Preliminary Draft

GEOCHEMICAL BUDGET FOR FILSON CREEK WATERSHED

by

Donald I. Siegel

Note: This includes the first ~~three chapters~~ 7 parts of the doctoral dissertation, "Geochemical Mass Balance of Filson Creek Watershed, Northeastern Minnesota."

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INTRODUCTION AND PURPOSE

The behavior of silicate minerals in the weathering environment and the effects of water-solute reactions on both the minerals and the resulting solution have been recently investigated for ground-water and surface-water systems. Through use of activity diagrams and an assumed equilibrium between solid and aqueous phases, Feth (1964) related ground-water quality of springs discharging from the Sierra Nevada batholith to the weathering products of feldspar. Garrels (1967) compared natural ground-water chemistry from major igneous rock types to calculated chemical quality based on theoretical weathering reactions of silicate minerals to kaolinite. Garrels and MacKenzie (1967) elaborated on this approach and stoichiometrically back-reacted the chemical quality of an average spring water reported by Feth (1964) with kaolinite to reproduce the original mineralogy of the bedrock.

These ground-water studies together have suggested that; most dissolved silica in ground water is derived from the weathering of silicate minerals other than quartz, reactions are so rapid that waters remain in near-equilibrium with one or more phases at all times, aluminum is chemically conserved, and that the chief buffer system is the CO_2 system (Bricker and Garrels, 1967).

Norton (1974) extended these studies to evaluate the surface water chemistry of the Rio Tanama system in Puerto Rico. Changes in river water quality were related to reactions between surface-water and rock-forming minerals in the watershed. Norton also calculated from activity-concentration plots a solubility product for montmorillonite which favorably compared with previously published data.

Bricker et. al. (1968) and Cleaves et al. (1970) utilized a mass balance approach coupled with silicate weathering models for a small watershed in Maryland. From their geochemical model they were able to determine detailed input-output budgets for major ions and the relative rates of chemical and mechanical weathering in the watershed.

Other chemical budget studies of small watershed have generally used a paired-watershed approach to evaluate disturbances to ecosystems by various stresses, such as logging or forest fires, and have not evaluated cation losses from the watersheds with comparable geochemical detail. For example, the classic studies by Johnson et al. (1969) and Likens et al. (1967, 1969) qualitatively evaluated the reactions controlling the release of major cations from Hubbard Brook watershed by comparing ratios of yearly cation losses to the chemical composition of the weathered and unweathered bedrock. Other studies by Johnson and Swank (1973), Fredrickson (1970, 1972), and Wright (1974) calculated cation budgets for small watersheds but did not address the mechanisms of mineral to account for net cation losses.

The cited watershed and ground water have not had to incorporate the kinetics of silicate weathering to geochemical models because aquifers or watershed soils and streambed materials contained silicates with similar stability, However, the rates of silicate weathering are different for the major silicate groups. Silicate susceptibility to weathering decreases in a series from olivine to quartz Goldich (1938), analogous to Bowen's Reaction Series and the Stunz (1941) classification of silicates from the least complicated structures, the neosilicates (e.g. olivine), to the most complicated structures, the tectosilicates (e.g. feldspar).

As opposed to earlier investigations, this dissertation extends geochemical modeling for a watershed which is underlain by a composite of igneous minerals including all major silicate groups. The results of this work will provide:

1). a means to quantitatively assess the relative rates of chemical weathering between major silicate groups under the same hydrological and geochemical conditions in the natural environment.

2). a means to determine the practical extent to which chemical mass balances and geochemical models can be applied to a natural system considerably more complicated than those previously studied.

In addition, because the watershed includes a mineralized zone containing copper and nickel sulfide minerals, this study will integrate, if necessary, both sulfide oxidation as well as hydrolysis of the silicate minerals in the geochemical analysis.

LOCATION AND PHYSIOGRAPHIC DESCRIPTION OF THE WATERSHED

Filson Creek is located on the Superior Upland Province of Minnesota and is approximately 8 miles southeast of Ely (fig. 1). It was chosen for study because:

1). Filson Creek is a small stream with a continuous U.S. Geological Survey stream gauge near its mouth.

2). Previous soils, water chemistry, geological and vegetational studies are available for the watershed.

3). All waters draining from the basin originate as precipitation on the watershed.

4). The watershed is relatively undisturbed by man.

5). The watershed is underlain by glacial till composed predominently of a mixture of igneous minerals derived from the underlying mafic Duluth Complex and nearby acid lithologies of the Giants Range Granite.

6). The watershed is predominently forested.

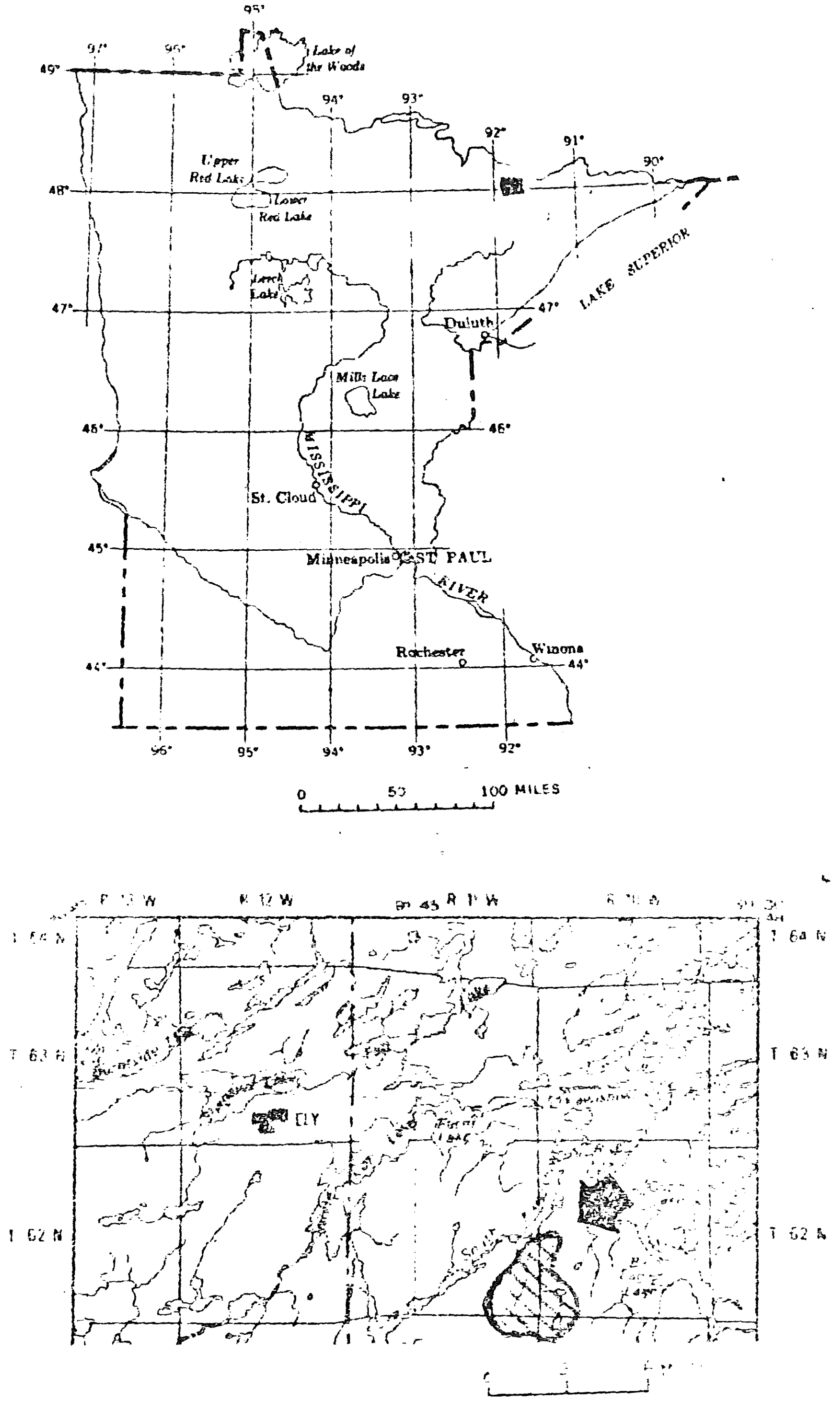


Figure 1 Location of Filson Creek Watershed

Filson Creek drains westward to the Kawishiwi River and has two tributaries, designated North Filson and South Filson for this study (fig. 2), which join approximately one-tenth of a mile upstream from the U.S. Geological Survey stream gauge on Spruce Road.

Total relief in the watershed is 317 ± 10 feet, with elevations ranging from greater than 1,760 feet east of Bogberry Lake in the eastern part of the basin to less than 1,443 feet near the mouth of the stream.

The general topographic grain trends northeast-southwest and reflects bedrock ridges in the Duluth Complex as well as the general direction of Wisconsian glaciation. South and southwest of Bogberry Lake, this general trend is broken by an east-west bedrock ridge which partly outlines the southern boundary of the watershed.

Between five and seven percent of the watershed is exposed bedrock.

South Filson Tributary

South Filson drains 2.42 square miles of fens and upland forest bordered on the west and east by bedrock ridges mantled by a thin veneer of till. The southern

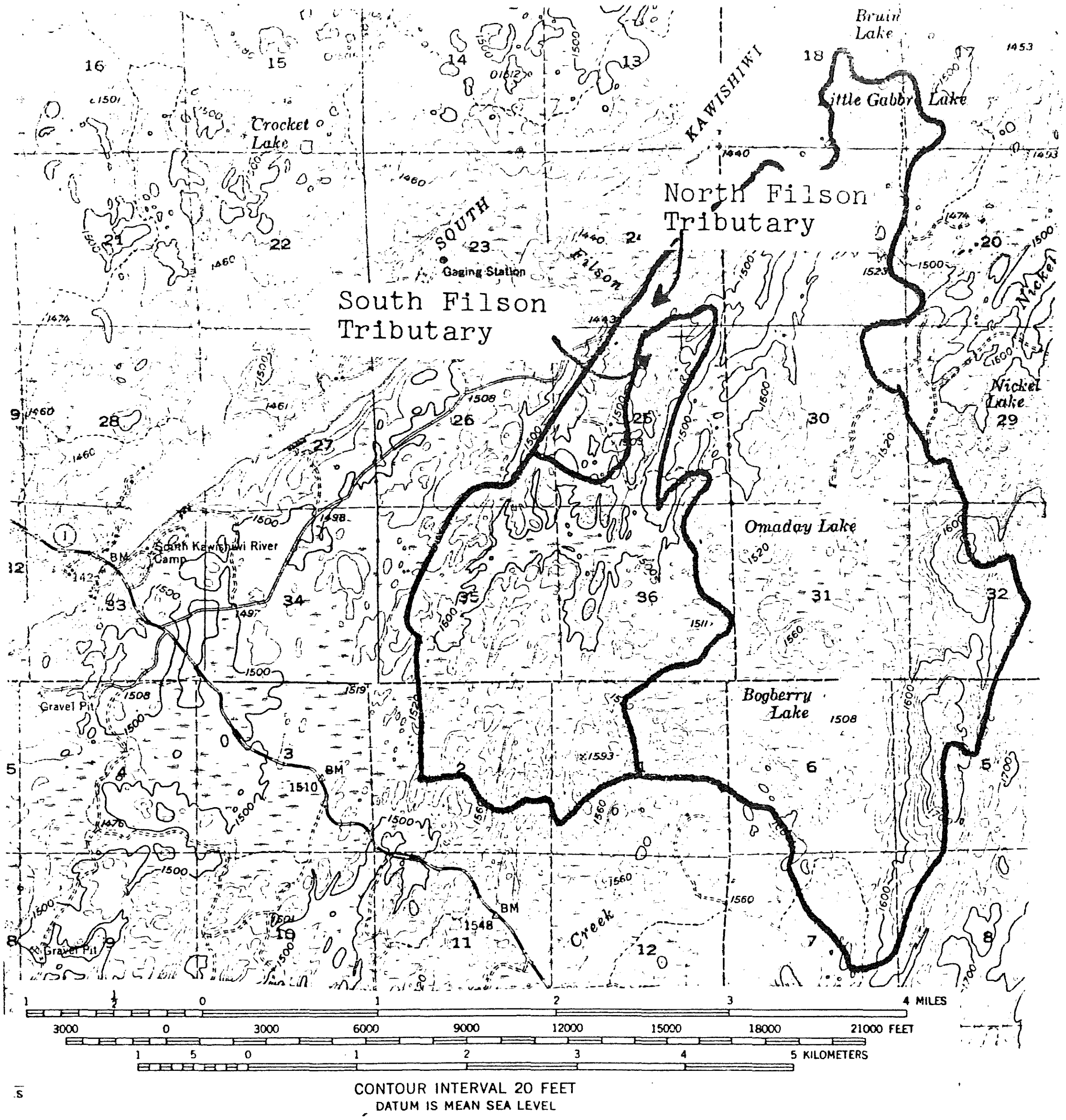


Figure 2 Topography of the Filson Creek Watershed

boundary of the watershed is indistinct and estimated from surface topography in the wetlands. South Filson is about 3.3 miles long and meanders in a linear fen which ranges from 500 to 1,250 feet in width.

Small rapids are located directly upstream from its confluence with North Filson and at other locations where bedrock ridges increase local gradients in the channel. The general gradient for South Filson watershed is 20 feet per mile.

North Filson Tributary

North Filson drains a 7.34 square mile area including Bogberry Lake (94 acres) and Omaday Lake (34 acres). The eastern and southern boundaries are well defined by forested topographic ridges having relief from 140 to 250 feet. The western margin consists of en'echelon bedrock ridges having relief from 20 to 60 feet.

Bogberry and Omaday Lakes range in depth from three to five feet, depending on the season, and are almost completely surrounded by wetlands. Bogberry Lake drains northward to Omaday Lake through a perennial stream.

North Filson has an average gradient of 14 feet per mile, one-third less than that of South Filson. As with South Filson, small riffles and rapids are located at nick points where the channel crosses bedrock ridges or leaves beaver dams. One particularly long rapids extends for about 600 feet upstream from the intersection of the creek with Spruce Road in T.62 N., R.11 W., section 9.

CLIMATE

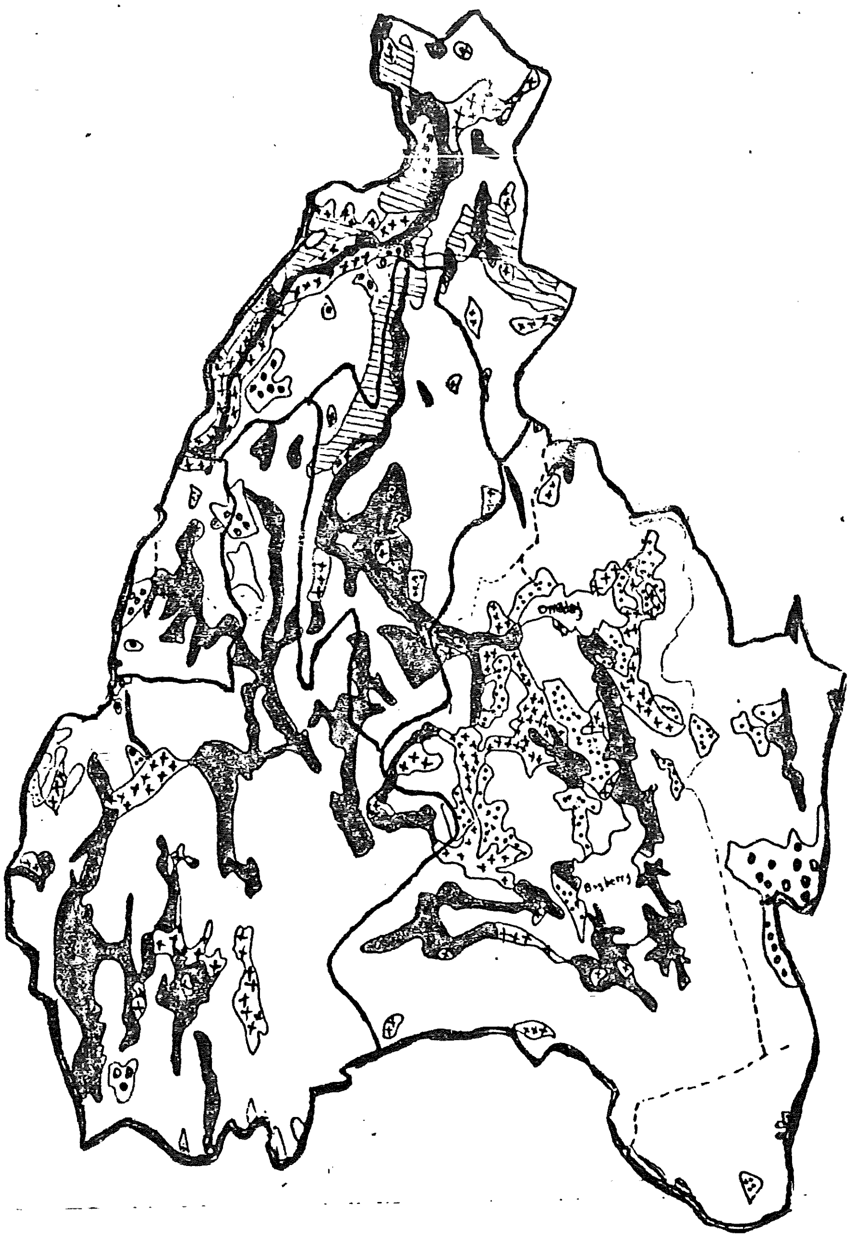
Filson Creek watershed has a mid-continental climate with long, cold winters and warm, short summers. The mean annual precipitation is about 27 inches, with monthly average temperatures ranging from 14°F in January to 62°F in July (Ahlgren, 1969). Precipitation occurs in the form of brief storm events of varying intensity which occur most frequently during the early spring and fall.

VEGETATION

During the past 50 years, much of the watershed has experienced various degrees of logging. Much of the original post-glacial climax vegetation of Jack Pine and White Pine (Marschner and others,1974) has been selectively cut. With the exception of parts of the high ridges marking the eastern boundary of the watershed, large scale clear-cutting and rock-raking techniques have not taken place. Those areas which were clear-cut are now generally covered with a secondary succession of aspen, birch, mixed coniferous species and various shrubs.

The vegetation in the watershed is composed of several distinct natural forest types, as well as some areas covered by planted species (fig. 3). About 75 percent of the watershed is classified as a mixed upland forest, 15 percent as fens and Black Spruce bogs, and the remaining 10 percent as natural or planted stands of Jack, Norway and Red Pine (Regional Cu-Ni Study Staff, 1976).

The mixed upland forest consists of an assemblage of aspen, birch, fir and other conifers. The dominant species along the margins of the watershed are aspen and birch, ranging from 30 to 70 feet in height, while the more mixed



After Sather (1977),
Unpublished map, Regional
Cu-Ni Study Staff and
Unpublished Forest Survey map,
Univ Minnesota Study, 1976.

EXPLANATION

- ☐ Mixed Upland Forest
- ■ **Fen**
- ✣ **Black Spruce**
- ⁘ Natural Pine Stands
- ▨ ⁙ Pine Plantations

Figure 3 Vegetation in the Filson Creek Watershed assemblages including conifers are found generally in the central part of the watershed where there are wetlands and lakes. Two small stands of Jack Pine occur on the north side and about one-half mile due south of Omaday Lake. In the extreme northern part of the watershed are tracts of planted Red and Jack Pine. The northern reach of North Filson meanders in a spruce bog for about one and one-half miles before it enters a reed-sedge bog near the mouth of Filson South.

It is assumed from the vegetation that the biomass in the watershed is near dynamic equilibrium. This implies that biomass on the average is being replaced at the same rate at which it is being dispersed, Odum (1975). Evidence that suggests such an equilibrium operating in Filson Creek Watershed is similar to that described by Cleaves et al. (1970):

1). Trees of all size classes from saplings to stands up to 70 feet high occur in the watershed.
2). Deadfalls are present.
3). Major clear-cutting disturbances have not occurred during the past twenty years.
4). There is a general lack of heavy first order undergrowth except around wetland areas.

BEDROCK GEOLOGY

The bedrock geology (fig. 4) of the watershed mainly consists of the mafic lithologies of the middle pre-cambrian Duluth Complex. The northern part of the watershed is underlain by the eastern edge of the Giants Range Granite as well as zenoliths of hornfels and Biwabik Iron-formation found within the Duluth Complex.

The eastern part of the Giants Range Granite is composed mainly of medium to coarsely crystalline, porphyritic, hornblende rich, plutonic rocks that range in composition from adamellite to diorite, but dominantly are ademellite and granodiorite. (Sims and Viswanathan, 1972). Green (1970) divided the eastern part of the Giants Range Granite into the Farm Lake and Clear Lake facies. Only the Farm Lake facies is found in the watershed, and consists mainly of porphyritic, hornblende ademellite and monzonite. The rock typically is hypidiomorphic-granular in texture, having microcline phenocrysts ranging up to two centimeters in cross section. Grading with the porphyritic rocks are minor amounts of non-porphyritic varieties.

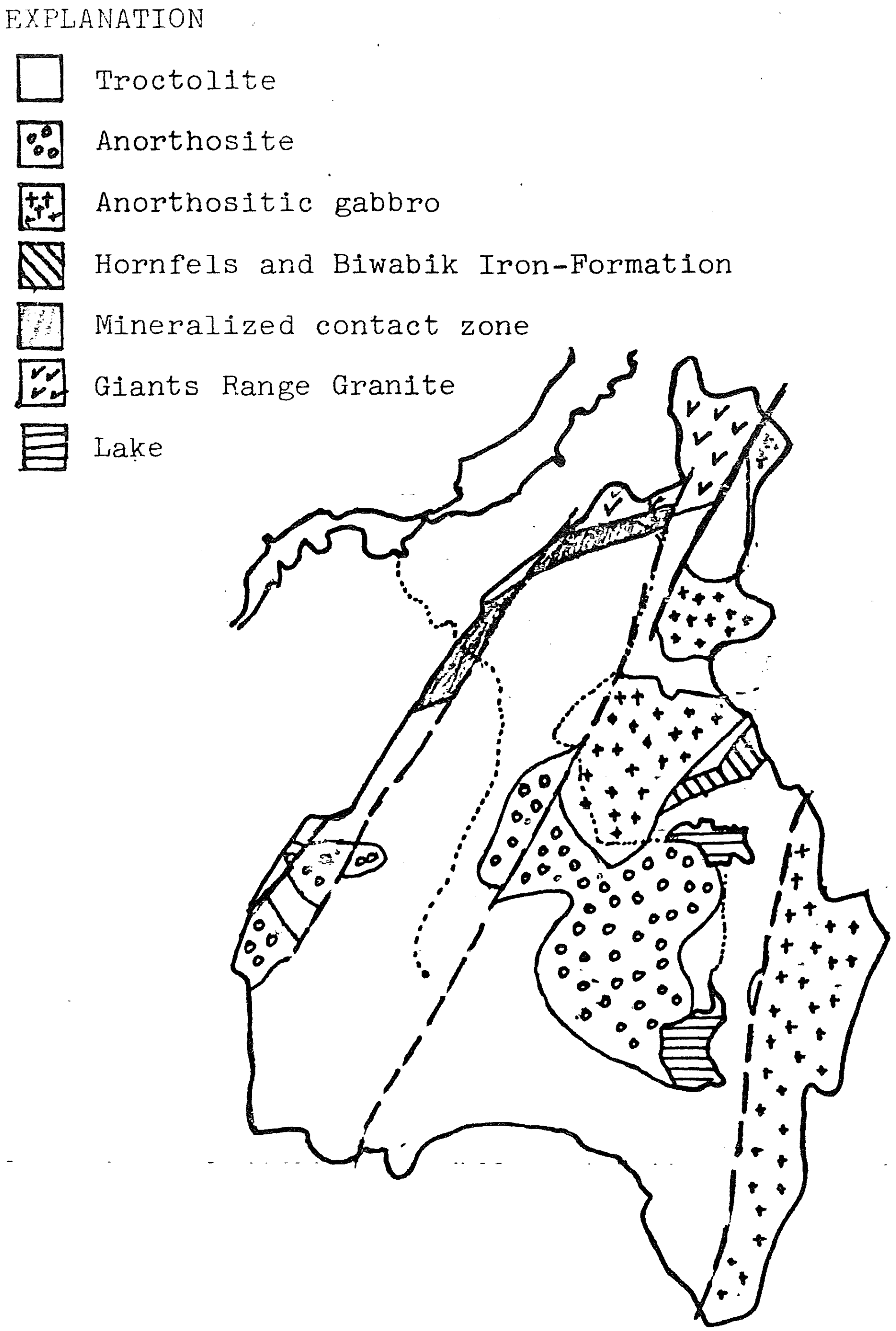


Figure 4 Bedrock Geology of the Filson Creek Watershed

The quartz content ranges from 15 to 25 percent, while the major mafic mineral, green hornblende, composes between 6 and 10 percent of the rock. The plagioclase type is oligoclase which ranges from An_{16} to An_{24}. In the field, oligoclase appears cloudy due to kaolinization which occurred prior to the intrusion of the Duluth Complex (Green, 1970).

The contact between the Duluth Complex and the Giants Range Granite along the northern margin of the watershed consists of a mineralized zone of gossen which is one quarter to one half mile wide. Mineralogy of the rock is transitional between the amphibolite, the hornblende-hornfels and the pyroxene-hornfels metamorphic facies (Green, 1970), and includes copper and nickel sulfide minerals which have potential economic value.

The Duluth Complex underlying approximately 90 percent of the watershed was first mapped by Green et al. (1966), with subsequent modifications by Morey and Cooper (1978).

The center and eastern parts of the watershed are underlain by lithologies ranging from poikilitic augite troctolite to anorthosite, with plagioclase (An_{60} to An_{65}) content ranging from 65 to 90 percent, olivine (Fa_{37-40})

content from less than 10 to 20 percent, and the remaining percentage composed of interstitial iron oxides and augite.

The eastern margin of the watershed is underlain by anorthositic gabbro with plagioclase (An_{60-88}) comprising between 75 and 95 percent of the rock. The remaining percent consists of interstitial augite and hypersthene.

Due north of Omaday Lake, the bedrock includes an elongated xenolith of metamorphosed Biwabik Iron-formation and hornfels.

Average modes in volume percent of the major rock types discussed are given in Table 1. Table 2 gives the percentages of the watershed underlain by major rock types.

Table 1 Average modes in volume percent of major rock types in the Filson Creek Watershed

	Troctolite[1]	Anorthosite[1]	Anorthositic Gabbro[1]	Giants Range Granite[2]
	(33)	(9)	(35)	(3)
Plagioclase	71.2	95.2	78.9	49.3
Augite	4.5	0.9	8.9	---
Orthopyroxene	0.6	0.6	1.1	---
Olivine	19.3	1.3	3.2	---
Opaques	2.0	1.3	2.9	0.2
Biotite	0.6	tr	2.5	2.0
Hornblende	---	---	---	8.7
Quartz	---	---	---	11.7
K-spar	---	---	---	23.7

[1] from Phinney,1972

[2] from Sims and Viswanathan,1972

Numbers after each rock type indicate number of thin sections used to calculate average mode

Table 2 Percentage of Filson Creek Watershed Underlain by Major Bedrock Type

Bedrock Type	Percentage of Watershed
Troctolite	56.7
Anorthositic Gabbro	20.3
Anorthosite	12.9
Giants Range Granite	3.5
Contact Zone	2.7
Hornfels	1.4

GLACIAL HISTORY

Northeastern Minnesota in the vicinity of Filson Creek experiences two advances from the north and northeast by the Rainy Lobe of the Laurential Ice Sheet during Wisconsin time (Wright, 1972).

The first advance, termed the St. Croix phase, deposited the Toimi Drumlin Field and St. Croix Moraine south of the study area. The second advance, termed the Autumba phase, deposited thin ground moraine and minot ice contact deposits in the watershed. The ground moraine consists of bouldery, sandy till (Stark, 1978; Winter and others, 1973; Olcott and Siegel, 1978).

Numerous test holes by the author,(Prettyman, 1976 ; Olcott and Siegel, 1978; and Stark, 1977) indicate that the bouldery till is the major drift type in the watershed. Glaciofluvial sand and gravel constitute no more than 10 percent of the surficial deposits.

Omaday Lake is underlain by about 22 feet of organic sediment, which covers sand and gravel of indeterminent thickness. The sand and gravel form a small beach on the northern side of the lake and may underlie wetlands near the mouth. U.S. Geological Survey test holes in and around Filson Creek (Olcott and Siegel, 1978) also indicate that wetland areas can be underlain by sand and gravel.

The total thickness of surficial materials, including postglacial wetland deposits, ranges from less than one foot over bedrock ridges to up to fifty feet in wetlands.

The thickness of the bouldery till is generally less than three feet thick over much of the watershed (Prettyman, 1976 ; Stark, 1977; Olcott and Siegel, 1978). It ranges, however, from only a few inches [illegible] to an estimated 15 feet thick near the contact zone between the Duluth Complex and the Giants Range Granite. Till on the western flanks of the bedrock ridges bordering the eastern side of the watershed is as much as 5 feet thick.

SOILS DESCRIPTION

Soils in the watershed (fig. 5) are a mixture of immature, shallow and gravelly loams which occur over and adjacent to bedrock ridges. Peat and muck occur in the wetlands (Prettyman, 1976). Soil development is poor, with parent till generally less than one foot below the A-horizon (Grigal, personal communication, 1976).

The A-horizon consists of up to three inches of fine, organic-rich material containing few rock fragments and ranging in color from black to dark red. The poorly developed B-horizon ranges in color from yellow-brown to dark brown like its parent till and contains coarse rock fragments and boulders. In work along the western margin of the area, Alminas (1975) reported a clay-rich layer at the base of the B-horizon where till thickness exceeded two feet. The discontinuous clay layer, when found, is yellow-olive to yellow-gray.

Large clasts in the till reflect local source areas. For example, stone counts of over one hundred clasts of greater than pebble size indicate that underlying and nearby bedrock types constitute most of the rock fragments (fig. 6).

After Prettyman(1976)

EXPLANATION

- ▨ Bog
- ▧ Sandy Loam, ≥ 40" thick
- ☐ Sandy Loam, < 40" thick
- ▤ Lake

Figure 5 Soils in the Filson Creek Watershed

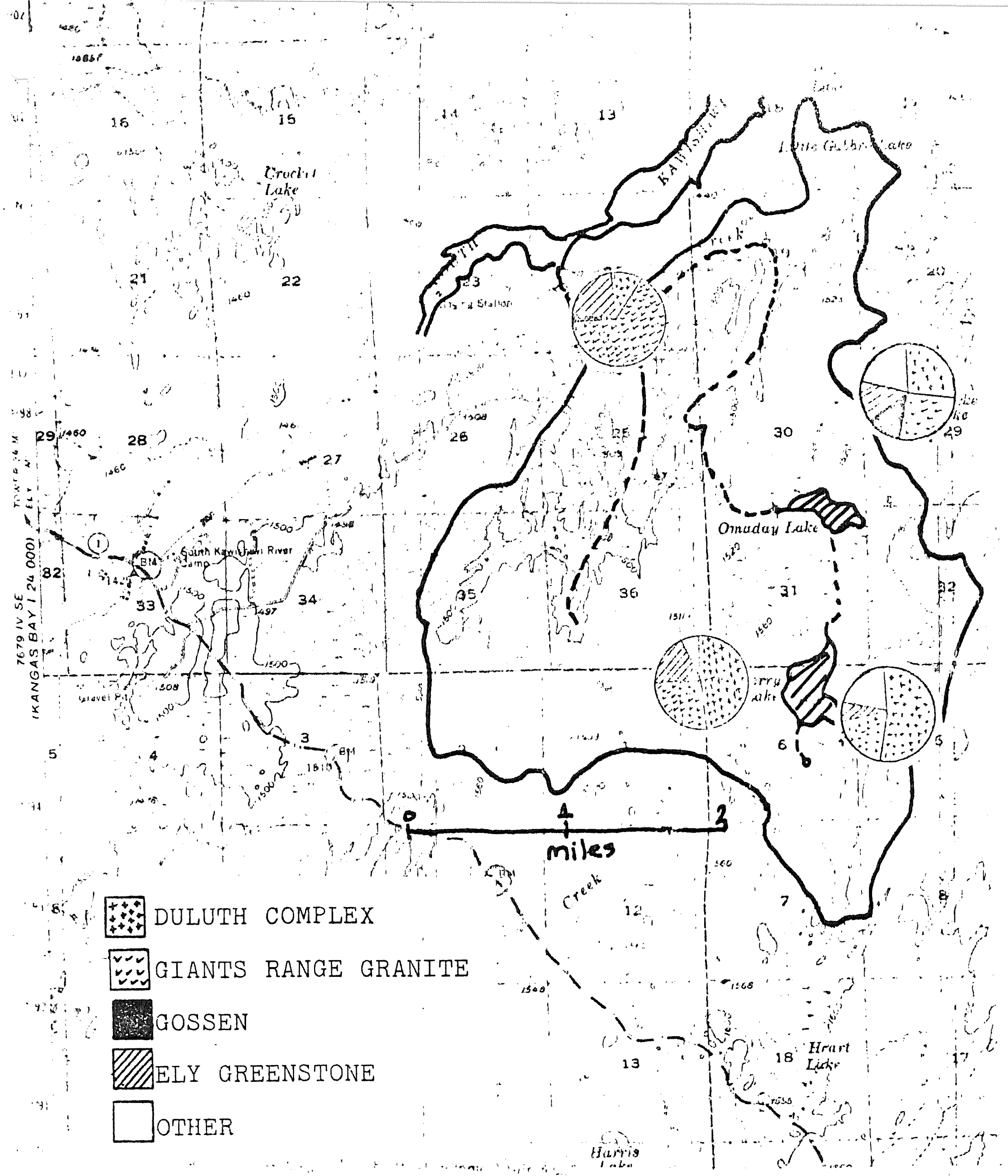


Figure 6 Composition of the **Greater than Pebble Size** Clasts in the Rainy Lobe Till

Because the most reactive part of the till is the finer-grained material having the greatest surface-area-to-volume ratio, 25 till samples were collected for complete sedimentological and mineralogical analysis of the sand and finer-sized fractions.

Methods

Sedimentological analysis of till samples (fig. 1) included particle size analysis, petrographic description and quantitative analysis of the fine sand-size fraction (Wentworth, 1922), and x-ray diffraction for the identification of mineral species in the clay and silt size ranges.

Till samples were collected at least one and one half feet below the A-horizon to ensure that parent material was sampled.

Standard methods outlined by Folk (1974) were followed for the grain size analyses of till samples of approximately fifty grams each. Dry sieving was done at half-phi intervals for the fine sand to granule size fractions while pipette analyses were performed for the clay to silt size fractions.

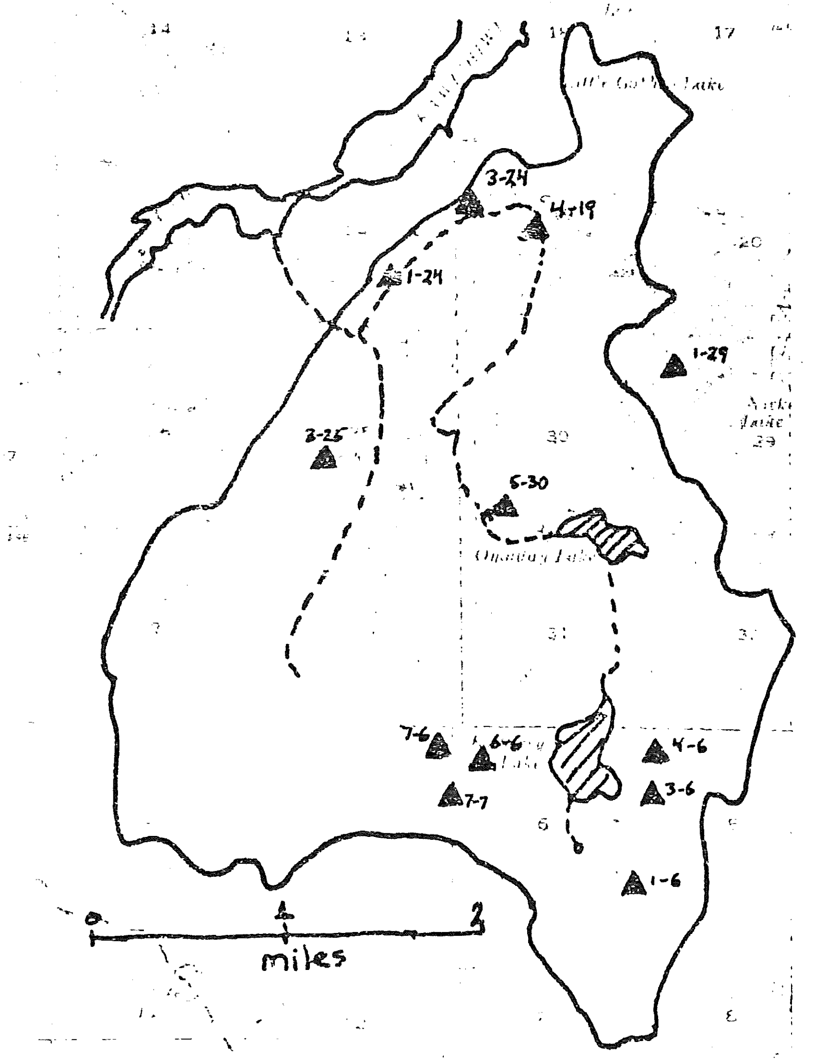


Figure 7 Till Sample Sites in the Filson Creek Watershed

Point counts of at least 400 grains were performed to determine the mineralogy of the fine sand size fraction of the till. Petrographic identifications were made through the use of such references as Krumbein and Pettijohn (1938) and Milner (1954).

X-ray diffraction for identification of clay mineralogy followed the procedures outlined by Carroll (1970) and Whittig (1965). Clays were first treated with hydrogen peroxide to remove organics and then with appropriate reagents to remove free iron oxides before x-ray diffraction. Patterns were run on a Phillips type 42273 x-ray diffractometer using Cu α radiation and a scan speed of one degree 2θ per minute.

Mineralogical distribution in the very fine sand size fraction

Minerals found in the very fine sand size fraction (0.125 to 0.0625 mm) of the till are a composite of the minerals found in ~~the~~ Giants Range Granite and the Duluth Complex, (Appendix 1).

The major minerals are the plagioclases and biotite, with lesser amounts of olivine, hypersthene, quartz and opaques. Sodic plagioclases from the Giants Range Granite are identified by intensive kaolinization which masks the polysynthetic twinning. Calcic plagioclases are clear and generally free of any alterations. Measurements of extinction angles from cleavage fragments place calcic plagioclase composition between An_{50}-An_{80}. Hypersthene shows excellent pleochroism from pink to green. Hornblendes are green under plane polarized light and pleochroic from green to brown. Opaques are usually unidentifiable except as aggregates of iron oxide. Olivines are clear to light green and have high relief. Biotite is brown to green in plane polarized light and occasionally "bleached."

Mean percentages of some minerals found in the very fine sand size fraction of the till differ from their modal percentage in source bedrock types (Table 3). Fifteen times as much biotite is found in the till as in either the Duluth Complez or Giants Tange Granite. Only trace amounts of microcline are found in the till, compared to a modal percentage in the Giants Range Granite of about 25 percent. This is due to the difference in susceptibility of the minerals to glacial erosion and transport.

Dreimanas and Vagners (1965, 1971) have determined that during glacial transport and erosion, rocks become abraded to two size modes of two groups of modes. One mode consists of rock fragments and the other consists of mineral fragments within the till matrix. Each mineral can be potentially worn down to a "terminal grade size" dependent upon the original crystal or grain size and its resistance to abrasion. The data suggest that biotite,

Table 3 Comparison between mean mineral composition of the Rainy Lobe till and the mean mineral modes of the Duluth Complex and Giants Range Granite in the Filson Creek Watershed

Major minerals in Duluth Complex	Percentage in very fine sand size of till (n=11)	Normalized Percentage	Average Mode (77)
Plagioclase	45.9	76.7	89.9
Olivine	2.3	3.8	4.1
Clinopyroxene	0.6	1.0	0.7
Orthopyroxene	5.1	8.5	13.1
Opaques	5.9	9.9	0.9
Major minerals in Giants Range Granite			
Oligoclase	19.4	48.9	49.3
Quartz	3.7	9.3	11.3
Hornblende	4.2	10.5	8.7
Biotite	12.4	31.2	2.0
K-spar	tr	tr	23.7

which has a prominent basal cleavage, is less resistant than other minerals in the source rocks. The absence of microcline compares favorable with work by Harrison (1960) who found the terminal grade size of orthoclase to be greater than fine sand size.

The larger amount of opaques in the till is because they occur in the mineralized zone in higher percentages than in the Duluth Complex in general.

Clay mineralogy

Kaolinite and chlorite were identified from diffractograms of the finer than +8ϕ size fraction of six till samples, and were differentiated by heating the samples to 600°C to determine if peaks at 7.15Å and 3.75 Å persisted (Carroll, 1970). At this temperature, kaolinite becomes disordered and these peaks, if present, are attributed to chlorite.

Clay-sized quartz was identified by a strong peak at 3.42 angstroms . Other minor peaks that occur at 3.32, 3.25 and 4.37 angstroms are probably reflections from small quantities of unidentified silicate minerals. Figure 8 shows representative x-ray diffractograms for typical till-clay size particles.

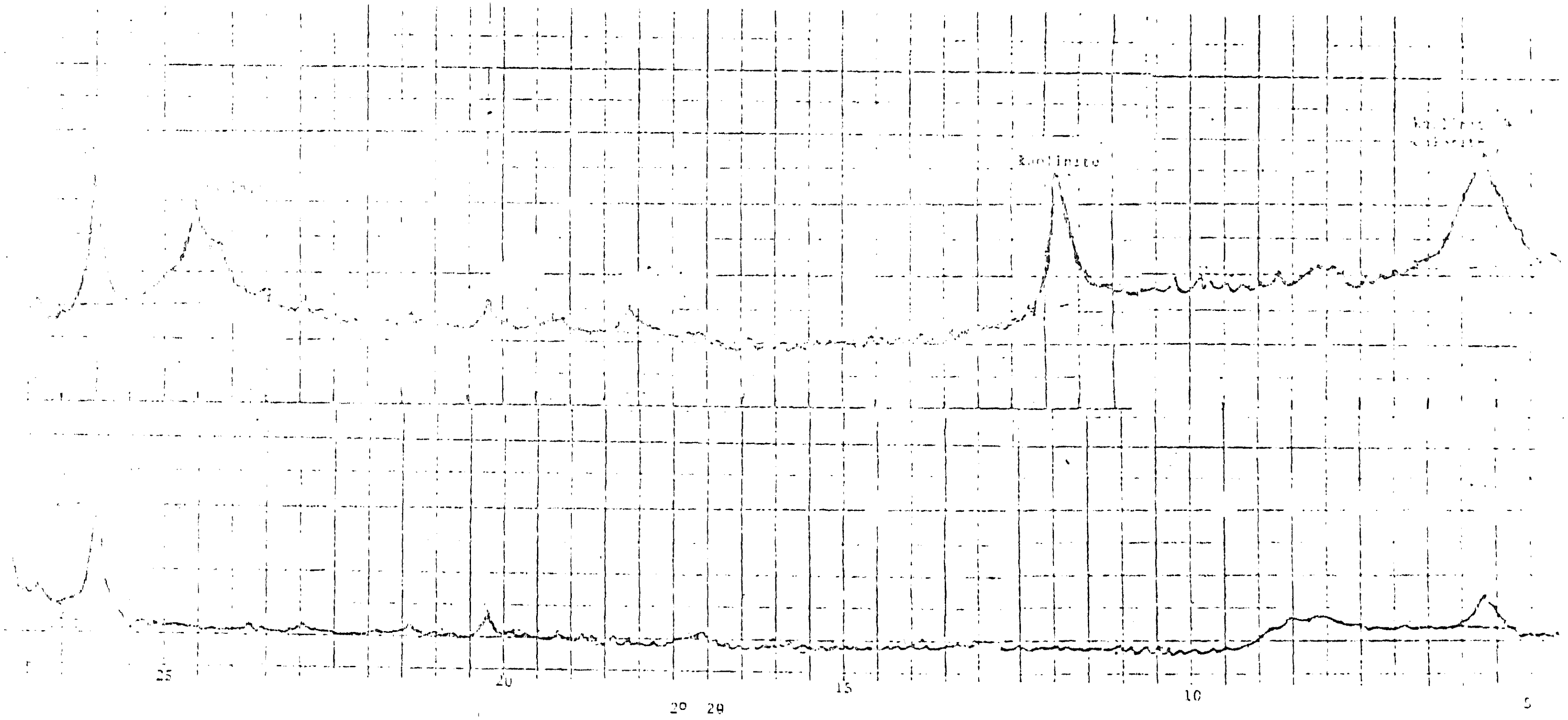


Figure 8 Typical x-ray diffractograms from clay sized fraction of Rainy Lobe till collected from the Filson Creek Watershed. Sample 7-6t was glycolated for 1 hour prior to analysis (a), and then heated to 600°C to separate the kaolinite peaks from chlorite (b). Diffractogram showed no peaks beyond 28° 2θ

HYDROLOGY

Introduction

Measurements of precipitation and stream runoff coupled with concentration data for dissolved solids, provide the means to calculate net loading rates in the watershed over the period of the study.

Runoff is composed of three parts: surface runoff, interflow, and ground water runoff. Of these components, ground water runoff is considered to be negligable from the thin till cover. The wetlands store ground water, but because peat is effectively impermeable below a few feet (Boelter, 1969; Durham and Hofstetter, 1971), sustained groundwater discharge to the creek is minimal and not enough to even keep the creek open during the winter months.

Interflow through the peat and till occurs during storm events and is incorporated into surface runoff discharged by the creek.

By measuring lake levels, precipitation, lake evaporation, and surface runoff, monthly hydrologic budgets can be estimated from the equation:

$$P = SRO + E_l \pm \Delta ST_l + ET \pm \Delta ST_{gw}$$

where: P = monthly total precipitation

SRO = monthly total stream runoff

E_l = monthly lake evaporation

ΔST_l = monthly change in lake storage

ET = monthly evapotranspiration

ΔST_{gw} = monthly change in groundwater storage

The first of these gauges (OL-1) was near the mouth of Omaday Lake where North Filson flows out of a small wetland. The second location (F3X)was one-tenth of a mile upstream from the location where North Filson initially crosses the mineralized contact zone. The third location (SF) was at the mouth of South Filson where it enters a reed-sedge bog.

Discharge was measured near Omaday Lake to determine the amount of runoff contributed to the North Filson by the Bogberry-Omaday Lake system. Discharge data at TX location, when combined with chemical quality datd, will enable chemical budgets to be calculated for North Filson before it is influenced by the reactions at the mineralized zone. Similar calculations with data from South Filson will give chemical budgets unaffected by either mineralized zone or lakes.

Stages were measured by a Leupold + Stevens level recorder at the OL-1 gauge and Friez Type FA recorders at the SF and F3X gauges. The Stevens recorder was equipped with a four week battery operated clock, and the Friez recorders were driven by weighted clock cables mounted high enough on the gauge house to record 14 days of continuous record before needing to be reset. Stilling wells were constructed of 10 inch diameter stove pipe attached to a platform mounted in a gauge housing

Methods

Precipitation was measured by a U.S. Forest Service recording rain gauge located at the North Central Forest Experimental Station on the South Kawishiwi River and three U.S. Forest Service non-recording gauges located west and south of the watershed (fig. 9).

Linear regressions between the precipitation gauge at the Kawishiwi Laboratory and the non-recording gauges gave high enough correlation coefficients to consider the Kawishiwi Laboratory data as being representative of the Filson Creek Watershed (fig. 10) to within 10 to 20 percent accuracy. Because record at the Kawishiwi Laboratory was terminated at the end of September, precipitation for October, 1977 was taken as the average of that measured at Winton and Babbitt (Climatological Data, 1977).

Stream discharge was measured by the U.S. Geological Survey continuous recording gauge (F1X) near the mouth of the creek and at three other locations by gauges installed for this study (fig. 9).

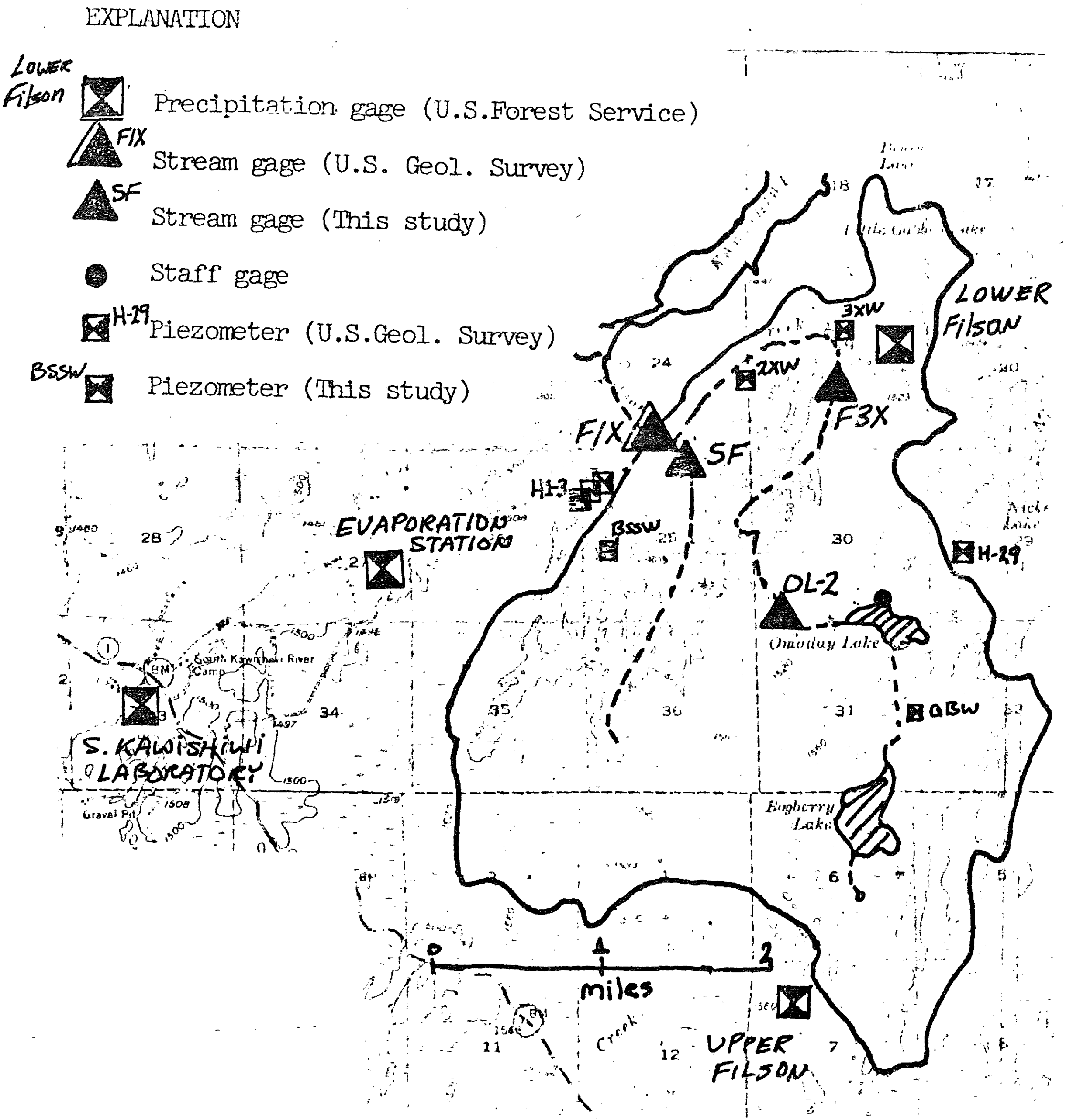


Figure 9 Hydrologic Monitoring Network

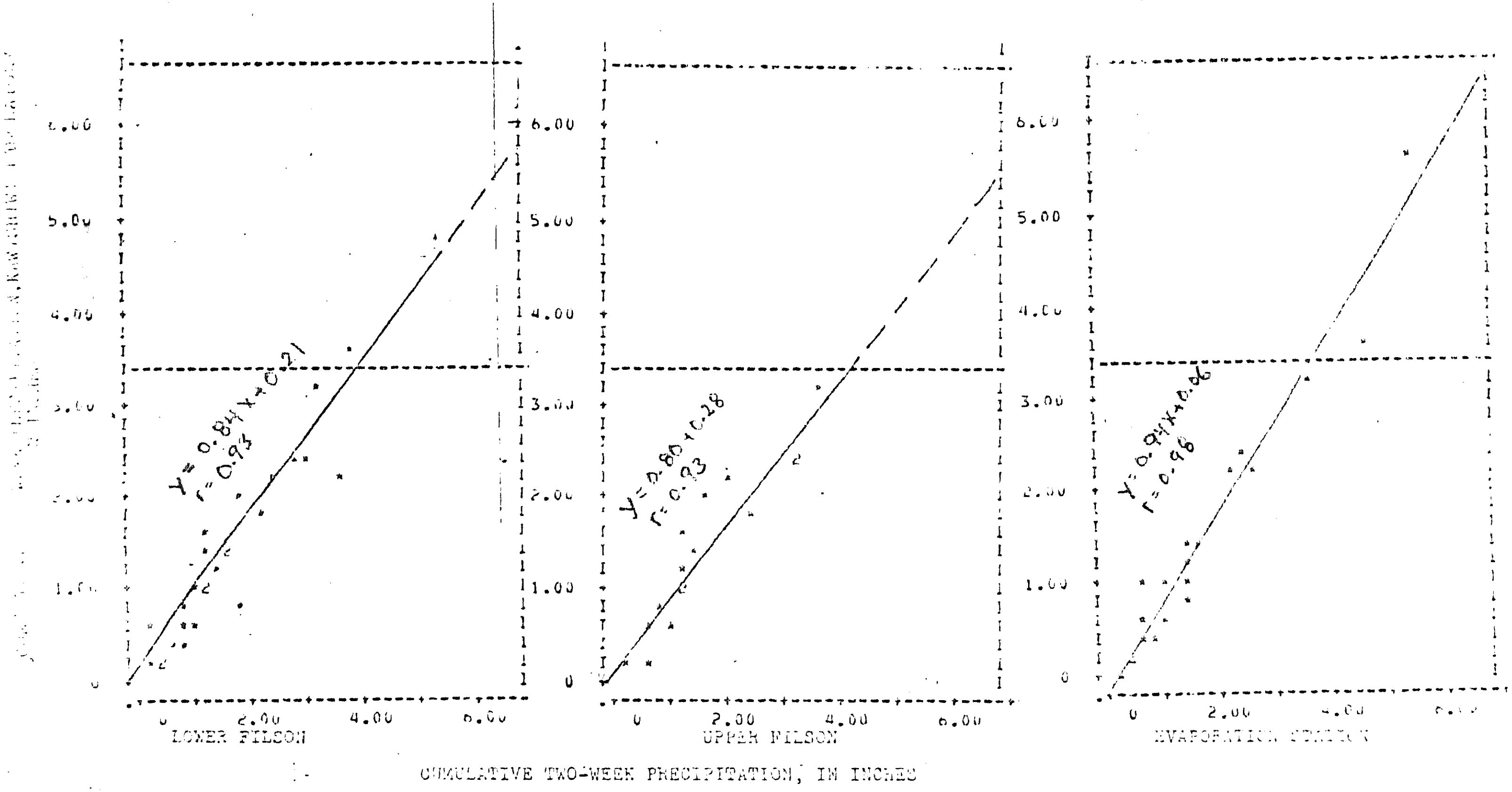


Figure 10 Correlations between cumulative two-week precipitation at Kawishiwi Laboratory and Upper [illegible] Filson and Evaporation Station non-recording rain gages. Data collected between [illegible] and 9/30/77 by U.S.Forest Service. Raw data are given in Appendix .

which consisted of either three feet wide culvert sections or a half inch plywood box. Two inch diameter PVC pipe extended from the base of the stilling wells to the center of the stream channel to assure record during low flow conditions.

Discharge was measured (Tables 4-6) by use of a pygmy current-meter and correlated with measurements from staff gauges installed near the recording gauges. Rating curves (fig. 11) were established in accordance with procedures of Carter and Davidian (1965). At the SF location, two rating curves were extrapolated from the data to account for a backwater effect caused by a beaver dam built during July, 1977. Previous rating curves were available for the OL-1 location from the U.S. Forest Service.

Ground water levels were measured by four piezometers installed in peat for this study and by five U.S. Geological Survey piezometers previously installed in till (fig 9, Appendix 4). The piezometers in the peat consisted of five to six feet lengths of one and one-quarter inch PVC pipe. A screen was made by slotting one foot of the pipe at one end and wrapping the end with fine nylon mesh to prevent coarse particles from entering the slots. Two inch diameter

TABLE 4 DISCHARGE-STAGE DATA FOR SF STREAM GAGE

Date	Discharge (cubic feet per second)	Stage (feet)
5-10	1.2	1.00
5-27	3.4	1.56
6-11	2.6	1.62
6-25	4.4	1.90
7-02	2.5	1.65
9-12	17.	3.38
9-19*	4.8	2.70
10-15*	16.	3.26
11-05*	1.9	1.73

TABLE 5 DISCHARGE-STAGE DATA FOR F3X STREAM GAGE

Date	Discharge (cubic feet per second)	Stage (feet)
5-10	0.91	1.10
5-28	2.2	1.30
6-11	6.3	1.62
6-25	7.0	1.70
10-15	23	2.54
11-05	3.0	1.42

TABLE 6 DISCHARGE-STAGE DATA FOR OL2 STREAM GAGE

Date	Discharge (cubic feet per second)	Stage (feet)
8-19-75	0.079	3.62
8-19-75	0.083	3.66
10-07-75	.281	3.91
10-07-75	.302	3.91
11-11-75	1.02	4.05
11-19-75	9.07	4.54
4-15-76	25.8	5.13
4-30-76	4.8	4.33

---

* gage affected by backwater

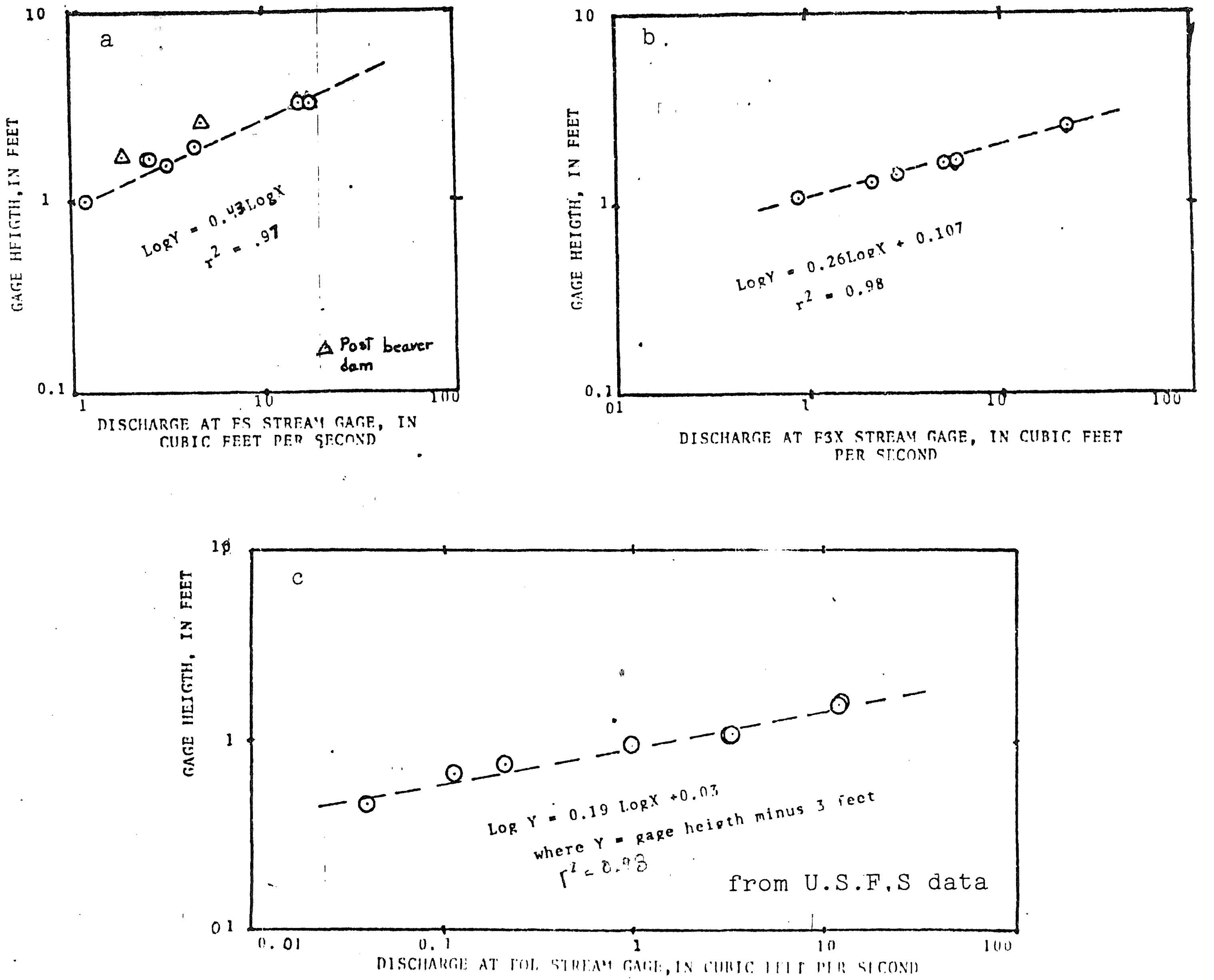


Figure 11 Rating curves for SF (a), F3X(b), and OL-2(c) stream gages

holes were augered by hand into the peat to a depth of three feet, and a two inch diameter PVC casing equipped with a slip cap was placed in the hole. The piezometer was fitted with a plastic collar 1 7/8 inches in diameter immediately above the screen, and then placed in the casing. The casing was pulled out of the hole, leaving the slip-cap at the base of the piezometer. Finally, a slurry of bentonite and water was placed into the hole on top of the collar and the remaining void space was filled with sediment removed from the hole. This arrangement assured that water samples collected from the piezometers were from the base of the peat.

The piezometers installed by the U.S. Geological Survey consisted of two inch PVC pipe and screen installed with the use of a power auger (Olcott and Siegel, 1978). Stratigraphic logs of the materials penetrated are given in the appendix.

Due to vandalism and instrument malfunction, the field record of discharge at OL2, F3X and SF gauges was incomplete. Missing data were generated by use of least squares regression equations (fig. 12) between measured discharges at these gauges and the U.S. Geological Survey gauge at F1X. (Table 7) Correlation coefficients were high enough to assure accuracy to within an estimated 15 percent

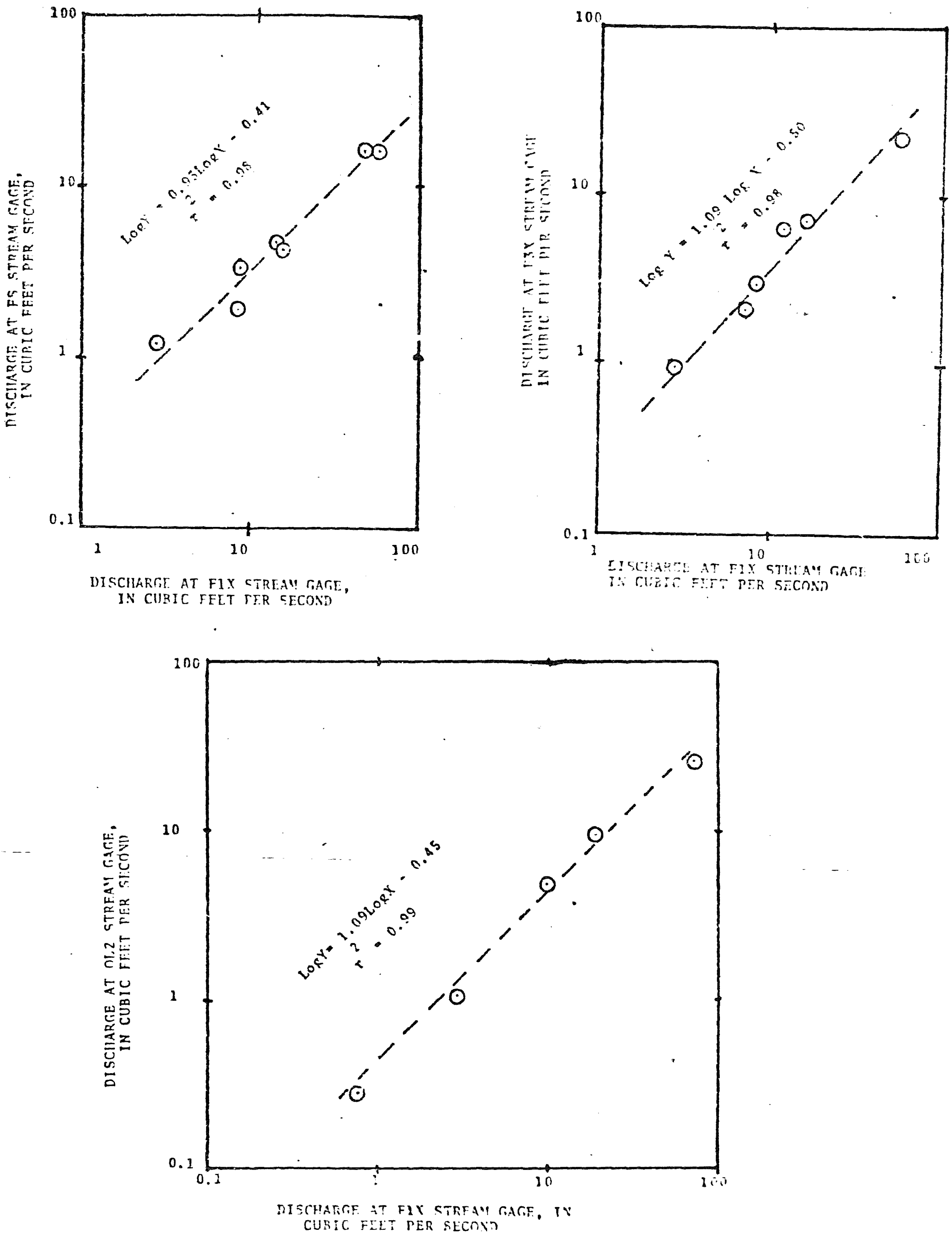


Figure 12 Correlations between discharge at F1X and SF(a), F3X (b) and OL-2(c)

Table 7

DISCHARGE AT STREAM GAGES, IN CUBIC FEET PER SECOND

DATE	F1X[1]	F3X[2]	FS[2]	FOL
10-07-75	0.78	--	--	0.29 (USFS)
11-11-75	3.8	--	--	1.02 (do)
11-19-75	18	--	--	9.07 (do)
4-15-76	72	--	--	25.8 (do)
4-30-76	4.8	--	--	10.0 (do)
5-10-77	2.8	0.91	1.2	--
5-27-77	8.8	--	3.4	--
5-28-77	7.0	2.2	--	--
6-11-77	12.	6.3	2.6	--
6-25-77	16.	7.0	4.4	--
7-02-77	8.5	--	2.5	--
9-12-77	46	--	17 (USFS)	--
9-19-77	14	--	4.8 (USFS)	--
10-15-77	58	23	16	--
11-05-77	8.2	3.0	1.9	--

---

[1] U.S.Geol. Survey

[2] Siegel, except where noted

of the true discharge. This compares favorably with an estimated 10 to 20 percent accuracy for the rating curves proper, given the natural controls of the gauged reaches.

Daily mean discharges at F1X, SE and OL2/F3X gauges are given in appendix 3 . The correlation equations for OL2 and F3X gauges with F1X are virtually identical. Increase in discharge between OL2 and F3X is undetectable because of the limitations of the instrumentation.

RESULTS

During 1977, precipitation occurred as brief and intense storm events. Filson Creek responded to these events quickly, once the soil and till was saturated by March and April snowmelt and rain. Because of the drought condition in 1976, the soil moisture deficit at the beginning of 1977 was abnormally high and the rapid response of Filson Creek to spring snowmelt did not occur as in 1975 and 1976 (figure 13). It is consequently necessary to determine the amount of recharge that went into soil moisture and surface depression storage before calculating the hydrologic budget for the watershed during 1977.

Total recharge to the watershed during early 1977 can be calculated as the sum of the water content of the snow cover at the end of March and the amount of precipitation during March and April. Snow course data by the U.S. Forest Service in the Superior National Forest indicated that the water content of the snow pack at the end of March was 2.0± .1 inches (Ramquist,1978, personal communication). Precipitation in April was 1.1 inches. The total recharge of 3.1 inches resulted in only 0.2 inches of runoff at the F1X gage. The difference between the recharge and discharge gives an estimate of the soil moisture deficit, depression storage, and groundwater deficit of about 2.9 inches,neglecting

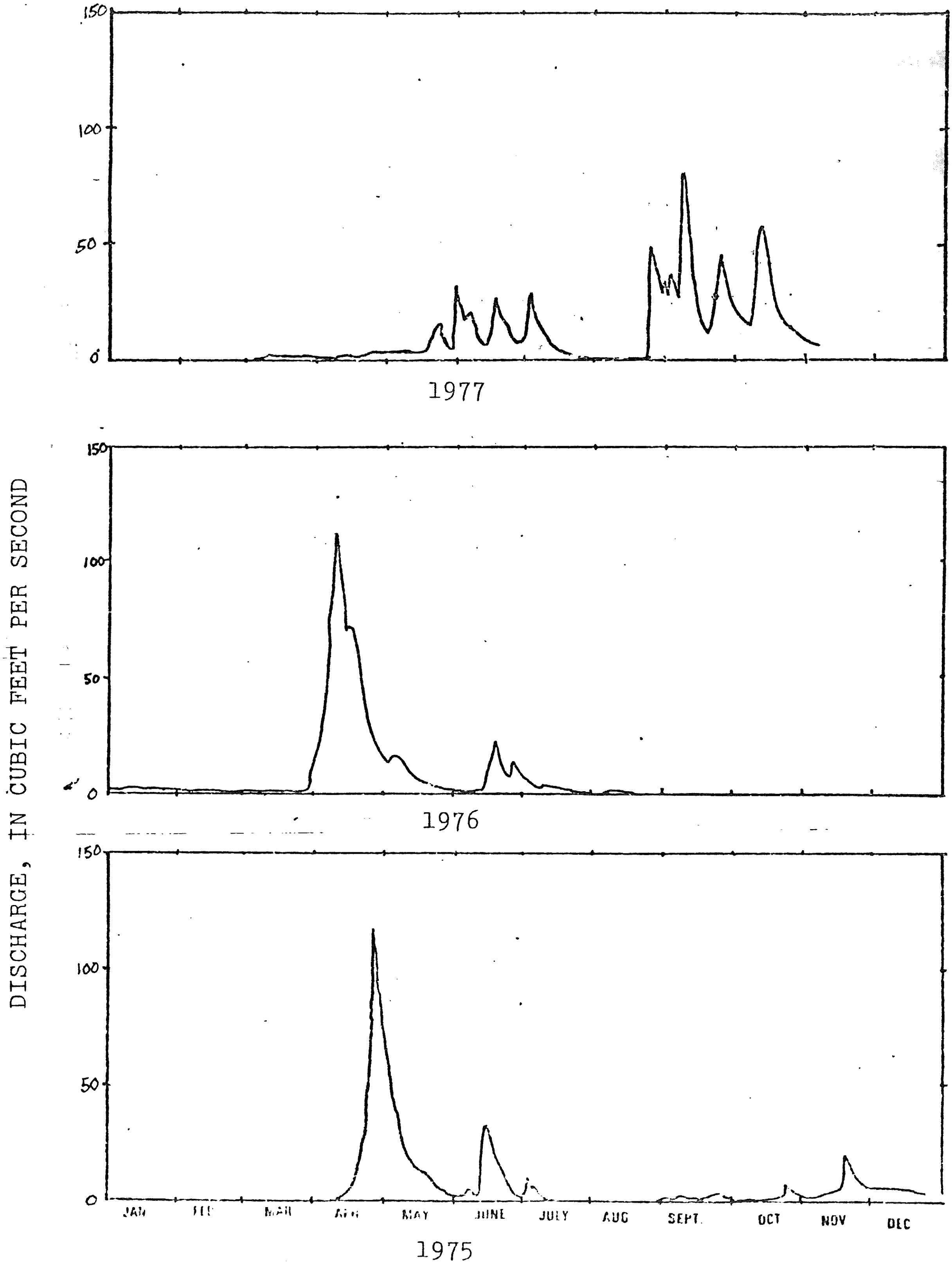


Figure 13 Annual discharge at F1X gage

evapotranspiration which would be minimal because of the very dry soil conditions at the beginning of the growing season.

The soil moisture deficit in fact probably extended through early May when precipitation events still were not reflected in discharge hydrographs at Filson Creek. The estimate of 2.9 inches may be consequently on the small side.

Part of the recharge to Filson Creek watershed went into surface storage, mainly Omaday and Bogberry Lakes. Pecise lake level measurements are not available prior to May 1977. However, correlation between the lake level measurements from May to June with discharge at F1X gage gives a correlation coefficient of 0.98 (figure 14). A plot of lake level versus time (figure 15) indicates that the linear rise in stage from spring recharge stopped at the end of June and then declined during the summer months until the heavy precipitation events in the fall. This decline is attributable to less recharge during the summer months and the increase in evaporation from the lake surface. From the correlation between lake level and F1X discharge, it is estimated that the lake level at ice melt in March was about 0.3 feet, relative to the staff gage installed in May. The rise in lake level of about 0.7 feet from snowmelt and precipitation until the end of April is equivalent to storage of 0.2± 0.05 inches. This figure subtracted from the combined soil moisture deficit and depression storage of 2.9 inches gives an estimated soil moisture deficit at the beginning of 1977 of from [illegible] 2.6 to 2.7 inches.

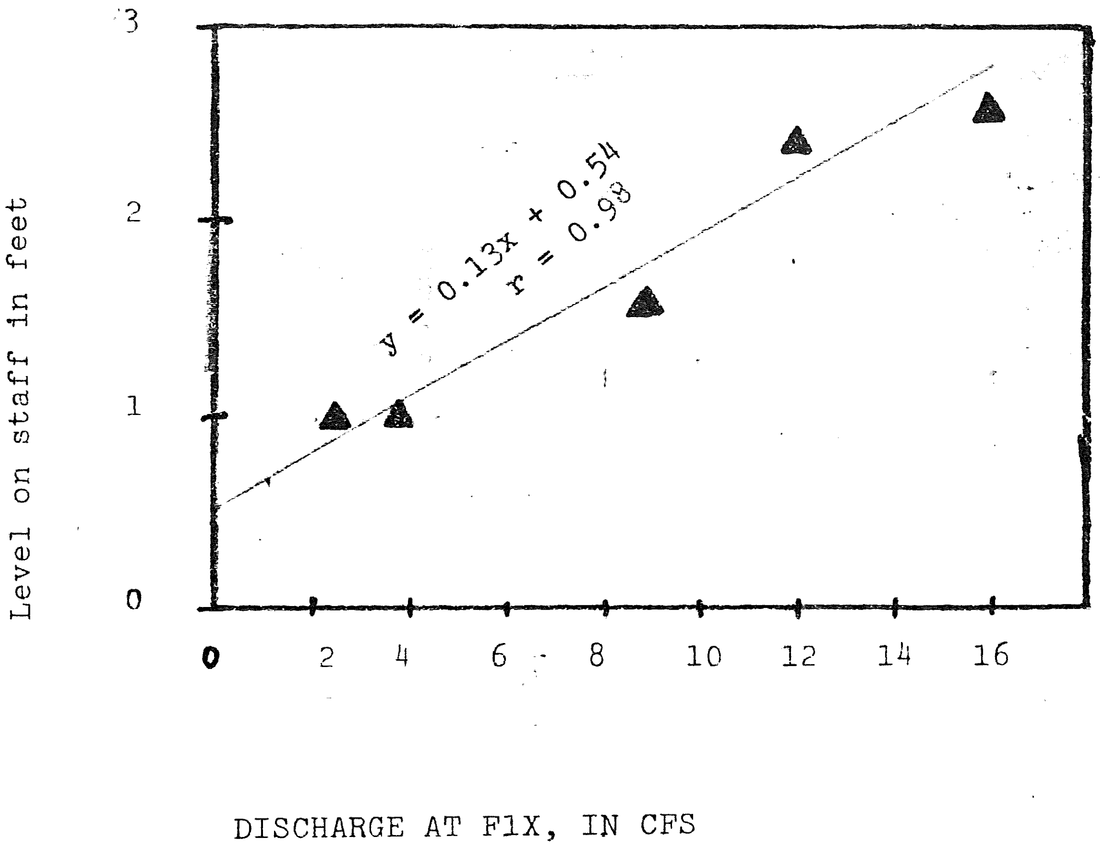


Figure 14 - Correlation between Omaday Lake level and Discharge at F1X Gage

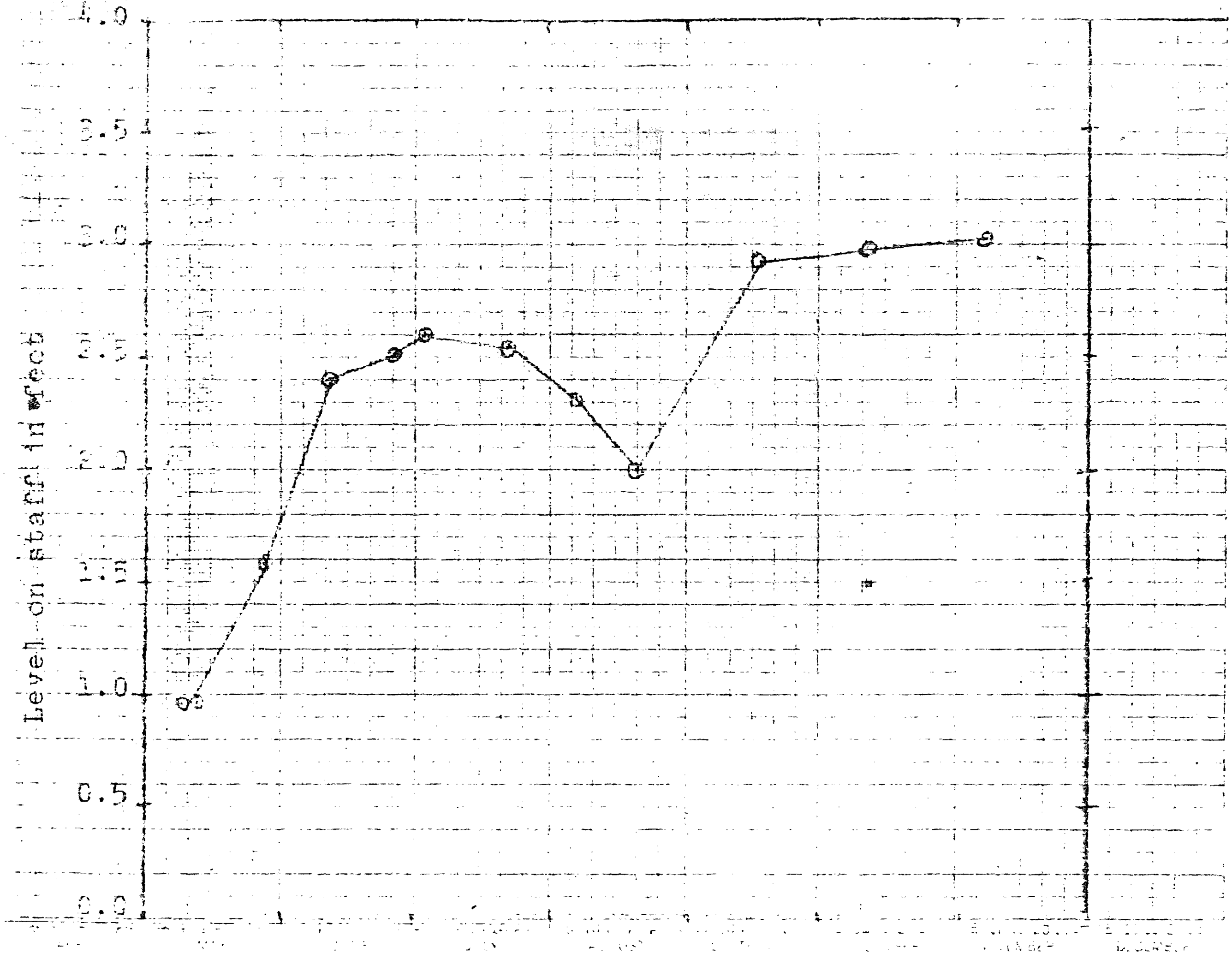


Figure 15 - Water Levels at Omaday Lake, 1977

Soil moisture deficit can also be calculated by using the Thorthwaith water balance method (Thorthwaith and Mather, 1955, 1957).

The Thornthwaith method contains assumptions which may not be directly applicable to Filson Creek Watershed. These assumptions are:

1) that there is neglig~~e~~able surface depression storage
2) that the rate of ET is uniform over the watershed
3) that the effects of humidity and wind velocity are minimal

Filson Creek watershed contains different types of vegetation and soils, lake storage, and indeterminate amount of surface depression storage. Despite these limitations, the method should give an approximation of the magnitude of the combined soil, lake and surface depression storage deficit that existed at the end of the 1976 drought.

The water balance equation used in the method is:

$$P = RO + INF + ET + PERC$$

where: P = monthly precipitation
RO= monthly discharge at F1X
INF= infiltration into the soil and till
ET= evapotranspiration
PERC= recharge to the groundwater system

The method uses mean monthly temperature to calculate a total annual heat index, a dimensionless measure of the amount of heat energy received on the surface of the watershed in one year. The index is applied in an equation that calculated a monthly potential evapotranspiration which is adjusted for latitude differences in the amount of sunlight. The actual evapotranspiration is limited by the moisture content in the soil. In the accounting procedure, the monthly potential evapotranspiration is subtracted from the monthly infiltration to determine when infiltration is in excess. When (INF-PE) is negative, soil moisture loss will occur. For use on a monthly basis, the negative values are summed from month to month. In order to determine how much evapotranspiration will remain in the soil after a given amount of ET, the cummulative negative values are applied to soil moisture retention tables developed from experimental work(Thorthwaith,1957). Finally, actual ET is calculated through use of the equation:

AE = PET +((INF-PET)- change in soil moisture storage)

Tabulation begins after the spring snowmelt in 1976 when it was assumed that the soil and till were fully saturated.
It was assumed that 85% of the FIlson Creek watershed is covered by an average of 6 inches of till, classified from grain size analyses as gravelly sand to gravelly,sandy loam (figure 16). This soil type would have an available water capacity of about 0.10 inches/inch (Irrigation GUide for Minnesota,1979). The average thickness cited is an estimate based on Prettyman (1976) and the author's experience in the field.

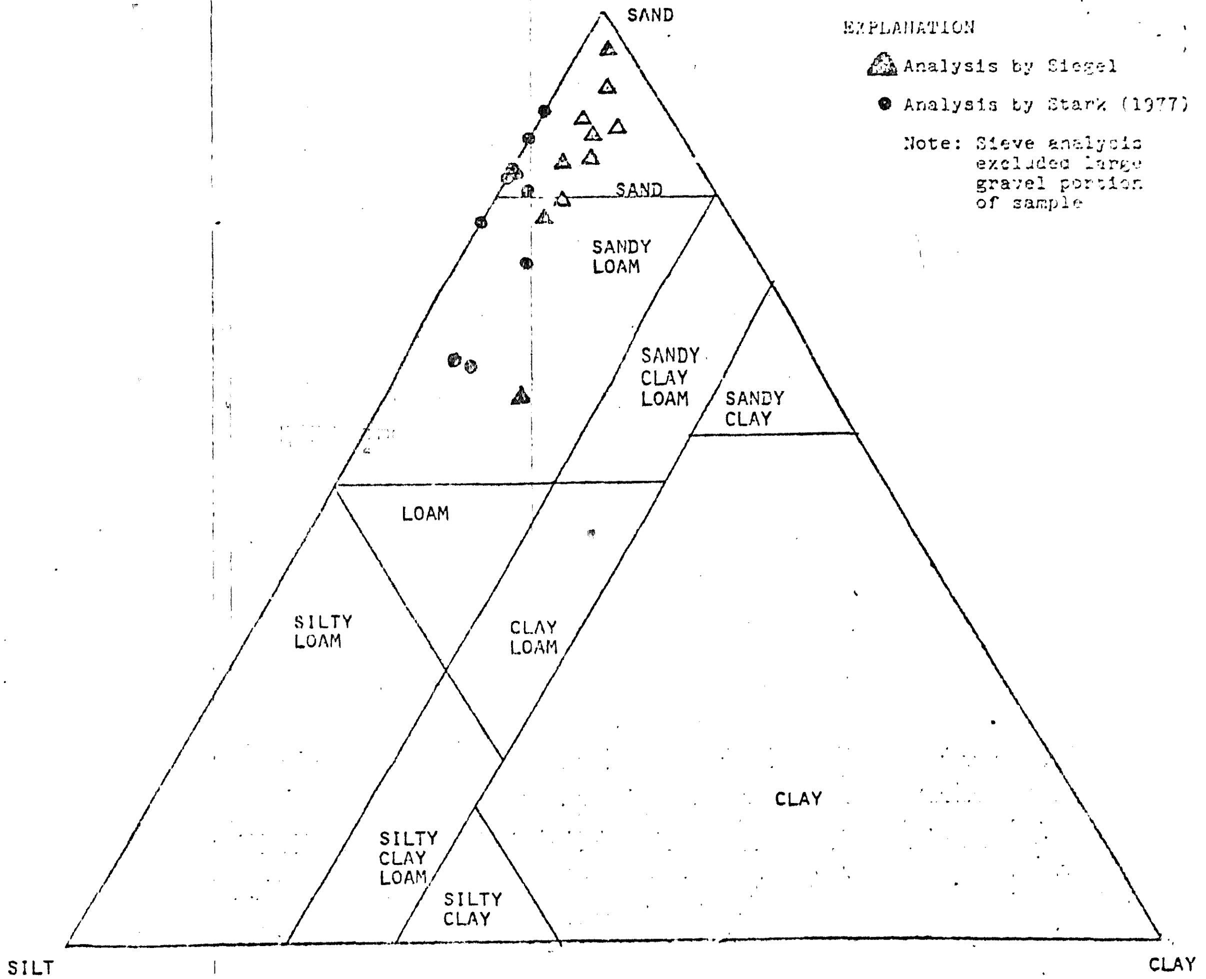


Figure 16 - GRAIN SIZE DISTRIBUTION OF TILL SAMPLES COLLECTED FROM FILSON CREEK WATERSHED

The remaining 15 percent of the watershed was assumed to be covered by woody peat having a specific yield of 0.25 inch/inch (Boelter,1966). Available moisture content, defined as the difference between the specific yield and the wilting point, is used in the Thornthwaith calculations. The concept of available moisture content generally applies to soils above the water table, and not to wetlands having the water table at or near the land surface. It is assumed, therefore, that the storage capacity of the peat lies somewhere between the porosity, of about 0.9 inch/inch, and the specific yield. For the Thornthwaith calculations, an average value of 0.6 inch/inch is assumed, realizing that the error may be as much as 30 percent.

Normalizing for the entire watershed gives an average soil cover having an "available moisture content" of between three and four inches/inch.

Table 8 gives the monthly water balance from the end of May to November 1976. The data indicate that the soil moisture deficit at freeze-up in November was between 2,8 and 3.5 inches, which compares favorably with the estimate obtained from the difference between precipitation and runoff during March and April 1977.

Table 8 Soil Moisture at the End of 1976, calculated by the Thornthwaith Water Budget Method

Month *	Temp., in C°	i	Unadj. PE	PE	P	RO	INF (P-RO)	(INF-PE)	Σ-(INF-PE)	Storage
June	17.2	6.61	3.5	4.6	5.9	0.9	5.0	0.4	---	4.0
July	18.9	7.49	3.8	5.1	1.9	0.2	1.7	-3.4	-3.5	1.6
Aug	17.9	6.90	3.6	4.4	1.7	0.0	1.7	-2.7	-6.1	0.8
Sept	12.8	4.15	2.6	2.7	1.7	0.0	1.7	-1.0	-7.0	0.6
Oct	2.1	0.27	0.2	0.2	1.2	0.0	1.2	-1.0	-8.0	0.5
Nov	-6.7	---	---	---	---	0.0	---	---		---

* Assuming an available soil moisture capacity of 4.0 inches

Month *	Temp., in C°	i	Unadj. PE	PE	P	RO	INF (P-RO)	(INF-PE)	Σ-(INF-PE)	Storage
June	17.2	6.61	3.5	4.6	5.9	0.9	5.0	0.4	---	3.0
July	18.9	7.49	3.8	5.1	1.9	0.2	1.7	-3.4	-3.4	0.9
Aug	17.9	6.90	3.6	4.4	1.7	0.0	1.7	-2.7	-6.1	0.4
Sept	12.5	4.15	2.6	2.7	1.7	0.0	1.7	-1.0	-7.0	0.3
Oct	2.1	0.27	0.2	0.2	1.2	0.0	1.2	-1.0	-8.0	0.2
Nov	-6.7	---	---	---	---	0.0	---	---		

* Assuming an available soil moisture capacity of 3.0 inches

A third method of estimating the storage deficit is to assume that most of the storage capacity is located in the wetlands.

At the end of October 1976 when the piezometers were installed for the study, saturation in the wetlands along Filson Creek and between Omaday and Bogberry Lakes was from 1 3/4 and 2 feet below the land surface. Much of the peat above the water table was visually "powder dry". Assuming a porosity of 90 percent (Boelter,1964,1969) for the woody, fibric peat typical of the fens, a value of between 2.8 and 3.2 inches of storage capacity is obtained.

Assuming an average value of 0.5 feet of till with an average porosity of 10 percent over 85% of the watershed, an additional 0.5 inches of storage is obtained. Summing gives a range in available storage between 3.3 and 3.7 inches. This range is undoubably high because upon recharge all the void spaces in the dry peat and till would not be immediately filled and because the peat was partly saturated immediately above the water table.

From these varied methods the best estimates of the storage deficit (lake,surface depression, and soil moisture) available at snowmelt in 1977 range from 2.8 to 3.5 inches. By the end of May 1977, wetlands were not only completely saturated, but contained free standing water. For the remainder of the year, most of the remaining storage in the watershed was within the lake basins and periodic saturation of the thin till overlying the bedrock ridges.

Groundwater levels (fig. 17) in piezometers BSSW and QBW, located in headwater wetlands, generally fluctuated at or near the land surface. Water levels fluctuated more widely in piezometers 2xW and 3XW which were located in fens immediately adjacent to FIlson Creek. The greater amplitude in water level changes probably is a result of many factors, including bank storage after large storms, and low hydraulic conductivity in horizons deeper than three feet. Standing water up to 0.5 feet deep on the fens correlated directly with water levels measured in the piezometers. This standing water remained at 3XW and 2XW even when Filson Creek, only a few feet away, was over a foot lower.

An anomalous dry period recorded during July for 2XW was caused by clogging of the well screen. After the screen was replaced, water levels returned to levels above the land surface comparable to the free standing water.

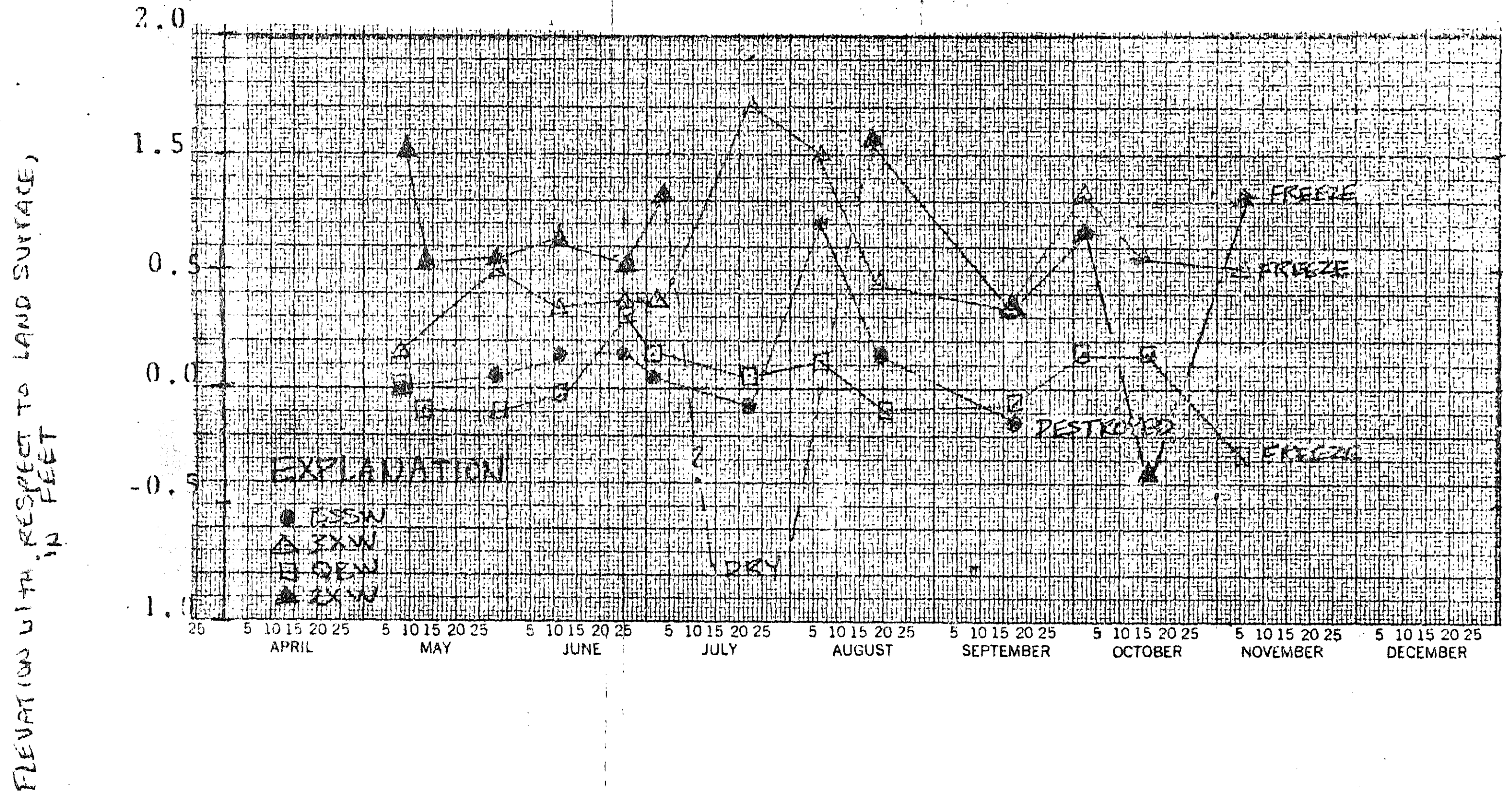


Figure 17 Water Level in Wetland Piezometers, 1977

Table 9 gives the estimated monthly water budget for Filson Creek watershed from May through September 1977 above the F1X gage. Changes in lake storage were estimated from lake level reading at Omaday Lake. Evaporation from the lakes was calculated by taking the product of 0.7, the lake area, and the evaporation measured by the U.S. Forest Service at an evaporation pan located about four miles southwest of F1X gage. Based on the groundwater hydrographs of the wetland piezometers located in the headwater areas, it was assumed that the wetlands were effectively saturated and groundwater storage remained effectively constant. Evapotranspiration was calculated as a residual. Due to the very flashy precipitation events that occured in both spring and fall of 1977, the Thornthwaith Water Budget method proved to be non-usable. The method is best used during seasons with one wet and one dry period, such as occured in 1976. When multiple precipitation events of similar or greater intensity occur late in the year, the method is very difficult to use and its reliabiliy falls, especially in watersheds as complicated as Filson Creek.

Table 9 Estimated Water Balance for Filson Creek Watershed between May and October, 1977

Month	Precipitation[3]	Stream Runoff	Lake Evaporation[1]	Lake Storage[2]	ET
May	5.1	0.6	0.9	+0.2	3.4[a]
June	4.4	1.9	0.7	+0.2	1.6
July	3.3	1.0	0.8	-0.1	1.6
Aug	5.9	0.7	0.9	0.0	4.3
Sept	6.2	3.8	0.7	+0.1	1.6

---

[1] Evaporation calculated using U.S.F.S. pan data

[2] Lake storage calculations assumed steep nearshore gradient at lake edge

[3] Precipitation data from South Kawishiwi Laboratory

[a] ET value includes unknown amount of soil moisture deficit at beginning of May

WATER QUALITY

Methods

Sampling for water quality was done approximately biweekly from March, 1977 to February, 1978 from a total of four locations on Filson Creek and Omaday Lake, four piezometers placed in wetlands in the Filson Creek Watershed, three precipitation collectors, and six infiltration water collectors placed at the interface between the A and B-soil horizons (fig. 16).

Filson Creek water samples were collected at midstream position near gauging points. Sampling was done by submerging a high density one liter polyethylene bottle below the water surface at approximately 2/3 of the total water depth, and allowing it to completely fill. Sample bottles were pre-rinsed once with ten percent nitric acid and three times each with de-ionized water and stream water at the time of sampling. Separate samples were taken for total copper and nickel analyses by submerging a fifty milliliter teflon bottle which was pre-rinsed with ultra-pure nitric acid and then washed out with de-ionized water. Samples collected for trace metal analyses were immediately acidified in the field with one milliliter of ultra-pure nitric acid.

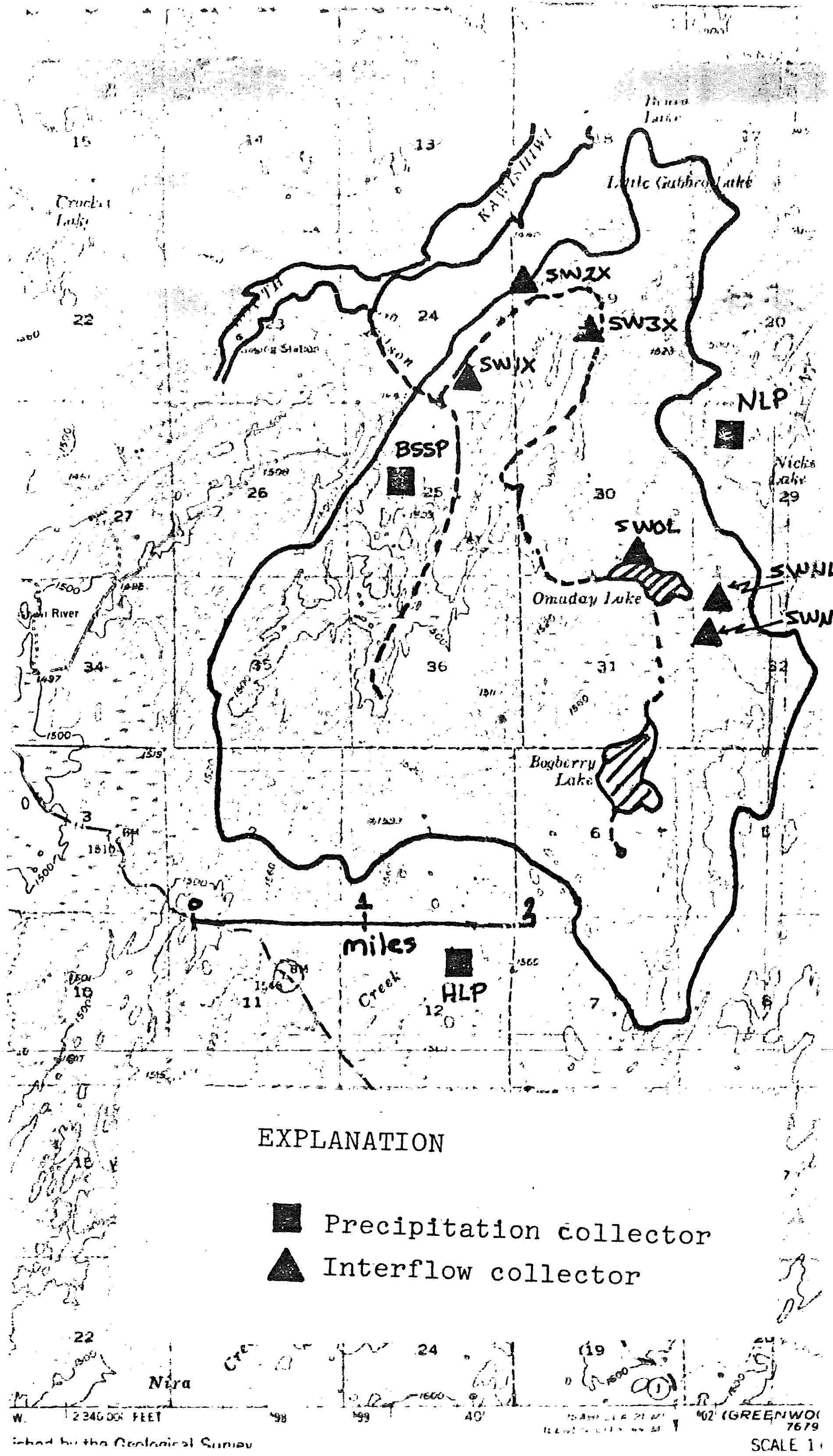


Figure 18 Location of precipitation and shallow interflow water collectors

Omaday Lake was sampled at a depth of two feet at a distance of fifteen feet from the north shore. Because Omaday Lake is less than five feet deep, it is assumed that it is fairly well mixed during the year and that the water samples were representative.

Water temperature and pH were determined in the filed for all samples except for surface infiltration and precipitation water, which were assumed to be in equilibrium with ambient temperatures, and neglecting other acid imputs, atmospheric carbon dioxide partial pressure.

Alkalinity was determined in the field for all ground water samples and within six hours of collection for Filson Creek, Omaday Lake , precipitation, and shallow surface interflow water. Titrations and pH measurements were done with a Radiometer #51 field pH meter . Alkalinity was done by potentiometric titration to the inflection point between 5.2 and 4.8 pH. When air temperature was below freezing, pH and alkalinity were determined in the laboratory.

Specific conductance was measured in the laboratory with a Radiometer Specific Conductance meter. Chloride was determined by the mercurimetric method (Brown and others, 1970). Sulfate was determined by the turbidimetric and silica by the ammonium molybdate methods (Standard Methods, 1978). Turbidity and color development were measured by a Beckman Model 24 spectrophotometer. Color blanks were run for all samples. Total and dissolved calcium, magnesium, sodium and potassium were determined by use of a Perkin Elmer Model 303 Atomic Absorption Spectrophototometer (Brown and others, 1970). When analyzing for calcium and magnesium, lanthanum oxide solution was added to the sample to mask interference from other cations (Perkin Elmer,).

Total copper and nickel were analyzed using a Perkin Elmer Model 360 Atomic Absorption Spectrophotometer equipped with a graphite furnace. Methods used were from the Perkin Elmer (manual). (1977).

Filter blanks were analyzed with each set of samples both for Nucleopore and Gelman 0.45 micron filters and for the Whatman #40 filters. Except for calcium, cations contributed in the filtering procedure were non-detectable in all cases. Anomalous calcium concentrations in filterates early in the project were determined to have come from the liners in the small polyethylene bottles used to store the filtered samples. The replacement of the caps eliminated further contamination.

A Summary of the techniques used and the minimum detection limits are given in Table 10. Concurrent with the project, split samples were run in cooperation with the Regional Copper-Nickel Study Staff and the U.S. Geological

Table 10 Summary of Analytical Techniques

Constituent	Method	Level of Detection	Source
Bicarbonate	Potentiometric titration	1 mg/l	Brown and others(1974)
Sulfate	Turbidimetric	1 mg/l	Standard Methods(1975)
Chloride	Mercuric Nitrate	0.1 mg/l	Brown and others (1974)
Silica	Ammonium molybdate	1 mg/l	Standard Methods (1975)
Calcium	Atomic-absorption		
Magnesium	Atomic-absprotion		
Sodium	do.		
Potassium	do.		
pH	Instrument method		Brown and others (1974)
Specific conductance	Wheatstone bridge method		Standard Methods (1975)
Copper	Atomic-absorption		
Nickel	Atomic-absorption		

Survey for quality control assurance. With the exception of sulfate and bicarbonate results for sample CONF, quality control results are favorable (Table 11).

The sulfate discrepancy for sample CONF probably reflects problems associated with the analysis for sulfate at low concentrations in organic rich and colored waters. The U.S. Geological Survey uses the thorin method which, in part, removes metal cations from the sample by ion exchange prior to a titration procedure (Brown and others, 1970). My work and other laboratories cited in Table 11 used the turbidimetric technique, which spectrophotometrically measures the degree of turbidity caused by the precipitation of $BaSO_4$ in a acid solution.

To assess the reliability of the turbidimetric technique beyond the replicate samples, Filson Creek water in which sulfate was non detectable was "spiked" with known amounts of sulfate in a blind test. Results of the test are given in Table 12 . More tests are being done, but the results suggest that the turbidimetric method will give accuracy to ± 40 percent at low concentrations. Furthermore, the tests suggest that the results will tend to be high, and inconclusive below 2 milligrams per liter.

Table 11 Quality Control Program

Concentration, in milligrams per liter

Lab	Sample	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Si
U.S.G.S.	CONF	3.0	2.0	0.7	0.1	1.8	9, 4.8, 5.7, 6.3	8	12
Siegel	CONF	2.9	1.9	1.0	0.4	1.8	N.D.*	3	12
Minn. Dept. Health[a]	BBL								
Siegel[a]	BBL	9.6	6.6	3.2	0.6	1.5	3.5	26	3.5

* ND. Not detected

a Total cation concentration

Lab	Sample	Cu µg/l	Ni µg/l	SO_4 mg/l	Alk mg/l
Environmental Research Lab-Duluth	D2511771	1.62±.07	1.44±.13	--	--
	D2511772	1.72±.12	1.08±.16	--	--
Erie Mining Company	D2511771	1	<5	33	24
	D2511772	1	<5	33	16
State Health Department	D2511771	1.8	<1	30	12
	D2511772	1.7	<1	27	11
SERCO	D2511771	1.4	1	14	10
	D2511772	1.4	1	12	6
Eisenreich	D2511771	--	--	--	--
	D2511772	--	--	--	--
Siegal	D2511771	1.1	ND	25.6	12.0
	D2511772	0.7	7.0	25.6	12.0

Lab	Sample	Cu µg/l	Ni µg/l	SO_4 mg/l	Alk mg/l	Silica mg/l
Environmental Research Lab-Duluth	BB328771	3.49±.10	57.8±4.0	-	-	-
	BB328772	3.79±.12	60.4±4.4	-	-	-
Erie Mining Company	BB328771	4	61	62	84	-
	BB328772	3	60	54	86	-
State Health Department	BB328771	7.9	49	54	71	34
	BB328772	8.8	56	55	71	34
Eisenreich	BB328771	2.4	51.2	51.0	-	-
	BB328772	2.4	55.2	53.4	-	-
Siegal	BB328771	3.5	51.1	58.8	67	36.6
	BB328772	2.6	58.8	54.5	62	37.4
Serco	BB328771	2.5	34	54	70	32
	BB328772	2.5	34	56	71	28

Table 12 Sulfate quality control experiment

Known concentration (mg/l)	analytically determined concentration (mg/l)
1	Not detected
2	2.5,2.6
5	6.8,7.8,7.8
7	8.8

Alkalinity of surface water in northeastern Minnesota will often change in time probably because of the breakdown of humic and fulvic acids typical of these waters (Malcolm, 1978) or equilibiation with atmospheric CO_2 if the titration is prolonged. Consequently, alkalinity should be rapidly measured soon after sample collection in the field or results may be anomalously high.

Ground water samples were collected by using a peristaltic pump connected to a pre-rinsed acid-washed Millipore filter apparatus equipped with Nucleopore 0.45 micron acid washed filters. Fifty milliliters of sample were filtered in the field and acidified by the addition of one milliliter of ultra pure nitric acid. In addition, up to one liter of unfiltered sample was collected for anion analyses.

Precipitation was collected in acid-washed, one liter, high density polyethylene bottles equipped with two plastic funnels separated by Whatman #40 filter paper previously washed in acid and de-ionized water. This filter paper was used to prohibit particulate material and insects from entering the bottle.

Surface infiltration water samples were collected by inserting a PVC plastic sheet, one quarter inch thick, 30 inches long and six inches wide between the A and B-soil horizons. Attached to the sheet was a PVC trough which funneled infiltrating water into an acid washed, polyethylene bottle. Both the trough and bottle opening were covered by nylon mesh to keep out large particulate material. The design of the apparatus was similar to that described by Wright (1977).

All water quality samples were chilled at about 40°F during transportation from the field and in subsequent laboratory storage. Twenty-five milliliters of each stream, precipitation and infiltration sample was filtered and acidified in the laboratory using the same techniques outlined for the collection of the ground water samples.

The results of water quality analyses are given in Appendix 5 .

Results

From March, 1977 to February, 1978, concentrations of dissolved calcium, magnesium, sodium and potassium, pH, sulfate, bicarbonate, specific conductance and silica were remarkable similar at the sampling locations on Filson Creek and at Omaday Lake (Table 13). Tests of significance between mean concentrations at the F1X location and at other locations on the creek and Omaday Lake generally show no difference at the 95 percentile level of significance (Appendix 6). Only the mean chloride and total potassium concentrations are significantly different, both being

Table 13 Summary statistics for water quality of [illegible] from 12-4-76 to 1-[illegible]. Concentrations in mg/l except [illegible] (ug/l), pH (units), specific conductance (umhos). "D" is dissolved, "T" is total. Cu and Ni values are for total metal.

F1X LOCATION

TOTAL N 25

VARIABLE	VALID N	MEAN	ST-DEV	MAXIMUM	MINIMUM
PH	21	6.11	.37	6.60	5.00
HCO3	21	7.28	3.30	13.00	2.00
SO4	21	2.33	3.01	13.00	0
CL	25	.95	.53	2.20	.40
TCA	22	3.72	1.01	5.60	2.10
DCA	16	2.81	.65	4.20	1.50
TMG	22	2.47	.80	3.80	1.60
DMG	20	1.56	.48	2.60	1.10
TNA	24	1.42	.35	2.50	1.10
DNA	22	1.30	.26	1.60	1.00
TK	25	.51	.28	1.20	.20
DK	22	.45	.23	1.00	.20
SILICA	21	8.78	4.26	18.60	1.00
SPCD	23	41.00	8.26	60.00	26.00
CU	15	6.44	1.79	9.00	1.95
NI	14	4.65	1.64	7.50	0.00

F3X LOCATION

TOTAL N 18

VARIABLE	VALID N	SUM	MEAN	ST-DEV	MAXIMUM	MINIMUM
PH	17		6.12	.27	6.58	5.50
HCO3	17		6.53	6.97	32.00	2.00
SO4	18		1.67	1.78	7.00	0
CL	18		1.28	.49	2.20	.50
TCA	18		3.30	.99	6.00	2.00
DCA	13		2.62	.72	4.00	1.80
TMG	17		2.19	.91	5.40	1.50
DMG	13		1.55	.37	2.10	1.00
TNA	18		1.40	.40	2.50	1.00
DNA	13		1.21	.22	1.70	1.00
TK	18		.74	.24	1.10	.30
DK	13		.62	.17	1.00	.30
SILICA	18		7.21	4.06	15.20	.80
SPCD	16		38.31	7.98	51.00	21.00
CU	9		4.64	1.38	6.60	0.00
NI	8		2.70	2.67	8.20	0.00

OL-2 LOCATION

TOTAL N 17

VARIABLE	VALID N	SUM	MEAN	ST-DEV	MAXIMUM	MINIMUM
PH	17		5.86	.26	6.53	5.55
HCO3	17		8.29	12.52	56.00	3.00
SO4	16		2.83	3.27	10.80	0
CL	17		1.29	.55	2.70	.40
TCA	17		3.73	.89	6.00	2.50
DCA	14		2.59	.60	3.60	1.70
TMG	17		2.58	1.12	6.20	1.50
DMG	14		1.61	.42	2.50	1.10
TNA	17		1.53	.75	4.20	1.10
DNA	14		1.24	.26	1.80	1.00
TK	17		.72	.40	1.90	.30
DK	14		.64	.29	1.50	.30
SILICA	17		7.22	3.38	14.70	1.60
SPCD	15		42.53	14.01	82.00	23.00
CU	8		2.15	1.97	3.70	.95
NI	5		1.21	.95	4.50	0

Table 13 (continued)

OMADAY LAKE

TOTAL N 21

VARIABLE	VALID N	SUM	MEAN	ST-DEV	MAXIMUM	MINIMUM
PH	21		6.27	.31	6.95	5.60
HCO3	21		6.59	5.33	19.00	3.00
SO4	21		2.67	3.76	15.00	0
CL	21		1.28	.48	2.20	.50
TCA	21		3.97	2.05	8.00	2.00
DCA	13		2.69	.71	3.90	1.90
TMG	21		2.65	1.39	5.60	1.50
DMG	13		1.60	.31	2.20	1.20
TNA	21		1.70	.74	3.40	1.10
DNA	13		1.27	.23	1.80	1.00
TK	21		.61	.18	.90	.50
DK	13		.62	.16	.90	.50
SILICA	21		6.18	4.95	16.80	1.00
SPCD	19		39.26	7.56	50.00	21.00
CU	11		2.44	3.60	9.00	
NI	9		0.50	1.00	3.10	

QST LOCATION

1 TOTAL N 11

VARIABLE	VALID N	SUM	MEAN	ST-DEV	MAXIMUM	MINIMUM
PH	11		6.00	.18	6.29	5.62
HCO3	11		6.18	2.82	12.00	3.00
SO4	11		1.91	1.38	4.00	0
CL	11		1.19	.56	2.40	.50
TCA	10		3.22	.36	4.00	2.60
DCA	8		2.41	.60	3.40	1.70
TMG	10		2.27	.51	3.30	1.60
DMG	8		1.81	.39	2.30	1.20
TNA	10		1.30	.15	1.60	1.10
DNA	8		1.20	.09	1.30	1.10
TK	10		1.00	.78	3.10	.60
DK	8		.96	.79	2.90	.60
SILICA	11		6.39	2.72	12.10	2.90
SPCD	9		39.00	7.76	55.00	31.00
CU	7		1.27	1.48	4.50	.30
NI	7		.16	.42	1.10	0

SF LOCATION

TOTAL N 17

VARIABLE	VALID N	SUM	MEAN	ST-DEV	MAXIMUM	MINIMUM
PH	17		6.38	.17	6.70	6.10
HCO3	17		9.35	6.29	26.00	3.00
SO4	17		1.59	2.66	10.00	0
CL	17		1.25	.79	3.60	.40
TCA	17		3.49	1.02	6.00	2.00
DCA	12		2.58	.66	3.90	2.00
TMG	16		2.53	1.04	5.50	1.70
DMG	11		1.64	.34	2.10	1.00
TNA	17		1.58	.67	3.80	1.10
DNA	11		1.17	.15	1.50	1.00
TK	17		.65	.45	2.10	.30
DK	11		.45	.09	.60	.30
SILICA	17		11.00	4.56	25.00	4.60
SPCD	14		41.51	12.2[illegible]	69.00	27.00
CU	10		[illegible]	[illegible]	7.80	3.0[illegible]
NI	10		[illegible]	[illegible]	3.10	0.03

a little lower at F1X than at other locations.

This difference is apparent rather than real because additional samples were collected at the F1X location during storm events in June, 1977 and not at the other locations.

Negative correlation coefficients between concentrations of major ions and discharge at the F1X location show fair concentration-discharge dependences (Table 14). When the additional samples at F1X are removed from the T-Test analysis, the means of chloride and total potassium concentration no longer are significantly different at the F1X location. ¶ T-Tests of significance indicate that the mean pH at F1X (6.1) is significantly different than that at OL-2 (5.8), which is immediately downstream from the wetlands at the mouth of Omaday Lake. The lower pH of OL-2 is typical of perched wetland streams which do not receive substantial amounts of their base flow from ground water sources (Verry, 1975).

Total concentrations of copper and nickel in 1977 generally increase from headwater locations, OL-1 and SF, to F1X near the mouth (fig. 19). Total nickel concentrations measured at QST and Omaday Lake were, except for one sample, less than one microgram per liter, while mean concentration at F1X and F3X were about 5 and 3 micrograms per liter respectively.

Table 14 Correlation coefficients between discharge and water chemistry at F1X location. Data from this study and Water Resources Data for Minnesota (1976)

Parameter	r	Number of samples	Significance
pH	-.14	37	.207
HCO_3	-.56	39	.001
SO_4	-.27	39	.049
Cl	-.30	43	.026
DCA	-.42	30	.001
TCA	-.49	19	.017
DMG	-.43	34	.006
TMG	-.46	19	.023
DNA	-.31	36	.030
TNA	-.56	21	.005
DK	-.01	36	.467
TK	-.29	22	.094
SILICA	+.22	39	.094
SP.COND.	-.37	41	.007

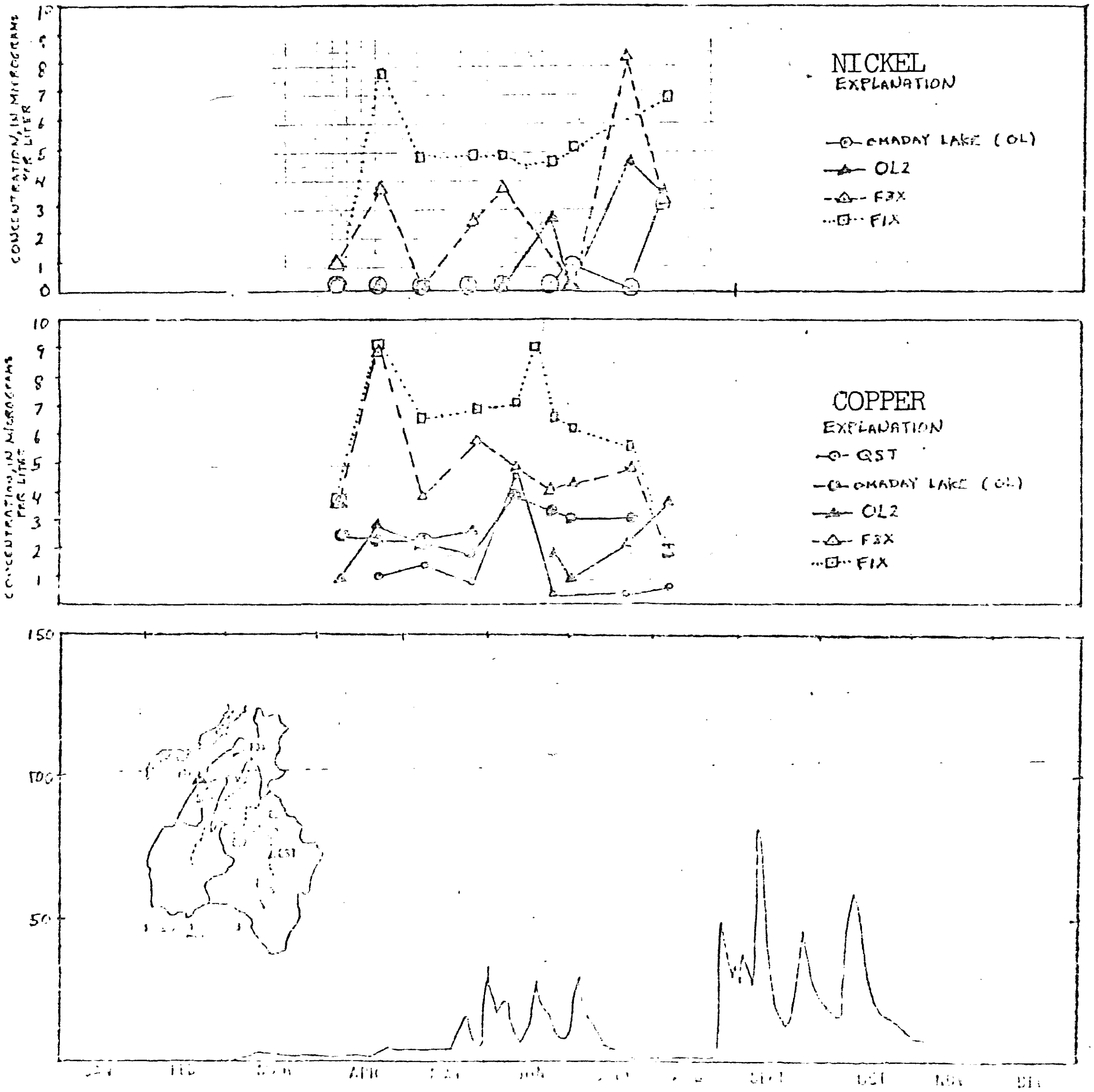


Figure 19 Concentrations of Copper and Nickel in Filson Creek

The smaller copper and nickel concentrations in Filson Creek headwater locations reflect the smaller percentage of sulfide bearing clases in the till and the greater distance of these locations from the contact zone.

Analyses of samples collected at F1X location during a runoff event in mid-June, 1977, show a slight decrease in copper and nickel concentrations during maximum discharge. Similar relationships are not present for other major cations (fig. 20). The observed decrease in copper and nickel is small and may in part reflect analytical limitations.

A comparison of mean concentrations of major cations Cl, HCO_3, pH, silica, and specific conductance for the calendar years 1976 and 1977 shows the difference between Filson Creek water quality during respective dry and wet years (Table 15). Concentrations of major cations and silica are higher in base flow conditions than in runoff events.

Comparison of dissolved cation concentrations over time for samples collected at F1X during 1976 and 1977 show similarity in general Trends. (figure 21). Duing precipitation events , concentrations decrease. Base flow in 1977 occurred only during early August, when concentrations of dissolved cations were very similar to concentrations in base flow during 1976. Cation concentrations measured in baseflow during January and February 1978 were also similar to that in 1976.

FIGURE 2.0 CONCENTRATION VARIATIONS FOR SELECTED CONSTITUENTS FOR STORM EVENT ON FILSON CREEK, [illegible]

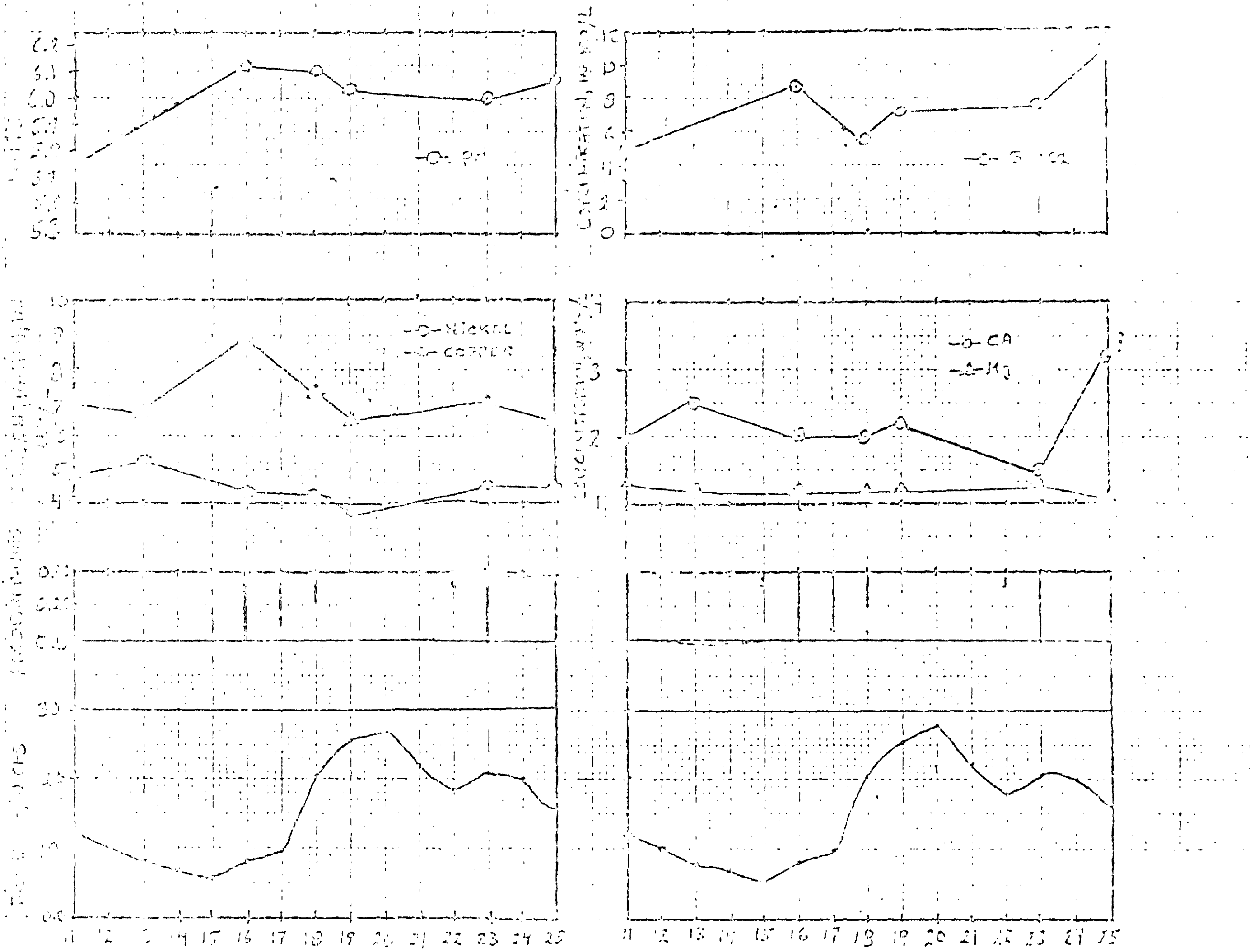


Table 15 COMPARISON BETWEEN MEAN CONCENTRATIONS AT FILSON CREEEK FOR MAJOR CONSTITUENTS BETWEEN 1976 and 1977 (March to December)

	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	Silica	Cu	Ni	[N]
1976[a]	6.36	3.5	2.2	1.3	.4	16	5	1.6	12.7	8.7	6.3	13
1977[b]	6.09	2.6	1.6	1.1	.5	8	2	0.9	8.6	6	4	[17]

[a] U.S.G.S. (1977)

[b] Siegel, this report

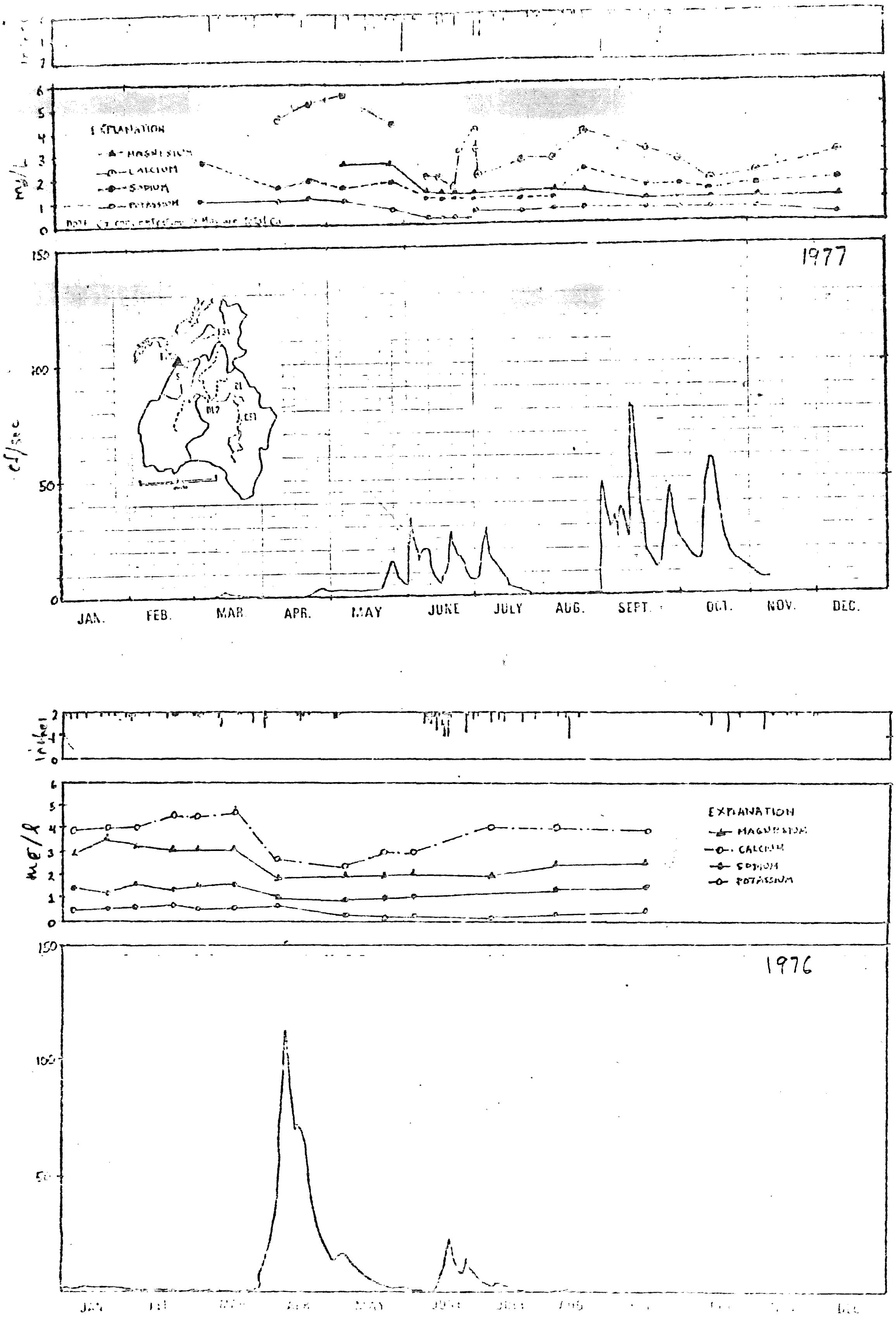


Figure 21 Variations in Cation Concentrations at F1X Location

Comparison between dissolved silica, sulfate and bicarbonate concentrations over time showed differences between 1976 and 1977 (fig.22). Silica concentrations are depressed during spring and summer months probably due to diatom activity in the headwater lakes and bogs. During base flow winter conditions, silica concentrations rose in 1976 to about 10 mg/l, and in 1977 to a little over 15 mg/l.

Sulfate concentrations in 1976 fluctuated only slightly, while during 1977, a marked increase in sulfate occurred during snowmelt at all locations on Filson Creek as well as Omaday Lake. This increase is attributable to the sulfate load accumulated in the snowpack during the winter. Concurrent with the sulfate increase, pH dropped to its minimum value for the year (fig.22a), reflecting the pH of the snowpack measured in March 1976 as 4.7. Similar increase in sulfate was not observed in 1976. The lack of sulfate fluctuation in 1976 contrasts with the rapid drop in sulfate concentration to nearly non-detectable limits after the snowmelt in 1976, and conceivably could be related to analytical difficulties mentioned earlier in the report.

Bicarbonate concentrations in in 1977 clearly reflect dilution of baseflow by precipitation having little or no alkalinity. Similar dilution by spring snowmelt also occurred in 1976, but not with the same magnitude.

The major dissolved cations in precipitation are calcium and potassium. The major anion is sulfate. Summary statistics of the concentrations of major cations and anions, silica and specific conductance from 16 samples of bulk precipitation (wet and dry) collected from snow and three locations in or near Filson Creek Watershed are given in Table 16 .

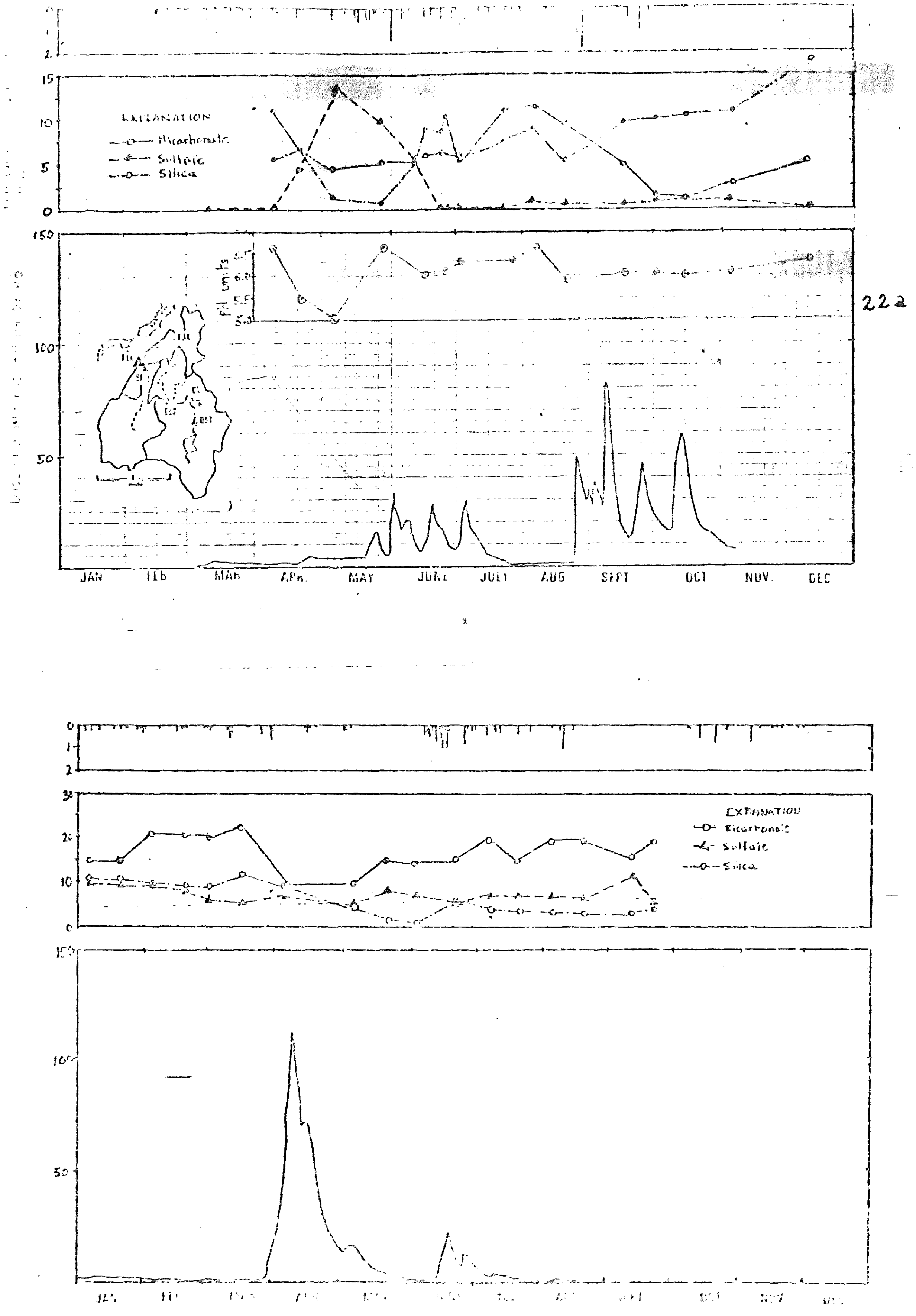


Figure 22 Variations in Anion Concentrations at F1X Location

Table 16 Summary statistics for precipitation water quality collected in and around Filson Creek Watershed, 1977

```
             1    TOTAL N       16

VARIABLE      VALID N              SUM        MEAN     ST-DEV    MAXIMUM    MINIMUM

PH                 14                         5.06        .48       6.30       4.50
HCO3               16                          .06        .25       1.00          0
SO4                15                         1.84       1.45       5.80          0
CL                 14                          .52        .26       1.20        .30
TCA                16                          .92        .37       1.50        .30
DCA                15                          .68        .27       1.30        .30
TMG                16                          .09        .09        .40          0
DMG                16                          .01        .03        .10          0
TNA                16                          .28        .29       1.00          0
DNA                16                          .15        .18        .60          0
TK                 16                          .50        .37       1.40          0
DK                 16                          .36        .24        .90          0
SILICA             16                          .14        .26        .90          0
SPCD               12                        19.00       6.70      34.00       7.00
CU                 16                            0          0         -0         -0
NI                 16                            0          0         -0         -0

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Because of vandalism, the collector at HLP location was discontinued in late July, 1977. Specific conductance was used as a measure of particulate contamination not removed by the filter paper in the collectors. Samples were deleted from statistical analysis if the specific conductance exceeded 35 micromhos. Analyses of those samples with greater than 35 umhos conductance showed anomalously high sodium or potassium concentrations. The source of the contamination probably was related to insects which were caught in the filter paper.

Atmospheric mean loading rates derived from bulk precipitation (Table 17) in the Filson Creek Watershed compare favorably with similar data collected by Regional Cu-Ni Study Group (1978).

Surface interflow water was collected at two locations at the base of two stands of aspen and birch within the mixed upland forest community, three locations at the base of an assemblage of mixed conifers, aspen and birch, and one location at the base of a stand of Jack Pine. Although most large particulate material was removed by the nylon mesh covering the apparatus, silt and clay size particles

Table 17 Atmospheric mean loading rates derived from bulk precipitation in the Filson Creek Watershed Area-1977
(all parameters in kg/hect/yr)

	Siegel, this study	Eisenreich (1978) (for Regional Cu-Ni Study Group)
Ca	4.9	4.1
Mg	1.7	1.7
Na	1.9	1.9
K	2.4	1.6
SO_4	16	14
Cl	4.4	7.4

and organic colloidal material were found in approximately 90 percent of the sample bottles at the time of collection. The measured water quality consequently is a composite of interflow water quality and additional leaching from this detritus.

Summary statistics of the interflow water quality are given in Table 18 . Mean concentrations of potassium are up to seven times greater in interflow water than in Filson Creek or Omaday Lake water. Dissolved sodium is comparable to that found in precipitation, as are concentrations of chloride and sulfate. Dissolved calcium and magnesium are greater here than in precipitation, but less than in Filson Creek. The occurrence of bicarbonate not found in precipitation reflects decomposition of organic detritus. Dissolved silica found in the interflow water is probably the result of leaching from small mineral or vegetation particles in detritus found in the bottles.

Ground water quality in the wetlands within Filson Creek Watershed appears to vary according to proximity to the mineralized zone. Ground water collected from 2XW, immediately over the contact zone, is classified as a Ca-Mg-SO_4 water compared to the Ca-Mg-HCO_3 classification of ground water

TABLE 18 SUMMARY STATISTICS FOR [illegible]

```
COLLECTED AT BASE OF NATURAL JACK PINE STAND

    1    TOTAL N        7

VARIABLE    VALID N          SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM

PH             5                      5.52       .55       5.93       4.50
HCO3           6                      2.13      2.26       6.20          0
SO4            5                       .42       .55       1.00          0
CL             5                       .60       .39       1.20        .30
TCA            7                      5.04      6.48      19.60       1.70
DCA            7                      3.23      3.32      10.70       1.50
TMG            7                       .81       .57       2.00        .30
DMG            7                       .43       .18        .70        .20
TNA            7                       .44      1.04       2.80          0
DNA            7                       .03       .05        .10          0
TK             7                      4.21      1.48       6.30       2.30
DK             7                      4.16      1.42       6.30       2.30
SILICA         4                      1.45      1.15       2.60          0
SPCD           7                         0         0          0          0
CU             7                         0         0          0          0
NI             7                         0         0          0          0
DIFF           5                       .14       .05        .18        .06
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
COLLECTED AT BASE OF ASPEN-BIRCH STANDS (SW2X,SW3X)

    1    TOTAL N        9

VARIABLE    VALID N          SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM

PH             6                      5.88       .57       6.51       5.36
HCO3           8                       .68       .83       2.00          0
SO4            9                       .84      1.18       3.30          0
CL             9                       .80       .43       1.60        .30
TCA            6                      2.40      1.48       4.80        .80
DCA            9                      1.76      1.32       4.00        .70
TMG            6                       .83       .63       2.00        .40
DMG            9                       .30       .52       1.60          0
TNA            9                       .29       .59       1.60          0
DNA            9                         0         0          0          0
TK             8                      6.89      6.02      20.00       1.30
DK             9                      6.20      7.49      20.00       1.30
SILICA         7                       .60       .77       2.10          0
SPCD           9                         0         0          0          0
CU             9                         0         0          0          0
NI             9                         0         0          0          0
DIFF           8                       .19       .24        .74        .03
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

COLLECTED AT BASE OF MIXED UPLAND FOREST STAND (SWNL-1 SWNL-2 SW1X)

         TOTAL N       12

VARIABLE    VALID N          SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM

PH             8                      5.65       .76       6.37       4.[illegible]0
HCO3           8                      3.95      2.93       7.00          0
SO4            9                       .11       .33       1.00          0
CL             8                       .8[illegible]       .39       1.40        .30
TCA           11                      3.44      1.69       6.20       1.40
DCA           12                      3.2[illegible]      2.0[illegible]       8.40       1.20
TMG           11                       .9[illegible]       .48       1.80          0
DMG           12                       .78      1.09       3.90          0
TNA           12                       .73      1.36       3.70          0
DNA           12                         0         0          0          0
TK            12                      4.99      3.29      12.30       1.70
DK            12                      3.55      3.66      12.30          0
SILICA         8                       .71       .90       2.10          0
SPCD          12                         0         0          0          0
CU            12                         0         0          0          0
NI            12                         0         0          0          0
DIFF           8                       .1[illegible]       .0[illegible]        .21        .04
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
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collected from the other piezometers (fig 23). This difference is even more apparent, considering that ground water from piezometer 3XW, located only about 30 feet north of the contact, is classified as identical to that from QBW, which is farthest removed from the contact zone. Similar sulfate predominance is reported by Siegel and others (1978) for ground water collected from Rainy Lobe till along the contact zone. Summary statistics for ground water chemistry are given in Table 19.

Copper and nickel concentrations vary considerably in wetland ground water over time and between four piezometers sampled (Appendix 5). Not enough analyses are available to statistically correlate these variations with other chemical parameters. Arithmetic means, however, suggest that total nickel concentrations decrease with distance from the contact zone. No similar trend is apparent in the mean copper concentrations.

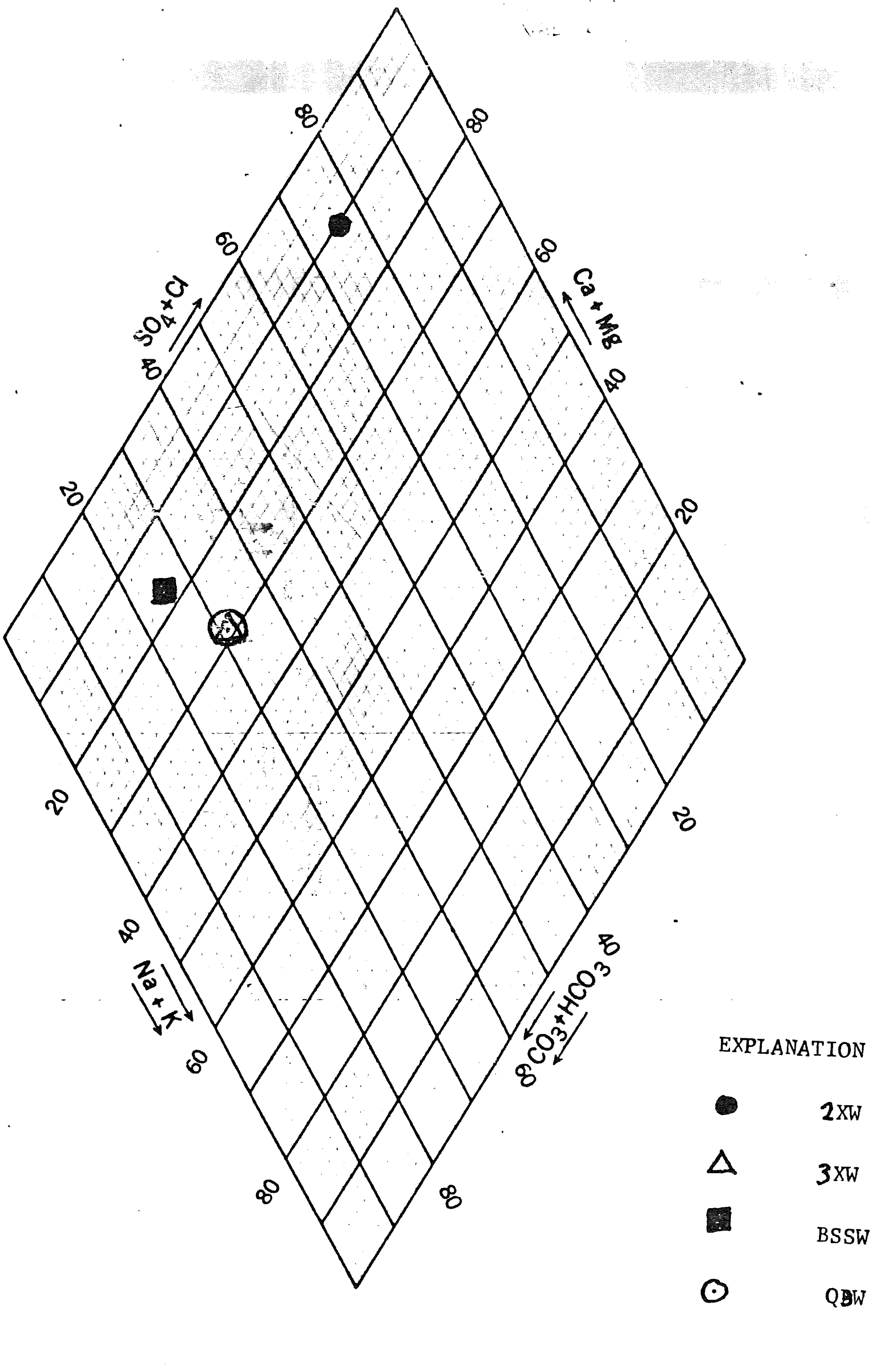

Figure 23 Piper plot of wetland water quality in Filson Creek Watershed Values plotted are mean values for 1977 samples

TABLE 19 SUMMARY STATISTICS FOR GROUNDWATER QUALITY IN WETLANDS IN THE FILSON CREEK WATERSHED

```
QEW        TOTAL N        10

VARIABLE     VALID N                 SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM
                                               5.76       .14       5.98       5.60
PH                 9                          31.40     23.81      71.00      11.00
HCO3               9                           6.36     12.13      40.00          0
SO4                9                           2.15      1.69       5.00        .20
CL                10                          10.71      5.46      20.00       3.30
DCA               10                           4.68      2.15       8.20       2.00
DMG               10                           4.65      1.53       7.40       1.70
DNA               10                           5.39      5.00      17.80       1.70
DK                10                          26.17      6.15      34.00      14.30
SILICA             9                          16.63      7.57      21.30       7.90
CU                 3                          14.27      5.20      20.10      10.10
NI                 3
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

[illegible]       TOTAL N        6

VARIABLE     VALID N                 SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM
                                               4.78      2.35       6.08         -0
PH                 6                          25.60     16.01      45.00         -0
HCO3               5                           6.09      5.00      11.00       1.00
SO4                3                            .95       .67       2.10         -0
CL                 4                          18.30     20.23      54.40       7.50
DCA                5                           3.20      2.49       6.30         -0
DMG                5                           3.32      2.28       6.40         -0
DNA                5                           3.70      4.63      10.40         -0
DK                 5                          12.20      6.63      20.20         -0
SILICA             4                           2.92      2.19       5.90         -0
CU                 5                          20.14     26.60      66.50       4.00
NI                 5
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

3XW        TOTAL N        12

VARIABLE     VALID N                 SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM
PH                12                           6.14       .23       6.53       5.[illegible]
HCO3              10                          51.46     24.16      93.00      11.00
SO4               11                          17.25     16.1[illegible]    44.00          0
CL                 9                           1.24       .44       2.00        .80
DCA               11                          10.[illegible]3      2.[illegible]      13.00       8.[illegible]
DMG               11                           6.21      1.35       7.70       4.00
DNA               11                           6.75      3.25      14.00       4.20
DK                11                            .[illegible]       .37       1.70        .4[illegible]
SILICA            11                          17.45      5.0[illegible]      29.00      10.00
CU                 3                          67.67     32.35     105.00      48.00
NI                 4                          88.00     57.46     144.00       9.50
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

[illegible]       TOTAL N        6

VARIABLE     VALID N                 SUM      MEAN     ST-DEV    MAXIMUM    MINIMUM
PH                 6                           5.77       .2[illegible]       6.20       5.[illegible]
HCO3               6                          19.17      9.55      33.[illegible]       9.[illegible]
SO4          [illegible]                          4[illegible].[illegible]7     17.[illegible]      72.00      2[illegible]
CL           [illegible]                           .[illegible]       .[illegible]       1.50        .2[illegible]
DCA          [illegible]                          1[illegible].[illegible]7      [illegible].43      20.00      10.5[illegible]
DMG          [illegible]                           7.[illegible]      [illegible]      11.40       6.1[illegible]
DNA          [illegible]                           [illegible]       .[illegible]       4.30       1.[illegible]
DK           [illegible]                            .73       .[illegible]       1.70        .3[illegible]
SILICA       [illegible]                     [illegible]      [illegible]      36.60      13.[illegible]
CU                 1                     [illegible]      [illegible]      [illegible]       [illegible]
NI                 2                     [illegible]      [illegible]      1[illegible]      [illegible]
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Chemical Budgets

The difference between the total chemical mass entering the watershed from precipitation and the amount leaving the watershed through discharge over a unit period of time comprises a chemical budget.

The yearly chemical budget for specific constituents can be expressed as:

$$\Sigma Q_p Cp_i - \Sigma Q_d Cd_i = \Delta M_i$$

where: Q_p = amount of monthly precipitation

Cp_i = concentration of constituent "i" in precipitation

Q_d = amount of monthly discharge

Cd_i = concentration of constituent "i" in discharge

ΔM_i = net gain or loss of the constituent from the watershed

Assuming dynamic equilibrium of the biomass with respect to dissolved calcium, magnesium and sodium, the budgets provide a qualitative index on the relative rates of weathering of the major silicate minerals in the watershed. Because chloride is chemically conservative, a net balance for the year will verify the previously calculated hydrologic budget.

The yearly budget for the major anions and cations for Filson Creek Watershed are given in Table 20 and figure 24. Monthly net loading on the watershed was obtained from the product of monthly precipitation measured at the Kawishiwi Laboratory and the monthly mean concentration data (if more than one sample were available) of the precipitation sampled around the watershed. It was assumed that snowmelt and precipitation during March and April, 1977 went into storage. During August, the major precipitation events occurred toward the end of the month and extended into September. Because of this, the chemical quality data collected at mid-September were considered representative of precipitation recorded between August 20 and 31. Similarly, quality data from October 1st precipitation were considered representative of precipitation that fell at the end of September.

The results of the yearly budget The sum of the monthly budgets (minus winter 1978 for which discharge data at F1X are not yet available) indicate that

1). Chloride input balances output by about 10%.

2). There is a net loss from the watershed of calcium, magnesium, sodium, silica and bicarbonate.

3). There is a net gain in the watershed of potassium and sulfate.

When the additional discharge data for winter 1978 are tabulated, the chloride balance will be a little below 10% and net losses will be a little larger.

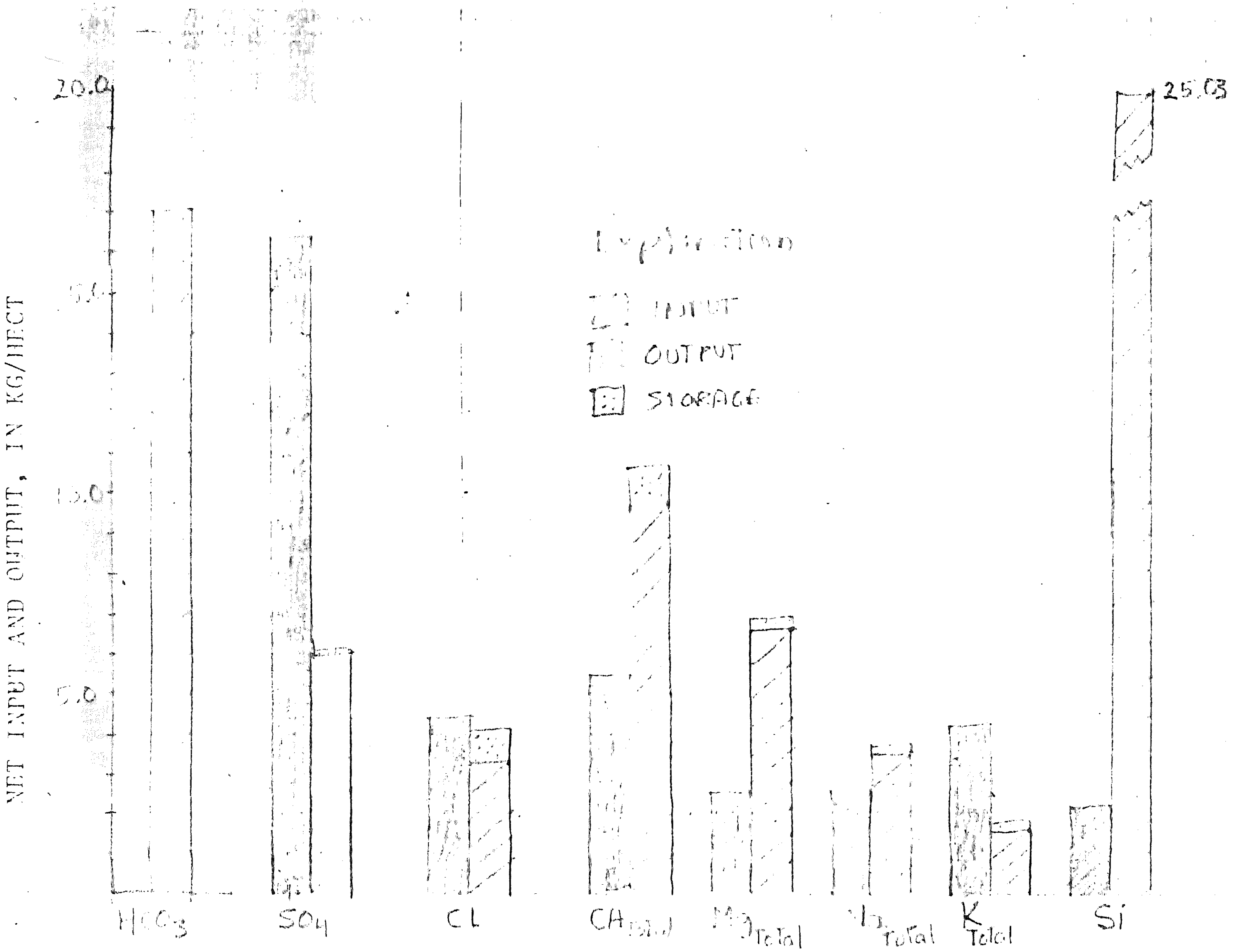

Figure 24 Bar graph showing net gains and losses of major cations and anions for Filson Creek watershed, March-October,1977

TABLE 20 Net chemical budgets for Filson Creek Watershed through March to October 1977. Snowpack and precipitation in March and April assumed to effectively have gone into storage

Mass, in Kg/Hectare

	HCO_3	SO_4	Cl	Ca_t	Ca_d	Mg_t	Mg_d	Na_t	Na_d	K_t	K_d	Si
INPUT	0.0	15.0	3.7	4.9	4.9	2.7	1.6	2.4	1.7	3.8	2.4	2.1
OUTPUT	17.2	6.3	3.3	9.8	7.1	6.6	4.4	3.5	3.3	1.5	1.5	25.0
NET LOSS OR GAIN	-17.2	+8.7	+0.4	- 5.1	-2.2	-3.9	-2.7	-1.1	-1.6	2.3	0.9	-22.9

APPENDICES

APPENDIX 1

Percentage of Mineral Species in 4ϕ Size Fraction of Till Collected from Filson Creek Watershed

Oligoclase	Labradorite Anorthite	Olivine	Clinopyroxene	Orthopyroxene Hypersthene	Enstatite	Biotite	Hornblende	Microcline	Quartz	Opaques	Number of grains
[illegible]2.7	9.1	4.4	1.3	0.7	0.5	30.2	2.4	0.5	3.1	4.8	5[illegible]
[illegible]3.0	17.2	4.3	0.4	1.2	1.6	16.2	3.6	---	1.6	10.9	5[illegible]
47.9	23.0	1.8	0.7	---	---	4.8	4.5	---	12.2	5.7	45[illegible]
43.0	11.0	3.1	0.2	4.3	1.6	19.5	2.1	---	4.1	5.5	41[illegible]
37.[illegible]	24.0	0.4	1.5	14.8	1.5	0.9	9.9	---	4.4	4.6	45[illegible]
51.[illegible]	26.1	2.3	0.7	7.0	---	4.4	1.7	---	1.0	5.2	45[illegible]
49.[illegible]	19.4	2.0	0.6	4.1	---	10.8	3.5	---	2.9	5.5	[illegible]
51.[illegible]	11.1	1.0	0.8	6.0	---	22.0	0.7	---	1.8	4.7	45[illegible]
43.[illegible]	16.5	0.6	---	5.0	---	5.0	7.5	---	2.8	3.0	46[illegible]
51.5	15.1	3.5	---	3.8	---	10.8	6.1	---	5.2	4.0	425
34.5	31.0	1.5	0.6	4.0	---	10.9	4.4	1.9	1.9	11.5	478

APPENDIX 2

Accumulated precipitation at gages in vicinity of Filson Creek Watershed during water year 1976. (All values in inches of water).

Time Period	Recording Gage at So. Kawishiwi Field Lab	Non-Recording Gages on Filson Creek Watershed: Lower Filson	Non-Recording Gages on Filson Creek Watershed: Upper Filson	Non-Recording Gages on Filson Creek Watershed: Evaporation Station	Average for Filson Creek Watershed
9/30/75 to 10/14/75	0.4	0.47	0.65	-	0.56
10/14 to 11/3	1.7	1.25	1.12	-	1.19
11/3 to 12/2	2.6	3.00	3.25	-	3.13
12/2 to 12/31	0.9	0.73	0.72	-	.73
12/31/75 to 1/30/76	1.6	1.51	1.47	-	1.49
1/30 to 2/26	0.7	0.73	0.65	-	0.69
2/26 to 3/24	2.1	1.82	1.60	-	1.71
3/24 to 4/30	2.0	2.13	2.48	-	2.31
4/30 to 5/17	0.7	1.08	1.00	1.04	1.04
5/17 to 6/16	3.4	3.24	3.67	3.52	3.48
6/16 to 7/1	2.5	2.72	3.14	2.45	2.77
7/1 to 7/14	1.2	1.15	1.13	1.47	1.25
7/14 to 8/16	2.4	2.37	1.97	2.22	2.19
8/16 to 9/23	1.4	1.34	1.25	1.35	1.31
9/23 to 10/1/76	0.3	0.21	0.28	0.30	0.26
Total precipitation Recorded for Water Year 1976 (in inches of water)	23.9	23.75	24.38	-	24.11

Accumulated precipitation at gages in vicinity of Filson Creek Watershed during water year 1977 (All values in inches of water).

Time Period	Recording Gage at So. Kawishiwi Field Lab	Non-Recording Gages on Filson Creek Watershed: Lower Filson	Upper Filson	Evaporation Station
10/1 to 10/29	1.2	1.0	1.1	0.5
10/29 to 11/30	0.4	0.4	—	0.4
11/30 to 12/30	0.6	0.7		0.7
12/30 to 1/31	0.6	0.7	1.4	0.7
1/31 to 3/14	1.6	1.5	—	1.5
3/14 to 4/15	1.1	1.1	2.9	1.1
4/15 to 5/5	1.0	1.8	—	1.5
5/5 to 5/16	0.8	0.2	2.7	0.5
5/16 to 6/1	3.8	3.7	3.5	4.6
6/1 to 6/30	2.4	3.6		2.6
6/20 to 6/30	1.6	1.3	4.5	1.4
6/30 to 7/6	2.6	2.1	—	2.5
7/6 to 8/1	---	1.6	3.2	1.3
8/1 to 8/15	0.2	---	—	0.2
8/15 to 9/1	5.7	---		5.4
9/1 to 9/15	—	---	8.9	3.9
9/15 to 9/30	6.2	---	2.7	2.7
Total precipitation Recorded for Water Year 1977 (in inches of water)	29.8	---	30.9	31.5

APPENDIX 3 DAILY MEAN DISCHARGES AT F1X,F3X, AND OL-2 ON FILSON CREEK, 1975-1977

```
STATION NUMBER      05124990  FILSON CREEK NEAR ELY, MINN.                                  STATE 27  COUNTY [illegible]
LATITUDE  475005    LONGITUDE  0914727        DRAINAGE AREA          9.0[illegible]   DATUM

          DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
                                           MEAN VALUES

DAY       OCT      NOV      DEC      JAN      FEB      MAR      APR      MAY      JUN      JUL      AUG      SEP

  1       .06      .04      .08      .00      .00      .00      .55      3.1      34       8.5      1.2      35
  2       .06      .12      .07      .00      .00      .00      .36      3.1      30       8.5      .97      30
  3       .06      .15      .06      .00      .00      .00      .31      3.1      24       15       [illegible] 24
  4       .31      .15      .06      .00      .00      .00      .31      2.9      21       17       .87      [illegible]
  5       .42      .15      .10      .00      .00      .00      .20      2.9      [illegible] [illegible] .77   37

  6       .22      .15      .15      .00      .00      .00      .22      3.8      24       30       .71      33
  7       .12      .18      .20      .00      .00      .01      .22      3.[illegible] 20    24       .62      29
  8       .02      .15      .18      .00      .00      .01      .31      3.4      20       19       .59      27
  9       .02      .15      .10      .00      .00      .01      .62      3.5      18       15       .55      [illegible]
 10       .02      .26      .15      .00      .00      .01      1.1      2.9      14       12       .5[illegible] [illegible]

 11       .02      .26      .15      .00      .00      .10      1.1      2.5      12       10       .5[illegible] [illegible]
 12       .02      .22      .15      .00      .00      .50      .87      2.[illegible] 10    9.5      [illegible] [illegible]
 13       .04      .22      .15      .00      .00      2.0      .70      2.5      9.0      8.5      .6[illegible] 3[illegible]
 14       .06      .22      .15      .00      .00      4.0      .42      2.5      7.1      6.2      .5[illegible] 2[illegible]
 15       .06      .22      .15      .00      .00      3.0      .48      2.6      5.5      4.0      .35      24

 16       .06      .18      .20      .00      .00      2.0      .48      3.0      6.0      4.1      .72      1[illegible]
 17       .06      .18      .25      .00      .00      1.9      .53      2.8      9.5      4.5      .70      1[illegible]
 18       .04      .22      .20      .00      .00      1.5      .71      2.8      21       4.5      .70      14
 19       .02      .26      .27      .00      .00      1.2      .90      2.8      26       3.8      .73      1[illegible]
 20       .02      .26      .20      .00      .00      .90      1.1      4.5      27       3.1      .55      13

 21       .04      .22      .15      .00      .00      .70      2.5      6.6      22       2.5      [illegible] 1[illegible]
 22       .12      .22      .06      .00      .00      .60      3.8      9.8      1[illegible] 2.1    [illegible] 1[illegible]
 23       .12      .22      .04      .00      .00      .50      4.3      15       21       2.1      .7[illegible] [illegible]
 24       .12      .22      .04      .00      .00      .50      5.3      15       20       1.[illegible] .46  2[illegible]
 25       .12      .22      .01      .00      .00      .60      4.5      12       1[illegible] 1.[illegible] .77 [illegible]

 26       .09      .22      .00      .00      .00      .70      4.1      10       12       1.4      2.1      4[illegible]
 27       .06      .16      .00      .00      .00      1.0      4.5      8.4      [illegible] 1.3     15       [illegible]
 28       .0[illegible] .13  .00      .00      .00      1.3      4.1      7.0      9.0      1.2      4[illegible] 39
 29       .09      .10      .00      .00      ---      1.6      3.[illegible] 6.[illegible] 6.5 1.2    33       [illegible]
 30       .09      .09      .00      .00      ---      .87      3.3      4.6      6.0      1.2      26       37
 31       .04      ---      .00      .00      ---      .96      ---      7.6      ---      1.2      29       ---

TOTAL     2.66     5.54     3.42     .00      .00      27.09    51.92    163.0    5[illegible]1.4 253.8 171.39  980.[illegible]
MEAN      .086     .18      .11      .000     .000     .87      1.73     5.26     16.7     8.19     5.53     32.[illegible]
MAX       .42      .26      .26      .00      .00      4.0      5.3      15       34       30       46       [illegible]
MIN       .02      .04      .00      .00      .00      .00      .22      2.5      5.3      1.2      .35      [illegible]
CFSM      .01      .02      .01      .000     .000     .10      .19      .58      1.85     .91      .61      3.[illegible]
IN.       .01      .02      .01      .00      .00      .11      .21      .67      2.07     1.05     .71      3.[illegible]

CAL YR 1976   TOTAL  2069.31   MEAN 5.65   MAX 114   MIN .00   CFSM .63   IN 8.53
WTR YR 1977   TOTAL  2169.22   MEAN 5.94   MAX  83   MIN .00   CFSM .66   IN 8.95
```

[illegible] DATA PROCESSING [illegible]

[illegible]

[illegible] CREEK NEAR ELY, MINN

PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1976 [illegible]

DATE	MAX GH (TIME)	MIN GH (TIME)	MEAN GH	EQUIV GH	MEAN Q(CFS)	SHIFT ADJ	AT HR	DATUM CORR	AT HR
10-13	[illegible] (2115)	[illegible] (1600)	[illegible]	[illegible]	[illegible]				
10-14	6.11 ([illegible])	6.00 (0615)	6.06	6.05	[illegible]				
10-15	6.08 (0015)	[illegible] ([illegible])	[illegible]	6.06	[illegible]				
10-16	[illegible] ([illegible])	5.86 (2330)	5.94	5.94	[illegible]				
10-17	[illegible] ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-18	[illegible] ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-19	5.60 ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-20	[illegible] ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-21	5.55 ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-22	[illegible] ([illegible])	[illegible] (1930)	[illegible]	[illegible]	[illegible]				
10-23	[illegible] ([illegible])	[illegible] (2130)	[illegible]	[illegible]	[illegible]				
10-24	[illegible] ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-25	[illegible] (0015)	[illegible] ([illegible])	[illegible]	5.39	[illegible]				
10-26	[illegible] ([illegible])	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
10-27	[illegible] (0015)	5.35 ([illegible])	5.37	5.37	16				
10-28	5.35 (0015)	[illegible] (0045)	[illegible]	[illegible]	[illegible]				
10-29	[illegible] ([illegible])	5.31 ([illegible])	5.31	[illegible]	11				
10-30	5.31 (0015)	[illegible] ([illegible])	[illegible]	[illegible]	11				
10-31	5.29 (0015)	5.28 ([illegible])	[illegible]	[illegible]	10				
11-01	5.28 (0015)	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
11-02	[illegible] (0015)	[illegible] ([illegible])	[illegible]	[illegible]	[illegible]				
11-03	5.25 (0015)	[illegible] (0015)	[illegible]	[illegible]	8.5				
11-04	5.25 (0015)	5.25 (0015)	5.25	5.25	8.5				

LOCATION-- NE¼SW¼,sec.1[illegible],T5[illegible]N.,R10W.,Lake County,on east bank 0.1 mile upstream from where Spruce Road crosses Tilson Creek, designated F3X

PERIOD OF RECORD-- April 1977 to November 1977

GAGE-- Water-stage recorder. Altitude of the gage is 1500 ft., from topographic map

REMARKS-- Records good to fair

EXTREMES FOR PERIOD OF RECORD-- Maximum discharge, 33 cfs. Sept.9

DISCHARGE, IN CUBIC FEET PER SECOND, APRIL 1977 to NOVEMBER 1977
MEAN VALUES

DAY	APR.	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1	.41	1.4	14	3.6	.91	14	12	4.2
2	.33	1.4	12	3.6	.91	12	11	3.8
3	.31	1.4	9.9	6.0	.57	9.8	9.0	3.6
4	.31	1.4	8.6	6.7	.54	15	7.8	3.6
5	[illegible]	1.4	7.4	7.5	.54	15	7.4	3.5
6	.28	1.7	9.8	11	.72	13	7.0	3.4
7	[illegible]	1.7	8.2	9.0	.72	12	6.2	3.3
8	.31	1.7	8.2	6.7	.72	11	6.2	3.2
9	.44	1.6	7.4	5.3	.78	33	6.2	3.6
10	.63	1.3	5.8	4.4	.78	32	6.2	4.6
11	.63	1.2	5.0	4.0	.78	25	6.2	
12	.54	1.2	4.2	3.7	.78	19	12	
13	.47	1.2	3.4	3.7	.78	15	19	
14	[illegible]	1.2	3.0	3.4	.78	12	20	
15	.78	1.2	2.3	2.8	.78	9.8	23	
16	[illegible]	1.4	3.4	2.4	.78	6.0	28	
17	.31	1.3	4.0	2.0	.78	5.3	19	
18	.47	1.2	6.6	2.0	.78	5.3	15	
19	.36	1.3	11	1.7	.78	5.1	13	
20	.63	1.9	11	1.4	.78	4.7	9.9	
21	1.2	2.8	9	1.4	.75	4.3	11	
22	1.7	4.2	7.4	1.3	.53	4.3	9.8	
23	1.9	6.2	8.6	1.2	.50	13	8.2	
24	2.3	6.2	8.2	1.2	.45	17	7.4	
25	2.0	5.0	6.6	1.1	.50	19	7.0	
26	1.8	4.2	5.0	1.0	1.0	18	6.6	
27	2.0	3.7	4.2	1.1	6.2	17	5.8	
28	1.8	3.0	3.8	1.1	19	17	5.0	
29	1.6	2.4	3.6	1.0	13	16	4.6	
30	1.5	2.0	3.4	1.1	11	15	4.6	
31		3.2	---	1.0	12	15	4.2	
Total	20.22	[illegible]	207	103.4	79.9	430.6	318.3	

LOCATION-- NW NE [illegible],T[illegible]N,R1[illegible]W,Lake COunty, about [illegible] mile upstream from U.S.GS. gage on Spruce Road, designated SF

PERIOD OF RECORD-- April 1977 to Nobember 1977

GAGE-- Water-stage recorder. Altitude of gage is 1445 ft, from topographic map

REMARKS-- Records fair to good, except after August 1977 when beaver dam created a backwater effect at gage location.

EXTREMES FOR PERIOD OF RECORD-- Maximum discharge 24 cfs on Sept.9

DISCHARGE, IN CUBIC FEET PER SECOND, APRIL 1977 to NOVEMBER 1977
MEAN VALUES

DAY	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV
1	.22	1.1	2.8	3.6	.46	11	9.2	3.3
2	.15	1.1	6.3	3.6	.38	9.2	8.1	3.0
3	.13	1.1	7.8	4.8	.37	7.5	6.9	2.9
4	.13	1.1	6.9	5.4	.34	11	6.0	2.9
	.11	1.1	5.8	8.3	.34	11.	5.7	2.8
	.10	1.3	5.0	9.2	.28	10	5.4	2.7
7	.10	1.4	5.1	6.9	.25	8.9	4.8	2.6
8	.13	1.1	5.4	6.0	.22	8.3	4.8	2.6
9	.25	1.1	4.6	5.1	.22	24	4.8	2.8
10	.43	1.0	4.4		.22	23	4.8	3.6
11	.43	1.0	3.5		.22	18	5.9	
12	.34	1.0	2.6	3.2	.20	14	14	
13	.28	1.0	1.8	2.9	.20	11	15	
14	.17	1.10	1.8	2.1	.20	8.9	17	
15	.20	1.3	2.2	1.3	.15	7.5	17	
16	[illegible]	1.6	2.9	1.3	.29	6.0	15	
17	.22	.80	1.1	1.4	.28	5.1	13	
18	.23	1.1	1.7	1.5	.28	4.5	11	
19	.27	1.5	8.1	1.5	.28	4.5	9.5	
20	.43	1.9	8.3	1.4	.33	4.2	8.3	
21	.71	2.5	6.9	1.4	.53	3.6	7.5	
22	1.4	3.0	5.7	1.6	.33	3.3	6.3	
23	1.5	3.9	6.6	.78	.31	3.0	5.7	
24	1.8	4.1	6.3	.71	.26	6.9	5.4	
25	1.6	4.2	4.9		.31	13	5.1	
26	1.5	4.0	4.6		.78	14	5.1	
27	1.6	2.0	3.9	.50	4.8	13	4.5	
28	1.5	3.2	3.7	.46	14	12	3.9	
29	1.1	2.8	3.7	.46	10	12	3.6	
30	1.2	2.1	3.5	.46	8.1	11	3.6	
31	----	2.3	---	.46	8.9	---	3.3	
Total	19.08	57.8	137.9	84.5	53.8	299.4	29.2	

APPENDIX 4 Stratigraphic Logs of Piezometers Installed in and around the Filson Creek Watershed

		Casing (2 inch plastic)					Materials penetrated	
Location (1)	Well number (2)	Total length, in feet (3)	Screen length, in feet (4)	Total depth below land surface, in feet (5)	Height above land surface, in feet (6)	Altitude at land surface, in feet (7)	Lithology (8)	Depth below land surface, in feet (9)
62-11-25bb	H1	17	None	13.5	3.5	1487.96	Silty clay, sandy to stoney, grey-green Silty clay, sandy to stoney, grey Bedrock	0-6 6-49.5 49.5
62-11-25bb	H2	9	3	6.5	2.5	1489.19	Fill, sandy Peat Silty clay, sandy to stoney, organic material Bedrock	0-3 3-4.5 4.5-6.5 6.5
62-11-25bb	H3	15	None	12	4	1487.07	Fill Silty clay, sandy to stoney, grey-green Bedrock	0-5 5-12 12
62-10-29cd	H29	16	3	13	3	1537±	Silty clay, sandy with some pebbles and organic material Bedrock	0-14 14

		Casing (1¼ inch PVC plastic)			Materials penetrated	
Location	Well number	Total length, in feet	Screen length, in feet	Total depth below land surface, in feet	Lithology	Depth below land surface, in feet
NW¼ NE¼ SE¼, sec 25, T62N, R11W	BSSW	6	1	3	Fibrous brown to black peat, silty	0 - 3
NE¼ SE¼, sec 24, T62N, R11W	2XW	7.3	1	3	Fibrous brown to black peat, sandy Till, sandy	0 - 3.2 3.2 -
SE¼ NW ¼, sec 19, T62N, R11W	3XW	6.1	1	3	Fibrous brown to black peat, sandy. Sand, med. fine, brown	0 - 2.8 2.8 - 3.1
SE¼ NW¼ SE¼, sec 31, T62N, R11W	QBW	3.7	1	3	Fibrous brown to black peat	0 - 3.2

APPENDIX 5 WATER QUALITY DATA FOR FILSON CREEK WATERSHED STUDY,1977-1978

WATER QUALITY DATA FOR OL-2 LOCATION

OL2

DATE OF SAMPLE	TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	SI	SC	TCU	TNI
124	0	6.5	56.0	5.7	2.7	6.0	-0	6.2	-0	4.2	-0	.5	-0	5.4	82.0	-0	-0
409	1.0	6.1	9.0	0	1.0	3.6	-0	2.7	-0	1.6	-0	.7	-0	1.8	23.0	.9	0
423	5.5	5.4	6.0	4.0	1.7	3.8	-0	3.1	-0	2.1	-0	1.9	-0	7.1	38.0	2.8	0
508	11.0	5.4	4.0	10.8	.9	4.0	2.6	2.6	2.5	1.7	1.7	.9	.9	3.6	-0	2.3	0
527	17.5	6.1	5.0	9.0	.9	4.3	2.1	2.2	2.1	1.7	1.6	.7	.7	3.8	-0	2.6	0
611	17.5	5.8	3.0	5.0	.5	2.9	1.7	2.0	1.2	1.3	1.2	1.5	1.5	7.8	45.0	-0	-0
625	18.0	5.8	4.0	-0	.4	4.0	2.6	2.0	1.3	1.1	1.1	.3	.3	8.1	40.0	1.8	2.4
702	17.0	6.0	6.0	0	1.6	4.0	1.8	3.0	1.1	1.2	1.0	.7	.6	5.3	39.0	.8	0
723	20.5	5.9	10.0	1.0	1.4	4.8	3.6	3.5	1.6	1.2	1.0	.7	.6	6.6	60.0	2.1	4.5
806	17.0	6.0	8.0	2.0	1.2	4.4	2.0	3.5	1.2	1.2	1.1	.6	.6	5.1	37.0	3.7	3.6
820	15.3	6.1	5.0	1.0	1.0	3.5	2.9	2.1	1.9	1.2	1.2	.6	.6	4.4	32.0	-0	-0
917	15.0	5.8	3.0	1.0	1.2	3.5	3.4	2.1	1.8	1.1	1.1	.6	.6	7.3	39.0	-0	-0
1001	9.8	5.7	3.0	2.0	1.8	3.1	2.7	1.8	1.1	1.1	1.0	.7	.6	9.1	36.0	-0	-0
1015	4.5	5.8	3.0	2.0	1.3	2.4	2.4	1.8	1.8	1.2	1.1	.6	.6	9.6	34.0	-0	-0
1105	4.0	5.8	4.0	2.0	1.4	2.3	2.3	1.8	1.7	1.2	1.2	.6	.6	12.3	37.0	-0	-0
1211	0	5.5	3.0	0	1.0	3.2	2.8	1.9	1.9	1.2	1.2	.3	.3	10.8	41.0	-0	-0
128	-0	5.9	9.0	-0	1.9	3.6	3.4	1.5	1.4	1.7	1.8	.4	.4	14.7	55.0	-0	-0

WATER QUALITY DATA FOR QST LOCATION

QST

423	.5	6.0	5.0	1.0	1.1	3.2	-0	2.3	-0	1.6	-0	1.5	-0	4.3	32.0	1.0	0
508	12.0	6.0	9.0	4.0	.9	2.8	-0	1.6	-0	1.4	-0	.7	-0	3.4	-0	1.4	0
527	18.0	6.2	6.0	2.0	.9	3.2	-0	2.0	-0	1.4	-0	.6	-0	2.9	-0	.8	0
611	18.0	6.1	5.0	2.0	.5	-0	1.7	-0	1.7	-0	1.2	-0	.7	3.6	34.0	4.5	0
625	18.0	6.3	12.0	0	.5	3.5	2.4	2.0	1.5	1.3	1.1	.6	.6	6.0	46.0	.3	0
722	21.0	6.0	9.0	0	2.4	4.0	2.0	3.3	1.5	1.1	1.1	3.1	2.9	7.0	55.0	.3	0
806	19.0	5.9	5.0	2.0	1.2	3.2	1.8	3.0	1.2	1.1	1.1	.7	.7	7.3	42.0	.6	1.1
820	16.0	5.8	7.0	3.0	1.0	3.2	2.9	2.1	2.0	1.2	1.2	.7	.7	7.1	37.0	-0	-0
917	15.5	6.1	4.0	1.0	1.2	3.4	3.4	2.2	2.3	1.3	1.3	.6	.6	7.2	34.0	-0	-0
1001	8.0	6.0	3.0	4.0	1.8	2.9	2.9	2.0	2.2	1.3	1.3	.7	.7	8.8	40.0	-0	-0
1105	4.0	5.6	3.0	2.0	1.6	2.8	2.2	2.2	2.1	1.3	1.3	.8	.8	12.1	31.0	-0	-0

WATER QUALITY DATA FOR OMADAY LAKE

DATE OF SAMPLE	TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	SI	SC	TCU	TNI
1204	0	6.6	19.0	5.0	1.0	8.0	-0	2.8	-0	2.2	-0	.4	-0	1.1	35.0	-0	-0
127	0	6.3	19.0	.5	1.6	7.8	-0	5.8	-0	3.4	-0	.5	-0	1.8	41.0	-0	-0
205	0	6.3	18.0	.5	1.6	7.8	-0	5.8	-0	3.2	-0	.6	-0	1.6	44.0	-0	-0
305	0	6.3	17.0	2.0	1.6	7.8	-0	5.8	-0	3.1	-0	.5	-0	2.2	42.0	9.0	-0
409	2.0	6.9	8.0	0	1.0	4.8	-0	2.7	-0	1.6	-0	.4	-0	1.0	21.0	2.4	0
423	13.2	6.7	8.0	2.0	1.1	4.0	-0	3.1	-0	2.5	-0	.7	-0	1.2	34.0	2.3	.2
508	14.0	6.3	7.0	15.0	.9	2.8	-0	2.7	-0	1.7	-0	.9	-0	1.7	-0	2.3	.3
527	21.0	6.7	7.0	9.0	.9	3.2	-0	2.4	-0	1.1	-0	.9	-0	2.4	-0	1.8	.2
611	17.5	5.8	5.0	6.0	.5	2.6	2.0	2.0	1.4	1.4	1.4	.9	.9	5.5	35.0	3.8	0
625	23.0	6.2	6.0	3.0	.5	2.6	2.0	2.0	1.2	1.2	1.2	.6	.6	8.6	35.0	3.3	0
702	18.0	6.5	6.0	1.0	1.2	2.2	2.0	1.5	1.2	1.2	1.1	.7	.7	4.2	50.0	3.0	.9
725	24.0	6.4	7.0	0	1.6	2.1	1.9	1.7	1.3	1.2	1.1	.7	.7	5.4	50.0	3.0	0
806	19.0	6.4	12.0	0	1.2	2.0	2.0	1.7	1.5	1.2	1.2	.6	.7	5.2	41.0	-0	3.1
820	-0	6.1	7.0	1.0	1.0	3.9	3.9	2.4	2.2	1.2	1.2	.7	.7	4.6	36.0	-0	-0
917	14.0	6.1	4.0	1.0	1.2	3.1	3.1	2.4	1.7	1.1	1.1	.7	.7	7.4	33.0	9.0	-0
1001	12.0	6.1	3.0	6.0	2.2	2.6	2.6	1.8	1.6	1.1	1.0	.8	.7	8.7	38.0	9.0	-0
1015	5.5	6.0	3.0	2.0	1.0	2.9	2.7	1.8	1.8	1.3	1.2	.6	.6	8.9	46.0	-0	-0
1105	4.0	6.3	3.4	2.0	1.6	2.6	2.6	2.0	1.7	1.2	1.2	.6	.6	12.2	29.0	-0	-0
1211	0	5.6	3.0	0	1.0	3.1	3.0	2.1	2.1	1.4	1.4	.3	.3	16.8	41.0	-0	-0
128	-0	6.2	8.0	-0	2.2	3.9	3.9	1.6	1.5	1.8	1.8	.4	.4	14.7	46.0	-0	-0
211	-0	5.9	10.0	-0	1.9	3.6	3.3	1.6	1.6	1.7	1.6	.4	.4	14.6	49.0	-0	-0

WATER QUALITY DATA FOR F3X LOCATION

DATE OF SAMPLE	TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	SI	SC	TCU	TNI
1204	0	6.3	32.0	0	1.0	4.0	-0	-0	-0	2.1	-0	1.1	-0	3.0	41.0	-0	-0
409	.8	6.3	9.0	2.0	1.0	3.8	-0	3.0	-0	2.5	-0	.9	-0	1.8	21.0	3.6	.8
423	6.4	6.3	10.0	3.0	1.6	4.2	-0	5.4	-0	1.6	-0	.9	-0	10.2	40.0	8.8	3.5
508	9.0	6.2	8.0	2.0	.9	3.2	-0	2.2	-0	1.5	-0	1.1	-0	.8	-0	3.8	0
527	20.0	6.6	7.0	7.0	.9	2.8	-0	2.6	-0	1.6	-0	1.1	-0	4.2	-0	5.3	2.4
611	20.5	5.6	4.0	4.0	.5	2.9	2.1	2.0	1.0	1.2	1.3	.8	.8	6.8	40.0	4.8	3.5
625	22.0	6.1	5.0	0	.5	2.8	2.0	2.0	1.3	1.2	1.1	.6	.6	7.5	47.0	4.0	-0
702	20.3	6.2	5.0	0	1.6	2.1	2.1	1.5	1.1	1.2	1.1	.7	.7	5.7	46.0	4.3	0
723	25.0	6.2	9.0	2.0	1.8	2.3	2.3	1.5	1.2	1.2	1.3	.7	.7	5.4	46.0	4.8	8.2
806	16.5	6.3	14.0	2.0	1.2	2.0	2.0	1.8	1.3	1.2	1.2	.8	.7	5.2	39.0	1.9	3.2
820	15.0	6.3	7.0	1.0	1.0	3.1	3.1	2.3	2.1	1.3	1.1	1.0	1.0	3.5	33.0	-0	-0
917	15.1	5.9	3.0	1.0	1.2	4.0	3.6	2.0	2.1	1.0	1.1	.6	.6	6.8	33.0	-0	-0
1001	8.0	6.1	3.0	2.0	1.9	3.6	2.9	1.9	1.6	1.0	1.1	.6	.6	8.6	39.0	-0	-0
1015	5.8	5.9	2.0	2.0	1.3	2.0	1.8	1.7	1.6	1.1	1.0	.6	.6	9.6	32.0	-0	-0
1105	5.3	5.5	4.0	2.0	1.6	6.0	2.0	2.0	1.7	1.2	1.1	.6	.6	10.4	28.0	-0	-0
1211	0	-0	-0	0	1.0	3.0	2.8	2.0	2.0	1.0	1.0	.3	.3	10.1	32.0	-0	-0
128	-0	6.2	12.0	-0	1.9	3.6	3.4	1.6	1.5	1.6	1.6	.4	.4	15.0	45.0	-0	-0
211	-0	6.1	11.0	-0	2.2	4.0	4.0	1.7	1.7	1.7	1.7	.5	.5	15.2	51.0	-0	-0

WATER QUALITY DATA FOR SF LOCATION

1204	0	6.7	28.0	5.7	3.8	6.0	-0	5.5	-0	3.8	-0	2.1	-0	25.0	69.0	-0	-0
409	.5	6.4	12.0	0	1.0	4.7	-0	4.1	-0	1.2	-0	1.1	-0	7.8	27.0	3.3	0
423	3.8	6.4	16.0	0	1.6	3.3	-0	3.1	-0	2.5	-0	1.2	-0	6.8	38.0	9.0	0
508	9.5	6.3	6.0	10.0	.9	3.6	-0	3.0	-0	1.8	-0	.9	-0	4.6	-0	3.0	0
527	18.5	6.2	5.0	1.8	.9	3.2	-0	3.1	-0	1.7	-0	.4	-0	7.0	-0	3.8	0
612	15.0	6.4	7.0	0	.4	4.2	2.0	2.1	-0	1.6	-0	.4	-0	9.4	-0	4.0	1.5
613	13.0	6.6	8.0	0	.4	4.1	2.0	-0	1.2	1.6	1.1	.4	.4	8.6	55.0	4.0	0
625	19.0	6.3	6.0	1.0	.4	4.1	2.1	2.4	1.0	1.6	1.0	.3	.3	12.3	55.0	4.0	1.1
702	21.0	6.4	9.0	0	1.2	2.0	2.0	1.8	1.4	1.2	1.1	.5	.5	7.5	45.0	4.1	1.5
725	23.7	6.4	15.0	0	1.2	2.6	2.6	2.0	1.8	1.3	1.3	.6	.6	12.1	49.0	3.3	1.4
806	16.0	6.7	12.0	2.0	1.2	2.4	2.4	2.0	1.8	1.3	1.3	.6	.6	11.4	42.0	7.8	3.1
820	14.0	6.5	9.0	1.0	1.0	3.1	3.1	2.3	2.1	1.2	1.2	.4	.4	10.9	33.0	-0	-0
917	13.3	6.3	5.0	1.0	1.2	4.0	3.6	2.0	2.1	1.1	1.1	.4	.4	11.4	38.0	-0	-0
1001	9.0	6.3	3.0	0	1.8	3.6	2.9	1.9	1.6	1.1	1.0	.4	.4	12.0	33.0	-0	-0
1015	5.0	6.2	3.0	0	1.0	2.4	2.4	1.7	1.7	1.1	1.1	.5	.5	12.1	27.0	-0	-0
1105	4.9	6.2	3.0	3.0	1.6	2.2	2.0	1.7	1.6	1.2	1.2	.5	.5	12.1	28.0	-0	-0
128	-0	6.1	12.0	-0	1.9	3.9	3.9	1.7	1.7	1.5	1.5	.4	.4	16.0	42.1	-0	-0

WATER QUALITY DATA ~~FOR~~ AT FIX LOCATION

DATE OF SAMPLE	TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	SI	SC	TCU	TNI
1204	0	6.5	6.0	0	1.0	4.3	-0	3.2	-0	2.5	-0	.7	-0	6.0	40.0	-0	-0
409	0	6.6	12.0	0	1.0	4.5	-0	2.0	-0	1.6	-0	1.0	-0	6.2	27.0	3.6	0
423	9.5	5.5	8.0	4.0	1.5	5.3	-0	3.6	-0	2.0	-0	1.2	-0	7.6	60.0	9.0	7.5
507	9.0	5.0	4.4	13.0	.9	5.6	-0	3.8	2.6	1.8	1.8	1.0	1.0	2.2	52.0	6.5	4.6
527	17.5	6.6	5.1	10.0	.9	4.4	-0	3.8	2.6	1.8	1.8	.6	.6	1.0	42.0	6.8	4.7
611	18.5	5.8	6.0	6.0	.4	2.6	2.0	2.1	1.3	1.2	1.2	.2	.2	5.0	40.0	7.0	4.8
612	-0	-0	-0	-0	.4	2.5	-0	2.1	1.2	1.2	1.2	.2	.2	-0	40.0	-0	-0
613	-0	-0	-0	-0	.4	2.5	-0	1.6	1.2	1.2	1.2	.2	.2	-0	40.0	6.8	5.3
616	-0	6.1	7.0	6.0	.4	2.5	2.0	1.6	1.2	1.1	1.1	.2	.2	8.6	42.0	9.0	4.2
618	-0	-0	-0	-0	.4	-0	-0	-0	-0	1.3	1.3	.2	.2	-0	-0	7.3	4.3
619	-0	-0	-0	-0	.4	-0	-0	-0	-0	1.1	1.1	.2	.2	-0	-0	7.2	4.5
623	-0	6.0	8.0	0	.4	3.2	1.5	2.0	1.3	1.2	1.1	.2	.2	7.8	39.0	7.0	4.5
625	24.0	6.1	7.0	0	.4	3.2	3.2	2.0	1.1	1.2	1.2	.2	.2	11.0	41.0	6.5	4.5
702	21.0	6.3	7.0	0	.6	4.8	4.0	3.0	1.1	1.3	1.3	.6	.6	6.8	43.0	6.3	5.0
703	21.0	6.2	5.0	0	.6	4.0	2.2	3.0	1.2	1.3	1.3	.6	.6	7.1	45.0	6.3	4.5
723	24.2	6.3	12.0	0	1.0	4.8	2.7	3.6	1.2	1.4	1.4	.6	.6	7.7	50.0	5.5	-0
806	17.0	6.6	13.0	2.0	1.2	4.4	2.7	3.6	1.2	1.4	1.4	.7	.7	8.6	43.0	1.9	6.7
820	15.0	5.8	9.0	1.0	1.0	4.1	3.9	2.4	2.4	1.4	1.4	.7	.7	5.8	36.0	-0	-0
917	13.0	6.1	5.0	1.0	1.3	3.3	3.1	2.0	1.6	1.1	1.0	.5	.5	9.5	32.0	-0	-0
1001	9.2	6.1	3.0	2.0	1.8	2.7	2.7	1.7	1.6	1.1	1.0	.6	.6	10.5	37.0	-0	-0
1015	5.0	6.0	2.0	2.0	1.2	-0	1.8	-0	1.4	-0	1.0	.6	.6	11.2	29.0	-0	-0
1105	4.5	6.1	3.4	2.0	1.4	2.1	2.1	2.1	1.7	1.2	1.0	.6	.6	12.3	26.0	-0	-0
[illegible]	0	6.3	6.0	0	1.0	3.0	3.0	1.9	1.9	1.2	1.2	.3	.3	18.6	37.0	-0	-0
128	-0	6.2	13.0	-0	1.9	3.8	3.8	1.6	1.6	1.7	1.7	.4	.4	15.5	50.0	-0	-0
211	-0	6.2	11.0	-0	2.2	4.2	4.2	1.7	1.7	1.8	1.8	.5	.5	15.3	52.0	-0	-0

WATER QUALITY DATA FOR SHALLOW INTERFLOW COLLECTORS

DATE OF SAMPLE	TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	SI
SW1X 723	-0	6.3	7.0	0	1.4	4.8	2.3	1.4	.4	0	0	3.5	1.8	1.8
SW1X 917	-0	6.0	7.0	0	.7	2.6	2.6	.6	.5	0	0	4.3	0	0
SW1X 1001	-0	-0	-0	0	1.8	5.4	5.4	1.8	1.8	0	0	6.7	0	0
SWNL1 611	-0	5.6	4.0	0	.3	2.0	1.8	.8	.4	0	0	4.2	4.2	0
SWNL1 722	-0	5.8	3.6	0	1.0	2.2	2.0	.7	.2	2.3	0	2.2	2.2	2.1
SWNL1 917	-0	5.2	0	1.0	.8	2.9	2.9	.9	.6	0	0	6.5	2.4	1.4
SWNL1U105	-0	-0	-0	-0	-0	-0	8.4	-0	3.9	0	0	9.2	9.2	-0
SWNL2 625	-0	5.9	3.0	0	.3	1.2	1.2	0	0	0	0	1.7	1.7	-0
SWNL2 806	-0	6.4	7.0	0	1.2	3.4	2.0	.7	.2	2.8	0	3.1	3.1	.4
SWNL2 820	-0	-0	-0	-0	-0	5.2	5.2	.9	.9	0	0	12.3	12.3	-0
SWNL2 723	-0	-0	-0	-0	-0	6.2	3.7	.7	.2	3.7	0	1.8	1.8	-0
SWNL2 917	-0	4.0	0	0	.7	1.9	1.9	.3	.3	0	0	4.4	4.4	0
SW2X 625	-0	5.4	1.0	0	.3	.8	.8	-0	0	0	0	3.0	3.0	-0
SW2X 723	-0	6.5	2.0	0	1.0	2.2	1.1	.4	0	0	0	2.5	2.5	.9
SW2X 820	-0	-0	-0	3.3	1.0	1.2	1.2	.4	.4	0	0	20.0	20.0	0
SW2X 1001	-0	5.8	1.0	1.3	3.0	4.8	4.0	2.0	1.6	0	0	19.6	16.6	0
SW3X 625	-0	5.4	1.0	1.0	.3	-0	.7	-0	.2	0	0	-0	1.7	-0
SW3X 723	-0	-0	0	0	1.2	2.0	.7	.6	0	1.0	0	1.3	1.3	.9
SW3X 806	-0	6.4	2.0	2.0	1.6	3.4	1.5	1.1	.2	1.6	0	2.6	2.6	.3
SW3X 821	-0	-0	0	0	1.2	-0	1.8	-0	.8	0	0	4.4	4.4	2.1
SW3X 917	-0	5.8	0	0	.7	-0	4.0	.5	.3	0	0	1.7	1.7	0
SW0L 611	-0	5.8	6.2	0	.6	2.5	2.2	.7	.5	.2	0	4.1	4.1	-0
SW0L 625	-0	4.5	.6	1.0	.3	2.0	2.0	.5	.4	0	0	2.9	2.9	-0
SW0L 722	-0	5.9	3.0	1.0	1.2	3.2	1.7	.9	.2	.1	.1	2.3	2.3	2.6
SW0L 806	-0	-0	-0	-0	-0	19.6	10.7	2.0	.6	2.8	.1	4.7	4.7	1.1
SW0L 820	-0	5.7	2.0	0	1.2	1.7	1.7	.3	.3	0	0	5.8	5.4	2.1
SW0L 917	-0	5.7	1.0	0	.7	2.0	1.5	.4	.3	0	0	3.4	3.4	0
SW0L 1001	-0	-0	0	-0	-0	4.3	2.8	.9	.7	0	0	6.3	6.3	-0

WATER QUALITY DATA OF PRECIPITATION

	DATE OF SAMPLE	TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	SI	SC
BSSP	806	-0	6.30	1.00	5.80	1.20	1.50	1.20	.40	0	.20	.20	1.40	.60	0	34.00
BSSP	723	-0	4.20	0	3.00	2.40	1.90	.90	.20	0	.30	.30	6.80	1.10	.90	52.00
BSSP	820	-0	-0	0	2.60	.80	.90	.80	.10	.10	10.70	10.70	1.10	1.00	.80	77.00
BSSP	508	-0	4.50	0	-0	-0	.50	.50	.10	0	.20	.20	1.30	.90	0	-0
BSSP	527	-0	5.10	0	3.20	.50	1.00	-0	.10	0	.20	.20	.30	.30	.30	-0
BSSP	625	-0	5.20	0	1.40	.30	1.30	.70	.10	0	0	0	.30	.30	0	26.00
BSSP	917	-0	4.80	0	2.50	.70	.70	.70	.10	0	0	0	.30	0	.90	18.00
BSSP	1015	-0	5.10	0	2.00	.60	.60	.60	.10	.10	.20	.20	.20	.20	0	14.00
QP	1015	-0	4.52	0	2.00	.30	.30	.30	0	0	.20	.20	.20	.20	0	49.00
QP	611	-0	4.78	0	0	.30	1.30	-0	.10	0	1.00	0	.60	.50	0	18.00
QP	625	-0	4.90	0	1.00	.30	.80	.70	.10	0	0	0	.50	.40	0	20.00
QP	702	-0	-0	0	1.00	-0	1.00	.80	.10	0	0	0	.50	.40	0	18.00
QP	723	-0	5.00	0	0	.60	1.00	.70	0	0	.10	0	.50	.40	.40	-0
QP	806	-0	5.80	0	3.00	1.20	1.50	1.30	.10	0	.60	.50	2.00	2.00	.20	12.00
QP	1001	-0	5.20	0	2.00	.30	.40	.40	0	0	.60	.60	.30	0	0	20.00
HLP	611	-0	5.20	0	.90	.30	1.00	.60	0	0	.20	.10	.50	.40	0	18.00
HLP	723	-0	-0	0	1.00	.60	1.10	.60	.10	0	.70	0	.50	.50	.50	13.00
SN77	309	-0	4.70	0	1.80	.70	.70	.60	.10	0	.20	.20	0	0	0	7.00

WATER QUALITY DATA OF WETLAND PIEZOMETERS

		TEMP	PH	HCO3	SO4	CL	TCA	DCA	TMG	DMG	TNA	DNA	TK	DK	ST	SC	TCU	TNI
[illegible]	[illegible]	2.0	5.[illegible]	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	128.0	-0	-0
[illegible]	[illegible]	2.9	6.2	11.0	72.0	1.1	-0	20.0	-0	11.4	-0	2.8	-0	.3	24.4	190.0	-0	116.0
[illegible]	811	6.2	6.2	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
[illegible]	[illegible]	16.1	5.4	34.0	30.0	.8	-0	14.0	-0	6.4	-0	4.3	-0	1.7	16.0	150.0	6.9	192.0
[illegible]	[illegible]	13.0	5.6	16.0	58.0	1.3	-0	16.1	-0	7.1	-0	3.8	-0	1.5	28.0	122.0	-0	-0
[illegible]	[illegible]	9.5	5.5	9.0	54.0	.6	-0	16.0	-0	6.0	-0	2.6	-0	.5	38.6	176.0	-0	-0
[illegible]	[illegible]	6.6	5.6	[illegible]	37.0	1.0	-0	11.7	-0	6.1	-0	1.9	-0	.3	16.7	106.0	-0	-0
[illegible]	[illegible]	6.5	5.[illegible]	[illegible]	29.0	1.0	-0	10.5	-0	6.6	-0	2.1	-0	.3	13.5	-0	-0	-0
[illegible]	[illegible]	2.5	5.9	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	92.0	-0	-0
[illegible]	[illegible]	2.0	6.5	11.0	34.0	1.6	-0	8.7	-0	5.4	-0	4.2	-0	.7	17.4	96.0	105.0	144.0
[illegible]	[illegible]	3.[illegible]	6.1	20.0	41.0	.9	-0	8.2	-0	4.3	-0	10.0	-0	.7	10.0	-0	-0	111.0
[illegible]	711	6.5	6.5	-0	34.0	.8	-0	11.7	-0	7.7	-0	7.0	-0	1.0	11.0	115.0	50.0	[illegible]
[illegible]	825	9.5	6.3	44.0	23.0	.8	-0	9.3	-0	6.6	-0	10.0	-0	.8	15.0	167.0	49.0	[illegible]
[illegible]	[illegible]	11.7	6.1	43.0	18.0	-0	-0	10.6	-0	5.8	-0	14.0	-0	1.3	17.8	190.0	-0	-0
[illegible]	[illegible]	14.0	6.4	42.0	27.0	1.2	-0	13.0	-0	6.0	-0	10.1	-0	1.7	16.0	144.0	-0	-0
[illegible]	[illegible]	11.0	5.8	67.0	[illegible]	2.0	-0	11.7	-0	5.2	-0	9.1	-0	.9	17.2	184.0	-0	-0
[illegible]	917	14.1	6.3	93.0	6.1	1.5	-0	15.3	-0	6.9	-0	11.6	-0	.9	16.1	192.0	-0	-0
[illegible]	[illegible]	10.0	6.1	72.0	2.0	.9	-0	13.7	-0	7.5	-0	11.1	-0	.9	18.7	218.0	-0	-0
[illegible]	1215	6.5	5.9	57.0	2.5	1.7	-0	6.1	-0	7.7	-0	4.8	-0	.4	29.0	-0	-0	-0
[illegible]	[illegible]	7.0	5.9	59.0	0	-0	-0	8.0	-0	7.3	-0	4.3	-0	.4	21.8	116.0	-0	-0
[illegible]	[illegible]	14.0	5.7	12.0	6.4	.2	-0	7.4	-0	3.1	-0	1.7	-0	2.9	23.0	[illegible]	7.9	12.0
[illegible]	[illegible]	13.0	5.6	11.0	2.0	.3	-0	6.0	-0	3.6	-0	4.3	-0	2.7	34.0	290.0	20.7	13.1
[illegible]	[illegible]	17.2	5.7	16.0	3.4	5.0	-0	7.5	-0	3.1	-0	5.6	-0	2.1	30.0	196.0	21.5	20.1
[illegible]	[illegible]	16.5	5.7	15.0	3.4	5.0	-0	9.4	-0	4.2	-0	4.6	-0	1.9	27.2	140.0	-0	-0
[illegible]	[illegible]	10.5	5.6	20.0	40.0	1.0	-0	10.0	-0	2.0	-0	7.4	-0	2.1	14.3	97.0	-0	-0
[illegible]	917	13.2	5.8	24.0	0	2.0	-0	5.3	-0	3.1	-0	4.6	-0	3.7	32.6	77.0	-0	-0
[illegible]	[illegible]	.5	5.6	25.0	11.0	.9	-0	7.5	-0	4.8	-0	6.4	-0	.7	15.2	69.0	3.0	4.0
[illegible]	[illegible]	4.0	5.6	19.0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	1.9	4.7
[illegible]	[illegible]	12.0	6.1	-0	-0	-0	-0	8.3	-0	4.9	-0	3.1	-0	16.4	-0	-0	-0	-0
[illegible]	911	14.5	5.9	45.0	1.0	2.1	-0	10.6	-0	6.3	-0	3.7	-0	6.7	13.4	100.0	5.9	[illegible]
[illegible]	[illegible]	15.5	5.4	46.0	6.0	.8	-0	10.7	-0	-0	-0	3.4	-0	.7	20.2	122.0	3.8	[illegible]
[illegible]	722	105.0	-0	-0	-0	-0	-0	54.4	-0	-0	-0	-0	-0	-0	-0	35.5	-0	[illegible]
[illegible]	[illegible]	17.0	-0	-0	8.0	1.2	-0	9.6	-0	5.2	-0	4.0	-0	13.4	29.2	240.0	-0	-0
[illegible]	[illegible]	17.0	6.0	[illegible]	5.0	1.2	-0	20.0	-0	6.6	-0	4.4	-0	17.8	31.0	-0	-0	-0
[illegible]	917	13.0	6.0	71.0	7.0	2.0	-0	18.0	-0	7.7	-0	3.6	-0	5.1	32.0	157.0	-0	-0
[illegible]	1105	5.0	5.8	58.0	-0	1.9	-0	15.9	-0	6.2	-0	6.1	-0	1.7	-0	-0	-0	-0

APPENDIX 6 T-TESTS BETWEEN WATER QUALITY DATA AT F1X SAMPLING LOCATION AND OTHER SAMPLING LOCATIONS ON FILSON CREEK

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                                                                        78/06/24.    15.12.11.     PAGE  14
 FILE [illegible]  (CREATION DATE = 78/06/24.)  DATA FOR SURFACE WATER FILSON CR  77

- - - - - - - - - - - - - - - - - - - - - - - - - - T - T E S T - - - - - - - - - - - - - - - - - - - - - - - - - - -

 [illegible]         25 CASES
 [illegible]         17 CASES
                                                                           * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                                 *                  *                            *
              NUMBER                STANDARD      STANDARD       *   F    2-TAIL    *   T   DEGREES OF 2-TAIL   *   T    DEGREES OF  2-TAIL
             OF CASES     MEAN      DEVIATION      ERROR         * VALUE  PROB.     * VALUE  FREEDOM   PROB.    * VALUE   FREEDOM    PROB.
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       21       6.1[illegible]      .373          .081   *                  *                           *
                                                                 * 1.[illegible]3   .223   *  2.25    36      .031   *  2.32    35.75      .025
 GROUP 2       17       5.8604      .275          .067           *                  *                           *
                                                                 *                  *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       21       7.2810     3.299          .720           *                  *                           *
                                                                 * 14.40  .000      *  -.36    36      .723     *  -.32    17.69      .749
 GROUP 2       17       8.2941    12.519         3.036           *                  *                           *
                                                                 *                  *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       21       2.7[illegible]     3.[illegible]10          .785   *                  *                           *
                                                                 * 1.22   .7[illegible]     *  -.[illegible]    35      .660     *  -.45    33.87      .656
 GROUP 2       16       2.[illegible]      3.274          .818           *                  *                           *
                                                                 *                  *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       25        .9[illegible]      .525          .105           *                  *                           *
                                                                 * 1.11   .79[illegible]    * -2.02    40      .050     * -2.00    33.27      .054
 GROUP 2       17       1.2[illegible]      .553          .134           *                  *                           *
                                                                 *                  *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       22       3.7182     1.007          .215           *                  *                           *
                                                                 * 1.29   .613      *  -.04    37      .971     *  -.04    36.30      .971
 GROUP 2       17       3.7294      .868          .215           *                  *                           *
                                                                 *                  *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       16       2.9062      .8471         .212           *                  *                           *
                                                                 * 2.02   .210      *   .79    28      .438     *   .81    26.65      .427
 GROUP 2       14       2.5929      .595          .159           *                  *                           *
                                                                 *                  *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
                                                                 *                  *                           *
 GROUP 1       22       2.8[illegible]      .803          .171           *                  *                           *
                                                                 * 1.94   .156      *  -.34    37      .739     *  -.32    27.92      .749
 GROUP 2       17       2.[illegible]765     1.118          .271           *                  *                           *
                                                                 *                  *                           *
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  GROUP 2      21      2.6524      1.388      .303  *  2.49   .015  *  -.52     41       .604  *  -.52     31.74      .609
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                                                                         78/06/24.     15.12.11.     PAGE   11

FILE    FIELD    (CREATION DATE =  78/06/24.)   DATA FOR SURFACE WATER FILSON CK  77
SUBFILE  FIRST        AL

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    GROUP 1 - FIRST      25 CASES
    GROUP 2 - NEXT       21 CASES
                                                                       * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                          *                  *                            *
VARIABLE            NUMBER               STANDARD   STANDARD  *    F    2-TAIL  *    T   DEGREES OF  2-TAIL *    T    DEGREES OF  2-TAIL
                   OF CASES     MEAN    DEVIATION     ERROR   *  VALUE   PROB.  *  VALUE   FREEDOM    PROB.  *  VALUE    FREEDOM    PROB.
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        20      1.5550       .481        .107  *                  *                            *
                                                          *  2.43   .119     *  -.30     31       .767    *  -.33     31.00      .745
    GROUP 2        13      1.6000       .308        .085  *                  *                            *
                                                          *                  *                            *
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        24      1.4208       .351        .072  *                  *                            *
                                                          *  4.43   .001     * -1.68     43       .100    * -1.61     27.75      .119
    GROUP 2        21      1.7048       .739        .161  *                  *                            *
                                                          *                  *                            *
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        22      1.2955       .265        .056  *                  *                            *
                                                          *  1.39   .572     *   .30     33       .767    *   .31     28.67      .757
    GROUP 2        13      1.2692       .225        .062  *                  *                            *
                                                          *                  *                            *
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        25       .5120       .285        .057  *                  *                            *
                                                          *  2.59   .030     * -1.43     44       .160    * -1.49     40.78      .145
    GROUP 2        21       .6143       .177        .039  *                  *                            *
                                                          *                  *                            *
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        22       .4500       .230        .049  *                  *                            *
                                                          *  2.01   .213     * -2.27     33       .030    * -2.48     31.80      .019
    GROUP 2        13       .6154       .163        .045  *                  *                            *
                                                          *                  *                            *
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        21      8.7762      4.257        .929  *                  *                            *
                                                          *  1.35   .507     *  1.82     40       .076    *  1.82     39.13      .076
    GROUP 2        21      6.1810      4.949       1.080  *                  *                            *
                                                          *                  *                            *
-------------------------------------------------------------------------------------------------------------------------------------
                                                          *                  *                            *
    GROUP 1        23     41.0000      8.263       1.723  *                  *                            *
                                                          *  1.20   .707     *   .70     40       .485    *   .71     39.55      .481
    GROUP 2        19     39.2632      7.554       1.733  *                  *                            *
                                                          *                  *                            *
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                                                                                 78/06/24.    15.12.11.     PAGE    3

FILE   FIELD     (CREATION DATE =  78/06/24.)   DATA FOR SURFACE WATER FILSON CK  77
SUBFILE   FIRST      THIRD

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   GROUP 1 - FIRST      25 CASES
   GROUP 2 - NEXT       16 CASES
                                                                                * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                                     *                                   *
 VARIABLE          NUMBER                STANDARD      STANDARD     *    F     2-TAIL    *    T     DEGREES OF  2-TAIL *    T      DEGREES OF   2-TAIL
                  OF CASES     MEAN     DEVIATION       ERROR       *  VALUE   PROB.     *  VALUE    FREEDOM    PROB.  *  VALUE     FREEDOM      PROB.
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     20        1.5550        .481          .107       *                   *                                  *
                                                                     *  1.72    .338     *    .01      31        .994       *    .01     30.03        .994
        GROUP 2     13        1.5538        .367          .102       *                   *                                  *
                                                                     *                   *                                  *
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     24        1.4208        .351          .072       *                   *                                  *
                                                                     *  1.31    .543     *    .18      40        .859       *    .18     33.69        .862
        GROUP 2     18        1.4000        .401          .095       *                   *                                  *
                                                                     *                   *                                  *
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     22        1.2455        .265          .056       *                   *                                  *
                                                                     *  1.48    .493     *   1.01      33        .320       *   1.06     29.31        .297
        GROUP 2     13        1.2077        .218          .060       *                   *                                  *
                                                                     *                   *                                  *
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     25         .5120        .285          .057       *                   *                                  *
                                                                     *  1.40    .477     *  -2.75      41        .009       *  -2.82     39.67        .007
        GROUP 2     18         .7389        .240          .057       *                   *                                  *
                                                                     *                   *                                  *
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     22         .4500        .230          .049       *                   *                                  *
                                                                     *  1.75    .316     *  -2.34      33        .026       *  -2.51     30.84        .017
        GROUP 2     13         .6231        .170          .046       *                   *                                  *
                                                                     *                   *                                  *
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     21        8.7762       4.257          .929       *                   *                                  *
                                                                     *  1.10    .853     *   1.17      37        .250       *   1.17     36.54        .249
        GROUP 2     18        7.2111       4.062          .958       *                   *                                  *
                                                                     *                   *                                  *
----------------------------------------------------------------------------------------------------------------------------------------------------
                                                                     *                   *                                  *
        GROUP 1     23       [illegible]   8.263         1.723       *                   *                                  *
                                                                     *  1.07    .909     *   1.01      37        .318       *   1.02     33.14        .315
        GROUP 2     16       38.3125       7.931         1.983       *                   *                                  *
                                                                     *                   *                                  *
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FILE   FILSON   (CREATION DATE =  78/06/24.)   DATA FOR SURFACE WATER FILSON CK  77
[illegible]

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[illegible]

                                                                      * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                          *                                  *                                 *
 VARIABLE          NUMBER               STANDARD    STANDARD  *    F     2-TAIL  *    T    DEGREES OF 2-TAIL *    T     DEGREES OF   2-TAIL
                  OF CASES      MEAN    DEVIATION     ERROR    *  VALUE  PROB.   *  VALUE   FREEDOM   PROB.  *  VALUE    FREEDOM      PROB.
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 [illegible]                                                   *                 *                           *
    GROUP 1          [illegible]  6.1[illegible]   [illegible].373   .0[illegible]1  *                 *                           *
                                                               *   1.43   .433   *  -1.53     40      .134   *  -1.53    3[illegible]     .13[illegible]
    GROUP 2          21      6.2[illegible]9[illegible]      .312      .06[illegible]  *                 *                           *
                                                               *                 *                           *
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 C[illegible]S                                                 *                 *                           *
    GROUP 1          [illegible]  7.2[illegible]1[illegible]  3.[illegible]9  .72[illegible]  *                 *                           *
                                                               *   2.61   .037   *   -.96     40      .344   *   -.96    33.35       .346
    GROUP 2          21      [illegible]75     5.333     1.164  *                 *                           *
                                                               *                 *                           *
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 SO4                                                           *                 *                           *
    GROUP 1          2[illegible]  2.733[illegible]  3.510   .796  *                 *                           *
                                                               *   1.08   .861   *   -.29     40      .771   *   -.29    39.99       .771
    GROUP 2          21      2.[illegible]     3.756      .820  *                 *                           *
                                                               *                 *                           *
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 CL                                                            *                 *                           *
    GROUP 1          [illegible]  .94[illegible]  .5[illegible]5  .105  *                 *                           *
                                                               *   1.22 [illegible] *  -2.2[illegible]  40  .035   *  -2.22    43.72       .032
    GROUP 2          [illegible]  1.2[illegible]62  [illegible]6  .191  *                 *                           *
                                                               *                 *                           *
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 T[illegible]                                                  *                 *                           *
    GROUP 1          22      3.7162    1.007      .215  *                 *                           *
                                                               *   4.12   .002   *   -.52     41      .607   *   -.51    28.86       .613
    GROUP 2          21      3.9714    2.046      .446  *                 *                           *
                                                               *                 *                           *
-------------------------------------------------------------------------------------------------------------------------------------
 [illegible]                                                   *                 *                           *
    GROUP 1          16      2.8[illegible]    .847      .212  *                 *                           *
                                                               *   1.41   .55[illegible] *    .59     27      .562   *    .59    26.95       .5[illegible]7
    GROUP 2          13      2.5625     .714      .198  *                 *                           *
                                                               *                 *                           *
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 T[illegible]G                                                 *                 *                           *
    GROUP 1          22      2.4727     .803      .171  *                 *                           *
                                                               *   2.99   .015   *   -.52     41      .6[illegible]  *   -.52    31.79       .6[illegible]
    GROUP 2          21      2.6520    1.389      .303  *                 *                           *
                                                               *                 *                           *
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                                                                    79/06/24.    15.12.11.     PAGE    2

[illegible] (CREATION DATE = 79/06/24.)   DATA FOR SURFACE WATER FILSON CK  77
[illegible] FIRST [illegible] THIRD (F3M)

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   [illegible]

                                                                   * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                       *           *                          *
                NUMBER           STANDARD  STANDARD    *  F  2-TAIL *   T   DEGREES OF 2-TAIL *   T    DEGREES OF  2-TAIL
              OF CASES   MEAN    DEVIATION   ERROR     * VALUE PROB. * VALUE  FREEDOM   PROB.  * VALUE   FREEDOM    PROB.
-----------------------------------------------------------------------------------------------------------------------------
                                                       *            *                         *
  [illegible]    21   [illegible]   .373       .081    *            *                         *
                                                       * 1.95  .179 *  -.14    36       .890  *  -.14    35.59     .8[illegible]6
  [illegible]    17   [illegible]   .267       .065    *            *                         *
                                                       *            *                         *
-----------------------------------------------------------------------------------------------------------------------------
                                                       *            *                         *
  [illegible]    21   7.[illegible] 3.297      .720    *            *                         *
                                                       * 4.46  .002 *  -.73    36       .471  *  -.68    21.76     .504
  [illegible]    17   2.5294      6.965       1.689    *            *                         *
                                                       *            *                         *
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                                                       *            *                         *
  [illegible]   [illegible] 2.[illegible] [illegible]   .7[illegible] *         *             *
                                                       * 4.11 [illegible] *  .71   37       .481  *   .75    30.13     .461
  [illegible]   [illegible] [illegible]  1.742     .422    *            *                         *
                                                       *            *                         *
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                                                       *            *                         *
  [illegible] 1  25   .9[illegible] .5[illegible] .105 *            *                         *
                                                       * 1.17 [illegible] * -2.1[illegible] 41 .039 * -2.16   38.37     .037
  [illegible] 2  18   1.2[illegible] [illegible]  .115 *            *                         *
                                                       *            *                         *
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                                                       *            *                         *
  GROUP 1        22   3.7182      1.007       .215     *            *                         *
                                                       * 1.04  .919 *  1.32    38       .196  *  1.32    36.71     .195
  GROUP 2        18   3.3000       .939       .233     *            *                         *
                                                       *            *                         *
-----------------------------------------------------------------------------------------------------------------------------
                                                       *            *                         *
  [illegible]    16   2.[illegible] .847      .212     *            *                         *
                                                       * 1.37  .591 *   .61    27       .542  *   .63    26.91     .535
  [illegible]    13   2.6231       .724       .201     *            *                         *
                                                       *            *                         *
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                                                       *            *                         *
  [illegible]    22   2.[illegible] .803      .171     *            *                         *
                                                       * 1.29  .573 *  1.[illegible] 37     .308  *  1.02    32.11     .317
                 17   2.[illegible] .913      .221     *            *                         *
                                                       *            *                         *
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                                                                                 78/06/24.    15.12.11.     PAGE    7

FILE   FIELD    (CREATION DATE =  78/06/24.)   DATA FOR SURFACE WATER FILSON CK  77
SUBFILE   FIRST      CONF

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GROUP 1 - FIRST     25 CASES
GROUP 2 - NEXT      17 CASES
                                                                                * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                                   *            *                           *
VARIABLE            NUMBER                 STANDARD     STANDARD   *   F   2-TAIL *    T   DEGREES OF 2-TAIL *    T    DEGREES OF   2-TAIL
                   OF CASES      MEAN     DEVIATION      ERROR     * VALUE  PROB. *  VALUE   FREEDOM   PROB. *  VALUE    FREEDOM     PROB.
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[illegible]                                                        *              *                           *
      GROUP 1        20        1.5550       .081         .107      *              *                           *
                                                                   *  2.02   .256 *  -.50     29       .624 *  -.55     27.00        .588
      GROUP 2        11        1.6364       .336         .102      *              *                           *
                                                                   *              *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
[illegible]                                                        *              *                           *
      GROUP 1        24        1.4208       .351         .072      *              *                           *
                                                                   *  3.68   .005 *  -.96     39       .341 *  -.87     22.18        .393
      GROUP 2        17        1.5765       .674         .163      *              *                           *
                                                                   *              *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
[illegible]                                                        *              *                           *
      GROUP 1        22        1.2955       .265         .056      *              *                           *
                                                                   *  3.15   .065 *  1.42     31       .165 *  1.70     30.40        .099
      GROUP 2        11        1.1727       .149         .045      *              *                           *
                                                                   *              *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
[illegible]                                                        *              *                           *
      GROUP 1        25         .5120       .285         .057      *              *                           *
                                                                   *  2.54   .038 * -1.24     40       .223 * -1.14     24.53        .267
      GROUP 2        17         .6529       .454         .110      *              *                           *
                                                                   *              *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
[illegible]                                                        *              *                           *
      GROUP 1        22         .4500       .230         .049      *              *                           *
                                                                   *  6.08   .006 *  -.06     31       .951 *  -.08     30.22        .937
      GROUP 2        11         .4545       .093         .028      *              *                           *
                                                                   *              *                           *
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[illegible]                                                        *              *                           *
      GROUP 1        21        9.7762      4.257         .929      *              *                           *
                                                                   *  1.15   .759 * -1.55     36       .130 * -1.54     33.28        .133
      GROUP 2        17       11.[illegible]  4.562     1.107      *              *                           *
                                                                   *              *                           *
--------------------------------------------------------------------------------------------------------------------------------------------
[illegible]                                                        *              *                           *
      GROUP 1        23       41.[illegible]  8.263     1.723      *              *                           *
                                                                   *  2.21   .098 *  -.15     35       .881 *  -.14     20.24        .893
      GROUP 2        14       41.5164     12.284        3.283      *              *                           *
                                                                   *              *                           *
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                                                                        78/06/24.    15.12.11.     PAGE  15
 [illegible]                     RIA FOR SURFACE [illegible] FIELD  OK  77

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              [illegible]
              [illegible]
                                                                        * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                                *       *                          *
              NUMBER                     STANDARD   STANDARD    *  F      2-TAIL  *   T   DEGREES OF  2-TAIL  *   T    DEGREES OF  2-TAIL
              OF CASES   MEAN            DEVIATION  ERROR       * VALUE   PROB.   * VALUE  FREEDOM   PROB.   * VALUE   FREEDOM    PROB.
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                                                                *                 *                          *
  GROUP 1     [illegible] [illegible]    [illegible] .1?7       *                 *                          *
                                                                *  1.32   .619    *  -.37     32     .712   *  -.38    30.?7      .705
  GROUP 2     14          1.6185         .419       .112        *                 *                          *
                                                                *                 *                          *
---------------------------------------------------------------------------------------------------------------------------
                                                                *                 *                          *
  GROUP 1     [illegible] [illegible]    [illegible] .072       *                 *                          *
                                                                *  4.51   .001    *  -.62     39     .536   *  -.56    21.66      .583
  GROUP 2     17          1.5???         [illegible] .191       *                 *                          *
                                                                *                 *                          *
---------------------------------------------------------------------------------------------------------------------------
                                                                *                 *                          *
  GROUP 1     22          1.2???         .26?       .056        *                 *                          *
                                                                *  1.00   .964    *   .66     34     .514   *   .66    27.80      .515
  GROUP 2     1?          1.????         .2??       .071        *                 *                          *
                                                                *                 *                          *
---------------------------------------------------------------------------------------------------------------------------
                                                                *                 *                          *
  GROUP 1     [illegible] .51??          .2??       .057        *                 *                          *
                                                                *  2.01   .118    * -1.99     40     .053   * -1.87    26.62      .073
  GROUP 2     17          .????          [illegible] .0?0       *                 *                          *
                                                                *                 *                          *
---------------------------------------------------------------------------------------------------------------------------
                                                                *                 *                          *
  GROUP 1     22          .?50?          .230       .049        *                 *                          *
                                                                *  1.01   .520    * -2.12     34     .041   * -2.01    23.07      .056
  GROUP 2     1?          .?35?          .2?2       .070        *                 *                          *
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                                                       73/06/28.     15.12.11.     PAGE    6

[illegible] = [illegible]   (DATA FOR [illegible] ITEM FILE [illegible] 77

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                                                                 * POOLED VARIANCE ESTIMATE * SEPARATE VARIANCE ESTIMATE
                                                  *              *                          *
                NUMBER            STANDARD   STANDARD  *   F    2-TAIL *   T   DEGREES OF 2-TAIL *   T    DEGREES OF  2-TAIL
               OF CASES   MEAN    DEVIATION   ERROR    * VALUE  PROB.  * VALUE  FREEDOM   PROB.  * VALUE   FREEDOM    PROB.
-----------------------------------------------------------------------------------------------------------------------------
                                                  *              *                          *
   [illegible]   21   [illegible]    .773     .081     *              *                          *
                                                  *  4.59   .003  *  -2.76     36     .009  *  -2.96    29.40      .006
   [illegible]   17     4.3771       .777     .092     *              *                          *
                                                  *              *                          *
-----------------------------------------------------------------------------------------------------------------------------
                                                  *              *                          *
   [illegible]   21   [illegible]   3.[illegible]   .720  *              *                          *
                                                  *  3.64   .007  *  -1.31     36     .200  *  -1.23    23.09      .232
   [illegible]   17     9.3529    6.[illegible]  1.527  *              *                          *
                                                  *              *                          *
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                                                  *              *                          *
   [illegible]   21   [illegible]   [illegible]    .79[illegible]  *              *                          *
                                                  *  1.[illegible]  .221  *    .7[illegible]   36   .[illegible]33  *    .82   35.70   .41[illegible]
   [illegible]   17   1.[illegible]    2.663    .[illegible]  *              *                          *
                                                  *              *                          *
-----------------------------------------------------------------------------------------------------------------------------
                                                  *              *                          *
   [illegible]   [illegible]   [illegible]    .[illegible]    .105   *              *                          *
                                                  *  2.29   .066  *  -1.56     40     .127  *  -1.44    25.45      .161
   [illegible]   17   [illegible]    .784     .190     *              *                          *
                                                  *              *                          *
-----------------------------------------------------------------------------------------------------------------------------
                                                  *              *                          *
   [illegible] 1   22     3.7192      1.007     .215     *              *                          *
                                                  *  1.03   .927  *    .68     37     .498  *    .68    34.27      .50[illegible]
   [illegible] 2   17     3.0041      1.020     .248     *              *                          *
                                                  *              *                          *
-----------------------------------------------------------------------------------------------------------------------------
                                                  *              *                          *
   [illegible] 1   16     2.9062       .847     .212     *              *                          *
                                                  *  1.64   .410  *    .75     26     .457  *    .78    25.93      .441
   [illegible] 2   12     2.9[illegible]33       .660     .191     *              *                          *
                                                  *              *                          *
-----------------------------------------------------------------------------------------------------------------------------
                                                  *              *                          *
   [illegible]   22   2.[illegible]27   .8[illegible]3   .171     *              *                          *
                                                  *  1.66   .269  *   -.17     36     .862  *   -.17    27.16      .868
   [illegible]   [illegible]   2.[illegible]   1.[illegible]   .[illegible]  *              *                          *
                                                  *              *                          *
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