WATER QUALITY ASSESSMENT OF LITTLE CACHE CREEK-DUTCHMAN CREEK WATERSHED, JOHNSON COUNTY, ILLINOIS, WITH NOTES ON THE BIOTA

Prepared for the

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

by the

ILLINOIS NATURAL HISTORY SURVEY
Natural Resources Building
Urbana, Illinois 61801

August, 1976

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Summary

The purpose of this assessment was to provide information regarding the existing water quality of the Little Cache Creek-Dutchman Creek watershed and to consider the biota of that watershed.

Water samples were collected from three stream stations at approximately weekly intervals from 1 October through 4 November 1975 and from the limnetic area of Dutchman Lake on 19 December 1975. Time restrictions imposed upon this study precluded adequate sampling of biological components of the stream ecosystem. Hence, results were based upon records in the collection of the Illinois Natural History Survey.

Results of water quality sampling and testing indicated that station 3, downstream from Vienna, differed significantly from upstream areas in the watershed for 10 of the 24 measured parameters [total dissolved ionizable solids, EDTA hardness, phosphorus (total and soluble orthophosphate), nitrogen (nitrate, nitrite, ammonia, and total), chloride, and flow]. In all instances, station 3 yielded the highest mean concentrations or levels. These differences in water quality are attributed to effluent from Vienna's municipal wastewater treatment plant.

Low dissolved oxygen and high free carbon dioxide and ammonia concentrations were likely an artifact of the season in which the study was conducted. The closed canopy over the stream, relatively low flow conditions, and organic input from autumn leaf fall present at the time of sampling could produce these conditions.

The biotic inventory was limited to taxonomic groups which have been well-studied in Illinois. In all, 221 taxa were listed, including seven Crustacea, 130 aquatic insects, 27 fishes, 24 amphibians, and 33 reptiles. A review of the proposed action and the status of recognized threatened and endangered fauna indicates that impact would be minimal upon those species occurring in affected areas.

The quality of any environment, frequently a function of the diversity of habitats within that environment, generally is expressed by a diverse assemblage of organisms. In stream ecosystems, habitat diversity typically includes a succession of riffles and pools. This riffle-pool series virtually was lacking in the study area. Instead, the streams were steep-banked, had sand-clay substrates, and sluggish flow. Hard substrates were provided only by fallen branches and by rubble, generally in the vicinity of bridges. The proposed grade transition sections would create riffle habitat which would serve to increase habitat diversity in the area.

A second result of the proposed structures would involve the creation of periphyton habitat. Periphyton is an attached community of microorganisms which develops best on hard (*e. g.*, rocks and branches), submerged

substrates. This community plays an important role in the assimilation of dissolved organic matter and nutrients from the water. It behaves as an "in-stream trickling filter." In addition to improving reaeration physically by the creation of turbulent flow, deoxygenation would be reduced through the removal of oxygen-consuming substances by the periphyton.

The proposed design for channel modifications of Little Cache Creek and Dutchman Creek reflects innovative and careful planning to provide channel capacity for flood waters with minimal environmental impact. Especially notable are limitations to modify only one stream bank, to alter that bank which provides the least wildlife and/or aquatic habitat, to place spoil material alongside the maintenance road, and to spare most of the existing channel.

WATER QUALITY ASSESSMENT OF LITTLE CACHE CREEK-DUTCHMAN CREEK WATERSHED, JOHNSON COUNTY, ILLINOIS, WITH NOTES ON THE BIOTA

Introduction

The purpose of this assessment was to provide information regarding the existing water quality of the Little Cache Creek-Dutchman Creek watershed to form the basis of an environmental impact statement of a PL-566 project. Subsequently, the scope of the assessment was expanded to include a brief consideration of the biota. This study was conducted by the Illinois Natural History Survey as a cooperative investigation with the Soil Conservation Service, U. S. Department of Agriculture. The investigation included field sampling and testing, laboratory analyses of samples, and a review of existing literature and biological samples from the study area. This report constitutes a summary of findings.

Proposed action in the Little Cache watershed project area consists of approximately 8.8 km (5.5 miles) of channel modification including the lower 1.6 km of Dutchman Creek and the lower 4.8 km of Little Cache Creek, both above the confluence of the two streams, and Dutchman Creek for 2.4 km downstream from the confluence.

Briefly, modification will transpose virtually all of the stream gradient in the modified portion of the stream to five grade transition sections. Existing channel will be impounded and floodways will be created upstream from these grade transition sections.

Proposed grade transition sections will be several hundred feet long, steep, and lined with rock riprap. Each may be headed with a concrete notch weir/or retaining wall. Existing channel upstream from each grade transition section will not be channelized in a traditional sense. Existing stream bed and banks below "normal flow" water level will not be excavated. Instead, a floodway will be excavated above "normal flow" water level from one stream bank. The bank selected for excavation will be that which provides the least terrestrial and/or aquatic habitat. The floodway will be dry except during high water periods. Constriction of the stream at each grade transition section will result in impoundment upstream. These impoundments will be within the existing channel and will vary in depth from near-0 m at the upstream end to near-1.5 m at the downstream end. Pools will vary in length from 150 m (500 ft) to 1500 m (5000 ft).

Description of the Study Area

The Little Cache Creek-Dutchman Creek watershed is located in southeastern Illinois. The streams originate northeast and northwest, respectively, of Vienna in central Johnson County. Little Cache Creek joins Dutchman Creek approximately 1.5 km southwest of Vienna. Flow continues southward to the confluence with Cache River, approximately 5.5 km south southwest of Vienna.

Two weather stations are located near the study area. Recorded data show temperatures ranging from 112 F (44 C) to -26 F (-32 C), an average growing season of 193 days, and a mean annual precipitation of 46.6 inches (118 cm).

The study area was located in an unglaciated region of the Shawnee Hills Section of the Interior Low Plateaus Province. This region is characterized by complex dissected uplands underlain by Mississippian and Pennsylvanian strata. Elevations range from 800 ft (245 m) MSL at the headwaters to 350 ft (105 m) MSL at the point where Dutchman Creek flows from the study area.

Three soil associations are represented in the study area: (1) Grantsburg-Robbs-Wellston Association in most of the Little Cache Creek basin, (2) Hosmer-Stoy-Weir Association in most of the Dutchman Creek watershed, and (3) Lawson-Beaucoups-Darwin-Haymond-Belknap Association downstream from the confluence of the two creeks.

Vienna, Illinois, discharges wastewater treatment plant effluent into Little Cache Creek, approximately 0.06 mgd. Since 1962 wastewater treatment has been via a secondary stabilization pond with a design capacity of 1,080 population equivalents (computed on a basis of 0.17 lbs day^{-1} per capita 5-day, 20 C biochemical oxygen demand). Sewerage is such that domestic and industrial wastewater is separate from stormwater runoff. Measured population equivalents of untreated wastewater was 1,000 (1960 population 1,094). Measured population equivalents of treated wastewater was 1,000. In essence, the treatment process had no effect upon the wastewater and unstabilized sewage enters Little Cache Creek (Environmental Protection Agency 1971).

Four sites were visited for water quality sampling and testing during the course of this inventory (Fig. 1). Stations 1, 2, and 3 are illustrated in Figure 2. Locations and brief descriptions of the stations are as follows:

Station 1: Illinois, Johnson County
Dutchman Creek at bridge 1.5 km WSW of Vienna
T13S, R3E, Sec. 6 (SW 1/4, NE 1/4, SW 1/4)

Stream width 4 m; mean depth 0.5 m; substrate clay and fine gravel

Station 2: Illinois, Johnson County
Little Cache Creek at U. S. Hwy 45 bridge in SE Vienna
T13S, R3E, Sec. 5 (SE 1/4, NE 1/4, SE 1/4)

Stream width 3 m; mean depth 0.5 m; substrate silt and clay

Figure 1. Locations of the four water quality sampling sites in the Little Cache Creek-Dutchman Creek watershed, Johnson County, Illinois.

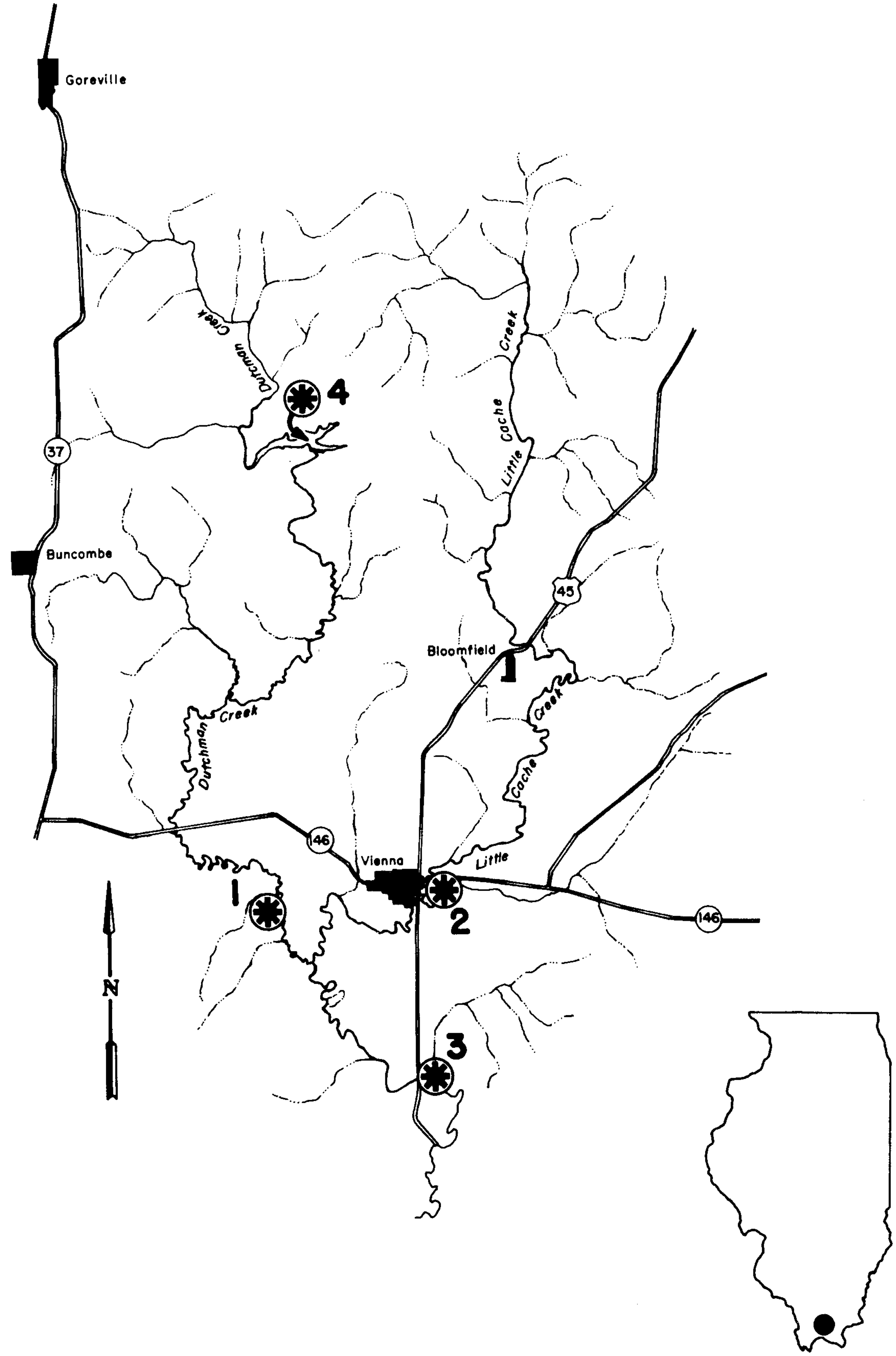
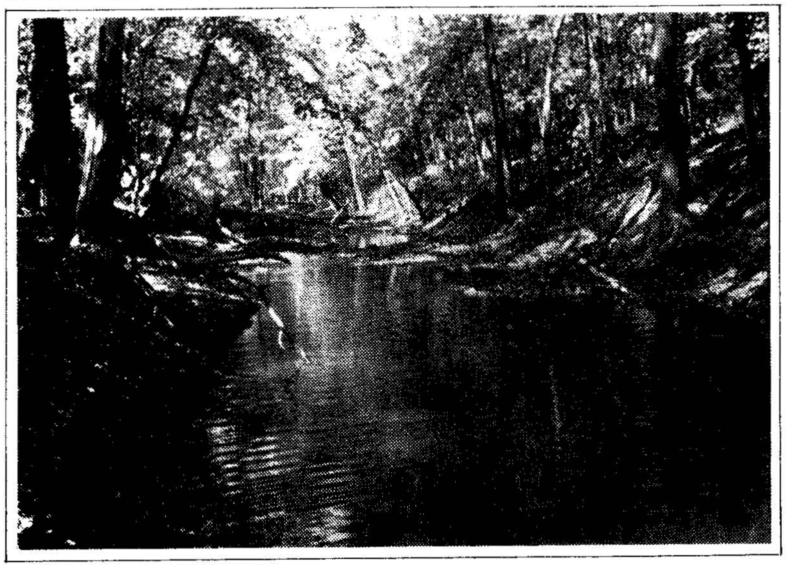

Goreville
Buncombe
37
Dutchman Creek
4
Little Cache Creek
45
Bloomfield
Dutchman Creek
Cache Creek
146
Vienna
Little
1
2
146
3
N

Figure 2. Photographs of the three stream sampling sites in the Little Cache Creek-Dutchman Creek watershed, Johnson County, Illinois.

STATION 1
DUTCHMAN CREEK

STATION 2
LITTLE CACHE CREEK



STATION 3
DUTCHMAN CREEK

Station 3:	Illinois, Johnson County Dutchman Creek at U. S. Hwy 45 bridge 3.5 km S of Vienna T13S, R3E, Sec. 16 (NW 1/4, SW 1/4, SW 1/4) Stream width 8 m; mean depth 1 m; substrate silt and clay
Station 4:	Illinois, Johnson County Dutchman Lake, an impoundment 8.1 km NNW of Vienna T12S, R3E, Sec. 7 (S 1/2, NE 1/4) Sampled in limnetic (open water) area

Water Quality

Methods. Triplicate samples were collected at each of the three stream stations on each of the six sampling trips made at approximately weekly intervals from 1 October through 4 November 1975. Three replicate surface samples were collected from the limnetic area of Dutchman Lake on 19 December 1975. In addition, water temperature and dissolved oxygen profiles from surface to bottom were recorded from the lake station. Summarized water quality data for stream and lake stations appear in the appendix.

Field measurements included water temperature, dissolved oxygen, hydrogen ion concentration (as pH), and water velocity. The cross-sectional area of the stream was "partitioned" into rectangles 0.50 m by 0.25 m, 0.125 m^2 area. Water velocity was recorded for each area as m sec^{-1}. Flow (m^3 sec^{-1}) was determined for each 0.125 m^2 area by multiplying it by the corresponding water velocity. All individual flows were summed to determine total flow at each station on each date.

All remaining analyses were performed in the laboratory on unpreserved raw water samples.

Most of the analytical procedures used for water analysis in this study are described in detail in the 13th edition of Standard Methods for the Examination of Water and Wastewater (American Public Health Association, American Water Works Association, and Water Pollution Control Federation 1971)(Standard Methods). Table 1 summarizes the particular method or equipment used for analysis where more than one was approved and also lists those parameters where selected methods were not included in Standard Methods or deviated from those methods.

The procedural modifications for EDTA hardness, ammonia, and nitrite methods resulted from the use of autoanalyzers (Technicon Corporation, Tarrytown, New York).

The automated procedure for EDTA hardness used disodium magnesium ethylenediaminetetraacetate (EDTA) to exchange magnesium on an equiva-

Table 1. Methods for physical and chemical parameters monitored in the Little Cache Creek-Dutchman Creek project area 1 October through 19 December 1975.

PARAMETERS	METHODS
Water Temperature (C)	Thermocouple Circuitry
Dissolved Oxygen	YSI Model 51A DO Meter
Dissolved Oxygen (% saturation)	By calculation
Free Carbon Dioxide	Nomographic Method[1]
Hydrogen Ion Concentration (pH)	Sargent-Welch Model PBX Method
Total Alkalinity (as $CaCO_3$)	Metrohm Autotitrator to pH 4.6[1]
Total Dissolved Ionizable Solids (as NaCl)	By Calculation from Specific Conductance Table
EDTA Hardness (as $CaCO_3$)	EDTA Colorimetric Method (Autoanalyzer)
Turbidity (JTU)	Monitek Model 150 Turbidimeter
Total Phosphorus (as P)	Stannous Chloride Method[1]
Soluble Orthophosphate (as P)	Ascorbic Acid Method (Autoanalyzer)[1]
Nitrate (as N)	Cadmium Reduction Method (Autoanalyzer)[1]
Nitrite (as N)	Diazotization Method (Autoanalyzer)
Ammonia (as N)	Berthelot Reaction Method (Autoanalyzer)
Organic Nitrogen (as N)	Modified Berthelot Reaction Method (Autoanalyzer)
Total Nitrogen (as N)	Sum All Forms
Total Iron	Phenanthroline Method[1]
Sulfate (as S)	Turbidimetric Method[1]
Residue, Total	Constant Weight Upon Drying @ 180 C, Unfiltered[1]
Residue, Dissolved	Constant Weight Upon Drying @ 180 C, Filtered[1]
Residue, Particulate	By Difference
Molybdate-Reactive Silica (as SiO_2)	Molybdosilicate Method[1]
Chloride	Argentometric Method[1] with Metrohm Autotitrator
Flow (m^3 sec^{-1})	Small Price AA Direct Reading Mechanical Current Meter

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[1] Standard Methods

lent basis for calcium and/or any other cation which formed a more stable EDTA chelate than magnesium. The magnesium then reacted with calmagite at pH 10 to form a red-violet complex. Percent transmittance was read at 520 nm.

The automated method for ammonia in water used the Berthelot Reaction. A green-colored compound was formed (closely related to indophenol) when the sample containing the ammonium salt was reacted with sodium phenoxide followed by a 5.25% sodium hypochlorite solution. A solution of potassium-sodium tartrate was added to eliminate the precipitation of heavy metal hydroxides. Percent transmittance was read at 630 nm.

In the automated procedure for nitrite, under acid conditions, nitrite reacted with sulfanilamide to form a diazo compound which coupled with N-1-naphthyl-ethylenediamine dihydrochloride to form a soluble violet dye. Percent transmittance was measured at 520 nm.

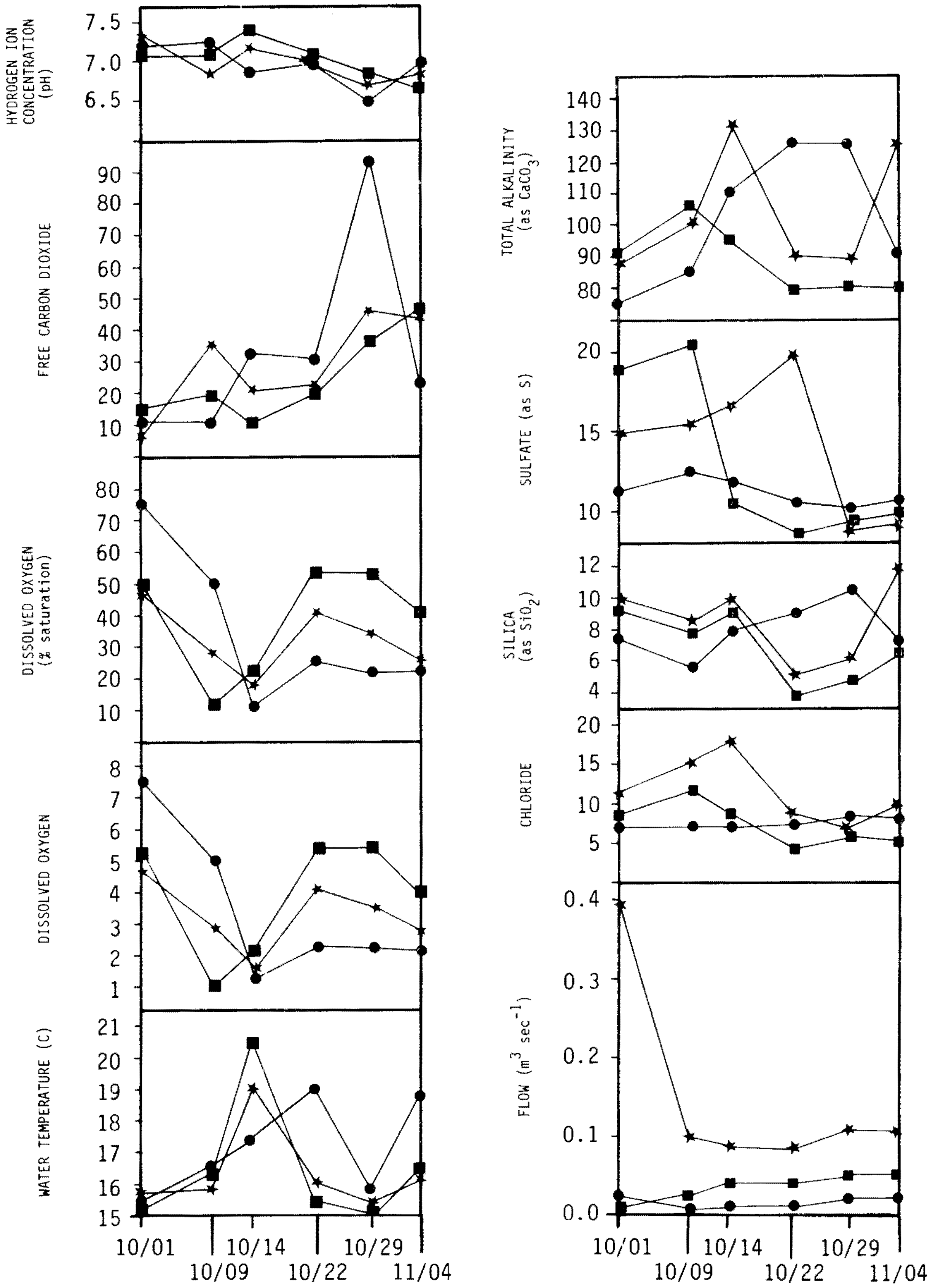
Existing Water Quality. The 6-week sampling program was completed at the three stream sampling stations on 4 November 1975. Each parameter, except flow, was determined 18 times at each station, three replicate samples on each of six dates. Flow was determined six times at each station.

Data for the physical and chemical parameters determined at each of the stream stations are illustrated graphically in Figure 3. Each datum point on the figure represents the mean of three replicate samples, except for flow. Each datum point for flow represents a single determination. Figure 3 demonstrates the variability in concentrations observed in short-term studies. With the possible exception of flow where station 3 was always greatest, there were no clear station-to-station trends apparent from the graphs. Concentrations or levels appeared to fluctuate randomly with time. For this reason, the data were analyzed and summarized further in Tables 2 and 3 to identify any differences which might exist among the stream stations, but which were not readily apparent from the graphic presentation.

Table 2 summarizes the results of the physical and chemical parameters measured at the three stream stations in the Little Cache watershed project area as number of measurements, mean, standard deviation, and minimum and maximum values. While the results cannot predict the total expected annual variation since sampling was restricted to a 6-week autumn period, these data are sufficient to describe baseline water quality in the project area. Water quality data are summarized by date in the appendix.

Data gathered from the three stream sampling stations were examined further using Model I one-way analysis of variance techniques. While the analysis of variance indicated whether or not there were any significant differences among stations for the parameters tested, it was necessary to use the Modified Duncan New Multiple-Range Test (Kramer 1956) to determine which stations were significantly different. In presenting the results of the Modified Duncan New Multiple-Range

Figure 3. Concentrations or levels of 24 parameters measured at three stream stations in the Little Cache Creek-Dutchman Creek project area. As mg $liter^{-1}$ unless other units are indicated (station 1, circle; station 2, square; station 3, star).


HYDROGEN ION CONCENTRATION (pH)
7.5
7.0
6.5
FREE CARBON DIOXIDE
90
80
70
60
50
40
30
20
10
DISSOLVED OXYGEN (% saturation)
80
70
60
50
40
30
20
10
DISSOLVED OXYGEN
8
7
6
5
4
3
2
1
WATER TEMPERATURE (C)
21
20
19
18
17
16
15
10/01
10/09
10/14
10/22
10/29
11/04
TOTAL ALKALINITY (as $CaCO_3$)
140
130
120
110
100
90
80
SULFATE (as S)
20
15
10
SILICA (as SiO_2)
12
10
8
6
4
CHLORIDE
20
15
10
5
FLOW (m^3 sec^{-1})
0.4
0.3
0.2
0.1
0.0
10/01
10/09
10/14
10/22
10/29
11/04

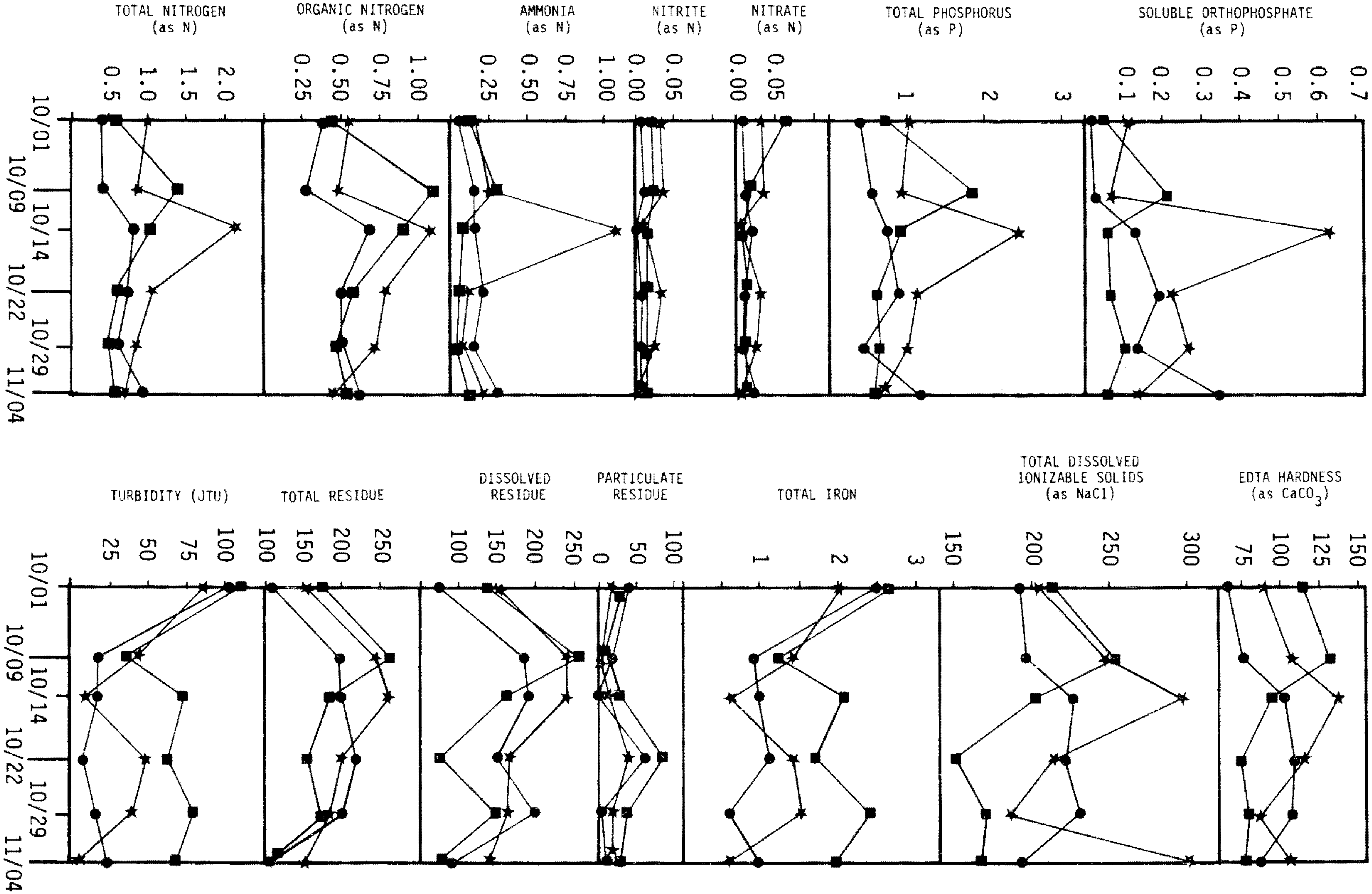

TOTAL NITROGEN (as N)
0.5 1.0 1.5 2.0
ORGANIC NITROGEN (as N)
0.25 0.50 0.75 1.00
AMMONIA (as N)
0.25 0.50 0.75 1.00
NITRITE (as N)
0.00 0.05
NITRATE (as N)
0.00 0.05
TOTAL PHOSPHORUS (as P)
1 2 3
SOLUBLE ORTHOPHOSPHATE (as P)
0.1 0.2 0.3 0.4 0.5 0.6 0.7
10/01 10/09 10/14 10/22 10/29 11/04
TURBIDITY (JTU)
25 50 75 100
TOTAL RESIDUE
100 150 200 250
DISSOLVED RESIDUE
100 150 200 250
PARTICULATE RESIDUE
0 50 100
TOTAL IRON
1 2 3
TOTAL DISSOLVED IONIZABLE SOLIDS (as NaCl)
150 200 250 300
EDTA HARDNESS (as CaCO3)
75 100 125 150
10/01 10/09 10/14 10/22 10/29 11/04

Table 2. Number (followed by dash), mean, standard deviation (in parentheses), and range observed for 24 parameters monitored at three stream stations in the Little Cache Creek-Dutchman Creek watershed from 1 October through 4 November 1975.

PARAMETERS[1]	STATION 1	STATION 2	STATION 3
Water Temperature (C)	18 - 17.14(1.43) 15.3 to 19.2	18 - 16.52(1.91) 15.1 to 20.9	18 - 16.35(1.34) 15.1 to 19.2
Dissolved Oxygen	18 - 3.40(2.21) 1.0 to 7.6	18 - 3.86(1.77) 1.0 to 5.8	18 - 3.25(1.12) 1.5 to 5.0
Dissolved Oxygen (% saturation)	18 - 34.59(21.72) 10.4 to 75.3	18 - 38.66(16.98) 10.1 to 56.9	18 - 32.54(10.66) 16.0 to 49.5
Free Carbon Dioxide	18 - 33.07(27.86) 4.8 to 95.0	18 - 23.19(13.23) 8.0 to 46.0	18 - 30.03(13.67) 11.0 to 60.0
Hydrogen Ion Concentration (pH)	18 - 6.93(0.30) 6.4 to 7.5	18 - 6.98(0.28) 6.6 to 7.4	18 - 6.92(0.23) 6.5 to 7.3
Total Alkalinity (as $CaCO_3$)	18 - 102.9(19.9) 76 to 127	18 - 88.1(10.6) 77 to 107	18 - 104.9(19.2) 89 to 134
Total Dissolved Ionizable Solids (as NaCl)	18 - 207.7(19.8) 170 to 239	18 - 191.3(36.6) 145 to 258	18 - 241.4(49.6) 183 to 333
EDTA Hardness (as $CaCO_3$)	18 - 89.8(17.0) 63 to 112	18 - 94.1(21.0) 72 to 130	18 - 105.5(17.6) 82 to 138
Turbidity (JTU)	18 - 32.3(36.4) 7 to 130	18 - 73.2(23.0) 37 to 118	18 - 39.4(27.9) 7 to 105
Total Phosphorus (as P)	18 - 0.670(0.334) 0.34 to 1.27	18 - 0.848(0.460) 0.53 to 1.86	18 - 1.180(0.609) 0.59 to 2.45
Soluble Orthophosphate (as P)	18 - 0.133(0.113) 0.01 to 0.35	18 - 0.083(0.066) 0.02 to 0.22	18 - 0.229(0.189) 0.07 to 0.62
Nitrate (as N)	18 - 0.013(0.008) <0.01 to 0.04	18 - 0.018(0.018) <0.01 to 0.06	18 - 0.078(0.107) <0.01 to 0.31
Nitrite (as N)	18 - 0.010(0.000) <0.01 to 0.01	18 - 0.011(0.003) <0.01 to 0.02	18 - 0.021(0.009) <0.01 to 0.03
Ammonia (as N)	18 - 0.167(0.079) 0.07 to 0.33	18 - 0.122(0.084) 0.04 to 0.32	18 - 0.321(0.345) 0.10 to 1.11
Organic Nitrogen (as N)	18 - 0.494(0.157) 0.14 to 0.76	18 - 0.662(0.272) 0.31 to 1.18	18 - 0.674(0.251) 0.33 to 1.14
Total Nitrogen (as N)	18 - 0.684(0.191) 0.42 to 0.95	18 - 0.812(0.332) 0.46 to 1.52	18 - 1.094(0.503) 0.62 to 2.22
Total Iron	18 - 1.17(0.65) 0.62 to 2.8	18 - 1.97(0.45) 1.2 to 2.6	18 - 1.25(0.53) 0.60 to 2.5
Sulfate (as S)	18 - 10.68(1.47) 8.0 to 12.5	18 - 12.68(4.99) 7.5 to 20.8	18 - 13.96(4.03) 7.7 to 20.7
Residue, Total @ 180 C	18 - 170.5(46.6) 90 to 216	18 - 178.4(47.7) 108 to 269	18 - 200.2(41.4) 146 to 258
Residue, Dissolved @ 180 C	18 - 149.7(50.4) 72 to 200	18 - 145.7(61.1) 65 to 257	18 - 181.3(45.2) 128 to 256
Residue, Particulate @ 180 C	18 - 20.8(25.3) 1 to 76	18 - 32.8(26.0) 4 to 90	18 - 18.8(13.4) 1 to 48
Molybdate-Reactive Silica (as SiO_2)	18 - 7.70(1.65) 5.1 to 10.4	18 - 6.75(2.08) 3.7 to 9.1	18 - 8.53(2.29) 5.3 to 12.0
Chloride	18 - 7.35(0.77) 6.2 to 9.7	18 - 7.02(2.47) 3.8 to 11.9	18 - 11.62(4.02) 6.1 to 18.3
Flow (m^3 sec^{-1})	6 - 0.015(0.005) 0.01 to 0.02	6 - 0.037(0.014) 0.02 to 0.05	6 - 0.150(0.123) 0.09 to 0.40

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[1] As mg liter^{-1} except where other units are indicated.

Table 3. Relationships among mean concentrations of physical and chemical parameters[1] at three stations in the Little Cache Creek-Dutchman Creek project area. Any two means underscored by the same line are not significantly different by the Modified Duncan New Multiple-Range Test (0.05 level).

PARAMETERS	STATIONS 1	 2	 3
Water Temperature (C)	17.14	16.52	16.35
Dissolved Oxygen	3.40	3.86	3.25
Dissolved Oxygen (% saturation)	34.59	38.66	32.54
Free Carbon Dioxide	33.07	23.19	30.03
Hydrogen Ion Concentration (pH)	6.93	6.98	6.92
Residue, Total @ 180 C	170.5	178.4	200.2
Residue, Dissolved @ 180 C	149.7	145.7	181.3
Residue, Particulate @ 180 C	20.8	32.8	18.8
Total Dissolved Ionizable Solids (as NaCl)	207.7	191.3	241.4
EDTA Hardness (as $CaCO_3$)	89.8	94.1	105.5
Total Phosphorus (as P)	0.670	0.848	1.180
Soluble Orthophosphate (as P)	0.133	0.083	0.229
Nitrate (as N)	0.013	0.018	0.078
Nitrite (as N)	0.010	0.011	0.021
Ammonia (as N)	0.167	0.122	0.321
Organic Nitrogen (as N)	0.494	0.662	0.674
Total Nitrogen (as N)	0.684	0.812	1.094
Sulfate (as S)	10.68	12.68	13.96
Chloride	7.35	7.02	11.62
Flow (m^3 sec^{-1})	0.015	0.037	0.150

PARAMETERS	STATIONS 1	 3	 2
Total Alkalinity (as $CaCO_3$)	102.9	104.9	88.1
Turbidity (JTU)	32.3	39.4	73.2
Total Iron	1.17	1.25	1.97

PARAMETERS	STATIONS 3	 1	 2
Molybdate-Reactive Silica (as SiO_2)	8.53	7.70	6.75

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[1] Expressed as mg $liter^{-1}$ except where other units are indicated; for each parameter, except flow, at each station, n = 18; for flow, n = 6 at each station.

Test in Table 3, any two means underscored by the same line are not significantly different at the 0.05 level.

Three major station groupings were observed among most parameters following the analysis of variance and multiple-range testings: (1) parameters which exhibited no significant differences among stations; (2) parameters for which station 3 not only was significantly different (0.05 level) from stations 1 and 2, but also exhibited the highest mean concentration; and (3) parameters for which stations 1 and 3 in Dutchman Creek were significantly different (0.05 level) from station 2. Only organic nitrogen, sulfate, and silica concentrations were not directly applicable to one of the above categories. The relationships among stations for these parameters were intergrades and not as clearly defined as for the other parameters.

No Differences Among Stream Stations

Eight parameters showed no significant differences among stations. These included water temperature, dissolved oxygen (as mg $liter^{-1}$ and % saturation), free carbon dioxide, hydrogen ion concentration as pH, and residues (total, dissolved, particulate)(Table 3).

The viscosity and density of water and also the solubility of gases, especially oxygen, in water are functions of water temperature. As the medium for aquatic organisms, water and its temperature are important. Aquatic organisms have lower and upper thermal tolerance limits, optimum growth temperatures, preferred temperatures in thermal gradients, and temperature limitations for reproduction, migration, and egg incubation (Committee on Water Quality Criteria 1972).

The water temperature regimes of Little Cache Creek and Dutchman Creek are the result of the combined effects of latitude, elevation, time of year, time of day, flow, depth, and the presence or absence of riparian vegetation, to name a few. The range of water temperature observed during the study was 15.1 to 20.9 C. Water temperatures were extremely variable during the 6-week study period as illustrated in Figure 3. At times, observed water temperatures were quite similar and at other times, quite dissimilar. No station ever demonstrated any consistent trend.

Apart from its importance in sustaining aquatic life, the presence of dissolved oxygen serves as an indicator that excessive oxygen-demanding substances are not present. It is therefore desirable for oxygen to be present in water at or near saturation. Levels of dissolved oxygen recorded at stream stations in the Little Cache watershed are presented both as mg $liter^{-1}$ and as percent saturation.

Observed concentrations of dissolved oxygen were quite low during the study period, ranging from 1.0 to 7.6 mg $liter^{-1}$. The mean concentrations observed at the stream stations ranged from 3.25 to 3.86 mg $liter^{-1}$. Percent saturation ranged from 10.1 to 75.3%, but mean values were from 32.54 to 38.66%.

Since dissolved oxygen concentrations observed during this study were often below 5.0 mg liter^{-1}, dissolved oxygen concentrations were checked at the stream stations over approximately an 18-hour period (from 1330 hours on 22 October 1975 to 0630 hours on 23 October 1975) to determine how much lower the concentrations became between sunset and sunrise. This can be a critical time period because, with the continued respiration of the entire aquatic community and no supplementary oxygen production through primary production, near oxygen depletion can occur. Results are summarized in Table 4.

The greatest difference was recorded from station 3 where dissolved oxygen concentrations decreased by 1.9 mg liter^{-1} over the 18-hour period. Little change was recorded from station 1, only 0.4 mg liter^{-1}. Station 2 was intermediate with 1.2 mg liter^{-1}. As concentrations recorded in the early afternoon were only about 30 to 55% of saturation, the additional loss of dissolved oxygen through the night would be an additional burden to the biota.

It is likely that the low dissolved oxygen concentrations observed throughout the study period were an artifact of the season in which the study was conducted. As illustrated in Figure 2, there was essentially a closed canopy over the stream stations. The additional oxygen demand exerted by leaf fall could make these low concentrations merely an autumn phenomenon.

Free carbon dioxide concentrations ranged from 4.8 to 95.0 mg liter^{-1} at all stream stations, with mean concentrations between 23.19 and 33.07 mg liter^{-1}. As described above, the decomposition of allochthonous materials derived from leaf fall was believed partly responsible for the low dissolved oxygen levels encountered in this study. This decomposition and accompanying oxygen demand are also believed responsible, in part, for the unusually high concentrations of free carbon dioxide.

Elevated carbon dioxide levels can interfere with respiration in fish thus affecting oxygen uptake. While most species of fish can extract dissolved oxygen from water below 60 mg liter^{-1} of free carbon dioxide, some interferences have been observed at higher concentrations (Committee on Water Quality Criteria 1972). Concentrations in excess of 85 mg liter^{-1} were recorded from station 1 in Little Cache Creek on 29 October 1975. In combination with low dissolved oxygen (2.1 to 2.4 mg liter^{-1}, early afternoon) and low hydrogen ion concentration as pH (6.4 to 6.5) conditions unsuitable to aquatic life could have occurred.

The complex interactions between carbon dioxide, bicarbonate and carbonate ions, and pH can be broadly summarized as waters with greater alkalinities are least subject to extreme variations in pH because of the buffering capacity, or the ability of the system to absorb carbon dioxide. Since the toxicity of most pollutants can be a function of pH and the tolerance of aquatic organisms to low dissolved oxygen, high temperature, cations, and anions also varies as a function of pH, the hydrogen ion concentration, expressed as pH, is a very important parameter.

Table 4. Diurnal variations in water temperature (C) and dissolved oxygen (mg liter^{-1}) at three stream stations in the Little Cache Creek-Dutchman Creek project area.

DATE	HOURS	STATION 1 TEMP.	STATION 1 D.O.	STATION 2 TEMP.	STATION 2 D.O.	STATION 3 TEMP.	STATION 3 D.O.
22 October 1975	1330-1430	19.2	2.6	15.3	5.4	16.0	4.1
22 October 1975	1830-1900	17.4	2.3	15.5	5.2	16.0	3.6
23 October 1975	0015-0045	15.6	2.0	15.0	4.6	15.3	2.8
23 October 1975	0600-0630	14.1	2.2	15.0	4.2	14.7	2.2

Levels of pH observed in this study were frequently below neutral (pH 7). The range at all stream stations was 6.4 to 7.5 with mean values from 6.92 to 6.98. Since the stream water was weakly buffered (total alkalinity and hardness both approximately 100 mg liter^{-1} as $CaCO_3$), pH would tend to vary as concentrations of free carbon dioxide increased or decreased.

Residues were quite variable at all stations with concentrations fluctuating over a considerable range during the 6-week sampling program (Table 2, Fig. 3). No station exhibited consistently higher or lower concentrations for any form of residue.

Parameters For Which Stations 1 and 2 Were Significantly Different From Station 3

For 10 parameters measured in the Little Cache watershed project area, stations 1 and 2 were not significantly different (0.05 level) from one another, but both stations were significantly different from station 3. In all instances, the highest mean concentration or level was recorded from station 3 (Table 3). These parameters included total dissolved ionizable solids, hardness, phosphorus (total and soluble orthophosphate), nitrogen (nitrate, nitrite, ammonia, and total), chloride, and flow.

Flow was greatest at the farthest downstream sampling station below the confluence of Little Cache Creek and Dutchman Creek (Fig. 1). In addition, the Vienna municipal wastewater treatment plant effluent was discharged into Little Cache Creek below station 2. Therefore, its volume (approximately 0.06 mgd) would be a sizable contribution to the total flow during the autumn low flow period at station 3, downstream in Dutchman Creek.

The significantly higher concentrations observed at station 3 for the parameters listed above are therefore considered to be the combined result of downstream position and wastewater effluent. The concentrations of most physical and chemical parameters have been demonstrated repeatedly to increase downstream. Likewise, the parameters listed above are generally present in higher-than-background concentrations in municipal wastewater treatment plant effluents.

Major sources of phosphorus to fresh water include runoff from surrounding agricultural land and municipal wastewater effluents. The source of phosphorus can frequently be determined by considering its form in water. Total phosphorus is derived chiefly from the particulate matter in water and often reflects an agricultural source. Thus, total phosphorus concentrations are generally positively correlated with turbidity.

High concentrations of soluble orthophosphate most often reveal a municipal wastewater source. Concentrations observed at station 3, below the outfall of the Vienna wastewater treatment plant, were generally higher than those observed at stations 1 or 2 above the influence of the plant.

Observed total nitrogen concentrations in the project area were low, mean concentrations approximately 1 mg liter^{-1} or less. In natural surface waters, nitrogen usually occurs most frequently in its oxidized form, nitrate. Since nitrogen is readily leached from soil, nitrate levels are often highest in spring following flooding or heavy rains. Concentrations in excess of 10 mg liter^{-1} as N are not uncommon in central Illinois streams and rivers at such times.

In the Little Cache Creek-Dutchman Creek watershed, however, nitrate and nitrite rarely exceeded 0.01 mg liter^{-1} as N. Virtually all of the nitrogen existed as unstabilized ammonia or organic nitrogen. Of these two forms, organic nitrogen comprised the greatest percentage (Table 2, Fig. 3). It is reasonable that the unstabilized nitrogenous compounds contributed to the severe oxygen demand described above. The decomposition of deciduous leaves would contribute organically-bound nitrogen at all stations while the discharge of unstabilized municipal waste would be a further source evident at station 3 (Table 2).

Dutchman Creek Versus Little Cache Creek

Total alkalinity, turbidity, and total iron were not significantly different at stations 1 and 3, but levels observed at station 2 were significantly different (0.05 level) from those at either stations 1 or 3 (Table 3). These parameters reflect possible differences in the Dutchman Creek watershed (stations 1 and 3) versus the Little Cache Creek watershed (station 2). This is not altogether a complete explanation, however, for these major watershed differences should have been apparent among the other parameters (*e.g.*, hardness, chloride, sulfate, residues, etc.). It is likely that the presence of Vienna effluent downstream at station 3 overshadowed these major watershed differences, making stations 1 and 2 appear more similar than they would be in the absence of the wastewater treatment plant effluent downstream.

Other Relationships

The relationships existing among stream stations for organic nitrogen, sulfate, and silica were not directly applicable to the three categories described above (Table 3). Station 1 was significantly lower (0.05 level) for organic nitrogen, with stations 2 and 3 of similar, but higher, concentrations. Sulfate increased downstream with station 2 intermediate in concentration. Station 1 was intermediate in concentration for silica, not significantly different from either station 2 or 3.

Dutchman Lake

One series of samples was analyzed from Dutchman Lake to provide background data for the environmental impact statement. Dissolved oxygen concentrations were in excess of 9.5 mg liter^{-1} from surface to bottom at 5 m. The water was soft, with total alkalinity of approximately 100 mg liter^{-1} as $CaCO_3$ and hardness near 70 mg liter^{-1} as $CaCO_3$. Concentrations of phosphorus were quite low, both total and soluble orthophosphate less than 0.05 mg liter^{-1} as P. Nitrogen concentrations were comparable to those observed at the stream stations, generally less than 1 mg liter^{-1} total nitrogen.

Comparison To The Water Pollution Regulations of Illinois. Of the 22 physical, chemical, and biological parameters measured in this study, 10 are specifically covered in the State of Illinois Environmental Protection Agency's (IEPA) Water Pollution Regulations of Illinois (7 March 1972) for general use, public and food processing water supply, and effluent standards.

Those parameters not included in the general standards, applicable to this project, included free carbon dioxide, total alkalinity, hardness, turbidity, soluble orthophosphate, nitrate, nitrite, organic nitrogen, residues, silica, and flow. Their concentrations or levels were within ranges often encountered in Illinois surface waters at the time of year sampling was conducted and, as such, were not considered to be limiting to aquatic life or potential recreational uses of the streams.

The general standards are intended to protect Illinois waters for aquatic life, agricultural use, primary and secondary contact use (swimming and boating), most industrial uses, and to guarantee the esthetic quality of the aquatic environment. These standards deal primarily with water temperature, dissolved oxygen, hydrogen ion concentration as pH, phosphorus, toxic and potentially toxic materials, and fecal coliform bacteria. The general water quality standards, except water temperature, apply at all times except during periods when stream flow is less than the average 7-day low flow which occurs once in 10 years.

Water temperatures observed during this study were all within the limits of the standards. Hydrogen ion concentration as pH were low (mean pH 6.92 to 6.98), but generally within the established range, 6.5 to 9.0. Two of three values recorded from station 1 on 29 October 1975 were 6.4, 0.1 unit below the established minimum.

Concentrations of dissolved oxygen cannot be less than 6.0 mg liter liter^{-1} during at least 16 hours of any 24-hour period, nor less than 5.0 mg liter^{-1} at any time. Mean concentrations of dissolved oxygen (early afternoon measurements) ranged from 3.25 mg liter^{-1} at station 3 to 3.86 mg liter^{-1} at station 2. Only three of 54 dissolved oxygen determinations were above 6.0 mg liter^{-1}. Only 20% of the concentrations observed in this study were above 5.0 mg liter^{-1}. Low dissolved oxygen concentrations are frequently observed during autumn when leaf fall occurs. This allochthonous material can exert a considerable oxygen demand. During decomposition, not only can dissolved oxygen concentrations be low, but hydrogen ion concentration as pH may decrease as the free carbon dioxide generated by decomposition and respiration increases.

Total phosphorus (as P) shall not exceed 0.05 mg liter^{-1} in any reservoir or lake or in any stream at the point where it enters any reservoir or lake. There are few streams or lakes in Illinois which could meet this recommendation. Concentrations of total phosphorus were in excess of this recommended IEPA maximum at stream stations in the project area. In Dutchman Lake, however, mean total phosphorus concentrations were 0.01 mg liter^{-1} as P on 19 December 1975 (appendix).

In the general standards, the levels of various chemical constituents which may occur in Illinois surface waters included five parameters which were monitored at the stream stations and determined for one series of samples from Dutchman Lake: ammonia nitrogen (as N), 1.5 mg liter^{-1}; chloride, 500 mg liter^{-1}; total iron, 1.0 mg liter^{-1}; sulfate (as S), 167 mg liter^{-1}; and total dissolved solids, 1,000 mg liter^{-1}.

Mean concentrations and ranges of ammonia nitrogen were below established limits during the sampling period (Table 2). The overall range of ammonia observed during the project period at all stations was 0.02 to 1.11 mg liter^{-1} as N.

Chloride concentrations were low, overall range observed 3.8 to 18.3 mg liter^{-1}. These concentrations were considerably below the established IEPA standard.

Mean concentrations of total iron exceeded the 1.0 mg liter^{-1} IEPA general water quality standard at all stream stations. At all stations, the range of concentration was 0.60 to 2.8 mg liter^{-1}. Concentrations of total iron are chiefly derived from the particulate matter suspended in the water. As such, total iron concentrations increase or decrease as a function of turbidity.

Sulfate concentrations were low, overall range observed 7.5 to 20.8 mg liter^{-1} as S. These concentrations were below the IEPA general water quality standard.

The values observed for total dissolved ionizable solids (as NaCl) ranged from 145 to 299 mg liter^{-1}, considerably below the general standard of 1,000 mg liter^{-1}. Dissolved residue concentrations ranged from 72 to 257 mg liter^{-1}.

The bacteriological portion of the IEPA general water quality standards specifies that, based upon a minimum of five samples taken during a 30-day period, fecal coliform bacteria concentrations may not exceed a geometric mean of 200 per 100 ml, nor may more than 10% of the samples during any 30-day period exceed 400 per 100 ml.

Only one series of bacteriological samples was performed in this study: Dutchman Lake, 19 December 1975. Three surface grab samples were analyzed from the center of the lake for total coliform bacteria, fecal coliform bacteria, and fecal streptococci. Results are presented in the appendix.

Concentrations of "total" coliforms were zero. Soil coliforms contribute virtually all organisms counted as total coliforms. Since the ground was frozen at the time of sampling, their concentrations were understandably low. These would increase when the ground thawed and surface runoff increased.

Concentrations of fecal coliforms averaged 300 per 100 ml. While this exceeded the 200 per 100 ml recommendation, it was less than the 400 per 100 ml maximum established for no more than 10% of the samples in any 30-day period. Fecal streptococci concentrations were of similar magnitude, 302 per 100 ml.

Biological Inventory

An aquatic ecosystem and its surrounding riparian community consist of a great number of microhabitats, each characterized by very specific physical and chemical conditions, but all sharing certain major physical and chemical conditions characteristic of a particular body of water or geographic region. Each microhabitat also supports a characteristic fauna and flora. A complete biological inventory would sample all microhabitats in the study area at all seasons, resulting in a very long list of organisms. The inventory presented below is not a complete one. Time restrictions imposed upon this study precluded intensive sampling. Hence, the inventory which follows is based upon recent records for specimens and voucher specimens in the collection of the Illinois Natural History Survey and published records, as follows: mayflies, Burks (1953); caddisflies, Ross (1944); hydrophilid beetles, Wooldridge (1967); and amphibians and reptiles, Smith (1961).

For purposes of this inventory, all potential aquatic microhabitats are grouped into seven major habitat types: riparian, bank, marginal vegetation, gravel riffle, sand pool, clay pool, and sticks and roots. No distinction is made as to flowing or standing water as these habitat types occur in both (riffle habitat often persists as wave-swept gravel or rocky shores of lakes and impoundments).

Crustacea. Table 5 lists seven taxa of crustaceans as known or likely to occur in the project area. Insufficient information exists regarding some of these species to determine whether or not their status is endangered or threatened.

Aquatic Insects. The predominant aquatic macroinvertebrates of the Little Cache Creek-Dutchman Creek ecosystem are aquatic insects. This fauna is poorly known and it is not possible to present a complete inventory for the group, especially in the absence of a thorough sampling program. Five orders of insects, in total or in part, have been relatively well-studied in Illinois. Based upon these previous studies, Table 6 lists 130 taxa of aquatic insects known or likely to occur in the project area.

Table 5. Aquatic crustaceans known or likely to occur in the Little Cache Creek-Dutchman Creek watershed.

LITTLE CACHE CREEK - DUTCHMAN CREEK FAUNAL INVENTORY

SPECIES	RIPARIAN	BANK	MARGINAL VEG.	GRAVEL RIFFLE	SAND POOL	CLAY POOL	STICKS ROOTS
ISOPODA							
Lirceus sp.				C			
AMPHIPODA							
Hyalella azteca (Saussure)			C				
DECAPODA							
Palaemonetes kadiakensis Rathburn			C			C	C
Procambarus acutus (Girard)						C	C
P. clarkii (Girard)			U				U
Orconectes illinoiensis Brown				C			
Cambarus diogenes Girard		C	C				

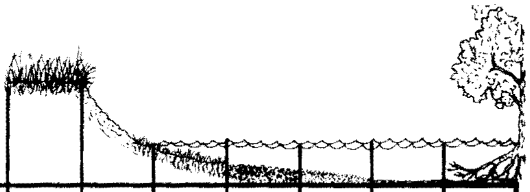
C = Common, usually readily observed in the project area.

U = Uncommon, but very likely to be observed in the project area.

R = Rare, project area within the range of the species, but species not likely to be observed.

Table 6. Aquatic insects known or likely to occur in the Little Cache Creek-Dutchman Creek watershed.

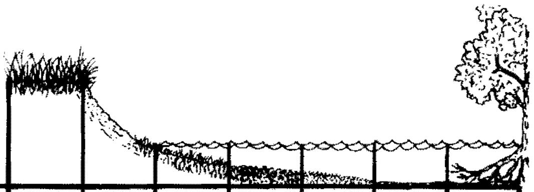
LITTLE CACHE CREEK - DUTCHMAN CREEK FAUNAL INVENTORY



SPECIES	RIPARIAN	BANK	MARGINAL VEG.	GRAVEL RIFFLE	SAND POOL	CLAY POOL	STICKS ROOTS
EPHEMEROPTERA - mayflies							
Baetidae							
Baetis propinquus (Walsh)			U	U			
Callibaetis fluctuans (Walsh)			C				
Caenidae							
Caenis forcipata McDunnough			C				
Caenis hilaris (Say)			C				
Caenis simulans McDunnough			C				
Ephemerellidae							
Ephemerella dorothea Needham			C	C			C
Ephemeridae							
Hexagenia limbata (Say)						C	
Heptageniidae							
Heptagenia diabasia Burks				C			
Pseudiron centralis McDunnough				U			
Stenonema bipunctatum (McDunnough)				C			C
Stenonema canadense (Walker)				C			
Stenonema minnetonka Daggy				C			C
Stenonema tripunctatum (Banks)				C			C
Leptophlebiidae							
Choroterpes basalis (Banks)				U			U
HETEROPTERA - true bugs							
Corixidae							
Cenocorixa spp.			U				
Hesperocorixa nitida (Fieber)			U				
Palmacorixa buenoi Abbott			U				
Sigara alternata (Say)			C				
Sigara grossolineata Hungerford			U				
Sigara virginiensis Hungerford			U				
Trichocorixa calva (Say)			C				
Trichocorixa kanza Sailer			C				
Trichocorixa naias (Kirkaldy)			U				
Gerridae							
Gerris spp.			C	C	C	C	
Rheumatobates rileyi palosi Blatchley			C				
Notonectidae							
Notonecta irrorata Uhler			U				
COLEOPTERA - beetles							
Haliplidae							
Peltodytes dunavani Young			C				
Peltodytes duodecimpunctatus (Say)			U				
Peltodytes edentulus (LeConte)			C				
Peltodytes lengi Roberts			R				
Peltodytes litoralis Matheson			R				
Peltodytes muticus (LeConte)			U				
Peltodytes pedunculatus (Blatchley)			R				
Peltodytes sexmaculatus Roberts			C				
Haliplus fasciatus Aubé			R				
Haliplus triopsis Say			U				
Hydrophilidae							
Anacaena limbata (Fabricius)			R				
Berosus aculeatus LeConte			U				
Berosus exiguus (Say)			R				
Berosus fraternus LeConte			R				
Berosus infuscatus LeConte			U				
Berosus pantherinus LeConte			R				
Berosus peregrinus (Herbst)			U				
Berosus pugnax LeConte			R				
Berosus striatus (Say)			R				
Chaetarthria atra (LeConte)			R				
Cymbiodyta beckeri picta Smetana			C				
Cymbiodyta blanchardi Horn			U				
Enochrus cinctus (Say)			R				
Enochrus consortus Green			R				
Enochrus ochraceus (Melsheimer)			R				
Enochrus pygmaeus nebulosus (Say)			C				
Helocharis maculicollis Mulsant			R				
Hydrochara obtusata (Say)			R				
Hydrophilus triangularis Say			R				
Laccobius agilis (Randall)			U				
Paracymus confluens Wooldridge			R				
Paracymus confusus Wooldridge			R				
Paracymus subcupreus (Say)			C				
Tropisternus blatchleyi modestus d'Orchymont			R				
Tropisternus collaris striolatus (LeConte)			C				
Tripisternus lateralis nimbatus (Say)			C				
Tropisternus mixtus LeConte			R				
Tropisternus natator d'Orchymont			U				

Table 6. (concluded).

LITTLE CACHE CREEK - DUTCHMAN CREEK FAUNAL INVENTORY



SPECIES	RIPARIAN	BANK	MARGINAL VEG.	GRAVEL RIFFLE	SAND POOL	CLAY POOL	STICKS ROOTS
TRICHOPTERA - caddisflies							
Hydropsychidae							
Cheumatopsyche analis (Banks)				C			
Cheumatopsyche campyla Ross				C			
Diplectrona modesta Banks				U			
Hydropsyche bidens Ross				C			
Hydropsyche incommoda Hagen				C			
Hydropsyche orris Ross				C			
Hydropsyche simulans Ross				C			
Potamyia flava (Hagen)				C			
Hydroptilidae							
Hydroptila grandiosa Ross			U	U			
Hydroptila hamata Morton			U	U			
Hydroptila spatulata Morton			U	U			
Leptoceridae							
Athripsodes tarsi-punctatus (Vorhies)			C				C
Athripsodes transversus (Hagen)			C	C			C
Leptocella candida (Hagen)			C				C
Oecetis inconspicua (Walker)			C				C
Philopotamidae							
Chimarra feria Ross				C			
Chimarra obscura (Walker)				U			
Wormaldia shawnee Ross				U		U	
Polycentropidae							
Neureclipsis crepuscularis (Walker)					C		
Psychomyiidae							
Polycentropus cinereus Hagen			C		C		
Rhyacophilidae							
Rhyacophila fenestra Ross				U			
DIPTERA - flies							
Chironomidae							
Chironominae							
Chironomus attenuatus Walker						C	C
Chironomus riparius Meigen						C	C
Chironomus stigmaterus Say						R	R
Cryptochironomus fulvus Johannsen complex			C			C	C
Dicrotendipes nervosus Staeger			C			C	C
Dicrotendipes modestus Say			C			C	C
Endochironomus nigricans Johannsen						R	
Glyptotendipes (Phytotendipes) lobiferus (Say)						U	
Micropsectra sp.			U	U			U
Paratendipes albimanus (Meigen)						U	
Phaenopsectra (Tribelos) jucundus Walker						R	
Polypedilum illinoense (Malloch)			U			U	U
Polypedilum scalaenum (Schrank)			C			C	C
Pseudochironomus richardsoni Malloch						U	
Tanytarsus sp.			C	U		C	C
Xenochironomus festivus Say						U	
Orthocladiinae							
Cricotopus bicinctus (Meigen)			C	C			C
Tanypodinae							
Ablabesmyia (Ablabesmyia) annulata (Say)			U		U		U
Coelotanypus scapularis (Loew)			U				U
Conchapelopia (Conchapelopia) rurika (Roback)			U		U		U
Larsia decolorata (Malloch)			R		R		R
Natarsia baltimoreus (Macquart)			U			U	U
Procladius (Psilotanypus) bellus (Loew)			C		C		C
Procladius (Procladius) sublettei Roback			U		U		U
Psectrotanypus (Psectrotanypus) dyari (Coquillett)			U				U
Tanypus (Apelopia) neopunctipennis Sublette			C			U	C
Tanypus (Tanypus) stellatus Coquillett			C			U	C
Culicidae							
Aedes canadensis Theobald					C		
Aedes sollicitans (Walker)							R
Aedes sticticus (Meigen)					C		
Aedes vexans (Meigen)			C		C		
Anopheles punctipennis (Say)			U		U		U
Anopheles quadrimaculatus Say			C				
Culex erraticus (Dyar & Knab)			C				
Culex peccator Dyar & Knab			U				
Culex pipiens Linnaeus			C		C		
Culex quinquefasciatus Say			C				
Culex restuans Theobald					C		
Culex salinarius Coquillett			U				
Culex territans Walker			U		U		
Culiseta inornata (Williston)			U				
Psorophora ciliata (Fabricius)					U		
Psorophora confinnis (Arribalzaga)					U		
Psorophora cyanescens (Coquillett)					U		
Psorophora ferox (Humboldt)					U		

Fourteen species of mayflies (Ephemeroptera) are listed for the project area (Burks 1953). Especially abundant in marginal vegetation are members of the genus *Caenis*. *Caenis* are replaced by *Stenonema* in gravel riffles.

Water bugs (Heteroptera) are not well known in southern Illinois, but are included here because 12 species are recorded specifically for the study stream (Table 6). Especially abundant are the water boatmen (Corixidae) which inhabit marginal vegetation. Further collection in the project area would add numerous species and several additional families to this list.

Only two families of aquatic beetles (Coleoptera) have been investigated thoroughly in Illinois; the crawling water beetles, or Haliplidae (W. U. Brigham, unpublished), and the water scavenger beetles, or Hydrophilidae (Wooldridge 1967). Ten and 28 species, respectively, are listed in Table 6 for these families. Again, marginal vegetation appears as the preferred habitat. This is not intended to be representative for the order, however, as unreported groups are characteristic of gravel riffles (Elmidae), sticks and roots (Dryopidae), and sand pools (Dytiscidae). The total water beetle fauna of the project area is probably near 100 species.

Table 6 further lists 21 species of caddisflies in the project area. The Trichoptera have been thoroughly investigated in Illinois (Ross 1944) and it is felt that few additional species would be added by an exhaustive inventory. Particularly abundant are the genera *Cheumatopsyche* and *Hydropsyche*, in gravel riffles, and *Hydroptila* and *Athripsodes*, which occur both in gravel riffles and marginal vegetation.

Although several families of Diptera have aquatic members, only two, the Chironomidae and Culicidae, typically yield large numbers of species in a given area. Table 6 lists 45 species of Chironomidae and 18 of Culicidae as known or likely to occur in the project area. It is probable that additional Chironomidae (midges) occur in Little Cache Creek and Dutchman Creek as the group is vary diverse and generally poorly known. By comparison, the Culicidae (mosquitoes) are well-known, no doubt due to their importance as vectors. A discussion of this aspect of the mosquitoes appears below.

As would be expected for such a diverse group, Chironomidae have invaded virtually all aquatic habitats. The Culicidae, however, are typically associated with standing and/or stagnant water. In streams, they are often concentrated in small pocks of standing water. Furthermore, those species associated with the sand pool habitat in Table 6, are considered to be nektonic or planktonic, *i. e.*, reasonably motile and suspended in the water column rather than associated with the substrate as benthic organisms typically are.

Vectors. Of the mosquitoes (Culicidae) listed in Table 6, four deserve special mention because of their importance as vectors of human disease. *Anopheles quadrimaculatus* Say is the most important carrier of malaria in the central states. It is common in small pools, backwaters, and shallow basins of large lakes and marshes. *Anopheles punctipennis* (Say) is the most abundant and widespread of the *Anopheles*. It, too, carries malaria (occasionally) and is found in backwaters of streams and lakes and in cattail marshes.

Culex restuans Theobald transmits encephalitis to birds. It is found commonly in farm and fish ponds and in other standing water where humus or organic matter is present. The St. Louis strain of encephalitis is transmitted to humans by *Culex pipiens* Linnaeus, an abundant mosquito inhabiting ponds and pools receiving organic pollution.

Fishes. Table 7 lists 27 species of fish as known or likely to occur in the project area. Although all aquatic habitats are utilized by these species, clay-bottomed pools with sticks, logs, and eroded root masses appear to be the preferred habitat.

Ackerman (1975) lists the banded pigmy sunfish as rare and endangered and indicates that it occurs in Johnson County. Habitat requirements of this species are such that it is not likely to be present in the project area. None of the species listed in Table 7 are listed as rare and endangered by Ackerman (1975).

Amphibians. Table 8 lists 24 species of amphibians as known or likely to occur in the project area. Most species are confined to riparian habitat except during the breeding period when they return to the water. Two uncommon salamanders, the mud puppy and lesser siren, are strictly aquatic throughout their life cycle.

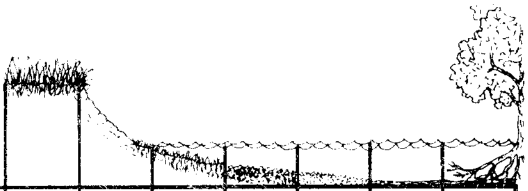
Ackerman (1975) lists two amphibians from Johnson County as rare and endangered, the mole salamander and eastern spadefoot. Distributional data presented in Table 8 indicate that two additional species listed elsewhere by Ackerman as rare and endangered probably occur in the project area. These are the long-tailed salamander and the wood frog. A review of proposed activities in the project area and the specific habitat utilization by these four species indicates that impact upon these species would be minimal to non-existent.

Reptiles. Table 9 lists 33 species of reptiles as known or likely to occur in the project area. Most turtles, water snakes (*Natrix*), and the cottonmouth are aquatic. The remainder of the reptiles are almost exclusively riparian.

Ackerman (1975) does not indicate the presence of any rare and endangered reptiles in Johnson County. Table 9 presented here indicates that three additional species listed elsewhere by Ackerman as rare and endangered probably occur in the project area. These are the mud turtle, worm snake, and timber rattlesnake. The timber rattlesnake is listed as endangered by the Illinois Nature Preserves Commission (1973). Implementation of the proposed project would adversely affect populations of the mud turtle. This species is southern in distribution and southern Illinois represents the northern-most extension of the species. The mud turtle is

Table 7. Fishes known or likely to occur in the Little Cache Creek-Dutchman Creek watershed.

LITTLE CACHE CREEK - DUTCHMAN CREEK FAUNAL INVENTORY



SPECIES	RIPARIAN	BANK	MARGINAL VEG.	GRAVEL RIFFLE	SAND POOL	CLAY POOL	STICKS ROOTS
CLUPEIDAE							
Dorosoma cepedianum (Lesueur) Gizzard shad					U	U	
ESOCIDAE							
Esox americanus vermiculatus Lesueur Grass pickerel			C				
CYPRINIDAE							
Campostoma anomalum (Rafinesque) Stoneroller				C			
Notemigonus crysoleucas (Mitchill) Golden shiner						C	C
Notropis fumeus Evermann Ribbon shiner						C	
Notropis lutrensis (Baird & Girard) Red shiner					C	C	
Notropis umbratilis (Girard) Redfin shiner					C	C	
Pimephales notatus (Rafinesque) Bluntnose minnow				C	C		
Semotilus atromaculatus (Mitchill) Creek chub					C	C	
CATOSTOMIDAE							
Catostomus commersoni (Lacépède) White sucker					C	U	
Erimyzon oblongus (Mitchill) Creek chubsucker					C	C	
ICTALURIDAE							
Ictalurus natalis (Lesueur) Yellow bullhead						U	U
CYPRINODONTIDAE							
Fundulus olivaceus (Storer) Blackspotted topminnow			C	C	C		
APHREDODERIDAE							
Aphredoderus sayanus (Gilliams) Pirate perch						C	U
CENTRARCHIDAE							
Centrarchus macropterus (Lacépède) Flier						C	C
Lepomis cyanellus Rafinesque Green sunfish			C			C	C
Lepomis gulosus (Cuvier) Warmouth						C	C
Lepomis macrochirus Rafinesque Bluegill			C		C	C	C
Lepomis megalotis (Rafinesque) Longear sunfish			C		C	C	C
Pomoxis annularis Rafinesque White crappie						U	U
Pomoxis nigromaculatus (Le Sueur Black crappie						U	U
PERCIDAE							
Etheostoma chlorosomum (Hay) Bluntnose darter						C	C
Etheostoma gracile (Girard) Slough darter						C	C
Etheostoma kennicotti (Putnam) Stripetail darter				C	C		
Etheostoma squamiceps Jordan Spottail darter				U		U	
Percina maculata (Girard) Blackside darter					U		
COTTIDAE							
Cottus carolinae (Gill) Banded sculpin				C			

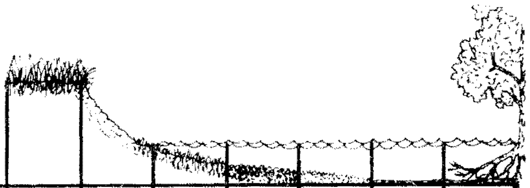
C = Common, usually readily observed in the project area.

U = Uncommon, but very likely to be observed in the project area.

R = Rare, project area within the range of the species, but species not likely to be observed.

Table 8. Amphibians known or likely to occur in the Little Cache Creek-Dutchman Creek watershed.

LITTLE CACHE CREEK - DUTCHMAN
CREEK FAUNAL INVENTORY



SPECIES	RIPARIAN	BANK	MARGINAL VEG.	GRAVEL RIFFLE	SAND POOL	CLAY POOL	STICKS ROOTS
AMBYSTOMATIDAE							
Ambystoma maculatum (Shaw) Spotted salamander	U						
Ambystoma opacum (Gravenhorst) Marbled salamander	C						
Ambystoma talpoideum (Holbrook) Mole salamander	R						
Ambystoma texanum (Matthes) Small-mouthed salamander	C						
Ambystoma tigrinum (Green) Tiger salamander	U						
SALAMANDRIDAE							
Notophthalmus viridescens Rafinesque Newt	U		U				
PLETHODONTIDAE							
Eurycea longicauda (Green) Long-tailed salamander	U						
Eurycea lucifuga Rafinesque Cave salamander	U						
Plethodon dorsalis Cope Zigzag salamander	R						
Plethodon glutinosus (Green) Slimy salamander	U						
PROTEIDAE							
Necturus maculosus (Rafinesque) Mud puppy					C		U
SIRENIDAE							
Siren intermedia LeConte Lesser siren			U				U
PELOBATIDAE							
Scaphiopus holbrooki (Harlan) Spadefoot	R						
BUFONIDAE							
Bufo americanus Holbrook American toad	C						
Bufo woodhousei fowleri Hinckley Fowler's toad	C	C					
HYLIDAE							
Acris crepitans Baird Cricket frog		C	C				
Pseudacris triseriata (Wied) Chorus frog	C						
Hyla crucifer (Wied) Spring peeper	C						
Hyla versicolor LeConte Gray treefrog	C						
RANIDAE							
Rana areolata Baird & Girard Crawfish frog	U						
Rana catesbeiana Shaw Bullfrog		C					
Rana clamitans Latreille Green frog	C	C					
Rana pipiens Schreber Leopard frog	C	C					
Rana sylvatica LeConte Wood frog	R						

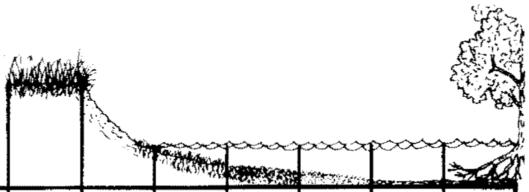
C = Common, usually readily observed in the project area.

U = Uncommon, but very likely to be observed in the project area.

R = Rare, project area within the range of the species, but species not likely to be observed.

Table 9. Reptiles known or likely to occur in the Little Cache Creek-Dutchman Creek watershed.

LITTLE CACHE CREEK - DUTCHMAN CREEK FAUNAL INVENTORY



SPECIES	RIPARIAN	BANK	MARGINAL VEG.	GRAVEL RIFFLE	SAND POOL	CLAY POOL	STICKS ROOTS
CHELYDRIDAE							
Chelydra serpentina (Linnaeus) Common snapping turtle			C				C
KINOSTERNIDAE							
Sternotherus odoratus (Latreille) Stinkpot			C				C
Kinosternon subrubrum (Lacépède) Mud turtle	U		R				
TESTUDINIDAE							
Terrapene carolina (Linnaeus) Eastern box turtle	C						
Chrysemys picta (Schneider) Painted turtle			C				C
Chrysemys scripta (Schoepff) Red-eared turtle			C				C
TRIONYCHIDAE							
Trionyx spiniferus LeSueur Spiny softshell		C			C		
IGUANIDAE							
Sceloporus undulatus (Latreille) Fence lizard	C						
TEIIDAE							
Cnemidophorus sexlineatus (Linnaeus) Six-lined racerunner		R					
SCINCIDAE							
Lygosoma laterale (Say) Ground skink	C						
Eumeces fasciatus (Linnaeus) Five-lined skink	C						
Eumeces laticeps (Schneider) Broad-headed skink	C						
COLUBRIDAE							
Carphophis amoenus (Say) Worm snake	U						
Diadophis punctatus (Linnaeus) Ringneck snake	C						
Farancia abacura (Holbrook) Mud snake	R	R					
Heterodon platyrhinos Latreille Eastern hognose snake	C	U					
Opheodrys aestivus (Linnaeus) Rough green snake	C						
Coluber constrictor Linnaeus Blue racer	C						
Elaphe obsoleta (Say) Black rat snake	C						
Lampropeltis calligaster (Harlan) Prairie kingsnake	C						
Lampropeltis getulus (Linnaeus) Common kingsnake	U						
Lampropeltis triangulum (Lacépède) Milk snake	R						
Thamnophis sirtalis (Linnaeus) Eastern garter snake	U						
Thamnophis proximus (Say) Western ribbon snake	R	R	R				
Virginia valeriae Baird & Girard Earth snake	U						
Storeria dekayi (Holbrook) DeKay's snake	U						
Storeria occipitomaculata (Storer) Red-bellied snake	R						
Natrix erythrogaster (Forster) Red-bellied water snake			U				
Natrix rhombifera (Hallowell) Diamond-backed water snake			U				
Natrix sipedon (Linnaeus) Northern water snake			C	C			
CROTALIDAE							
Agkistrodon piscivorus (Lacépède) Cottonmouth			R				
Agkistrodon contortrix (Linnaeus) Copperhead	U						
Crotalus horridus Linnaeus Timber rattlesnake	R						

C = Common, usually readily observed in the project area.

U = Uncommon, but very likely to be observed in the project area.

R = Rare, project area within the range of the species, but species not likely to be observed.

extremely rare in Illinois, although habitats in southern Illinois are identical with habitats in the southern United States where it is common.

Impact of the Proposed Action

Perhaps the most serious impact of site preparation and excavation activities is the increased load of suspended solids which will enter the stream as a result of clearing vegetation, earthmoving, and heavy equipment operation. Increased turbidity during site preparation and excavation will decrease the aesthetic quality of the stream.

Quite a variety of substances may enter the stream via this route. Incoming soil particles will carry phosphorus and pesticides bound to their surfaces. Soluble materials, including nitrates, will enter the stream and increase the total dissolved solids concentration. Organic matter entering the stream will increase the oxygen demand, lower dissolved oxygen concentrations, and increase free carbon dioxide concentrations. All of these detrimental effects will be increased if cleared vegetation is burned near the stream.

The impacts described above are detrimental and unavoidable. They are also short-term and will affect the environment only during and shortly after construction of the modified channel. These impacts may be mitigated by confining proposed activities to low-precipitation seasons when erosion of denuded areas would be minimal.

No long-term adverse impacts upon water quality are expected from the proposed channel modifications. In fact, as described below, some potentially beneficial side effects are anticipated. The major long-term water quality consideration would be, however, potential increased water temperatures which could result from the channel modifications.

Since only one stream bank will be altered, the adverse impacts commonly associated with increased water temperature will be minimized or eliminated. The adverse side effects of increased water temperature include the lower solubility of dissolved oxygen and the potential for enhanced algal growth in the enriched areas downstream from the Vienna municipal wastewater treatment plant during the warmer months of the year.

By maintaining a tree canopy along at least one bank of the stream, water temperature increases will be minimal. This is undoubtedly one of the most important long-term considerations since *any* impact which could reduce dissolved oxygen concentrations in these streams should be minimized because of the potential adverse effects upon aquatic life.

Dissolved oxygen concentrations were low at the stations sampled during autumn. Further decreases in the potential solubility of oxygen through higher water temperatures could have had serious consequences for aquatic life in Little Cache and Dutchman Creeks.

Direct loss by removal of the benthic community is expected in the area of the five grade transition sections. The fish populations of these reaches of stream will be displaced upstream or downstream. Return of fishes will be governed by a number of factors, but principally by the availability of suitable habitat and food organisms. Recolonization of the benthos, principally from upstream areas, should proceed rapidly.

The quality of any environment is frequently a function of a diversity of habitats within that environment. This habitat diversity is expressed in a diversity of organisms. In stream ecosystems, habitat diversity typically includes a succession of riffles and pools. This riffle-pool series is virtually lacking in the study area. Instead, the streams are steep-banked, have sand-clay substrates, and sluggish flow. Hard substrates are provided only by fallen branches and by rubble, generally in the vicinities of bridges. The proposed grade transition sections will create riffle habitat. Hence, habitat diversity may be increased with potential corresponding increases in species diversity. Side effects could be increased oxygenation of water and the creation of new feeding and spawning sites for aquatic animals.

A second result of these structures involves the creation of periphyton habitat. Periphyton is an attached community of microorganisms which develops best on hard (*e. g.*, rocks and branches), submerged substrates. This community plays an important role in the assimilation of dissolved organic matter and nutrients from the water. It behaves as an "in-stream trickling filter." In addition to physically improving reaeration by the creation of turbulent flow, deoxygenation will be reduced through the removal of oxygen-consuming substances by the periphyton.

The proposed design for channel modifications of Little Cache Creek and Dutchman Creek reflects innovative and careful planning to provide channel capacity for flood waters with minimal environmental impact. Especially notable are limitations to modify only one stream-bank, to alter that bank which provides the least wildlife and/or aquatic habitat, to place spoil material alongside the maintenance access road, and to spare most of the existing channel.

Literature Cited

Ackerman, K. 1975. Rare and endangered vertebrates of Illinois. Illinois Dept. Transp., Bur. Environ. Sci., Springfield. 50 pp.

Allen, J. S. 1971. Johnson County surface water resources. Illinois Dept. Cons., Springfield. 47 pp.

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1970. Standard methods for the examination of water and wastewater, 13th ed. Washington, D. C. 874 pp.

Burks, B. D. 1953. The mayflies, or Ephemeroptera, of Illinois. Illinois Nat. Hist. Surv. Bull. 26:1-216.

Committee on Water Quality Criteria. 1972. Water quality criteria 1972. Nat. Acad. Sci., Nat. Acad. Eng., Washington, D. C. 594 pp.

Environmental Protection Agency, Office of Media and Water Programs. 1971. 1968 inventory of municipal waste facilities, region V. Vol. 5, EPA Publ. No. OWP-1. 249 pp.

Illinois Environmental Protection Agency. 1972. Water pollution regulations of Illinois. Env. Prot. Agency, Springfield. 36 pp.

Kramer, C. Y. 1956. Extension of multiple range tests to group means with unequal numbers of replications. Biometrics 12:307-310.

Ross, H. H. 1944. The caddis flies, or Trichoptera, of Illinois. Illinois Nat. Hist. Surv. Bull. 23:1-326.

Smith, P. W. 1961. The amphibians and reptiles of Illinois. Illinois Nat. Hist. Surv. Bull. 28:1-298.

Wooldridge, D. P. 1967. The aquatic Hydrophilidae of Illinois. Illinois State Acad. Sci. Trans. 60:422-431.

APPENDIX

1 OCTOBER 1975

PARAMETERS[1]	STATION 1			STATION 2			STATION 3		
Water Temperature (C)	15.6	15.4	15.3	15.2	15.2	15.2	15.4	15.5	15.5
Dissolved Oxygen	7.5	7.6	7.3	4.8	5.5	5.3	4.9	5.0	4.8
Dissolved Oxygen (% saturation)	74.3	75.3	73.3	47.1	53.9	52.0	48.5	49.5	47.5
Free Carbon Dioxide	15.0	4.8	11.0	10.0	9.5	12.5	11.0	13.5	11.0
Hydrogen Ion Concentration (ρH)	7.1	7.5	7.2	7.3	7.3	7.2	7.3	7.2	7.3
Total Alkalinity (as $CaCO_3$)	77	76	78	90	90	90	89	89	89
Total Dissolved Ionizable Solids (as NaCl)	182	215	170	232	201	201	204	207	199
EDTA Hardness (as $CaCO_3$)	63	65	65	110	113	111	88	88	88
Turbidity (JTU)	84	130	112	116	118	104	82	103	78
Total Phosphorus (as P)	0.35	0.39	0.34	0.66	0.72	0.67	1.03	1.04	0.99
Soluble Orthophosphate (as P)	0.01	0.01	0.01	0.02	0.02	0.02	0.10	0.10	0.10
Nitrate (as N)	<0.01	<0.01	<0.01	0.06	0.06	0.05	0.29	0.31	0.30
Nitrite (as N)	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03
Ammonia (as N)	0.08	0.07	0.08	0.12	0.11	0.09	0.15	0.16	0.16
Organic Nitrogen (as N)	0.42	0.43	0.32	0.48	0.39	0.31	0.55	0.54	0.54
Total Nitrogen (as N)	<0.52	<0.52	<0.42	0.67	0.57	0.46	1.02	1.04	1.03
Total Iron	2.2	2.8	2.6	2.6	2.5	2.5	1.8	2.5	1.7
Sulfate (as S)	12.5	9.1	11.9	18.2	18.7	19.1	14.4	15.2	14.5
Residue, Total @ 180 C	90	136	120	185	174	172	157	181	148
Residue, Dissolved @ 180 C	80	72	80	121	141	168	140	149	144
Residue, Particulate @ 180 C	10	64	40	64	33	4	17	32	4
Molybdate-Reactive Silica (as SiO_2)	7.3	7.2	7.2	9.0	9.1	9.0	9.4	9.7	9.6
Chloride	9.7	6.6	6.2	7.8	7.4	7.4	11.7	11.5	11.5
Flow (m^3 sec^{-1})		0.02			0.02			0.40	

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[1] As mg $liter^{-1}$ except where other units are indicated.

9 OCTOBER 1975

PARAMETERS[1]	STATION 1			STATION 2			STATION 3		
Water Temperature (C)	16.4	16.8	16.2	16.8	16.2	16.2	16.0	15.7	15.8
Dissolved Oxygen	4.8	5.2	4.7	1.2	1.0	1.0	2.7	3.0	2.6
Dissolved Oxygen (% saturation)	48.7	53.3	47.2	12.3	10.1	10.1	27.0	30.0	26.0
Free Carbon Dioxide	10.0	10.5	12.0	18.0	20.0	20.0	34.0	34.0	35.0
Hydrogen Ion Concentration (ρH)	7.3	7.2	7.2	7.1	7.1	7.1	6.8	6.8	6.8
Total Alkalinity (as $CaCO_3$)	87	86	86	105	107	107	102	100	101
Total Dissolved Ionizable Solids (as NaCl)	193	196	190	258	249	253	247	247	247
EDTA Hardness (as $CaCO_3$)	73	75	75	129	130	129	105	106	109
Turbidity (JTU)	21	20	20	38	41	37	42	44	42
Total Phosphorus (as P)	0.37	0.37	0.40	1.82	1.77	1.86	0.89	0.97	0.88
Soluble Orthophosphate (as P)	0.02	0.02	0.03	0.21	0.22	0.22	0.07	0.07	0.07
Nitrate (as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.09	0.12
Nitrite (as N)	<0.01	<0.01	<0.01	0.02	0.01	0.02	0.03	0.03	0.03
Ammonia (as N)	0.14	0.26	0.10	0.25	0.32	0.30	0.20	0.16	0.37
Organic Nitrogen (as N)	0.26	0.14	0.40	1.05	1.18	1.10	0.50	0.64	0.33
Total Nitrogen (as N)	<0.42	<0.42	<0.52	<1.33	<1.52	<1.43	0.80	0.92	0.85
Total Iron	0.88	0.86	0.90	1.2	1.3	1.2	1.4	1.4	1.4
Sulfate (as S)	13.9	12.1	11.1	19.6	20.8	20.0	15.1	14.7	15.8
Residue, Total @ 180 C	192	198	201	261	264	269	252	245	246
Residue, Dissolved @ 180 C	180	178	198	250	257	256	250	241	245
Residue, Particulate @ 180 C	12	20	3	11	7	13	2	4	1
Molybdate-Reactive Silica (as SiO_2)	5.1	5.3	5.2	7.4	7.5	8.0	8.5	8.7	8.3
Chloride	6.9	6.8	6.8	11.9	11.2	11.3	15.4	14.9	14.9
Flow (m^3 sec^{-1})		0.01			0.02			0.10	

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[1] As mg $liter^{-1}$ except where other units are indicated.

14 OCTOBER 1975

PARAMETERS[1]	STATION 1			STATION 2			STATION 3		
Water Temperature (C)	17.5	17.3	17.3	20.9	20.2	20.2	19.2	19.0	19.0
Dissolved Oxygen	1.5	1.0	1.2	2.2	2.1	2.0	1.7	1.6	1.5
Dissolved Oxygen (% saturation)	15.6	10.4	12.4	24.4	22.8	21.7	18.2	17.0	16.0
Free Carbon Dioxide	32.0	32.0	36.0	12.5	8.0	9.5	18.0	21.0	22.0
Hydrogen Ion Concentration (ρH)	6.9	6.8	6.8	7.2	7.4	7.3	7.2	7.1	7.1
Total Alkalinity (as $CaCO_3$)	110	110	110	96	95	94	133	132	134
Total Dissolved Ionizable Solids (as NaCl)	221	224	224	205	198	198	299	299	289
EDTA Hardness (as $CaCO_3$)	96	97	105	95	94	93	134	138	134
Turbidity (JTU)	18	19	16	72	74	78	11	10	12
Total Phosphorus (as P)	0.76	0.71	0.78	0.88	0.89	0.85	2.44	2.39	2.45
Soluble Orthophosphate (as P)	0.10	0.17	0.11	0.06	0.05	0.05	0.62	0.62	0.60
Nitrate (as N)	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite (as N)	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (as N)	0.13	0.14	0.15	0.09	0.09	0.09	1.00	1.06	1.11
Organic Nitrogen (as N)	0.57	0.76	0.75	0.81	1.01	0.91	1.10	1.14	0.99
Total Nitrogen (as N)	0.74	<0.92	<0.92	<0.92	<1.12	<1.02	<2.12	<2.22	<2.12
Total Iron	0.89	0.96	0.95	2.1	2.1	2.0	0.62	0.62	0.60
Sulfate (as S)	12.5	10.9	10.9	9.5	10.9	9.9	16.0	17.2	16.0
Residue, Total @ 180 C	196	190	202	188	178	192	252	258	258
Residue, Dissolved @ 180 C	193	185	192	164	165	165	237	237	246
Residue, Particulate @ 180 C	3	5	10	24	13	27	15	21	12
Molybdate-Reactive Silica (as SiO_2)	7.7	7.7	7.5	9.0	9.0	8.8	9.8	9.3	9.8
Chloride	6.9	7.3	7.0	8.4	7.3	7.4	18.3	17.7	18.0
Flow (m^3 sec^{-1})		0.01			0.04			0.09	

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[1] As mg $liter^{-1}$ except where other units are indicated.

22 OCTOBER 1975

PARAMETERS[1]	STATION 1			STATION 2			STATION 3		
Water Temperature (C)	19.2	18.9	18.9	15.3	15.4	15.4	16.1	16.0	16.0
Dissolved Oxygen	2.6	2.0	2.5	5.2	5.4	5.6	4.2	4.1	4.1
Dissolved Oxygen (% saturation)	27.8	21.2	26.5	51.5	53.5	55.5	41.6	41.0	41.0
Free Carbon Dioxide	28.0	32.0	32.0	22.0	18.0	17.5	24.0	24.0	23.0
Hydrogen Ion Concentration (pH)	7.0	6.9	7.0	6.9	7.0	7.0	6.9	6.9	6.9
Total Alkalinity (as $CaCO_3$)	127	127	126	79	77	77	90	89	89
Total Dissolved Ionizable Solids (as NaCl)	222	202	227	145	151	150	217	216	219
EDTA Hardness (as $CaCO_3$)	105	110	112	73	72	73	112	111	114
Turbidity (JTU)	8	7	8	62	68	62	45	50	52
Total Phosphorus (as P)	0.87	0.84	0.89	0.57	0.57	0.55	1.23	1.15	1.10
Soluble Orthophosphate (as P)	0.19	0.19	0.19	0.09	0.06	0.06	0.20	0.23	0.22
Nitrate (as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	0.04	0.03
Nitrite (as N)	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.03	0.03	0.02
Ammonia (as N)	0.21	0.19	0.19	0.09	0.08	0.07	0.14	0.14	0.16
Organic Nitrogen (as N)	0.49	0.61	0.51	0.51	0.62	0.53	0.76	0.76	0.84
Total Nitrogen (as N)	<0.72	<0.82	<0.72	<0.62	<0.72	<0.62	1.00	0.97	1.05
Total Iron	1.2	1.1	1.1	1.6	1.8	1.7	1.4	1.3	1.4
Sulfate (as S)	9.3	10.5	10.1	7.5	8.7	8.2	19.0	20.7	19.1
Residue, Total @ 180 C	216	215	211	155	156	155	208	201	199
Residue, Dissolved @ 180 C	191	139	137	65	67	97	160	163	165
Residue, Particulate @ 180 C	25	76	74	90	89	58	48	38	34
Molybdate-Reactive Silica (as SiO_2)	8.8	9.0	8.7	3.9	3.7	3.7	5.4	5.3	5.3
Chloride	7.0	7.1	7.3	3.8	4.0	4.1	8.6	8.6	8.7
Flow (m^3 sec^{-1})		0.01			0.04			0.09	

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[1] As mg $liter^{-1}$ except where other units are indicated.

29 OCTOBER 1975

PARAMETERS[1]	STATION 1			STATION 2			STATION 3		
Water Temperature (C)	15.8	15.8	15.7	15.1	15.1	15.1	15.1	15.1	15.1
Dissolved Oxygen	2.1	2.3	2.4	5.0	5.5	5.8	3.8	3.2	3.5
Dissolved Oxygen (% saturation)	21.0	23.0	24.0	49.0	53.9	56.9	37.3	31.4	34.3
Free Carbon Dioxide	95.0	90.0	85.0	34.0	34.0	37.0	38.0	38.0	60.0
Hydrogen Ion Concentration (pH)	6.4	6.4	6.5	6.7	6.7	6.6	6.7	6.7	6.5
Total Alkalinity (as $CaCO_3$)	127	126	126	81	81	80	89	89	89
Total Dissolved Ionizable Solids (as NaCl)	239	229	227	171	166	168	184	184	183
EDTA Hardness (as $CaCO_3$)	105	105	107	81	81	80	83	84	82
Turbidity (JTU)	16	16	16	85	70	85	38	42	37
Total Phosphorus (as P)	0.46	0.39	0.39	0.64	0.55	0.60	0.88	0.97	1.01
Soluble Orthophosphate (as P)	0.11	0.12	0.12	0.10	0.10	0.10	0.24	0.25	0.27
Nitrate (as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite (as N)	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.02	0.02	0.02
Ammonia (as N)	0.12	0.12	0.12	0.05	0.06	0.04	0.11	0.11	0.10
Organic Nitrogen (as N)	0.48	0.48	0.48	0.55	0.44	0.46	0.69	0.69	0.70
Total Nitrogen (as N)	<0.62	<0.62	<0.62	<0.62	<0.52	<0.52	<0.83	<0.83	<0.83
Total Iron	0.62	0.63	0.64	2.4	2.6	2.2	1.5	1.5	1.5
Sulfate (as S)	10.1	8.0	9.2	10.3	9.6	7.7	7.7	8.9	10.1
Residue, Total @ 180 C	198	197	202	180	173	182	180	172	185
Residue, Dissolved @ 180 C	197	194	200	149	145	152	165	153	160
Residue, Particulate @ 180 C	1	3	2	31	28	30	15	19	25
Molybdate-Reactive Silica (as SiO_2)	10.3	10.4	10.4	4.6	4.7	4.5	6.2	6.2	6.1
Chloride	8.0	7.7	7.8	7.0	6.1	6.0	6.9	6.2	6.1
Flow (m^3 sec^{-1})		0.02			0.05			0.11	

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[1] As mg $liter^{-1}$ except where other units are indicated.

4 NOVEMBER 1975

PARAMETERS[1]	STATION 1			STATION 2			STATION 3		
Water Temperature (C)	18.8	18.8	18.8	16.8	16.6	16.5	16.8	16.5	16.5
Dissolved Oxygen	2.3	2.1	2.1	4.0	3.9	4.0	2.6	2.7	2.5
Dissolved Oxygen (% saturation)	24.3	22.2	22.2	41.0	39.6	40.6	26.7	27.4	25.4
Free Carbon Dioxide	24.0	24.0	22.0	46.0	46.0	43.0	50.0	42.0	42.0
Hydrogen Ion Concentration (pH)	6.9	6.9	6.9	6.6	6.6	6.6	6.7	6.8	6.8
Total Alkalinity (as $CaCO_3$)	92	92	90	80	79	77	128	128	128
Total Dissolved Ionizable Solids (as NaCl)	198	188	191	166	165	166	239	333	333
EDTA Hardness (as $CaCO_3$)	87	86	85	78	75	76	107	107	109
Turbidity (JTU)	23	23	24	68	69	71	7	7	8
Total Phosphorus (as P)	1.27	1.27	1.21	0.53	0.58	0.56	0.62	0.61	0.59
Soluble Orthophosphate (as P)	0.35	0.33	0.32	0.05	0.05	0.04	0.12	0.11	0.12
Nitrate (as N)	0.04	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite (as N)	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (as N)	0.29	0.28	0.33	0.14	0.05	0.15	0.15	0.26	0.23
Organic Nitrogen (as N)	0.61	0.62	0.57	0.46	0.55	0.55	0.55	0.44	0.37
Total Nitrogen (as N)	0.95	0.92	0.92	<0.62	<0.62	<0.72	<0.72	<0.72	<0.62
Total Iron	1.0	0.95	0.98	2.0	1.9	2.0	0.60	0.61	0.67
Sulfate (as S)	10.1	10.4	9.7	9.6	9.6	10.3	9.3	8.8	8.7
Residue, Total @ 180 C	96	97	112	108	108	112	146	157	158
Residue, Dissolved @ 180 C	90	92	96	73	97	90	128	129	152
Residue, Particulate @ 180 C	6	5	16	35	11	22	18	28	6
Molybdate-Reactive Silica (as SiO_2)	6.8	6.9	7.1	6.6	6.2	6.9	11.8	12.0	12.0
Chloride	8.1	7.6	7.5	5.1	5.1	5.1	9.9	10.2	10.1
Flow (m^3 sec^{-1})		0.02			0.05			0.11	

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[1] As mg $liter^{-1}$ except where other units are indicated.

DUTCHMAN LAKE
19 DECEMBER 1975

PARAMETER[1]	CONCENTRATION		
Water Temperature (C)			
Surface		6.5	
1 m		6.5	
2 m		6.5	
3 m		6.5	
4 m		6.5	
5 m		6.5	
Dissolved Oxygen			
Surface		10.0	
1 m		9.8	
2 m		9.8	
3 m		9.8	
4 m		9.8	
5 m		9.8	
Dissolved Oxygen (% saturation)			
Surface		81.0	
1 m		79.4	
2 m		79.4	
3 m		79.4	
4 m		79.4	
5 m		79.4	
Free Carbon Dioxide		1.15	
Hydrogen Ion Concentration (ρH)	8.23	8.23	8.20
Total Alkalinity (as $CaCO_3$)	70	102	104
Total Dissolved Ionizable Solids (as NaCl)	179	177	179
EDTA Hardness (as $CaCO_3$)	66	69	69
Turbidity (JTU)	30	30	29
Total Phosphorus (as P)	0.03	<0.01	<0.01
Soluble Orthophosphate (as P)	0.01	0.01	0.01
Nitrate (as N)	<0.01	<0.01	<0.01
Nitrite (as N)	0.05	0.08	0.05
Ammonia (as N)	0.02	0.05	0.03
Organic Nitrogen (as N)	0.98	0.65	0.67
Total Iron	0.69	0.65	0.60
Sulfate (as S)	14.9	14.5	14.9
Residue, Total @ 180 C	176	180	168
Molybdate-Reactive Silica (as SiO_2)	4.8	5.0	4.8
Chloride	7.8	6.7	6.7

DUTCHMAN LAKE
19 DECEMBER 1975

PARAMETER[1]	CONCENTRATION
Total Coliforms (# per 100 ml)	0
Fecal Coliforms (# per 100 ml)	300
Fecal Streptococci (# per 100 ml)	302

[1] As mg liter^{-1} except where other units are indicated.