0.39	1.40	2.7
Accotink Inflow N. 7/20/81	8593	0.24	0.04	0.51	0.37	0.50	12.1
Lake Accotink Comp A 7/20/81	8594	0.16	0.03	0.29	0.50	1.40	32.4
Lake Accotink Comp B 7/20/81	8595	0.11	0.02	0.22	0.47	1.35	35.6
Accotink Creek Outflow 7/20/81	8596	0.14	0.02	0.23	0.44	1.25	34.8
Lake Fairfax EPi A "	8597	0.02	0.02	0.32	0.39	0.85	3.1
Lake Fairfax EPi B "	8598	0.03	0.02	0.33	0.40	0.75	4.4
Lake Fairfax Hypo A "	8599	0.08	0.04	0.28	1.02	2.05	13.2
Lake Fairfax Hypo B "	8600	0.09	0.02	0.32	0.97	1.95	14.7
Lake Fairfax Meta A "	8601	0.04	<0.01	0.37	0.42	0.70	7.3
Lake Fairfax Meta B "	8602	0.04	<0.01	0.30	0.42	1.00	5.8
Colvin South "	8603	0.08	0.02	1.32	0.32	0.50	11.0
Anne Run "	8604	0.02	<0.01	0.65	0.51	1.25	2.5

7/20/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)	Chlorophyll-a (mg/m^3)
	Determined	0.558	0.97	2.94	3.30	146	
	Theoretical	0.500	0.95	3.00	3.00	162	
QC Standards	% Recovery	112	102	98.0	110	90.1	
	Sample #	8613	8613	9613	8613		
	Orig. Conc.	0.068	2.73	0.33	0.50		
	Conc. Spike Added	0.200	1.17	1.15	12.5		
	Conc Spike Recov.	0.217	1.10	1.10	14.8		
Spike	% Recovery	108	94.0	95.6	118		
Duplicates	Sample #	8613	8613	8613	8607	8594	8589
	Orig. Conc.	0.068	2.73	0.33	1.02	32.4	31.6
	Duplicate Conc.	0.074	2.73	0.34	1.60	34.4	37.4
	Duplicate Conc.	0.064	2.73	0.32	1.65	30.4	25.9

Comments No Analytical PRoblems

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES ACCOTINK AND FAIRFAX
ON AUGUST 4, 1981

Sample Designation		Bios #	Total Phophorus (mg P/1)	Soluble Phosphorus (mg P/1)	Nitrate-Nitrite (mg N/1)	Ammonia (mg N/1)	Total Kjeldahl Nitrogen (mg/N/1)	Suspended Solids (mg/1)	Chlorophyll-a (mg/m^3)
Accotink Creek Braddock Rd.		8822	0.08	0.02	0.41	0.02	0.30	7.2	
Accotink Creek Long Branch		8823	0.07	<0.01	0.45	0.04	0.25	10.4	
Accotink Creek Inflow	8/4/81	8824	0.07	0.01	0.48	0.01	0.60	6.8	
Accotink Creek North		8825	0.07	<0.01	0.51	0.09	0.55	4.2	
Accotink Creek Outflow		8826	0.09	<0.01	0.31	0.12	1.30	21.0	
Flag Run		8827	0.44	0.33	0.19	0.09	0.95	4.1	
Colvin Run Inflow		8828	0.04	<0.01	0.55	0.12	0.40	4.5	
Colvin Run Outflow		8829	0.03	<0.01	0.30	0.11	0.95	14.4	
Colvin Run South		8830	0.03	<0.01	1.15	0.09	<0.25	<1	
Anne Run		8831	0.06	0.02	2.40	0.55	0.65	15.8	
Lake Accotink Camp A		8832	0.07	0.02	0.29	0.19	1.00	6.4	
Lake Accotink Camp B		8833	0.13	0.01	0.27	0.62	1.50	24.6	
Lake Fairfax Epi Camp A		8834	0.04	<0.01	0.24	0.19	0.95	4.1	
Lake Fairfax Epi Camp B		8835	0.22	0.12	0.22	0.14	0.70	3.7	

7/28 & 8/5/81

Control Check	Total Phoshorus (mg/1)	Nitrite-Nitrate (mg N/1)	Ammonia (mg N/1)	TKN (mg N/1)	Total Suspended Solids (mg/1)
QC Standards					
Determined	0.49	0.91	2.88	2.73	366
Theoretical	0.50	0.95	3.00	3.00	380
% Recovery	98.0	95.8	96.0	91.0	96.3
Spike					
Sample #	8742	8734	8734	8833	
Orig Conc.	0.11	0.57	0.24	1.50	
Conc. Spike Added	0.31	1.17	1.15	6.25	
Conc. Spike Recovered	0.31	1.04	1.13	5.90	
% Recovery	100	88.9	98.3	94.4	
Duplicates					
Sample #	8742	8734	8734	8742	8742
Orig. Conc.	0.11	0.57	0.24	0.55	72.5
Duplicate Conc.	0.12	0.56	0.26	0.55	76.3
Duplicate Conc.	0.11	0.58	0.22	0.55	68.7

Comments

ROUTINE WATER CHEMISTRY ANALYSES FOR LAKES FAIRFAX AND ACCOTINK
ON August 18 and 19, 1981

Sample Designation	Bios #	Total Phosphorus (mg P/l)	Soluble Phosphorus (mg P/l)	Nitrate-Nitrite (mg N/l	Ammonia (mg N/l)	Total Kjeldahl Nitrogen (mg N/l)	Total Suspended Solids (mg/l)	Chlorophyll-"a" (mg/m3)
Colvin Run Inflow	9802	0.01	0.02	0.97	0.04	0.90	3.2	-
Colvin Run Outflow	9803	0.03	0.02	0.46	0.08	0.85	3.5	-
Colvin Run South	9804	0.02	< 0.01	1.33	0.02	0.60	3.6	-
Ann Run	9805	0.02	< 0.01	0.89	0.05	0.70	17.6	-
Lake Fairfax 0.5m	9806	0.06	< 0.01	0.42	0.06	1.00	10.0	-
Lake Fairfax 1.5m	9807	0.06	0.02	0.38	0.10	0.70	8.3	-
Lake Fairfax 2.5ma	9808	0.08	< 0.01	0.26	0.25	0.60	17.0	-
Lake Fairfax 2.5mb	9809	0.06	< 0.01	0.30	0.17	1.40	15.8	-
Lake Fairfax 3.5m	9810	0.12	< 0.01	0.17	0.53	1.65	33.0	-
Lake Fairfax 4.5m	9811	0.06	0.03	0.25	3.55	4.00	50.0	-
Lake Accotink Comp A	9812	0.14	0.04	0.51	0.24	1.15	21.5	-
Lake Accotink Comp B	9813	0.10	< 0.01	0.49	0.18	1.40	27.5	-
Accotink Creek Outflow	9814	0.12	< 0.01	0.48	0.16	1.25	26.9	-
Accotink Creek North	9815	0.41	< 0.01	0.55	0.11	0.65	6.4	-
Accotink Creek Inflow	9816	0.04	< 0.01	0.51	0.09	0.45	4.9	-
Accotink Creek Braddock	9817	0.02	< 0.01	0.51	0.11	1.30	6.9	-
Long Branch	9818	0.03	< 0.01	0.39	0.06	1.65	7.6	-
Flag Run	9819	0.08	0.02	0.23	0.07	0.80	4.2	-
Lake Accotink Chlorophyll "a" A 8/18/81	9820	-	-	-	-	-	-	24.6
Lake Accotink Chlorophyll "a" B 8/18/81	9821	-	-	-	-	-	-	20.8
Lake Fairfax Chlorophyll "a" A 8/19/81	9822	-	-	-	-	-	-	42.7
Lake Fairfax Chlorophyll "a" B 8/19/81	9823	-	-	-	-	-	-	45.3

8/19/81

Control Check		Total Phosphorus (mg/l)	Nitrite-Nitrate (mg N/l)	Ammonia (mg N/l)	TKN (mg N/l)	Total Suspended Solids (mg/l)	Chlorophyll-a (mg/m^3)
QC Standards	Determined	0.194	0.458	1.80	2.15	450	
	Theoretical	0.200	0.450	2.00	2.00	461	
	% Recovery	97.0	102	90.0	108	97.6	
Spike	Sample #	9819	BAWQ #1	BAWQ #1	9810		
	Orig. Conc.	0.08	1.13	0.12	1.65		
	Conc Spike Added	0.200	1.17	1.15	2.50		
	Conc Spike Rec'd.	0.210	1.32	1.08	2.40		
	% Recovery	105	113	93.9	96.0		
Duplicates	Sample #	9819	BAWQ #1	BAWQ #1	9810	9811	
	Orig-Conc.	0.08	1.13	0.12	1.65	50.0	
	Duplicate Conc.	0.08	1.13	0.11	1.80	51.5	
	Duplicate Conc.	0.07	1.13	0.12	1.50	48.5	

Appendix II.10.c.

Quarterly data summaries for routine sampling of Lake Fairfax and tributaries during the Phase 1 Study, September 1980 to August 1981,

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: Dam
Watershed: Difficult Run

Project: Phase 1-Routine
Interval: Sept.-Dec., 1980
Other: Fall Quarter Summary

Sample Date	Sample No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
9/18/80	4	Epilim. .5-2.0	24.06	6.37	102.9	0.158	0.053	0.0032	0.064	0.061	0.32	0.875
	2	Hypolim. 3-4.0	21.04	5.99	191.4	0.415	0.075	0.006	0.070	0.029	3.05	4.10
	6	.5-4.0	22.6	6.28	143.9	0.272	0.063	0.0045	0.067	0.062	1.56	2.31
10/16/80	6	.5-4.0	14.3	7.11	125.8	0.104	0.074	0.013	0.174	0.162	0.352	0.465
11/13/80	5	.5-4.0	7.83	7.38	106.7	0.127	0.064	0.014	0.317	0.303	.301 0.961	1.25
12/18/80	5	.5-4.0	3.75	7.11	89.65	0.068	0.032	<0.01	0.464	>0.454	0.25	0.799
Fall Mean				6.97	116.5	0.143	0.058	0.0104	0.256	0.245	0.781	1.206

Sample Date	Sample No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Notes
9/18/80	4	Epilim. 0.5-2.	40.4	5.18	35.22	N.D.	8.67	103.1	5.94	8.18	1.6m	
	2	Hypolim. 3-4.0	70.85	7.38	63.48	N.D.	0.41	4.6	10.05	41.60	1.6m	
	6	.5-4.0	85.42	9.44	75.98	N.D.	4.45	52.8	8.74	25.83	1.6m	
10/16/80	6	.5-4.0	99.4	11.8	87.6	N.D.	6.06	61.12	6.19	7.11	1.0m	
11/13/80	5	.5-4.0	80.1	13.3	66.80	34	9.71	84.4	12.33	22.29	0.6m	
12/18/80	5	.5-4.0	n=2 40.25	n=5 8.81	31.44	34	13.4	104.5	18.66	22.24	1.0m	
Fall Mean			76.3	10.84	65.46	34	8.41	75.71	10.22	17.88		
								ratio of means				

*Determined by difference

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Anne Run
Station: Inflow
Watershed: Difficult Run
Project: Phase I-Routine
Interval: Sept.-Dec. 1980
Other: Fall Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. ^oC	pH Unit	Cond. µmhos /cm At 25^oC	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
9/18/80	-Not taken-											
10/16/80	2	Surface	12.9	7.3	90.5	0.159	0.113	0.005	0.470	0.465	0.275	0.35
11/13/80	1	Surface	5	7.11	93.6	0.124	0.124	<0.01	0.40	0.39	0.8	0.43
12/18/80	1	Surface	2.1	6.98	89.5 52	0.027	0.040	<0.01	0.51	>.50	0.20	0.32
Fall Mean				7.13	91.2	0.103	0.092	0.008	0.46	0.452	0.425	0.367

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Notes
9/18/80	-Not taken-											
10/16/80	2	Surface	67	1.7	65.3	N.D.	N.D.	-	5.15	6.59		
11/13/80	1	Surface	77.6	13.5	64.1	N.D.	N.D.	-	6.69	9.68		
12/18/80	1	Surface	31.0	2.2	28.8	34	N.D.	-	30.74	17.75		
Fall Mean			58.5	5.8	52.7	34	-	-	8.03	9.62		

* Determined by difference

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run

Station: Inflow

Watershed: Difficult Run

Project: Phase I-Routine

Interval: Sept.-Dec., 1980

Other: Fall Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. oC	pH Unit	Cond. µmhos /cm At 25^{o}C	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
9/18/80	2	Surface	21.5	6.13	84	0.28	0.15	0.014	0.845	0.831	0.35	0.965
10/16/80	2	Surface	12.2	7.3	78.3	0.068	0.05	0.0035	0.905	0.902	0.275	0.46
11/13/80	2	Surface	5.5	7.05	81.9 82.7	0.330	0.131	<0.01	0.665	0.65	.238 ~~0.8~~	0.33
12/18/80	2	Surface	2.6	6.68	48.	0.0335	0.028	<0.01	0.745	> .735	0.20	0.75
Fall Mean				6.79	81.73	0.178	0.090	0.009	0.790	0.780	0.406	0.626

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Notes
9/18/80	2	Surface	72.8	23.75	49.05	N.D.	N.D.	-	6.46	7.96		
10/16/80	2	Surface	86.5	11.35	75.15	N.D.	N.D.	-	20.07	23.6		
11/13/80	2	Surface	56.4	1.55	54.85	N.D.	N.D.	-	3.01	11.18		
12/18/80	2	Surface	32.0	1.30	30.7	34	N.D	-	44.63	51.61		
Fall Mean			61.93	9.49	52.44	34	-	- ratio of means	7.96	13.29		

* Determined by difference

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run
Station: Outflow
Watershed: Difficult Run

Project: Phase I-Routine
Interval: Sept.-Dec., 1980
Other: Fall Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. oC	pH Unit	Cond. µmhos /cm At 25oC	P-Tot mgP/1	P-Sol mgP/1	N-NO2 mgN/1	N-NO2 + NO3 mgN/1	N-NO3* mgN/1	N-NH3 mgN/1	N-TKN mgN/1
9/18/80	2	Surface	24	6.48	104.8	0.145	0.075	0.004	0.105	0.101	0.4	0.89
10/16/80	2	Surface	16	7.7	114.5	0.182	.094 ~~0.499~~	0.0125	0.185	0.173	0.775	1.82
11/13/80	2	Surface	8.5	7.45	102.4	0.218	0.149	0.0365	0.435	0.399	.488 $\boxed{0.85}$	0.385
12/18/80	2	Surface	2.5	7.10	86.5 51.	0.072	0.036	0.011	0.50	0.489	0.20	0.80
Fall Mean				7.18	102.1	0.154	0.190	0.016	0.306	0.291	0.556	0.974

Sample Date	Repl. No.	Depth m	Solids Tot mg/1	Solids Sus mg/1	Solids* Dis mg/1	Alkal mg/1 CaCO3	Diss Oxyg mg/1	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Notes
9/18/80	2	Surface	67.4	7.25	60.15	N.D.	N.D.	-	6.86	6.73		
10/16/80	2	Surface	98	11.3	86.7	N.D.	N.D.	-	11.02	10.21 ~~1.92~~		
11/13/80	2	Surface	71.5	7.1	64.4	N.D.	N.D.	-	3.76	8.62		
12/18/80	2	Surface	51.70	19.5	32.2	34	N.D.	-	18.06	19.44		
Fall Mean			72.15	11.29	60.86	34	-	-	8.31	4.54		

* Determined by difference

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: Dam
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: March-May 1981
Other: Spring Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos/cm At 25°C	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
3/24/81			5.9	7.08**	121	0.054	0.030		0.81		0.09	0.57
4/10/81	Epilim	0-3	13.3	7.21	112.0	0.036	0.013		0.53		0.22	0.275
	Hypolim	3-5	9.4	6.79	121.3	0.027	0.01		0.51		0.30	0.33
	$\overline{X}$	0-5	11.7	7.04	115.7	0.0324	0.0118		0.52		0.252	0.297
4/24/81	Epilim	0-2.5	17.0	7.40	113	0.018	0.01		0.42		0.09	0.27
	Hypolim	2.5-4.5	13.2	6.69	118.3	0.016	0.013		0.37		0.07	0.41
	$\overline{X}$		15.3	7.05	115.3	0.017	0.011		0.40		0.08	0.34

**from 3/20

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	$\frac{TN}{TP}$	$\frac{\text{Inor N}}{\text{Sol P}}$	Trans-parency m	Notes
3/24/81				9.1			11.1	92.	26.0	30.		
4/10/81	Epilim	0-3		11.9			9.3	92.	22.4	58.		
	Hypolim	3-5		13.8			3.4	31.	31.	81.		
	$\overline{X}$			12.66			7.25	70.			1.2	
4/24/81	Epilim			10.6			10.0	107.	38.3	51.		
	Hypolim						4.0	40.	49.	34.		
	$\overline{X}$						7.3	75.			1.25	

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: Dam
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: March-May 1981
Other: Spring Quarter Summary (Cont'd)

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
5/5/81	$\bar{X}$		15.	6.71	81	0.058	0.025		0.56		0.19	0.66
5/22/81	Epilim	0-2	18.		99	0.048	0.018		0.43		0.13	0.41
	Hypolim	2-4.5	14.4		115	0.038	0.025		0.44		0.21	0.69
	$\bar{X}$	0-4.5	16.		108	0.042	0.022		0.435		0.174	0.57

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN/TP	Inor N/Sol P	Trans-parency	Notes
5/5/81				15			6.3	65.	21	30.		
5/22/81	Epilim			8.0			9.6	105.	17.5	31.		
	Hypolim			5.1			3.3	33.	30.0	26.		
	$\bar{X}$			6.39			6.4	67.			.95	

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Anne Run

Station: Inflow

Watershed: Difficult Run

Project: Phase 1-Routine

Interval: March-May 1981

Other: Spring Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. ^oC	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
3/20/81		Surface	2.7	6.73	118	0.03	0.027		0.36		0.09	0.67
4/10/81		Surface	15.4	7.06	103	0.025	0.011		0.45		0.19	0.27
4/24/81		Surface	16.0	7.05	102	0.017	<0.01		0.32		0.06	<0.25
5/5/81		Surface	18	6.92	100	0.04	<0.01		0.53		0.04	0.43
5/22/81		Surface	22.7		100	0.017	<0.01		0.32		0.06	<0.25

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency m	Notes Discharge L/S:
3/20/81		Surface		3.9			11.8	87	34.3	16.7		30.49
4/10/81		Surface		6.8					28.8	58.2	~1.5	44.26
4/24/81		Surface		13.8					33.5	38	~2.0	73.77
5/5/81		Surface		4.7					24	57	~ 1.0	35.89
5/22/81		Surface		13.8					33.5	38		20.0

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run
Station: Inflow
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: March-May, 1981
Other: Spring Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos At 25°C /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
3/20/81		Surface	2.5	7.01	110.	0.036	0.027		0.38		0.13	0.70
4/10/81		Surface	15.2	7.06	98.4	0.027	0.013		0.43		0.12	<0.25
4/24/81		Surface	17.0		95.3	0.040	0.021		0.30		0.07	0.90
5/5/81		Surface	18.5	6.93	95.0	0.025	<0.010		0.56		0.03	0.32
5/22/81		Surface	19.8		97.7	0.016	<0.010		0.67		0.11	0.32

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN/TP	Inor N/Sol P	Trans-parency	Notes
3/20/81		Surface		8.3					30.	18.9		
4/10/81		Surface		5.6					25.2	42.3		
4/24/81		Surface		30.9					30.	17.6		
5/5/81		Surface		4.4					35.2	59.		
5/22/81		Surface		3.2					61.9	78.		

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run
Station: Outflow
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: March-May 1981
Other: Spring Quarter Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	N-NO2 mgN/l	N-NO2 + NO3 mgN/l	N-NO3* mgN/l	N-NH3 mgN/l	N-TKN mgN/l
3/20/81		Surface	4.2	7.17	121	0.059	<0.01		0.53		0.12	0.64
4/10/81		Surface	15.0	7.14	120	0.036	<0.01		0.56		0.18	0.32
4/24/81		Surface	19.0	7.62	120	0.036	0.028		0.39		0.11	0.34
5/5/81		Surface	18.1	7.08	101	0.050	0.015		0.55		0.13	0.74
5/22/81		Surface	23.5		100	0.050	<0.01		0.45		0.06	0.43

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Discharge L/S:
3/20/81		Surface		10.5			12.0	95	19.8	65		73.02
4/20/81		Surface		7.7					24.4	74		136.10
4/24/81		Surface		44.2					20.3	17.8		126.69
5/5/81		Surface		10.8					25.8	45.3		87.26
5/22/81		Surface		4.0					17.6	51		80.00

NUSAC, Incorporated
Lake Management

DATA SUMMARY

Location: Lake Fairfax
Station: Dam
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: June 5-17 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. ^{o}C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
6/5 (E)	2	2	21.95	7.30	95.13	0.038	0.027	1.17	0.46	0.580	0.120	0.710
6/5 (H)	2	2.5	15.11	6.85	122.38	0.042	0.021	1.165	0.335	0.475	0.140	0.830
6/5 (T)		4.5	18.48	7.08	107.44	0.040	0.024	1.167	0.391	0.522	0.131	0.777
6/17 (E)	2	2	27.60	7.4	98.63	0.03	<0.01	0.635	0.33	0.540	0.210	0.305
6/17 (H)	2	2.5	15.38	6.8	144.38	0.045	<0.01	1.050	0.215	0.900	0.685	0.835
6/17 (T)		4.5	21.49	7.1	121.51	0.0383	<0.01	0.867	0.266	0.740	0.474	0.599

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN/TP	Inor N/Sol P	Trans-parency S.D.	Notes
6/5 (E)	2	2		5.7			9.188	108.25	30.79	21.48		
6/5 (H)	2	2.5		6.50			0.806	8.25	27.74	22.62		
6/5 (T)		4.5		6.23			4.878	56.61	29.10	22.11	1.25	
6/17 (E)	2	2		2.35			8.294	106	21.17	54.00		
6/17 (H)	2	2.5		7.95			0.463	4.59	23.33	90.00		
6/17 (T)		4.5		5.46			4.387	55.29	22.37	74.00	1.55	

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: Dam
Watershed: Difficult Run

Project: Phase 1-Routine
Interval: July 6-July 20 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/1	P-Sol mgP/1	TN	N-NO2 + NO3 mgN/1	TIN	N-NH3 mgN/1	N-TKN mgN/1
7/6 (E)	2	2.5	23.23	6.8	75.68	0.21	0.02	1.21	0.30	0.405	0.105	0.91
7/6 (H)	2	2.0	15.9	6.75	197.3	0.09	0.025	1.675	0.205	0.720	0.515	1.47
7/6 (T)		4.5	21.43	6.775	112.27	0.157	0.022	1.416	0.258	0.545	0.287	1.21
7/20 (E)	2	2	27.13		94.48	0.025	0.02	1.125	0.325	0.72	0.395	0.80
7/20 (M)	2	.75	21.7		90	0.04	<0.01	1.210	0.335	0.755	0.42	0.875
7/20 (H)	2	1.75	15.12		216.55	0.085	0.03	2.300	0.300	1.295	0.995	2.00
7/20 (T)		4.5	21.89		136.73	0.051	0.022	1.596	0.317	0.95	0.633	1.279

Sample Date	Repl. No.	Depth m	Solids Tot mg/1	Solids Sus mg/1	Solids* Dis mg/1	Alkal mg/1 CaCO3	Diss Oxyg mg/1	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency S.D.	Notes
7/6 (E)	2	2.5		16.9			5.22	63.03	5.76	20.03		
7/6 (H)	2	2.0		36.4			0.25	2.183	18.61	28.8		
7/6 (T)		4.5		25.57			3.05	36.54	11.47	23.93	.50	
7/20 (E)	2	2		3.75			8.75	110.45	45	36.00		
7/20 (M)	2	.75		6.55			0.85	9.9	30.25	75.50		
7/20 (H)	2	1.75		13.95			0.183	1.88	27.06	43.167		
7/20 (T)		4.5		8.18			4.102	51.47	31.29	43.181	1.45	

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Lake Fairfax
Station: Dam
Watershed: Difficult Run

Project: Phase 1-Routine
Interval: August 4-19 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. ^oC	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
8/4 (E)	2	2	25.45	7.1	94.7	0.13	0.065	1.055	0.23	0.395	0.165	0.825
8/4 (H)	2	3	16.32	6.77	154.7	0.095	0.01	2.96	0.225	2.580	2.355	2.735
8/4 (T)		5	19.97	6.902	130.7	0.109	0.032	2.198	0.227	1.706	1.479	1.971
8/19 (E)	2	2.5	23.76	6.83	80	.063	0.013	1.26	0.360	0.483	0.123	0.900
8/19 (H)	2	2.5	18.01	6.543	234.6	.083	0.0167	2.783	0.233	1.663	1.43	2.55
8/19 (T)		5.0	20.89	6.687	157.3	.073	0.0149	2.022	0.297	1.074	0.777	1.725

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN/TP	Inor N/Sol P	Trans-parency S.D.	Notes
8/4 (E)	2	2		3.9			7.438	92.7	8.12	6.077		
8/4 (H)	2	3		16.65			0.176	1.87	31.16	251.0		
8/4 (T)		5		11.55			3.081	38.202	20.165	53.313	1.35	
8/19 (E)	2	2.5		11.57		27	5.99	72.45	20.0	37.15		
8/19 (H)	2	2.5		33.13		57	0.124	1.39	33.53	99.58		
8/19 (T)		5.0		22.35		42	3.057	36.92	27.70	72.08	0.65	

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Anne Run
Station: Inflow
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: June-August 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
6/5	1	Surface	20.2	7.0	106	0.058	0.048		0.49		0.04	0.60
6/17	1	Surface	24.	7.1	110	0.03	<0.01		0.37		0.15	0.23
7/6	1	Surface	25.3	6.9	98	0.05	<0.01		0.36		0.04	0.80
7/20	1	Surface		7.2	96.6	0.02	<0.01		0.65		0.51	1.25
8/4	1	Surface		7.11	93.9	0.06	0.02		2.40		0.55	0.65
8/19		Surface	19.0	6.93	82	0.02	<0.01		0.89		0.05	0.70

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	$\frac{\text{TN}}{\text{TP}}$	$\frac{\text{Inor N}}{\text{Sol P}}$	Trans-parency	Discharge L/S
6/5	1	Surface		2.4								34.58
6/17	1	Surface		3.2								18.13
7/6	1	Surface		11.1								48.90
7/20	1	Surface		2.5								14.9
8/4	1	Surface		15.8								78.5
8/19		Surface		17.6								10.67

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run
Station: Inflow
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: June-August 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
6/5	1	Surface	20.2		97.	0.056	0.036		0.62		0.08	0.74
6/17	1	Surface	26.	7.1	99.	0.04	<0.01		0.64		0.31	0.38
7/6	1	Surface	25.3	6.85	93.	0.04	0.03		0.62		0.05	0.58
7/20						.066	.018		.810		.460	1.071
8/4	1	Surface		7.2	93.	0.04	<0.01		0.55		0.12	0.40
8/19	1	Surface	18.0	6.61	90. Use south data	.02 .01	<.01 .02		.97		.04	.90

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN/TP	Inor N/Sol P	Trans-parency	Discharge l/s
6/5	1	Surface		5.7								73.15
6/17	1	Surface		13.5								52.3
7/6	1	Surface		10.8								88.5
7/20												85.0 63. 13+48
8/4	1	Surface		4.5								98.62
8/19	1	Surface		3.2								29.34

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run
Station: South
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: June-August 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. °C	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
6/5	1	Surface	19.1	7.1	87	0.098	0.058		1.08		0.07	0.65
6/17	1	Surface	24.5	7.2	92	0.05	0.02		0.78		0.42	0.48
7/6	1	Surface	25.3	6.88	90	0.31	0.02		0.92		0.11	0.56
7/20	1	Surface		6.8	112.5	0.08	0.02		1.32		0.32	0.50
8/4	1	Surface		7.25	91.6	0.03	<0.01		1.15		0.09	<0.25
8/19		Surface	17.	7.00		.02	<0.01		1.33		.02	.60

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Discharge l/s
6/5	1	Surface		7.2								38.57
6/17	1	Surface		7.9								34.17
7/6	1	Surface		10.4								39.6
7/20	1	Surface		11.0								48.0
8/4	1	Surface		<1.								20.12
8/19	1	Surface		3.6								18.67

DATA SUMMARY

NUSAC, Incorporated
Lake Management

Location: Colvin Run
Station: Outflow
Watershed: Difficult Run
Project: Phase 1-Routine
Interval: June-August 1981
Other: Summer Summary

Sample Date	Repl. No.	Depth m	Temp. oC	pH Unit	Cond. µmhos /cm	P-Tot mgP/l	P-Sol mgP/l	TN	N-NO2 + NO3 mgN/l	TIN	N-NH3 mgN/l	N-TKN mgN/l
6/5	1	Surface	24.1	7.4	95	0.063	0.061		0.50		0.03	0.66
6/17	1	Surface	21.5	8.1	97	0.03	0.03		0.37		0.21	0.39
7/6	1	Surface	25.3	7.3	83	0.06	<0.01		0.41		0.08	1.03
7/20	2	Surface	8.0	7.42	93.6	0.025	0.02		0.325		0.395	0.80
8/4	1	Surface	29.0	8.1	102.6	0.03	<0.01		0.30		0.11	0.95
8/19	1	Surface	24.	7.13	101	0.03	0.02		0.46		0.08	0.85

Sample Date	Repl. No.	Depth m	Solids Tot mg/l	Solids Sus mg/l	Solids* Dis mg/l	Alkal mg/l CaCO3	Diss Oxyg mg/l	Diss Oxyg o/oSat	TN / TP	Inor N / Sol P	Trans-parency	Discharge l/s
6/5	1	Surface		2.5								86.27
6/17	1	Surface		4.3								56.48
7/6	1	Surface		15.0								103.4
7/20	2	Surface		3.75								40.0
8/4	1	Surface		14.4								29.0
8/19	1	Surface		3.2								13.19

II.10.d. Method Used for Measuring Primary Productivity

1. The Light-Photosynthesis Approach.

Primary productivity was determined using a modification of the calculation model proposed by Jones (1980) for epiphytic algae. Composite samples from the mixed layer were incubated with carbon 14 as bicarbonate in the lab under conditions simulating those found in the lake. Two light levels were used; one at low light to determine the initial slope of the photosynthesis - light curve, and another at higher light to determine the photosynthetic rate at light-saturation. Knowing the relationship between light and photosynthesis and that between light and depth obtained using the light extinction coefficient and solar radiation data, primary productivity can be calculated at any point in time at any depth. For calculations, the photic zone was divided into 10 depth sections, and daylight into hourly intervals.

Photosynthesis was calculated for each of these components and summed over all depths to obtain the daily rate of primary productivity. With this approach, productivity can also be calculated under various light conditions; a real advantage when assessing the potential for light limitation of algal growth.

2. Method Specifics.

Carbon 14 incubations were for one hour under a 1000 watt Lucalox ^{R} Lamp at constant temperature. Following incubation, algae were filtered through 0.45 u cellulose acetate filters. The filters were then exposed to HCL fumes for 30 minutes to remove inorganic ^{14}C, placed in scintillation vials with 10 ml toluene-based counting cocktail, and counted for 10 minutes in a scintillation counter. Counts per minute were converted to disintegrations per minute using a channels ratio technique, and carbon uptake was calculated by standard techniques (Wetzel and Likens 1979).

II.10.e. Phytoplankton Methods

Phytoplankton were enumerated using a modification of the Utermohl technique (Lund, et. al. 1958). In this technique, the algae in an intact water sample are preserved with acid Lugol's iodine and allowed to settle overnight onto a cover slip mounted on the bottom of a specially prepared plexiglass slide. Phytoplankton are then counted with an inverted microscope. Two slides were counted for each monthly or bimonthly sample, and one transect was counted per slide. A minimum of seventy-five organisms were enumerated on each transect. Identification was to at least genus level, except for one rather insignificant group of green flagellates. Prescott (1964) was used as the definitive work for most algae; Hustedt (1930) was the authority for diatoms and Bourrelly (1966) for desmids.

The volume for each species was determined by representing each species as a standard solid figure (e.g., cube, sphere, cylinder, etc.) and measuring the appropriate dimensions. Total wet weight was found by multiplying volume per cell by total cell number for each sample.

Chlorophyll '*a*' was determined on freshly collected samples using the method described in Vollenweider (1968) for determining chlorophyll '*a*' in the presence of pheopigments.

II.10.f. Method Used for Algal Assays for Nutrient Limitation and Heavy Metal Inhibition

Algal assays using the green alga Selenastrum capricornutum followed standard EPA procedures (Miller et. al. 1978) for assessment of nutrient limitation and heavy metal inhibition. Epilimnetic composites were autoclaved at 121°C under pressure for 30 minutes, then filtered through acid-rinsed glass fiber filters (Whatmas 984AH). Duplicate 125 ml flasks of eight treatments were constructed along a 2^3 factoral design with presence or absence of P, N, and EDTA spikes at standard concentrations (Miller et. al. 1978) constituting the factors.

Flasks were inoculated wth about 2000 cells/ml from a 7-14 day S. capricornutum culture. Incubation was at 4300 ± 10% lumens at 24 ± 1°C for two weeks. Algal yield was determined by duplicate cell counts from each of the two flasks. Yield as cell counts was converted to yield as dry weight by a regression equation determined in preliminary experiments in 500 ml flasks. Experimental results were subjected to analysis of variance for determination of mean squares and F values for each treatment and interaction.

Appendix III.1.

1. An October 13,1981 final engineering report on the feasibility of various alternative restoration techniques.
2. A July 2, 1981 preliminary engineering report on the feasibility of alternatives for lake restoration.
3. Correspondance and engineering analyses regarding the Dunkers Stormwater Treatment System.

Boyle Engineering Corporation

October 13, 1981

Dr. Garth W. Redfield
NUSAC, INC.
7926 Jones Branch Drive
McLean, Virginia 22102

Reference: Feasibility Studies for Fairfax County Park Authority Lakes

Attached are drafts of the revised studies for Lake Accotink and Lake Fairfax. We have incorporated most of your comments in the text and will address in this letter your verbal comments.

It is our conclusion that the most effective solution to the problem of restoration of the lakes will be to deepen the lakes by dredging and to construct areas for spoil disposal within the lakes. By-passing flows or construction detention basins upstream of the lakes would improve water quality in the future; however, the costs to implement these solutions to improve water quality appear to be excessive.

The estimates contained in the report are preliminary and should only be used for the purpose for which they were developed, to evaluate the relative rankings of potential alternatives. You will note that some of the estimates are substantially greater than in the first draft you reviewed because we have developed more detailed earthwork calculations, and evaluated in greater detail, the methods to construct the different structures required.

We have not done a detailed costing, other alternatives for bypassing flows. The 96-inch pipe, flowing at a relative high velocity of 5 fps would only carry 250 cfs. Comparing this to the 10-year storm flow of about 9,200 cfs, indicates very little effect for the pipe. Scaling down which is not a truly valid basis in hydrological studies, we can say that flows in excess of 1,000 cfs are likely at least once a year. The force required to move silt is proportional to depth in wide channels; depth generally increases approximately linearly with flow increases unless a stream bank is overtopped and the flow spreads into a flood plain. Therefore, the silt loads associated with larger flows are probably quite significant relative to the total volume of silt entering the lake each year. Thus, we think that the inlet is probably stable for most flows but exceptional silt loads would enter the lake with exceptional flows and any pipe (whether plastic or concrete) would not prove cost effective in excluding silt. We have discussed in the report, a cross-lake channel; although it doesn't appear to be extremely expensive, its successful implementation depends greatly on soil characteristics that we don't know at this time.

Multiple basins, small or large, were not considered further based on their excessive costs, the problems (besides cost) with land acquisition, and maintenance. The cost for a single basin was substantially increased because when this specific watershed is considered, it becomes evident that to create the basin, a second dam would be required. It would not be possible to develop the required storage volume without additional land acquisition; the pool developed would be deeper than 10 feet and might inundate property not owned by the Park district.

Chemical treatment was discussed briefly in terms of cost and practicality; it would seem to us that the Park Authority would consider it as a cost burden and not helping solve the shallow-depth problem. With the widely varying and unpredictable flows, we doubt that anyone would predict the level of improvement from chemical additions in terms of reducing the size of a detention basin or a percentage reduction in deleterious water quality parameters.

Please review this draft and give us your comments.

Very truly yours,

M. Barry Woods

M. Barry Woods, P.E.
Project Manager

MBW/jr

Engineering Feasibility and Preliminary Cost Estimates for Clean Lakes Study

Lake Fairfax

Introduction

NUSAC, Inc. has retained Boyle Engineering Corporation to assist in preparation of a report to the Fairfax County Park Authority regarding Lakes Accotink and Fairfax.

Boyle is to provide engineering advice regarding two basic questions: 1) what to do with sediment already in the Lakes, and 2) what could be done to exclude or minimize future sedimentation of the Lakes. Included in the Boyle assignment is the preparation of preliminary cost estimates and related aspects of implementing the different alternatives. The estimates are based on standard estimating prices, consultation with dredge manufacturers and dredging contractors, and review of actual contract amounts for similar kinds of work. The estimates should be used only to compare the relative costs of alternatives. Funding-level estimates could only be prepared after specific soils borings, and engineering designs for a selected alternative.

Alternatives for disposal of existing sediment are discussed in the Restoration section of this report. Alternatives for exclusion or minimization of further sediment in the Lake are discussed in the Protection Against Further Degradation section. Costs, assumptions, and technical considerations are presented for each of the alternative discussions and with costs summarized in two tables. Figures are included to show areas or alignments discussed in the alternatives.

o Restoration

Restoration of urban lakes often involves extensive removal of sediment from the lake bottom. The sediment can be removed by either dredging (removal while the lake is full of water) or by excavation (removal after the lake is drained). Sediment removal is a necessary portion of the overall restoration program for Lake Fairfax. Preliminary estimates by NUSAC, Inc. indicate that to significantly increase the depth of Lake Fairfax, a minimum of 26,200 cubic yards of sediment should be removed. The existing lake could be dredged to a greater or lesser extent depending on the costs to remove the material. Because the costs for hauling the material are high, costs have also been prepared for filling a portion of the lake deepening the remaining area but reducing the total surface area of the lake. The dredged area will probably refill with additional sediment unless either the sediment-laden waters are diverted around or through the lake or the sediment is excluded upstream.

Four factors must be considered in evaluating sediment removal alternatives: the removal method, the location of a spoil dewatering site, the dewatering method, and the ultimate disposal of the dewatered spoil.

o Sediment Removal Alternatives

A hydraulic dredge removes sediment from the lake bottom with a rotating cutter head and pumps the sediment as a slurry to a site on the shore. Conventional hydraulic dredges pump a slurry of about 10 to 15 percent solids.

Specialized hydraulic dredges small enough to maneuver in small lakes have been developed and are appropriate for use in Lake Fairfax. A deflector shield has been designed for the cutter head on these dredges so that the solids concentration ranges from 20 to 25 percent solids and the resuspension of sediment in the lake water is minimized.

Sediment can be dredged by a crane-mounted clam shell or dragline with the sediment pumped to land as a slurry. Production rates are slow compared to hydraulic dredging which make these methods more costly than hydraulic dredging.

The drain and excavate method has certain advantages that make it attractive from a construction standpoint; however, there are also significant disadvantages. The sediment removed would be much easier to handle because it will already be dewatered. The construction costs directly related to sediment removal will be the costs for excavation and hauling to the ultimate disposal site(s). Costs would be incurred for the construction of haul roads necessary for access to the lake and excavation sites.

If the lake were drained and given the opportunity for the bottom sediments to dewater and consolidate, the use of excavation equipment would become possible; however, the time to achieve consolidation could be from several months to several years. The disadvantages of this alternative are that the lake would be out of use for an extended period of time and the uncertainty regarding the length of time required to dewater the lake to a state dry enough to support construction equipment. For these reasons, we do not consider this a viable alternative.

o Spoil Dewatering Site

A dewatering basin is necessary with either method of dredging so that the spoil can be concentrated; under optimum conditions, the dewatering site becomes the ultimate disposal site. The dewatering basins can either be dug on shore or created in the lake by diking. In the case of Lake Fairfax, substantial tree cutting and/or spoil pumping would be required to create basins on shore. Not only would this increase costs, it would destroy a number of trees. For these reasons, it was assumed that basins would be built in the lake. If the dewatering requires re-excavating the consolidated sediments for haul to another disposal site, the costs of hydraulic dredging increase substantially. Dewatering can be the controlling time factor required to complete the dredging.

o Spoil Dewatering Methods

The spoil slurry can be consolidated by two methods depending on the location of the spoil dewatering basins. If the basins are located on ground higher than the Lake, a drain in the bottom of the basin can be created flowing filtered water back to the lake. If basins are created in the Lake by excavating and diking or diking alone, the materials below the lake level will be saturated but will not drain well. Therefore, for basins in the lake, our estimates assume construction of an impervious clay dike. The slurry would then be allowed to settle and the clarified surface waters decanted with a pump back to the Lake. A minimum of two basins are required to allow settling for at least one day in one basin while maintaining continuous dredging operation.

o Spoil Disposal

The spoil material is not expected to be suitable as a construction material because of the anticipated uniform gradation. As the water-borne sediments enter the lake, the heavier particles drop first and the smaller particles are carried further into the lake. Thus, discrete areas of coarse granular material occur in the upstream portions of the lake, and silt and clays predominate in the downstream portions.

The only practical uses for the spoil appear to be as topsoil or soil amendment, or as cover material at a landfill. Potential users would have to be identified and the quantities required by those users would have to be known. If a market of users does not exist, the spoil could be disposed at the lake sites.

o Cost Estimates for Restoration Alternatives

The preceding discussions describe the components of restoration alternatives. Some of the alternatives have been eliminated based on practical, environmental, technical or cost bases. However, for completeness and to verify the costs we have prepared estimates for some alternatives that we have dismissed. The following is a brief discussion of each alterantive costed and the cost bases. Where unit operations are repeated, the cost bases are as the first time described, i.e. mobilization and demobilization of hydraulic dredge for a contractor is $25,000.

Alternative 1 - Although not considered practical because to attain stability of the Lake bottom, this alternative was costed as though the bottom was stable. Costs were prepared for hauling material or disposing in place. Mobilization and demobilization costs were assumed as $1,100. Sediment excavation was estimated at $6.00/cu. yd. Hauling excavated sediment was estimated at $7.13/cu. yd. The construction of access roads was estimated at $2.75/sq. yd. of road surface for 2 miles of road, 10-feet wide. For disposal in-place construction of a berm to contain the excavated material was assumed necesary. The cost to create the berm was based on $6.00/cu. yd., 2:1 side slopes, and a 8-ft. top width on the berm.

The rounded costs for three amounts of sediment excavation are as follows:

Sediment excavated and hauled - $380,000

Sediment excavated and disposed in-place - $210,000

Alternative 2 - This alternative assumed dredging using a barge-mounted dragline. The cost of excavation using a dragline is assumed at $7.00/cu. yd. The contractor would have to construct temporary dewatering basins to consolidate the dredged material. The optimum use of a dragline requires that it can cast to its interim or ultimate disposal point.

The cost for mobilization/demobilization for this alternative is assumed as $25,000.

Again two methods of spoil disposal were considered.

Sediment dredged and hauled - $415,000

Sediment dredged and disposed in-place - $230,000

Alternative 3 - This alternative assumes the County contracts for the dredging work, and a contractor uses a hydraulic dredge. Again as in Alterantive 2, before hauling, the contractor is assumed to have to construct dewatering basins for the spoil before it is hauled. The costs for mobilization/demobilization for this operation is included at $25,000. The estimated costs are as follows:

Sediment dredged and hauled - $375,000

Sediment dredged and disposed in-place - $190,000

The preceding costs are summarized in Table 1. The tabulation shows the resulting unit cost per cubic yard of excavation. The disposal area selected is shown on Figure 1.

Alternatives 4 and 5 have been developed with the idea that, if the Park Authority chooses to purchase a hydraulic dredge, the dredge will be utilized to restore both Lake Fairfax and Lake Accotink. Therefore, the purchase price of a dredge has not been included in the cost estimates for these two alternatives. Table 2 is a summary of the costs for dredging Lake Accotink and Lake Fairfax with a Park Authority purchased dredge. This table shows the cost for the dredge included in the Lake Accotink figures.

Alternative 4 - This alternative assumes that the Park Authority purchase a hydraulic dredge and perform the work with Park Authority employees. In alternative 4, it is assumed that the Authority keeps the dredge. The cost for mobilization and demobilization of the County-owned dredge is assumed as $10,000. The estimated costs are:

Sediment dredged and hauled -	$360,000
Dredge purchase price -	180,000
Total	$540,000

Sediment dredged and disposed in-place -	$173,000
Dredge purchase price -	180,000
Total	$353,000

Alternative 5 - This alternative is based on the assumption that the Authority sells the dredge for 50 percent of the purchase cost after dredging Lake Fairfax. The costs are:

Sediment dredged and hauled -	$360,000
Dredge purchase price -	180,000
Dredge salvage value -	-90,000
Total	$450,000

Sediment dredged and disposed in-place -	$173,000
Dredge purchase price -	180,000
Dredge salvage value -	-90,000
Total	$263,000

o Environmental Effects

Return of decant water could create potential water quality problems because the bottom sediments will be rich in nutrients, heavy metals and pesticides. These compounds may be redissolved in the decant water. One reason for dredging is to remove these compounds that are trapped in the benthic deposits and are recycled in the limnological system at various seasons of the year. The decanted water can contain concentrations of these compounds which may be unacceptable, in which case chemical treatment would be appropriate before the decanted water is allowed to return to the lake. The spoil would contain clays and silts which adsorb heavy metals and pesticides. However, the concentration of heavy metals would not be sufficient to retard plant growth in areas used for disposal. Phosphorus can be removed by addition of chemical coagulants; however, nitrogen compounds require biological treatment or ion-exchange, both of which are prohibitively expensive. The decanted water could be pumped downstream of the lake as an alternative to allowing it to flow back into the lake.

The fluidization of the bottom sediment with a cutter head causes material to be dispersed throughout the lake water. The environmental impact of this fine material being suspended in the water of a clean lake can be a significant shock to the lake's ecosystem by reducing light penetration (necessary for plant life) and increasing nutrient, heavy metal and refractory organic compound concentrations. However, in the case of Lake Fairfax, the water is already turbid. Therefore, the additional temporary turbidity caused by dredging would have a short-term environmental impact.

The water quality of Lake Fairfax is an important consideration in an overall restoration program. Because of the characteristic of lakes to become layered as a result of heating and cooling from the surface (thermal stratification), the bottom layer (hypolimnion) tends to have little or no dissolved oxygen. This phenomenon also causes the unwanted chemical compounds to be trapped in the lake.

Lake Fairfax is a man-made lake with an impoundment structure that has two means of withdrawing water. The purpose of withdrawing water is to control the level of the lake and to pass through excess stormwater. One means of withdrawal is an overflow concrete spillway and the other is a drop inlet structure, both of which remove water from the lake surface.

The two structures have been designed to pass the average daily inflow into Lake Fairfax during dry weather conditions and during storm events. If the dry weather inflow could be removed from the bottom layer of the lake, many of the unwanted compounds would be passed through the lake instead of being trapped. Bottom withdrawal would also encourage a breakdown of the thermal stratification and would tend to increase the dissolved oxygen concentration in the lower depths of Lake Fairfax.

Consideration has been given to the installation of a siphon device which would pass lake bottom water over the existing concrete spillway. A siphon device could possibly siphon Lake Fairfax dry if not carefully controlled. As an alternative to a siphon, the drop inlet could used to draw water from the bottom of Lake Fairfax. The existing drop inlet has already been scheduled for replacement by the Park Authority, and the addition of a simple control mechanism and an electric operator on the new valve would accomplish the purposes desired. It is recommended, however, that daily inspection to be a scheduled maintenance task to insure that the lake does not drain because of a valve or operator failure. A system of this type would be easier to construct and control and would be more aesthetically acceptable than a siphon device. The cost for modification of the replacement valve would not exceed $10,000 more than the cost of the planned replacement.

- Protection From Further Degradation

Once a lake has been dredged and an acceptable depth has been achieved, methods to reduce or eliminate the rate of further sedimentation and water quality degradation can be considered. If the dredged material were deposited in the flood plain upstream of the lake, the spoil area(s) would need to be protected to prevent flood waters from transporting this material back into the lake.

Several structural methods can be used to protect the lake from further degradation. Alternative protections include one or more stormwater detention basins constructed on major streams entering the lake or throughout the watershed, a stormwater detention basin with a bypass spillway circumventing the lake, or just the by-pass channel to flow sediment-laden waters through the lake. Theoretically, any solution involving an upstream basin can be designed as multi-purpose structure to reduce sedimentation and to improve water quality.

Capital cost of structures is an important factor; however, operating and maintenance (O & M) costs can also be significant. These O & M costs will include additional dredging or excavation of sediment from the detention basins and periodic outlet structure cleaning.

Stormwater detention basins reduce the peak flow rates from runoff from a design frequency storm. While there will be sediment removed in a detention basin, sediment removal is not a primary parameter in the design of these basins. Detention basins generally remove large size particles but the smaller clay and silt particles are passed through the basin.

In an urbanized watershed, erosion is not as significant a factor in runoff as is water quality. Urban runoff water quality is usually characterized by high concentrations of phosphorus, lead, nitrogen and compounds exerting biochemical oxygen demand. These compounds are usually adsorbed to silt and clay particles which are the most difficult size of particles to remove by settling. These compounds are also generally associated with the "first flush" phenomenon of storm events. The first runoff generated by a storm contains the highest concentration of these compounds and as the storm progresses, the concentrations decrease as the runoff flow subsides. The smaller, more frequent storms tend to transport the majority of these compounds.

In the design of a detention basin to limit the impact of sedimentation on a lake, the basin can be designed to serve as a water quality control device since the majority of compounds of interest are absorbed to the smaller sediment particles. The Regional Resources Division of the Northern Virginia Planning District Commission in a 1979 report concluded that a detention basin providing a 24-hour detention time for the runoff from a 2-year storm will remove more than 90 percent of the objectionable compounds in the runoff water.

Two alternative construction strategies for detention basin construction are possible; building one large basin on the major tributary flowing into the lake or building numerous smaller basins throughout the watershed. Initial cost is the primary concern; however, maintenance costs and accessibility to the detention sites are also important. It is less costly to remove sediment from one site than from several sites. In addition, one large detention basin will receive sediment from the entire watershed, but several smaller basins protect the lake only from the watershed of the tributaries to the major stream.

The construction of one or several detention basins upstream of the lake would eventually create additional material to be removed from a less accessible location than the present lake. The cost benefit to other basins is that the excavation could probably be worked in the dry at less cost than dredging. However, if extensive earthwork was required to create the detention basin, the total cost for the alternative might not show a significant cost advantage.

However, to satisfy the criteria of holding 2-year storm flow for 24 hours would require a basin with a volume of from 220 to 400 acre-feet (or about 1 to 2 times greater than the volume of Lake Fairfax, 230 acre-feet). Clearly, if such a basin could be developed it would be of greater value than Lake Fairfax. It would be most readily achieved by constructing a second dam upstream of the Lake, with a capacity to pass all stormwater flows. However, that impoundment could remain a lake only if it is possible to maintain active storage capacity of 400 acre-feet above a nominal depth.

There are several disadvantages to building a detention basin with 400 acre-feet capacity upstream of Lake Fairfax. The Park Authority would have to acquire more land because the detention will flood property that is privately owned. Secondly, the area to be flooded contains an existing sanitary sewer line which would either require relocation or rebuilding using ductile iron pipe and waterproof manholes. The cost of building an impoundment of this size is about $350,000 not including land costs or sanitary sewer relocation.

The construction of detention basins aggravates the Park Authority problems with sediment removal and does little to solve their basic problem of inadequate depth in Lake Fairfax. This can only be resolved by some form of dredging or raising the existing dam. This latter alternative is beyond the scope of this study.

Another approach to water quality control is by chemical treatment to improve settling. Chemicals could be added to the lake to precipitate the sediment. The cost of the feeding equipment assuming flow-paced feed would be approximately $20,000. The chemical costs would be difficult to estimate based on the variability of the inflows and the design basis for feeding. However, to put chemical treatment in perspective, we estimated an alum requirement to treat the base flow ($87X10^{6}$ cu. ft.) which is about 1/8 of the average annual rainfall or 1/4 of the runoff, assuming 50 percent of the rain runs off. Assuming a dosage of 50 mg/l of alum, would require $41,000/year just for chemical alone, exclusive of any labor, structures, mixers, storage or appurtenances. Further, the addition of chemicals would aggravate the sediment dewatering problem by 1) increasing the time to dewater the sediment and 2) increasing the volume of sludge or sediment to be stored. Thus chemical treatment was dropped from consideration.

Another means of protecting the lakes is to provide a stormwater detention basin with a diversion channel or pipe that circumvents the lake. This would prevent stormwater runoff from causing siltation problems in the lake and alleviate some of the water quality problems associated with the sediments. This method has the potential of being the most effective means of protecting the lakes; however, the costs are prohibitively expensive. The primary cost elements consist of the detention basin required to provide storage, the bypass spillway and maintenance of the structure (i.e., cleaning the spillway and removal of the sediment in the detention basin).

A concrete pipe bypass would be constructed in addition to the stormwater detention basin. The determination of an accurately sized by-pass pipe would require development of an inflow hydrograph and a flood routing analysis. This level of effort is beyond the scope of this work. However, for estimating purposes a length of 2,000 feet of 60-inch pipe has been used. The estimated cost of this pipe based on $135/ft. is $236,000.

Cost estimates assume 1981 dollars and the time value of money has been neglected. The consideration of the time value of money will not affect the relative costs of the alternatives; however, it should be recognized that the small hydraulic dredge O & M costs, excavation costs, and any other costs incurred over a long period of time (greater than one year) will be increased due to the time value of money.

Table I

COST DATA - RESTORATION LAKE FAIRFAX

Volume of sediment to be removed - 26,200 cubic yards.

Alternatives	Sediment Disposal	Total $	$/cu.yd.
1. Drain & excavate	Hauled	$380,000	14.43
	On-site	$210,000	8.03
2. Dragline	Hauled	$415,000	15.82
	On-site	$230,000	8.69
3. Contractor Dredge	Hauled	$375,000	14.32
	On-site	$190,000	7.19

COST DATA

Alternatives	Sediment Disposal	$\frac{\text{Lake Fairfax}}{\text{Lake Accotink}}$	Total cu.yd.	Lake Fairfax	Lake Accotink	Total $	Total $/cu.yd.
4. County buys and keeps dredge*	Hauled	$\frac{26,200}{100,000}$	126,200	360,100	1,550,000	1,910,100	15.14
		$\frac{26,200}{131,000}$	157,200	360,100	1,965,000	2,325,100	14.79
		$\frac{26,200}{200,000}$	226,200	360,100	2,923,000	3,283,100	14.51
	On-site	$\frac{26,200}{100,000}$	126,200	173,300	837,000	1,010,300	8.01
		$\frac{26,200}{131,000}$	157,200	173,300	1,031,000	1,204,300	7.66
		$\frac{26,200}{200,000}$	226,200	173,300	1,497,000	1,670,300	7.38
5. County buys and sells dredge*	Hauled	$\frac{26,200}{100,000}$	126,200	360,100	1,460,000	1,820,100	14.42
		$\frac{26,200}{131,000}$	157,200	360,100	1,875,000	2,235,100	14.22
		$\frac{26,200}{200,000}$	226,200	360,100	2,833,000	3,193,100	14.15
	On-site	$\frac{26,200}{100,000}$	126,200	173,300	747,000	920,300	7.29
		$\frac{26,200}{131,000}$	157,200	173,300	941,000	1,114,300	7.09
		$\frac{26,200}{200,000}$	226,200	173,300	1,407,000	1,580,300	6.99

* Costs for purchasing and selling dredge are included in Lake Accotink costs.

Figure 1

Boyle Engineering Corporation

Garth Redfield, Ph.D.
NUSAC, INC.
7926 Jones Branch Drive
McLean, Virginia 22102

July 2, 1981

Reference: Clean Lakes Study, Lake Fairfax and Lake Accotink

Dear Dr. Redfield:

Attached is a summary report of the results of Boyle's work to date on the engineering feasibility and cost estimates for alternative methods of lake restoration and protection. We have taken care to write the report in a format that can be adapted to the final Clean Lakes Study document with a minimum of editing.

Also attached is a memorandum describing an actual hydraulic dredging operation that has been recently completed for the Fairfax County Department of Public Works at Lake Royal.

We will await your review comments concerning our report before expending anymore time on this project. I am looking forward to hearing from you.

Very truly yours,

M. Barry Woods

M. Barry Woods, P.E.
Associate Engineer

MBW/jr

Attachments

Engineering Feasibility and Preliminary Cost Estimates for Clean Lakes Study

Lake Accotink and Lake Fairfax

Introduction

This is a report of the results to date of a study of the advantages, disadvantages, and preliminary costs for various restoration and degradation prevention alternatives for Lake Accotink and Lake Fairfax. This study is an effort to identify those alternatives that appear to be viable from a practical standpoint and to provide preliminary cost estimates for these alternatives.

The report is divided into three major sections; Methods of Restoration, Protection From Further Degradation, and Cost Data. The Restoration Section and the Protection Section identify the most promising approaches; however, it is recognized that limited funding may preclude implementation of a full restoration and protection program.

Methods of Lake Restoration

Restoration of urban lakes often involves extensive removal of sediment from the lake basin. The sediment can be removed by either dredging (removal while the lake is full of water) or by excavation (removal while the lake is drained). Sediment removal is a necessary portion of the overall restoration program for both Lake Accotink and Lake Fairfax. Preliminary estimates by NUSAC, Inc. indicate that Lake Accotink will require the removal of a minimum of 131,000 cubic yards of sediment, particularly in the upstream half of the lake, and Lake Fairfax will require the removal of a minimum of 26,200 cubic yards of sediment.

Sediment removal requires selection of an economical method, location of a dewatering site for the spoil, consideration of dewatering methods and the anticipated ultimate disposal of the dewatered spoil. The solutions to these problems depend primarily upon cost considerations.

o Sediment Removal Alternatives

There are basically two types of dredging; hydraulic dredging where the sediments are fluidized and pumped or by digging using either a clam shell or dragline. Another means of removing the sediment would be to drain the lake and excavate the unwanted sediment and allow the lake to refill.

The drain and excavate method has certain advantages that make it attractive from a construction standpoint; however, there are also significant disadvantages. The sediment removed would be much easier to handle because it will already be dewatered. The only construction costs directly related to sediment removal will be the actual earthwork costs and hauling costs to the ultimate disposal site. Additional costs would be incurred for seeding or other ground cover for the exposed lake bottom and for the construction of haul roads necessary for access to the lakes.

In a 1967 study of dredging Lake Accotink, Whitman, Requardt and Associates indicated that the bottom sediment would not support construction equipment even in a drained state. If the lake were drained and given the opportunity for the bottom sediments to dewater and consolidate the use of excavation equipment would become feasible.

The length of time for adequate dewatering to occur could take from several months up to 3 years. The obvious disadvantage is that the lake would be out of use for an extended period of time. The length of time required to dewater the lakes to a state dry enough to support construction equipment and the high costs involved preclude further consideration of this alternative.

Dragline or clam shell dredging removes sediments at solids concentration close to the in-situ density. Production rates are slow compared to hydraulic dredging which make these methods more costly than hydraulic dredging. The sediment is pumped as a slurry to the dewatering site; however, land requirements for dewatering are less than that for hydraulic dredging because the dredged material is at a higher solids concentration than that removed by hydraulic dredging.

Hydraulic dredging is a process by which the sediment is removed from the lake bottom by loosening with a cutter head and pumping the sediment as a slurry from the bottom of the lake to a site on the shore. Conventional hydraulic dredges pump a slurry of about 10 - 15 percent solids.

Thus, a dewatering site is necessary so that the spoil can be concentrated which under optimum conditions becomes the ultimate disposal site. This process requires considerable land area. Dewatering can be the controlling factor in the length of time required to complete the dredging. If the dewatering basins are re-excavated for haul to another site for disposal, the costs of hydraulic dredging increase substantially.

Specialized hydraulic dredges small enough to maneuver in small lakes have been developed and are appropriate for use in Lakes Accotink and Fairfax. A deflector shield has been designed for the cutter head on these dredges so that the solids concentration ranges from 20 to 25 percent solids and the suspension of sediment in the lake water is minimized.

o Implementation of Restoration

If a small dredge was leased or purchased and operated by Fairfax County Park Authority personnel, the Park Authority could then lease, loan, or sell their dredge to agencies needing a dredge such as the Northern Virginia Regional Park Authority or the Fairfax County Department of Public (both agencies require dredges periodically) after completion of the dredging of Lakes Fairfax and Accotink. If the dredge purchase is funded by EPA for the restoration of Lake Fairfax and/or Lake Accotink under the Clean Lakes Program, any income or benefit derived from the use of the dredge at other lakes or sedimentation basins may be grounds for EPA to reduce their reimbursement of construction grants funds applied to the purchase price. This could be avoided by another county agency purchasing the dredge for its use and leasing it to the Park Authority for dredging Lake Accotink and Lake Fairfax at a competitive rate.

o Spoil Disposal

The spoil material is not expected to be suitable as a construction material because of the uniform gradation anticipated. As the water-borne sediments entered these lakes, the heavier particles dropped out of suspension first and the smaller particles were carried further into the lake. Thus, discrete areas of course granular material occur in the upstream portions of the lakes and clays and silt predominate the downstream portions.

The only practical uses for the spoil appear to be as topsoil or soil amendment, or as cover material at a landfill. Potential users would have to be identified and the quantities required by those users would have to be known. If a market of users does not exist, the spoil could be disposed at the lake sites. There are numerous ravines located at both lakes that have capacity adequate for disposal of the spoil if dams are constructed. Lake Accotink has an extensive area located in the flood plain above the lake which would serve as a disposal site. Lake Fairfax also has an area above the lake that could serve as a disposal site.

An important factor in the disposal of the dredged material is dewatering. Dewatering could be accomplished by constructing cells to contain the spoil. The cells could be designed to serve as decanting basins, or as solar evaporation basins depending on the acceptable time to complete the dredging. Evaporation would require much more land area for dewatering and more time than decanting. It will also be affected by climatic conditions which tend to render evaporation impractical since annual rainfall exceeds annual evaporation in the Northern Virginia area.

o Environmental Effects

Return of decant water could create potential water quality problems because the bottom sediments will be rich in nutrients, heavy metals and pesticides. These compounds may be redissolved in the decant water. One reason for dredging is to remove these compounds that are trapped in the benthic deposits and are recycled in the limnological system at various seasons of the year. The decanted water can contain concentrations of these compounds which may be unacceptable, in which case chemical treatment would be appropriate before the decanted water is allowed to return to the lake. Clays and silts adsorb heavy metals and pesticides. The spoil would contain these materials. However, the concentration of heavy metals would not be sufficient to retard plant growth in areas used for disposal. Phosphorus can be removed by addition of chemical coagulants; however, nitrogen compounds require biological treatment or ion-exchange, both of which are prohibitively expensive. The decanted water could be pumped downstream of the lake as an alternative to allowing it to flow back into the lake.

The fluidization of the bottom sediment with a cutter head causes material to be dispersed throughout the water column. The environmental impact of this fine material being suspended in the water of a clean lake can be a significant shock to the lake's ecosystem by reducing light penetration (necessary for plant life) and increasing nutrient, heavy metal and refractory organic compound concentrations. However, in the case of Lake Accotink, the water column is already highly turbid from poor water quality. Therefore, the additional temporary turbidity caused by dredging has an insignificant environmental impact in Lake Accotink.

Protection From Further Degradation

Once a lake has been dredged and an acceptable depth has been achieved, the lake should be protected to reduce the rate of further siltation and the rate of water quality degradation. If the dredged material were deposited in the flood plain upstream of the lake, as is a possibility for both Lakes Fairfax, and Accotink, the spoil area would need to be protected to prevent flood waters from transporting this material back into the lake.

Several structural methods can be used to protect the lakes from further degradation. Most of these methods can be designed as multi-purpose structures to reduce siltation and to improve water quality.

Alternative protections include a stormwater quality management detention basin constructed on major streams entering the lakes, a series of stormwater quality management detention basins constructed at several locations throughout the water shed and a stormwater detention basin with a bypass spillway circumventing the lakes.

Capital cost of structures is an important factor; however, operating and maintenance (O & M) costs can also be significant. These O & M costs will include additional dredging or excavation of sediment from the detention basins and periodic outlet structure cleaning.

Traditional stormwater management detention basins reduce the peak flow rates from runoff from a design frequency storm. While there will be sediment removed in a detention basin, sediment removal efficiency is not a primary design parameter in design of these basins. Detention basins generally remove large size particles but the smaller clay and silt particles are passed through the basin.

The watershed of Lake Accotink can be characterized as an urbanized area with almost 100 percent development. Construction activity in the watershed is expected to be insignificant in the future.

There are some conflicting reports concerning the quantity of sediment expected from the Lake Accotink watershed. Whitman Requardt & Assoc. in a 1967 report indicated that in the first 27 years of the life of Lake Accotink, 650,000 cubic yards of sediment were built up in the lake. The report estimated that from 1967 to 1977, 300,000 cubic yards of silt would be deposited in the lake at an average rate of 30,000 cubic yards per year. Assuming that the density of sediment in a lake is 60 pounds/cubic foot, this represents a sediment load of 1.2 tons/acre/year. This sediment load is typical of stablized urban land use in comparison to 50 - 60 tons per year typically for uncontrolled construction site runoff.

In a report by G. Harry Stopp in 1978, it was stated that the measured sediment transport of Accotink Creek above the lake was 63 tons/acre/year in 1961, 129 tons/acre/year in 1972 and 79 tons/acre/year in 1977. If the measured load for 1977 reached Lake Accotink and remained there, it would result in almost four million cubic yards of sediment in the lake. A possible explanation for the difference in these values is that the measured sediment transport is not a measure of the sediment reaching or remaining in the lake. Another explanation is that the sediment transport measurements may be based on grab samples during flood events. The results of these grab samples may also have been extrapolated using annual rainfall data to provide an indication of the sediment transport. A value of about 1 to 2 tons/acre/year (or about 1 to 2 cubic yards/acre of material) is expected based upon the history of sediment build-up in the lake.

In a watershed that is essentially 100 percent developed, siltation is not as significant a factor in runoff as water quality. Urban runoff water quality is usually characterized by high concentrations of phosphorus, lead, nitrogen and compounds exerting biochemical oxygen demand. These compounds are usually adsorbed to silt and clay particles which are the most difficult size of particles to remove by settling. These compounds are also generally associated with the "first flush" phenomenon of storm events. The first runoff generated by a storm contains the highest concentration of these compounds and as the storm progresses, the concentrations decrease as the runoff flow subsides. The smaller, more frequent storms tend to transport the majority of these compounds.

In the design of a detention basin to limit the impact of sedimentation on a lake, the basin can be designed to serve as a water quality control device since the majority of compounds of interest are adsorbed to the sediments. The Regional Resources Division of the Northern Virginia Planning District Commission in 1979 concluded that a detention basin providing a 24-hour detention time for the runoff from a 2-year storm will remove more than 90 percent of the objectionable compounds in the runoff water.

Two approaches can be made to this strategy; construct one detention basin on the major tributary flowing into the lake or construct several smaller basins at various locations throughout the watershed. Several factors influence the desirability of one of these alternatives over the other. Initial cost is the primary concern; however, maintenance costs and accessibility to the sites are also improtant. It is less costly to remove sediment from one site than from several sites. In addition, one large detention basin will receive sediment from the entire watershed, but several smaller basins protect the lake only from the watershed of the tributaries to the major stream. A single basin located just upstream of either lake would be located primarily on land already owned by the Fairfax County Park Authority, but several smaller basins scattered throughout the watershed would require separate acquisitions of land.

Another approach to water quality control is by chemical treatment to improve settling. This method does not appear to be practical for a number of reasons. This approach would require a chemical feed system that would have to be accuated during a storm event, probably by level sensing and then turned off when the runoff and stream level subside. Mechanical equipment requires maintenance and chemicals increase annual operating costs. Even if chemicals are added, there is still a need for an efficient sediment trap basin which will require periodic cleaning and the addition of chemicals would increase the volume of materials to be removed.

Another means of protecting the lakes is to provide a stormwater detention basin with a diversion channel or pipe that circumvents the lake. This would prevent stormwater runoff from causing siltation problems in the lake and alleviate some of the water quality problems associated with the sediments.This method has the potential of being the most effective means of protecting the lakes; however, the costs are prohibitively expensive. The primary cost elements consist of the detention basin required to provide storage, the bypass spillway and maintenance of the structure (i.e., cleaning the spillway and removal of the sediment in the detention basin).

Cost Data

The advantages and disadvantages of the various alternatives for lake restoration and protection from further degradation have been discussed above. Cost is the most significant factor in deciding which alternative is the most desirable, particularly since funding may be limited.

This section is a summary of those costs associated with the various alternatives discussed. The previous discussion eliminated some of the alternatives because of expense; however, the cost of all approaches considered are presented below for comparison.

o Restoration Costs

o Sediment removal by excavation has several cost elements including earthwork, hauling, erosion control and construction road costs. Earthwork is estimated to cost

$4.00/cubic yard, hauling costs $2.00 per cubic yard, construction roads $2.75 per square yard of road and erosion control in the form of seeding $.45 per square yard.

For Lake Accotink:

Earthwork, 131,000 cubic yards	$ 524,000
Hauling, 131,000 cubic yards	262,000
Erosion control, 88 acres	192,000
Roads, 6 miles X 10 feet wide	97,000
Total	$ 1,075,000

For Lake Fairfax:

Earthwork, 26,200 cubic yards	$ 105,000
Hauling, 26,200 cubic yards	52,000
Erosion control, 23 acres	50,000
Roads, 2 miles X 10 feet wide	33,000
Total	$ 240,000

o Barge mounted clam shell or dragline dredging costs include mobilization/demobilization costs and dredging costs. Mobilization/demobilization is expected to cost $35,000 and dredging is expected to be $7.00 per cubic yard.

Lake Accotink:

Mobilization/demobilization	$ 35,000
Dredging, 131,000 cubic yards	917,000
Total	$ 952,000

Lake Fairfax:

Mobilization/demobilization	$ 35,000
Dredging, 26,200 cubic yards	184,000
Total	$ 219,000

o Conventional hydraulic dredging costs include the same elements as dragline except the dredging unit cost is about $5.00 per cubic yard.

Lake Accotink:

Mobilization/demobilization	$ 35,000
Dredging, 131,000 cubic yards	655,000
Total	$ 690,000

Lake Fairfax:

Mobilization/demobilization	$ 35,000
Dredging, 26,200 cubic yards	131,000
Total	$ 166,000

o Dewatering costs estimates are extremely speculative at this time. The costs depend a great deal upon the method of dredging utilized and the length of time in which to complete the project. Assuming that 8,000 cubic yards of material can be dewatered per acre of land area with a six-foot dike wall that has a top width of two feet and side slopes of 3:2, approximately 11,500 cubic yards of earthwork would be required for Lake Accotink and 5,250 cubic yards for Lake Fairfax. Including a contingency of 25 percent, the dewatering costs would be as follows:

Lake Accotink:

Earthwork	$ 46,000
25 percent contingency	12,000
Total	$ 58,000

Lake Fairfax:

Earthwork	$ 21,000
25 percent contingency	5,000
Total	$ 26,000

o Operation of a County owned/leased small hydraulic dredge consists of two components, the purchase or lease price and the operation and maintenance costs. The purchase price including taxes and transportation of a representative small dredge is $180,000. Since the lease of the same dredge and equipment is $135,000 per year and the estimated earliest finish of dredging Lake Accotink is 2 1/2 years, purchase costs will be the only alternative discussed in this section. Since the purchase of a dredge would be used for dredging both lakes, the cost of the dredge is combined with the estimated operation and maintenance costs for both lakes.

Lake Accotink and Lake Fairfax:

Purchase price	$ 180,000
Lake Accotink O & M	72,000
Lake Fairfax O & M	17,000
Total	$ 269,000

o Prevention Costs

Although prevention of further degradation is essential to keeping the lakes in an acceptable condition, the costs are much greater than the restoration costs.

o Cost estimates for construction of detention basins have been based upon a 1977 cost study formula done in Montgomery County, Maryland and escalated to 1981 dollars based in the <u>Engineering News Record</u> construction cost index. The estimating formula relates storage capacity to costs. Storage capacity was determined by expected rainfall for a 2 year 24-hour storm. Since the design criteria is to detain a 2-year storm for 24 hours, the costs would be related to the runoff component of the total volume of rainfall from a 2-year, 24-hour storm event. The costs for constuction of several small detention basins versus one large basin was evaluated for Lake Accotink. These costs do not include land acquisition.

Lake Accotink:

One large detention basin	$ 900,000
Twenty-four small basins	$3,900,000

Lake Fairfax:

One large detention basin	$ 320,000

o At the time of this study representative 100-year storm hydrographs and peak flows were not available; however, 25-year storm peak flows were available. In order to place costs for bypass spillways in perspective, the following assumptions were made: The bypass would be constructed of reinforced concrete pipe, the bypass would be in addition to the stormwater quality detention basin and the storage capacity of this basin would be enough to allow installation of a pipe that does not have to be sized to carry peak inflow of a 100-year storm. For estimating purposes 4,000 feet of 96-inch pipe has been used for Lake Accotink and 2,000 feet of 60-inch pipe has been used for Lake Fairfax.

Lake Accotink:

96-inch bypass	$ 740,000

Lake Fairfax:

60-inch bypass	$ 236,000

The previous cost estimates were based on 1981 dollars and the time value of money has been neglected. The consideration of the time value of money will not affect the relative costs of the alternatives; however, it should be recognized that the small hydraulic dredge O & M costs, excavation costs and any other costs incurred over a long period of time (greater than one year) will be increased slightly due to the time value of money.

Cost data has been based upon averages from several sources including Means Cost Data, 1981, contact with several contractors, actual contract amounts for similar kinds of work and data supplied by equipment manufacturers.

June 19, 1981

Memorandum

To: Files, VA N09 001 00

From: M. Barry Woods MBW

Subject: Urban Lake Dredging Field Visit

John Koenig of the Fairfax County Department of Public Works was contacted concerning the County's experience in dredging lakes and disposal of the spoil. He said that the County did not have any criteria for the disposal or handling dredge spoil but did have experience with the problem. Most of the County's dredging projects have been small compared to the proposed Accotink and Fairfax dredging projects. The County generally tries to identify a use for the spoil or a disposal site at the lake. If there is no acceptable site for disposal, the spoil is hauled to the County landfill. Landfilling seemed to be the most frequent solution.

When asked about the possibility of selling the spoil to homeowners as a soil amendment or topsoil or to developers as fill, John indicated that the spoil is generally not as rich in nutrients as would be expected; therefore its attractiveness as a soil amendment is not a selling point. In John's estimation, the County would consider it lucky if someone would haul the material out at their own expense rather than the more optimistic approach of selling the material. He agreed that the material generally does not have much value as a construction material, particularly if it requires any bearing capacity.

John identified two dredging contracts that the County is currently administrating; Royal Lake and Huntsman Lake. Royal Lake is being dredged of 1900 cubic yards of material at a cost of $36,800 and Huntsman Lake, 4200 cubic yards for $39,900. These costs are for just the dredging operation and does not include administrative expense, stakeout, etc. The wide variance in quantities removed at relatively similar costs would indicate that the contractor's fixed charges comprise a significant percentage of the contract. If it is assumed that the fixed charges are the same for each contract and that the operating charges per cubic yard are the same for each contract, the fixed charge is $34,239 for each project and the additional operating charges are $1.35 per cubic yard.

John indicated that the MUDCAT is an excellent alternative dredge for urban lakes but, like any other mechanical device, it has problems. He used the Royal Lake project as an example. The MUDCAT being used there is five years old and he thought that the down time was about 50% of the working day because of clogging. He said that they were probably pumping at a rate of 10 to 20% solids into the decanting basin and about 1 to 2% solids are being returned to the lake. The decanting basin has a detention time of 3 to 4 hours but there had been a problem with the basin leaking.

John suggested that I talk to the Contractor at Royal Lake to get some idea of the problems associated with operating a MUDCAT. He requested that I not offer any personal opinions to the Contractor concerning the operation because there is a dispute about part of the work.

I asked John if Public Works had plans to purchase a MUDCAT because of the economics of purchase vs. contracting. He said the Pubic Works had been considering the purchase of a MUDCAT for a number of years but the magnitude of the expenditure causes a myriad of difficult questions by County officials and the decision has not yet been made to purchase one.

I discussed the dredging of Lake Accotink with John. He was curious to know how the spoil was going to be dewatered and disposed. I told him about some of the costs for dredging that I had identified as well as the problems I foresee. I feel that after the dredging and dewatering is complete, there will be no funds to haul the spoil out of the flood plain. He agreed that the hauling costs were probably going to be greater than the Park Authority's funding capability. We discussed the impact of leaving the spoil in the flood plain which was Whitman Requardt's recommendation in a report in 1967. I conveyed my concerns about development that has occurred since 1967. John said that leaving that much material in the flood plain could affect the flood wave in such a way as to cause flooding of houses and apartments.

I made a field visit to Lake Royal in hopes of talking to the Contractor. The MUDCAT was in the lake and was operating. I talked to Martin Firth of Maine Structural Applications, Inc. He said they work 10 - 11 hours a day and of that time about 35 - 40% is down time because of clogging with debris. The clogging usually occurs on the suction side which takes about 20 - 30 minutes to correct each time. He said that the discharge line requires as much as 2 hours to clear when it becomes clogged.

Their production rate is about 150 cubic yards a day. He said that the slurry is about 10% solids and most of that returns to the lake because of design problems with the decant basin. The solids in the basin are washed out every mornng because of problems with the filter fabric which has to be replaced everyday. The basin is designed with an underdrain channel in the middle filled with rip rap and is covered with filter fabric. Since the fabric is only over the underdrain channel and is not anchored, the solids tend to wash out of the basin. Martin said that they feel like they are not accomplishing anything and that they will not contract for dredging jobs where this type of dewatering basin is to be used. Evidently the basin was designed and built at the same time the lake was constructed.

I asked if there were any special skills or training required to operate a MUDCAT. Martin said that he is a tugboat captain by profession and that he had been with MSA for two months and he is still learning about the MUDCAT. He estimates that it would take six months for someone who understands marine equipment to learn the most efficient means of operating and maintaining the equipment. He said that it was not enough to be familiar with the pumping equipment and motors, you have to know something about boating also.

He said that they would spend about a total of three weeks dredging, 10 - 11 hours a day and would consume about 300 gallons of fuel. The biggest problem is maintenance. He did say that, although the MUDCAT seemed to consist of several different kinds of "off the shelf" equipment thrown together, getting parts was easy. He has an 800 telephone number and several parts catalogs and can field order what he needs and get immediate delivery directly to the field.

Comment from John Crane: "Based on the preceding, maybe you can see where you've underestimated costs. I'd be curious to check his net production rate per hour (how does he do it?)."

cc: Garth Redfield

RECEIVED MAY - [illegible] 1981

Ingenjörsbyrå
KARL DUNKERS

Civilingenjörer, SVR
Forskning, uppfinningar
inom vattenteknik

Stockholm - Täby, April 28th, 1981

Dr. Garth Redfield
NUSAC Incorporated
7926 Jones Branch Drive
McLean, VA 22102
USA

Lake Fairfax

Dear Garth,

As a follow-up to the meeting held at the Fairfax Park Authority January 29, 1981, I send you enclosed one copy of my proposal and my letter to the Park Authority.

The project is aiming for a total phosphorous reduction in loading to about 20 % of current levels. However, this cannot be calculated in detail, unless knowing how the phosphorous concentration in the lake water and in the Colvin Run is divided in soluble phosphorous and in suspended solids bound phosphorous. Do you have any ideas on this?

Please do not hesitate to contact me with your and others comments on my proposal.

Yours,

Karl Dunkers

Encl.

Ingenjörsbyrå
KARL DUNKERS
Civilingenjörer. SVR
Forskning, uppfinningar
inom vattenteknik

Stockholm - Täby, April 28th, 1981

Fairfax County Park Authority
4030 Hummer Road
Annandale, Virginia 22003
USA

Att: Gilman C. Aldridge
Superintendent
Division of Conservation

Lake Fairfax

Dear Mr. Aldridge,

As a follow-up to the meeting held in your offices on January 29, 1981, I send you enclosed the proposal in two copies. I ask your Park Authority to decide if you would be ready to go further with this presumptive project. If so, application for federal grants should be prepared.

I wait with interest for your decision.

Yours,

Karl Dunkers

Enclosures a/s

cc: R. Field, EPA, Storm and Combined Sewer Section, Edison, NJ.
J. Copeland,
J. Gregory, Virginia State Water Control Board, Richmond, VA
T. Grizzard, Occoquan Watershed, Manassas, VA
G. Redfield, NUSAC Inc. McLean, VA

Adress Telefon Telex Postgiro

KARL DUNKERS

Lake Fairfax
Fairfax County Park Authority
Storm Water Treatment Plant
Proposal made by Karl Dunkers
Stockholm, April 27th, 1981

GENERAL

Lake Fairfax in the Lake Fairfax Park, Fairfax County, Virginia, is suffering from an eutrophication process, indicated by all the common limnologic criterias used, as phosphorous loading, Secchi transparency, oxygen dynamics and algal populations. Since the lake forms an important nature part of the popular Lake Fairfax Park recreation center, there is an obvious interest to stop further eutrophication and to bring the trophic status of the lake back to the mesotrophic or even to the oligotrophic zone. For this purpose a certain new storm water and lake water technology, which has been well proved in some Swedish inland lakes, is proposed to be applied in Lake Fairfax. This paper presents the design, the function, the dimensioning, the site plan and the estimated installation cost for such an application.

The base material and information used for the design and calculation are taken from the following sources:

1) Application to the EPA Clean Lake Program, Region III, for assistance in conducting Phase 1, diagnostic-feasibility studies of Lake Accotink and Fairfax, Fairfax County, Virginia, made by NUSAC Inc, Dr. Garth Redfield.

2) Lake Fairfax - Background Information. A summary of morphometry, hydrology, precipitation, inflow and lake trophic state datas, by G.W. Redfield dated 1/29/81.

3) Flow-duration curve and flood peak discharge frequency curves, received from NUSAC in a letter dated February 11, 1981, Garth Redfield.

NEW STORM WATER TREATMENT TECHNIQUE

A new method for treatment of storm water flows, urban runoff and combined sewer overflows has recently been developed by me under the grants from the National Swedish Board for Technical Development and the Swedish Council for Building Research.

The system consists of floating tanks in which the walls are made of pontoons with hanging curtains. The tank bottom is the lake bottom itself.

The floating tank system can be applied either as flow balancing tanks, as floating settling tanks or as a combination of balancing-settling. The latter is proposed for Lake Fairfax.

The floating tanks are presented in the attached pamphlet No. 79-03. The pictures show a full-scale installation made for the balancing tank application.

Conventional storage tank operation using concrete tanks and batchwise filling-emptying status is in my method replaced by floating pontoon tanks in an always-filled status. During rainy weather the floating tanks will be filled gradually with storm water. The lake water inside the tank will be simultaneously pushed against the tank outlet. At dry weather the lake water enters reversible the tank and starts to push the storm water by plug flow towards the continously operated pump in the first compartment. Thus, the lake water itself is utilized as the flow balance medium. All flow events through the tank have hydraulically a laminar character whereby substantial settling effects are obtained.

The system has been well proved in three full-scale installations in inland lakes in the Stockholm area. It withstands reasonable lake wave-action as well as severe icing conditions.

LAKE FAIRFAX APPLICATION

The proposal for Lake Fairfax is illustrated in the attached drawings No. 1 and 2.

Drawing No 2 is an orientation map showing the lake area needed for the tank and the corresponding area to be dredged. The dredging has to be done until a minimum water depth of 6 feet. The drawing also shows the proposed location of the chemical treatment plant and the plant outlet line.

Drawing No. 1 is a site plan and shows the floating tank for settling, balancing and storage of the Colvin Run outfall. All storm water from Colvin Run is forced to pass through the tank for settling and storage. The front side entering wall is equipped with hanging curtains having openings for an equal distribution of the flow through the tank cross section. The lake side short wall is equipped with similar curtains intended for an equal distribution of the lake water flow at reverse entering. Instead of conventional overflow weirs, a system of submerged flow-through openings, close to the water level, will be used in the lake side wall.

In order to protect the tank against over-pressure at peak flows and at extreme storms, there are two underflow by pass arrangements on both length sides of the tank. At a certain water level difference on both sides of the inlet shore side pontoons, the curtains weight will automatically rise up somewhat from the lake bottom and allow a part of the peak flow to pass under the curtains and run outside the tank length side. This action is in principle similar to usual safety valve functions.

In order to withstand extreme storms the tank is fixed to landside supports by means of several security cable anchorings.

The storm water pump in the inlet compartment is in continuous operation throughout the year and in all weathers. It feeds the water from a floating pump sump in the first compartment to a chemical treatment plant on land. The pump capacity, and accordingly the chemical treatment plant capacity, is proposed to be 350 gpm (= 80 m^3/h).

The major part of silt and settleable solids carried from the Colvin Run will be separated and settled on the tank bottom. This separated fraction will continuously be pumped by two submerged sludge pumps to the pump sump in the inlet compartment for further transportation to the chemical treatment plant. This separated fraction - the tank underflow - will normally be a mixture of storm water suspended solids - sludge - lake water. The capacity of the sludge pumps is 100 gpm each. The sludge pump pontoon is easy movable by hand. Its position has to be moved with some feet every week. The sludge pumping function is in this case not aiming for thick sludge concentrations.

PHOSPHOROUS LOADING REDUCTION

An application to the model of VOLLENWEIDER - DILLON, shows that a substantial improvement in Lake Fairfax trophic condition will require a reduction in phosphorous loading to about 20 % of the current levels.

The achievement of the required phosphorous removal will be devided into the following process parts as to different discharge events;

at no discharge	lake water will flow reversed through the tank and will further be pumped to the land side plant for complete chemical removal of soluble phosphorous

at low discharge	all settleable suspended solids will be separated in the tank and pumped as an underflow fraction to the land side plant for chemical treatment
at medium discharge	the tank acts partly for settling and partly for flow balancing. The discharged flow from Colvin Run will partially be subject to mechanical treatment (= sedimentation) and partially to chemical treatment
at peak discharge	partial sedimentation at high overflow rates. After the peak discharge period a discharged water volume - equal to the tank volume - will be pumped for chemical treatment. At high peaks a certain flow will pass through the tank and another part through the length side by-passes, both without treatment.

CHEMICAL TREATMENT PLANT

Due to the trophic status of the lake, the Colvin Run discharge and the lake water as well, has to be treated subject to a removal of soluble phosphorous. If mechanical treatment would be used only, the phosphorous removed would be limited to the suspended phosphorous part. Such kind of algal nutrient removal would not be sufficient as to the existing limnologic conditions in the lake. Therefore, a chemical treatment with dosing of coagulants (ferrichloride, chalk or alun), floculation and floc separation has to be provided in the system.

An example of a suitable chemical treatment plant used in similar full-scale schemes in Sweden, is shown in the attached pamphlet No. 79-01. Due to the applied plate settling system in crossflow, the plant is extremely concentrated and compact. This will make it easier to hide the pre-fabricated plant behind a surrounding fence somewhere in the Fairfax park area.

For handling the chemical sludge the plant has to be provided with a gravity sludge thickener. The thickened sludge will have a dry solid concentration of about 1 to 2 per cent. Further handling has to be made either with sludge drying beds, mechanical sludge dryers or wet sludge transportation and dumping. The produced amount of wet sludge is estimated to about 250 cft daily (7 m^3).

DIMENSIONING AND TECHNICAL DATA

The tank dimensions are:

- length 279´ (85 m)
- width 59´ (18 m)
- mean depth 6.9´ (2.1 m) (after dredging)
- tank area 16.461 sq.ft. (1530 m^2)

tank volume 113.581 cft (3213 m^3)

The hydraulic loads at different flows are shown in the attached Table No. 1.

PRELIMINARY COST ESTIMATION

The cost estimation is made using the experiences from similar Swedish installations. Some adjustments are made due to the lower labour cost level in the United States.

		$
1)	One floating tank with pontoons, curtains, weights, pumps, cable anchorings and erection, according to Drawing No. 1	175.000
2)	Civil engineering works, including dredging, pontoon shore supports, concrete base plate for the treatment plant, fence, sludge drying beds and pipe lines	64.000
3)	One prefabricated chemical treatment plant, (350 gpm), with dosing equipment, one sludge thickener, instruments and electrical wirings	75.000
4)	Consulting works, including the final design, calculations, inspections and the purchasing documents	20.000
5)	Miscellaneous and unexpected items	9.000
	Total	$ 343.000

REALIZATION

The project can be realized within a total time of approx. twelve (12) months, starting from the date of signing the contractor documents.

April 27th, 1981

Karl Dunkers

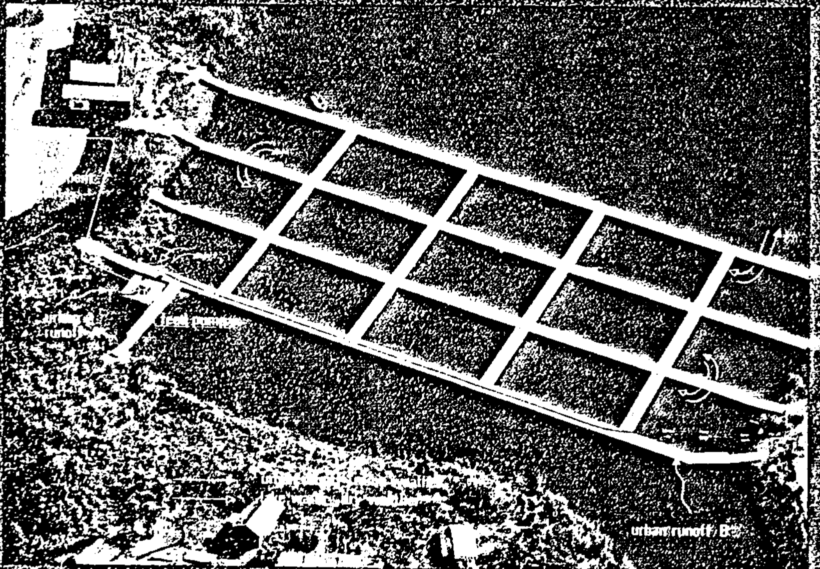
Table 1

Lake Fairfax
Dunkers´ Flow Balance Method
Hydraulic Loads

Floating Tank Size:
length 279´ (85 m)
width 59´ (18 m)
mean depth 6.9´ (2.1 m)
(after dredging)
tank area 16.461 sq.ft. (1530 m^2)
tank volume 113.581 cft (3213 m^3)

Type of discharge, Colvin Run	flow m^3/h	flow cfs	overflow rate m/h	overflow rate gal./d.sq.ft.	retention time hours
exceeding 50% of time	232	2.3	0.15	89	14
average discharge, recorded 1980	268	2.6	0.18	103	12
exceeding 25% of time	387	3.8	0.25	149	8
exceeding 3% of time	1.836	18.0	1.2	707	1.75
expected annual peak discharge within this decade, min.	20.000	196	13.1	7.704	0.16
2-year peak flow	35.000	343	22.9	13.482	0.09

A simple method for balancing the storm water flow



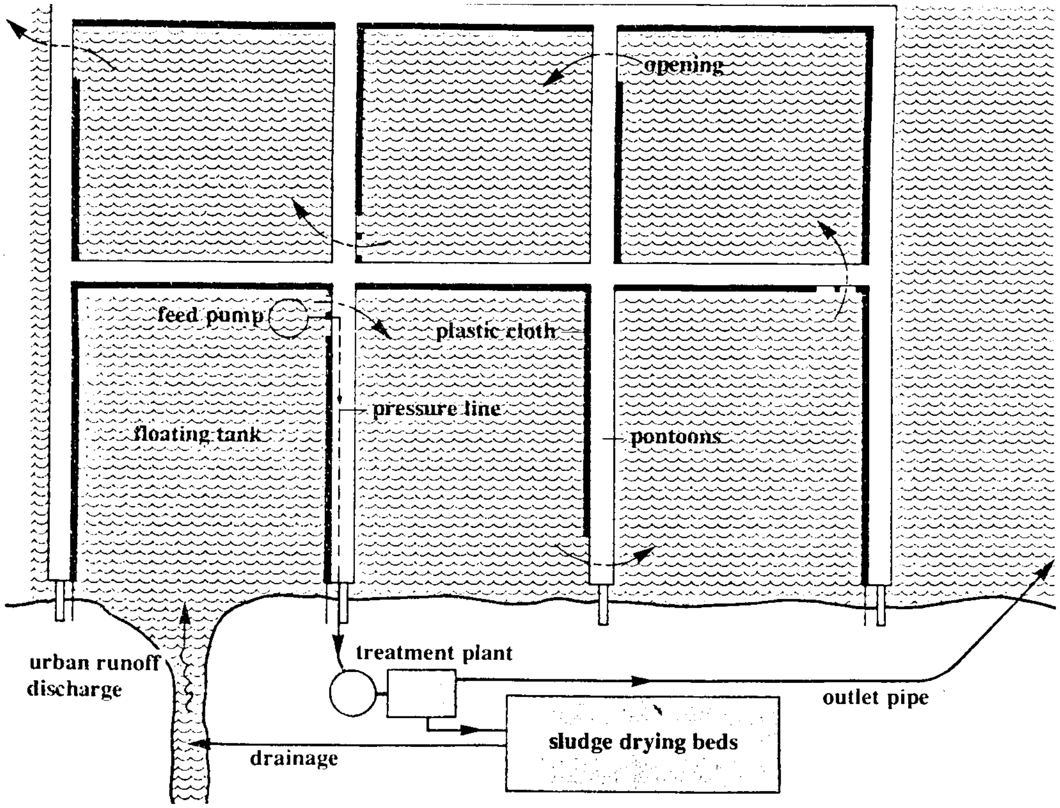
Here the brown colour—reflected by the light—indicates urban runoff whereas the dark grey indicates lake water. Note that the balance volume, at this actual moment, is filled 2/3 with urban runoff and 1/3 with lake water.

Pumping to the chemical treatment plant goes on continuously—whether it rains or not. When raining, the discharged flow to the lake exceeds the pump capacity. Consequently, the excess flow passes the pump and starts to fill up the tank compartments by "pushing" the lake water in the tank towards the outlet point. After the rain, the discharged flow is reduced to less than the pump capacity, and the tank starts to

Lake recovery requires continued protection against pollution from storm water, urban runoff and overflow water. Due to heavy flow variations these waters cannot be properly treated without systems for flow equalization. Conventional systems, i.e. concrete tanks or ponds, are far too expensive and too much land area will be needed. Therefore, a simple new balance method has been invented and developed.

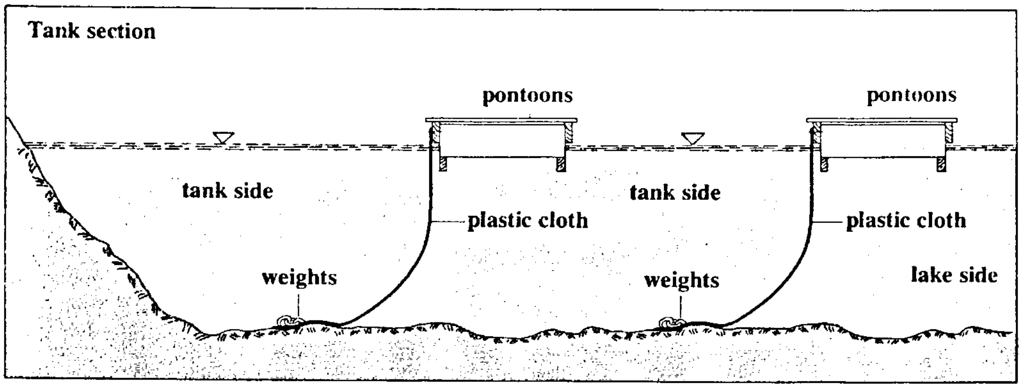
The storm water flow (urban runoff) is equalized in a pontoon tank system according to the plug flow principle. The tank bottom is the lake bottom itself.

The pictures on this page show the first installation erected in 1978 at Lake Trehörningen in Huddinge, Sweden. The tank volume is always filled up, either with polluted urban runoff from the land side or with lake water from the lake side. When raining, the urban runoff will "push" the lake water from one compartment to another. When not raining, the lake water again fills up the balance volume in the same way—but in the opposite direction. Thus, the lake water is utilized as a flow balance medium.



This plan view illustrates a plant for one-point discharge. The feed pump and the discharge point are connected to the first compartment. Excess storm water flow is diverted through large openings in the intermediate baffles. In order to prevent stratification caused by water temperature differences – these openings are placed alternately at the bottom and at the water level.

The treatment plant is in continuous operation. In highly eutrophicated lakes – as in the case of Lake Trehörningen – the treatment goes on even after the tank is filled with lake water. This gives the possibility to utilize the dry weather periods for a decrease in the internal phosphorous content of the lake water.



The section view shows the baffles, made of plastic cloth, hanging from the pontoons. Due to hydraulic communications between the lake side and the tank side – there cannot occur any one–sided pressure on the baffles.

The cloth is attached to the bottom with weights. There is no demand for absolute tightness against the bottom – the sole function of the baffles is plug flow conveying.

This flow balance method for polluted storm water, urban runoff and overflow water, was invented and developed by Karl Dunkers, Stockholm-Täby, Sweden, in 1978. Karl Dunkers works as an independent research engineer and inventor within the sewage and water treatment field. He is commissioned by the National Swedish Board for Technical Development and by the Swedish Council for Building Research.

Patents have been filed for our new flow balance method in the USA, Canada and several European countries.

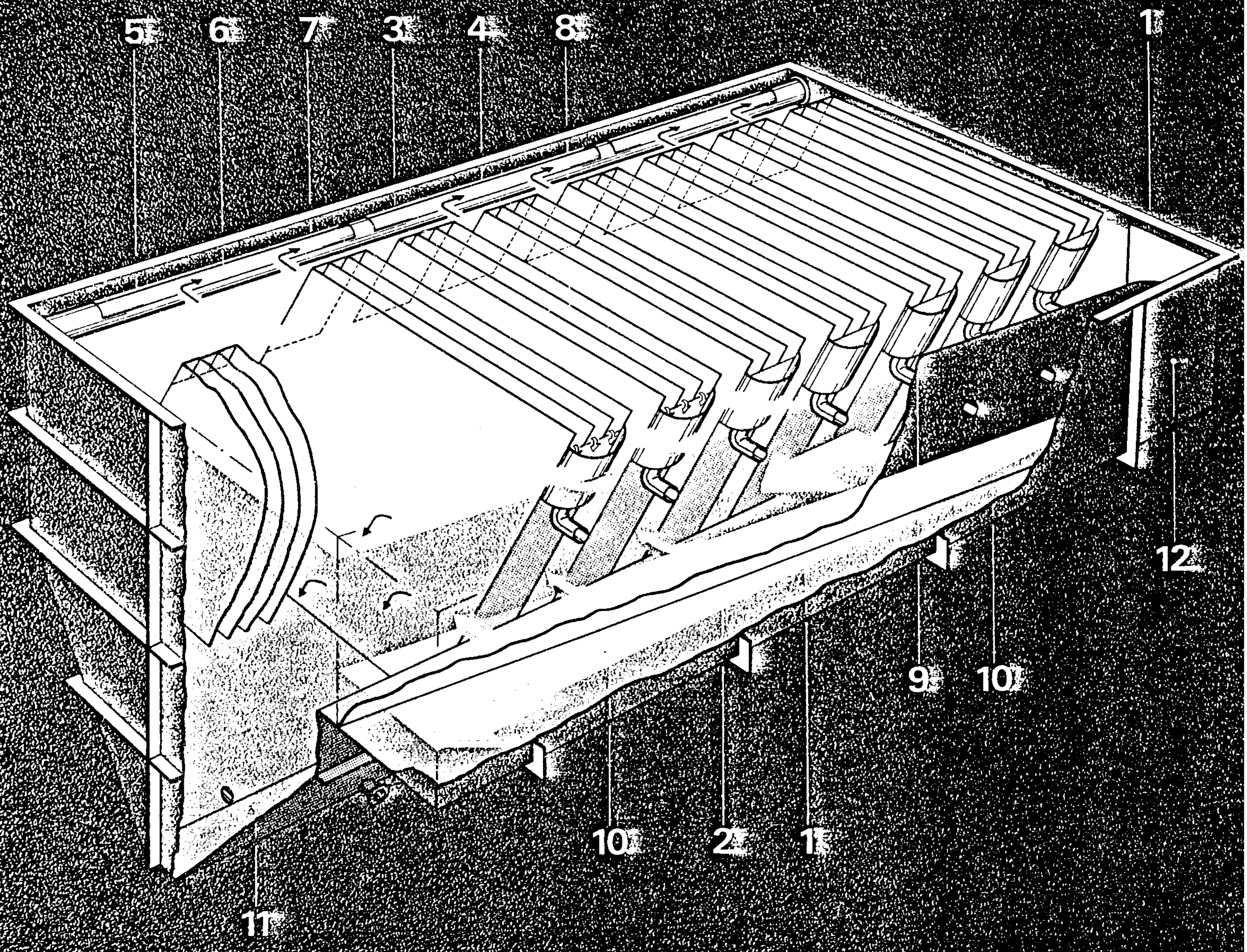
At the same time we developed a new type of sedimentation unit – a plate settler in crossflow with double passage. In 1978 in Huddinge, this unit was successfully tested in combination with this flow balance method – for chemical treatment of polluted urban runoff.

The crossflow plate settler is presented in our pamphlet No. 79-01.

Karl Dunkers

Address: Hästskovägen 7
S-183 50 TÄBY, Sweden
Phone: 08-768 43 34
Telex:)
New Telex No.
14006 TAEBY S
Att: Dunkers

Plate settling in crossflow —a reliable separation principle

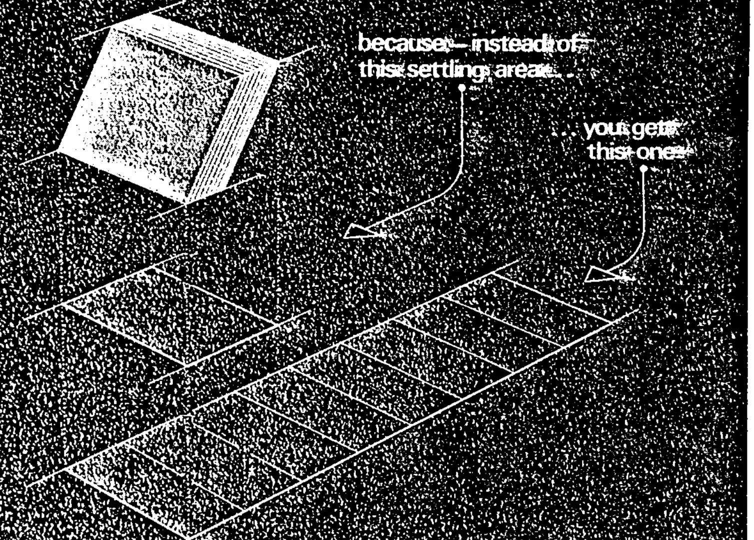


1. influent channel
2. inlet slots — formed by the space between the plate packs
3. plate packs — each consisting of four plates and two side baffles
4. inlet passage between two packs
5. turn side compartment
6. skim pipe for scum and oil removal
7. turn side baffles
8. effluent passage between the plates
9. overflow boxes
10. effluent channel
11. sludge compartment
12. tank side wall

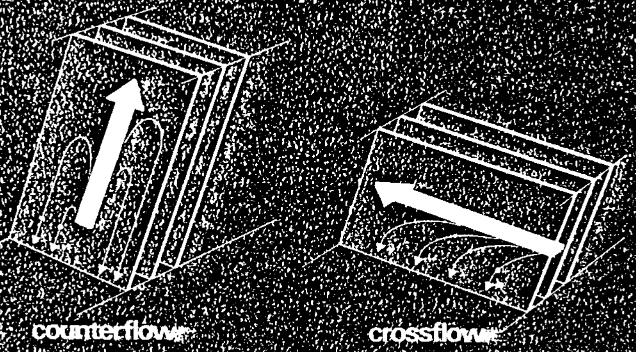
This pamphlet presents a further improvement of sedimentation by means of the crossflow principle. The water flow between the plates is arranged as a double passage — with the plate distances divided into inlet and outlet slots and with a turning of the flow in the turn side compartment. This gives a very steady flow distribution. The turn side compartment is simultaneously utilized for oil and scum removal. Through the same compartment one can easily reach the sludge bottom pits underneath the plates with tools for sludge control and maintenance. The water flows through the plate system without being forced through any narrow holes or openings. Consequently, there are no risks for clogging.

These good points, characterizing the double passage, have been confirmed through surprisingly favorable test results obtained in two pilot plants — see our pamphlet No. 79-02.

Why plate settling?



Why in crossflow?



The invention and the inventor

This new plate settling system was invented and developed by Karl Dunkers, Stockholm-Täby, in 1976–1978. Karl Dunkers works as an independent research engineer and inventor within the sewage and water treatment field. The development work is based on more than 10 years of experience with different plate settling systems. Karl Dunkers is commissioned by the National Swedish Board for Technical Development and by the National Swedish Industrial Development Foundation.

Karl Dunkers

Address:
Hästskovägen 7
S-183 50 TÄBY, SWEDEN
Phone:
08-768 43 34
Telex:

New Telex No.
14006 TAEBY S
Att: Dunkers

It's about surfaces

Good settling efficiency requires sufficient settling area. In conventional settling tanks this area is limited to the tank area itself. When using sloping plates (lamellas) the settling area can be increased with multiples of 10 or even 15 within the same tank volume.

At the same time the load on the projected plate area can be kept at least on the same level as for conventional tanks. Thus, plate settling means very compact plants with maximum savings in space required. And consequently, the existing limits for application of prefabricated and standardized units can with plate settlers be expanded to rather large plant sizes. Which of course means a substantial decrease in the investment cost.

And there are more advantages. The steady hydraulic flow conditions between the plates do not allow any disturbing short circuits. Temperature differences and wind effects cause well-known settling disturbances in conventional tanks. In plate settlers such disturbances are very unusual.

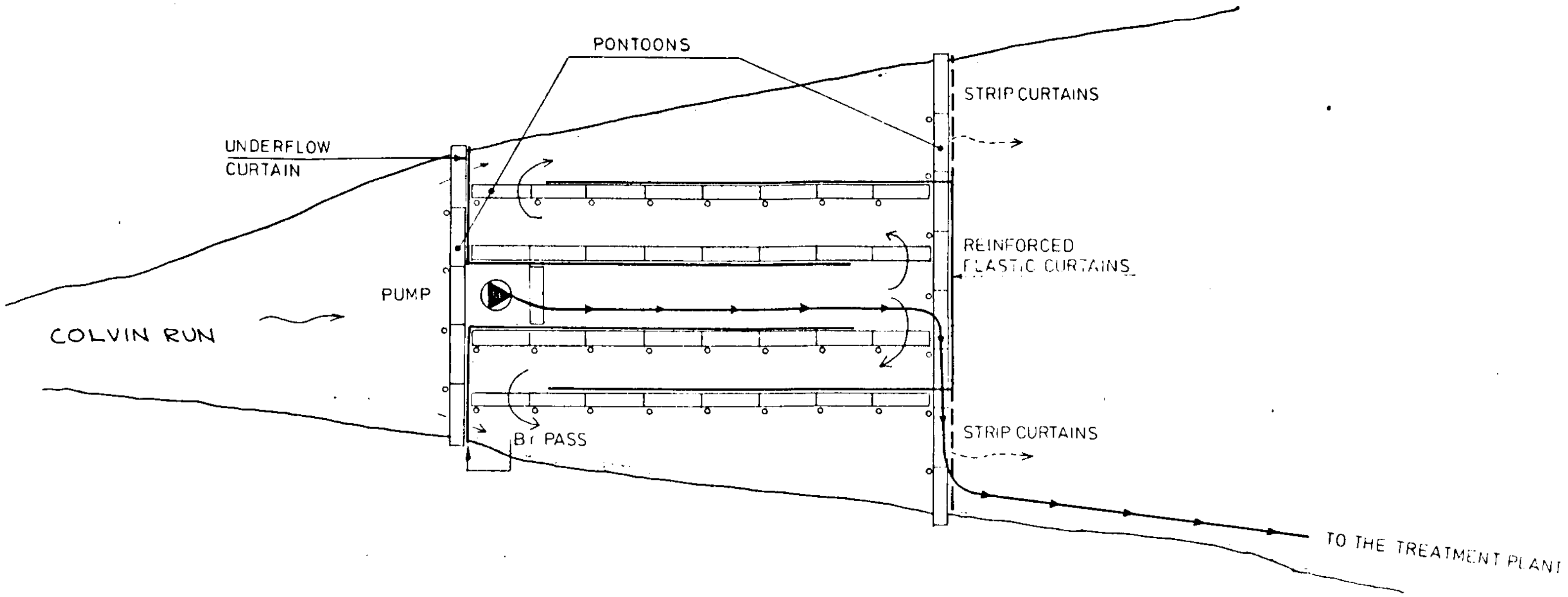
Features

Existing plate settlers can be classified in current flow, counterflow and crossflow systems. From theoretical considerations, as well as from practical experience, we know that the current flow and the counterflow systems still have some operative disadvantages. In current flow the outlet slots have to be located too close to the downflowing sludge layer on the plates. This results often in an unfortunate sludge escape to the clear water outlet. In counterflow systems there is a contradictory balance action on the plates. Gravity forces the sludge down the plates whereas the upflow water friction attempts to bring the sludge into an upflow movement. This, of course, limits the plate settling efficiency. Moreover, in counterflow systems there will always be some "critical" flow sections in which the settled sludge stream clashes with the inlet water flow – which again causes disturbing sludge escapes. Another disadvantage is that scum removal devices can hardly be applied in current or in counterflow systems.

As to the basic design, the crossflow system offers better flow conditions. There is neither critical flow sections nor disturbing sludge balance on the plates. The construction itself gives favorable solutions for equal distribution of the flow on the plates. And for installation of convenient scum removal equipment. These qualities jointly afford the crossflow system reliable operation, higher load capacities and less sensitivity to flow variations.

Applications

As to the fields of use – this plate settler can be used for all separation tasks within the treatment of potable water, sewage and wastewater. One entirely new application is the treatment of urban runoff, stormwater and overflow water for lake protection. In this application our plate settler is combined with our special flow equalization system – see our pamphlet No. 79-03.



LAKE FAIRFAX
STATE OF VIRGINIA
STORM WATER AND
LAKE WATER TREATMENT
PRINCIPAL LAY OUT

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P O Box 5107 · S-102 43 STOCKHOLM 5 · Sweden
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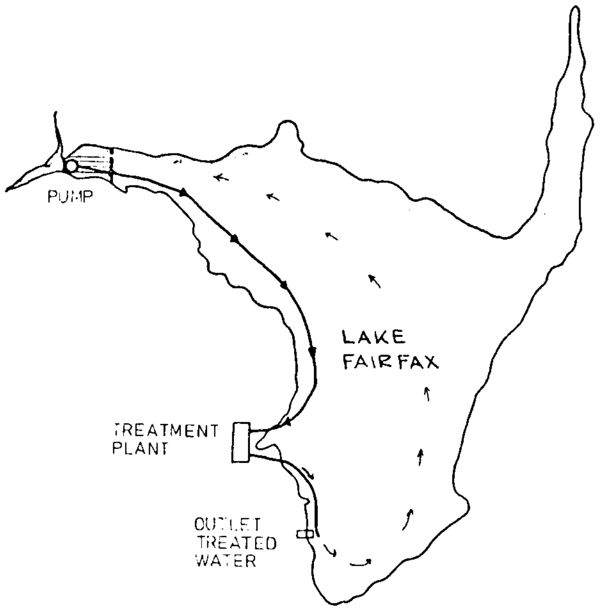

LAKE FAIRFAX
STATE OF VIRGINIA
STORM WATER AND
LAKE WATER TREATMENT
LAY OUT MAP

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