REPORT ON THE GEOLOGY AND HYDROLOGY OF THE FRASER BROOK WATERSHED , IHD-IWB-RB- 23

BY : T. W. HENNIGAR 1966

REPORT ON THE GEOLOGY AND HYDROLOGY OF THE FRASER BROOK WATERSHED, COLCHESTER CO., NOVA SCOTIA

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ABSTRACT

Geology mapping was carried out with some detail on a scale of 1" = 400'; the area under study is confined within the I.H.D. - I.W.B. - RB - 23 Fraser Brook Watershed. The complete area is underlain by sediments of the Canso Group which is made up entirely of non-marine siltstones and sandstones. Within the map area eight different and separate lithologic rock units were identified and mapped. These units, which all form components of a moderately folded geologic structure, have a regional NNE-SSW strike which only varies from this direction in the SW corner of the map area. It is suggested that this variation is a result of a major normal fault which brings the younger Canso sediments into contact with the older Horton rocks lying to the west of the map area.

Rocks of wide variation in lithology were observed to outcrop in the area. The sediments ranged from a brick red shale unit to a highly quartzitic sandstone with lenses of quartzite, which appeared to be the result of either precipitation or fusion of a pure sandstone. In all, the units were composed of shales, siltstones and sandstones, and the contacts between any of these units were usually very sharp and distinct.

From the bedding and cleavage relationships observed in one of the siltstone units it was concluded

that the beds are right side up and the position of the syncline with respect to that station confirmed continuity of sedimentation of the section.

Estimated thicknesses of the units vary from about 700' for the thickest siltstone unit to about 50' for the brick red shale unit.

Folding in the area has resulted in a central Anticline which transverses through the center of the watershed and trends in a NE direction. This main anticline is flanked on the SE by the Greenfield syncline and on the NW by the Archibald syncline both which parallel the Central anticline.

None of the mapable lithologic units appear to have a promising water bearing potential greater than that required for a small domestic or farm supply. Porosity is very low and any permeability is probably secondary; resulting from the few joint systems observed and the well defined cleavage pattern which parallels the bedding in most of the area.

A short pump test at the weir site indicated a transmissibility of about 350 gpd/ft, representing the hydraulic conductivity of one of the siltstone units.

Chemical analyses of water samples collected at various points throughout the watershed area indicate a good quality of water. The SAR and SSP, both being below 2.0, can be used in conjunction with the content of other chemical constituents to classify the water as to its suitability for irrigation purposes. The low values of the SSP and SAR indicate that the water will most likely be classed as an excellent quality of water for irrigation.

INTRODUCTION

Purpose & Scope

The detailed geological survey of the rock units within the Fraser Brook Watershed was carried out in an attempt to learn the character of the deposits, both lithologic and mineralogic, and the possible relation between the structure of the basin and its influence on the groundwater flow system.

As part of Nova Scotia's contribution to the I.H.D. program in Canada, the Fraser Brook Watershed was choosen to represent the geohydrological characters of the Salmon River watershed and the Truro area in general. This report is an attempt to investigate the geology as an approach to understanding the geological environment of the area and its likely influence on the groundwater regimes of this drainage basin.

This report is mainly confined to the bedrock geology of the area and also covers a brief reconnaissance of the groundwater chemistry of both the surficial and bedrock aquifers and the surface water.

It is hoped that this basic introduction into the geohydrology of the watershed will initiate further study and also be of some value to whoever pursues the subject in greater detail.

In order to properly carry out a hydrogeological assessment of a basin the geology should be sufficiently

LOCATIC.I MAP OF TRURO AREA AND FRASL.. BROOK WATERSHED AREA

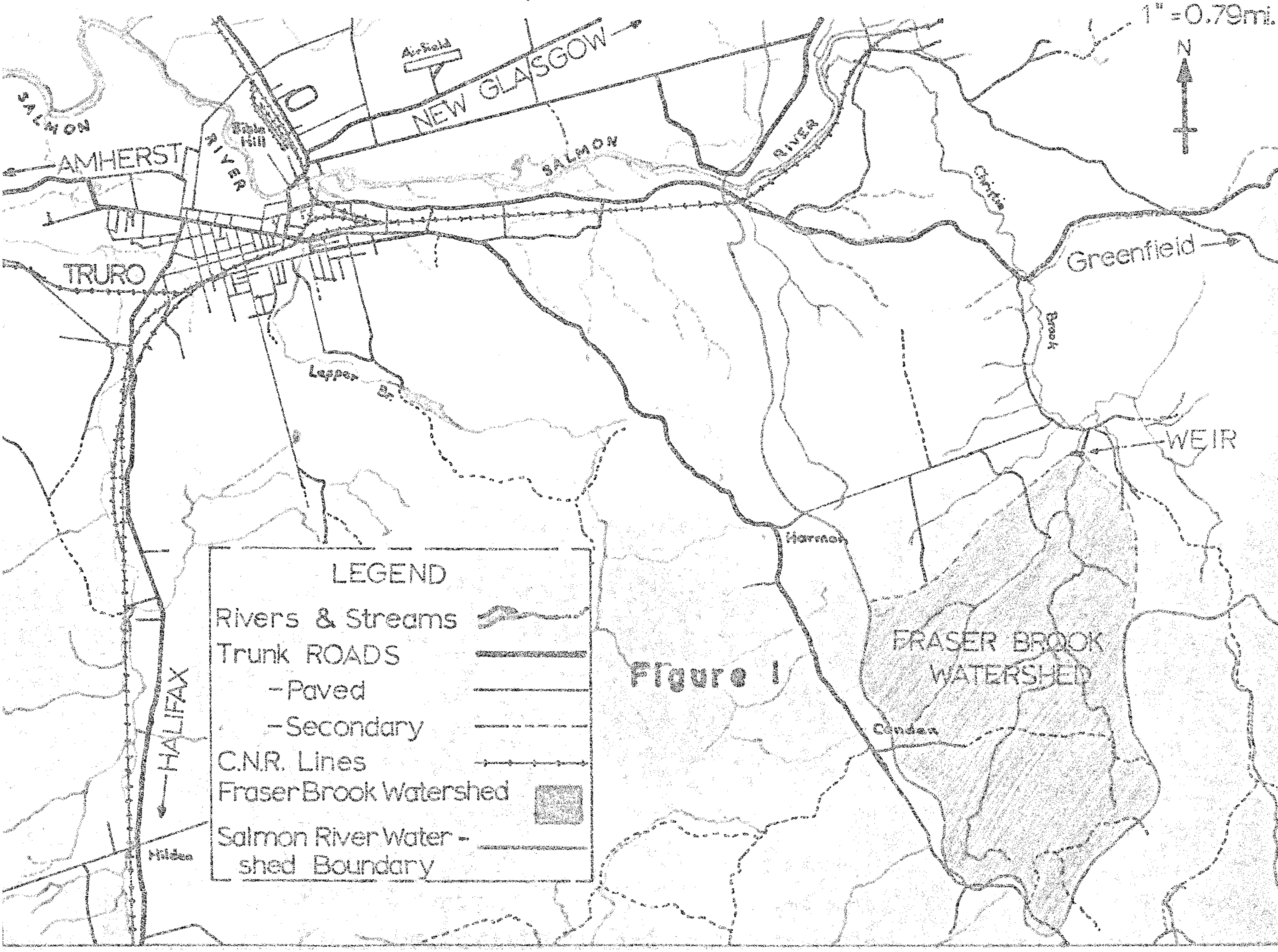


Figure 1

familiar to ensure a reliable estimate of the "tightness" or "leakiness" of the hydrologic unit. With close geologic control a measure of the amount of water entering and leaving the basin as groundwater can be estimated either by using a model of the basin or by instrumenting and basing the estimate on field measurements.

Location; Areal Extent; Drainage

The I.H.D. Watershed at Fraser Brook is located in the Harmony and Camden area, about 4 miles east of Truro. The location of the weir site is at Longitude 63°10'6"; Latitude 45°20'36". Using the National Topographic Series, the location can be given as 11-E-6-A-81-J-NE.

In nature and size the Fraser Brook Watershed is a small component of the Salmon River Watershed complex which has a drainage area of about 140 square miles above the bridge and gauging station at Murray Village. The drainage area of the Frase Brook Basin being 3.4 square miles, with drainage northward and emptying into Christie Brook which ultimately discharges into the Salmon River above the gauging station and about ½ mile below the bridge at Valley Village.

The drainage system in the basin forms a well defined dendritic pattern which cuts into bedrock in most of the lower portion of the basin. The stream beds in the upper half of the basin are composed of loose boulders and gravel washed clean from the surficial cover. Also much of the stream flow is derived from base flow which is mainly contributed in the bottom portion of the basin during drought periods.

Physiography

Relief within the watershed reaches about 310 feet. The lowest point of land is at the weir site and is about 340 feet above sea level. From here the land rises to reach a height of 650 feet above sea level at a point on the extreme south limit of the drainage divide.

The Topography within the watershed is undulating to rolling. Two main ridges, which result from the bedrock structure, trending NE-SW account for much of the rolling topography.

The Fraser Brook Watershed lies on the North Flank of the Camden ridge which trends in a ENE - WSW direction. This ridge is in the area which is generally known as the ~~Atlantic upland~~ Colchester lowlands belonging to the ~~upland~~ lowland physiographic region of Nova Scotia.

Soils

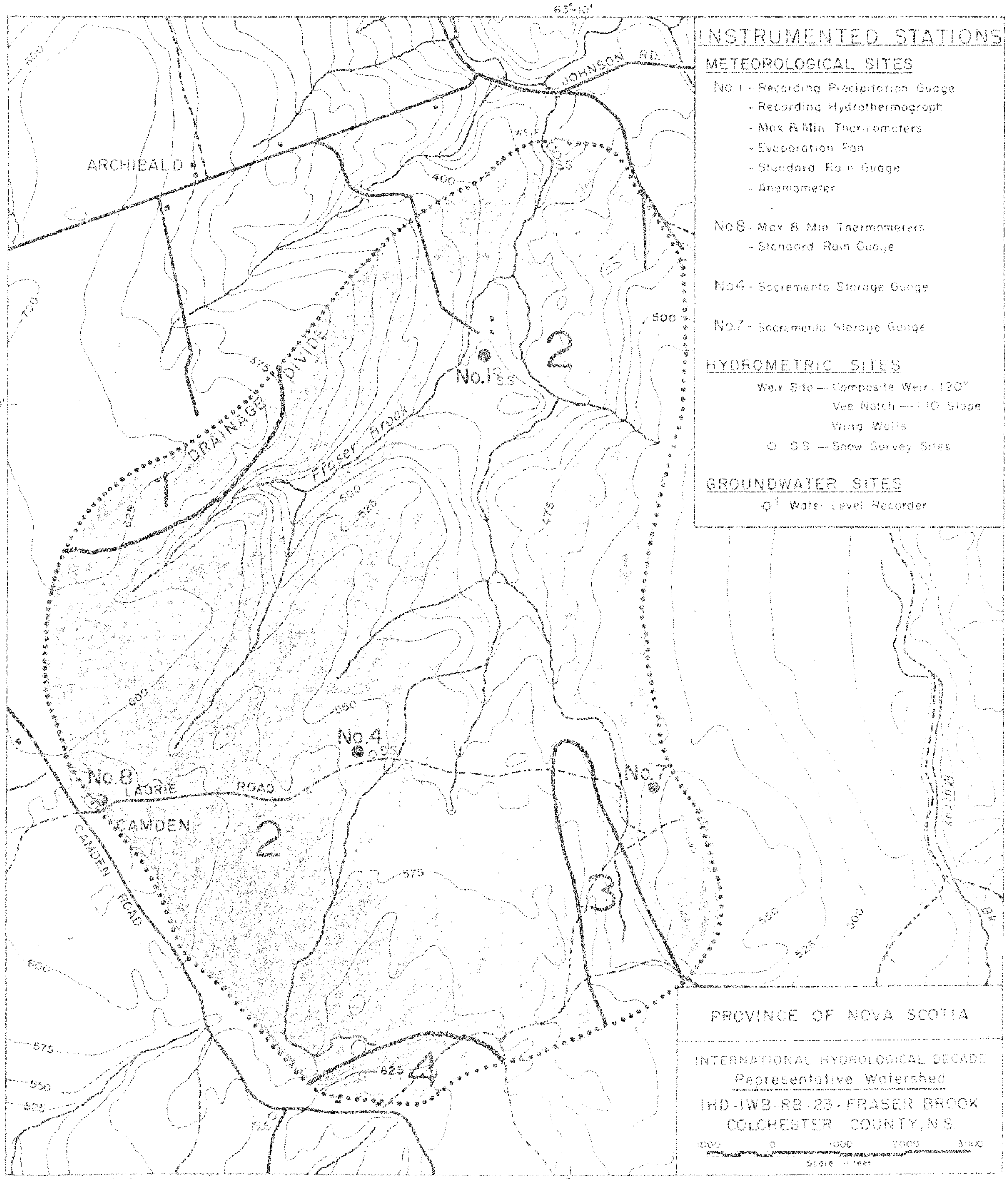
The soil types within the watershed have been classified into three separate associations. An Association being the highest category and includes groups of soils which have developed on the same kind of parent material. Each Association may contain Associates and/or classes which differ only in drainage characteristics and textural properties respectively. The three main soils mapped* are called the Harmony, Londonderry and Hebert Associations.

The most prominent soil in the watershed is classified as the Harmony Association. It is best described as a brown gravelly sandy loam with variations of a light brown gravelly sandy clay loam. The gravel content ranges from 39 to 60 per cent. The parent material is a dark brown gravelly clay loam till derived from the underlying reddish brown siltstones and sandstones. Dranage of this soil type is considered good. According to the N.S. Dept. of Agriculture (Wickland and Smith, 1948) the stone content of these soils is usually so great as to make them unsuitable for agricultural soils.

On the South east limit of the watershed is an area of soil classified as a poorly drained associate of the Harmony Associates. This soil exhibits deeply leached layers and stongly mottled profiles. Its parent material is similar to that of the Harmony Association.

A small area of the watershed on the North west side is covered by soil of the Londonderry Association.

Figure 2



SOIL TYPES

Hebert Association	4
Harmony Associate	3
Harmony Association	2
Londonderry Association	1

These soils are described as light brown clay loam over light brown clay loam. Their parent material is purplish brown clay loam till derived from dark red shale and sandstone. They have only fair drainage and are considered as of no great agricultural importance.

Soils derived from water deposited materials, consisting of gravel and cobblestones, are found in a small area on the extreme south limit of the watershed. These soils are classed as the Hebert Association and consist of brown gravelly sandy loam over yellowish brown stony sandy loam. This Association is made up of well developed podzols which are very well or excessively drained.

The Hebert soils are cultivated to some extent and are best suited for crops of grain, hay and vegetables.

Forest Types

A forest inventory of the woodlands within the watershed was carried out by the Department of Lands and Forests of Nova Scotia during the early spring of 1966. The topics included in the general "Nova Scotia Forest Inventory" were all considered when mapping the Fraser Brook Watershed. A forest type map was prepared on a scale of 1 inch to 20 chains (1" = 1320'). Over 30 miles of cruise lines were surveyed, measuring trees in 61 acres of the watershed and giving a 2% sample of the area.

Five main topics were considered for classification of the forest cover. They were: 1. Species; 2. Crown Closure; 3. Height; 4. Age; and 5. Non forest land.

Species composition was subdivided into 3 main areas: 1. Softwood land; 2. Hardwood land; and 3. Mixed wood land. Softwood land is classed as that land with less than 25% hardwood by volume. The survey revealed that 58.6% or 2.32 square miles of the watershed area is covered by softwood land; with spruce and fir the two types of softwood present in any significant amounts.

Hardwood land is classed as that land with more than 75% hardwood or less than 25% softwood by volume. The survey showed that 7.3% or 0.3 square mile of the drainage basin is covered with hardwood lands.

Any area that contains between 26% and 74% hardwood by volume is classed as mixed wood land. About 25.4% or 1.0 square mile of the watershed is classified as mixed wood lands.

A volume compilation was done on the basis of softwood and hardwood only. As a result 77.6% of the volume is in softwood species and 22.4% in hardwood species.

The topic of Crown Closure was subdivided into 3 classes depending on the per cent of crown closure. These measurements being taken from areal photographs flown in 1964.

Forest types were also subdivided into five main height classes. The smallest class being 15 feet or less in height whereas the highest class included trees 51 feet or higher.

Five age classes were used to group trees into roughly the same growth stage. Each class interval has a length of 20 years, the oldest class being those trees which are between 81 and 100 years of age.

Non forest land, the fifth topic considered, was subdivided into 3 area, which covered 8.7% or .35 square mile of the watershed. The largest area mapped was classed as agricultural or cleared land. Six per cent or 0.24 square mile of the watershed fell into this classification. The next largest area was classed as alders and brush which covered 1.6% or about 0.07 square mile of the drainage basin. The third class of non forest land was blueberry land which covered about 0.04 square mile or 1.1% of the watershed. This area is confined entirely to the South extremity of the watershed and overlies the Hebert Association of soils, which is derived from the underlying ice contact deposits of sand and gravel.

TABLE # 1

FOREST TYPES IN FRASER BROOK WATERSHED AREA

Type	Area in M:^{2}	Acres	% Area
Softwood	2.320	1482	58.6%
Hardwood	0.292	187	7.3%
Mixed Wood	1.013	647	25.4%
Alders	0.067	43	1.6%
Blueberry	0.044	28	1.1%
Cleared Land	0.240	154	6.0%
Totals	3.976	2541	100.0%

Fraser's Brook I.H.D. Watershed No. 1 Forest Type Volume Summary.

Type	Area Acres	Species	Vol./Acre Cords	Total Vol. for Type - Cords
S3CC	899	Softwood	10.8	9,709.2
		Hardwood	.3	269.7
S2CC	171	Softwood	4.6	786.6
		Hardwood	.4	68.4
S3BB	71	Softwood	1.8	127.8
S2BB	138	Softwood	1.5	207.0
		Hardwood	.05	6.9
S1BB	54	Softwood	.3	16.2
S1AA	82	Softwood	.02	1.6
		Hardwood	.01	.8
S2AA	50	Softwood	.03	1.5
S3AA	3	No Tally		
S1BC	2	Softwood	1.1	2.2
S1CD	14	Softwood	2.5	35.0
S3CD	26	Softwood	6.3	163.8
S2BC	3	Softwood	1.0	3.0
S1CC	4	No Tally		
Total	1,517	Softwood		11,053.9
		Hardwood		345.8
H1BB	4	Hardwood	1.0	4.0
H2CC	20	Hardwood	5.1	102.0
		Softwood	.25	5.0
H1CD	65	Hardwood	2.9	188.5
		Softwood	.2	13.0
H2CD	72	Hardwood	11.3	813.6
		Softwood	.2	14.4
H3DD	20	Hardwood	10.1	202.0
H3CD	18	Hardwood	11.4	205.2
		Softwood	.3	5.4
Total	199	Hardwood		1,515.3
		Softwood		37.8

Type	Area Acres	Species	Vol./Acre Cords	Total Vol. for Type - Cords
MIAA	6	Hardwood Softwood	.1 .04	.6 .2
M2BB	8	Softwood Hardwood	1.5 .5	12.0 4.0
MICC	13	Hardwood Softwood	3.0 2.0	39.0 26.0
M2CC	31	Softwood Hardwood	3.3 2.7	102.3 83.7
MICD	133	Hardwood Softwood	1.3 1.0	172.9 133.0
M2CD	471	Softwood Hardwood	2.6 2.5	1224.6 1177.5
M3CD	5	Softwood Hardwood	2.0 .04	10.0 2.0
Total	667	Softwood Hardwood		1508.5 1,479.7
Agriculture	150	No		
Blueberry	30	No		
Alder's	22	No		
Mill Site	2			
Total	204			
Total (All Types)	2587	Softwood Hardwood		12,600.2 3,340.8

Fraser's Brook I.H.B. Watershed No. 1 Forest Cover Summary by Diameter Group.

pecies	D.B.H.	No.Trees Per Acre	Total No. of Trees	Total No. of Tree Percent of Block Total	Volume Per Acre Cords	Total Volume Cords	Total Volume Percent of Block Volume
oftwood	4	24.6	58,621	17.60	.248	590.98	3.69
	5	26.8	63,864	19.10	.536	1,274.90	7.97
	6	25.1	59,813	17.90	.852	2,030.31	12.68
	7	12.7	30,264	9.10	.767	1,827.76	11.42
	8	11.9	28,357	8.50	.927	2,209.04	13.82
	9	5.2	12,391	3.70	.550	1,310.65	8.19
	10	3.5	8,340	2.50	.471	1,122.39	7.01
	11	1.1	2,621	.80	.182	433.70	2.71
	12	1.4	3,336	1.00	.307	762.28	4.76
	13	0.3	714	.20	.068	162.04	1.01
	14	0.5	1,191	.40	.163	388.42	2.43
	15	0.2	476	.12	.058	138.21	.86
	16	0.06	143	.04	.030	71.49	.45
	17	0.02	47	.02	.009	21.44	.13
	18	0.05	119	.04	.029	69.10	.43
ub-Total			270,297	81.02		12,412.71	77.56
rdwood	4	4.1	9,770	2.90	.042	100.09	.62
	5	5.6	13,345	4.00	.112	266.90	1.67
	6	5.5	13,107	3.90	.185	440.86	2.75
	7	4.0	9,532	2.90	.217	517.11	3.23
	8	3.4	8,102	2.40	.266	633.88	3.96
	9	1.5	3,575	1.10	.156	371.75	2.32
	10	1.4	3,336	1.00	.194	462.30	2.89
	11	0.2	476	.10	.057	135.83	0.85
	12	0.6	1,430	.40	.119	283.58	1.77
	13	0.1	238	.07	.036	85.79	0.54
	14	0.2	477	.10	.065	154.90	.97
	15	0.04	95	.03	.013	30.98	.19
	16	0.09	214	.06	.037	88.17	.55
	17	0.02	48	.02	.009	21.45	.13
ub-Total			63,745	18.98		3,593.59	22.44
rand Total			334,042	100.00		16,006.30	100.00

GEOLOGY

Surficial Geology

Drift material making up the bulk of the surficial deposits within the watershed are of three main classifications: Ice-contact material; Sandy till and Clay till. Two other materials, swamp and bog and recent alluvium, cover only a minor portion of the area, the two together amount to about 5.6% of the drainage basin area.

The non-stratified drift deposits or till within the drainage basin may be divided into two main types: Clay till and Sandy till. A reddish brown clay till with boulders of various sizes, covers about 15% of the drainage area. The major till unit, a reddish brown sandy till, covers about 79% of the basin. This sandy till component is of a granular texture and closely resembles the bedrock in both colour and composition. The soil grain properties, or the properties of the individual grains of which the soil is composed, of the sandy till unit are identical to the soil grain properties of the siltstone and sandstone units making up the bedrock geology. It follows that the source or parent material is most likely to be the bedrock very near or within the watershed area.

Glacial till is composed of material deposited by a glacier without subsequent transportation by water.

Since large masses of moving ice are able to carry materials of all sizes with equal ease, typical till is a heterogeneous mixture of soil and rock fragments varying in size from that of boulders to that of clay.

A till with a large content of clay will have a cohesive strength that holds a mass of the material together when immersed in water or moulded into a ball shape. A field examination of this sandy till unit revealed that the cohesive value was very low indicating a minor content of clay.

Field observation of the clay till unit indicated a relatively high cohesive value. Also the abundance of pebble size fragments in the material were sparse; the major portion of the till being made up of silt and clay components. The main criterion used in the field to distinguish between the clay till and the sandy till was the cohesive property of the material. If the cohesion appeared high, then the material was called clay till.

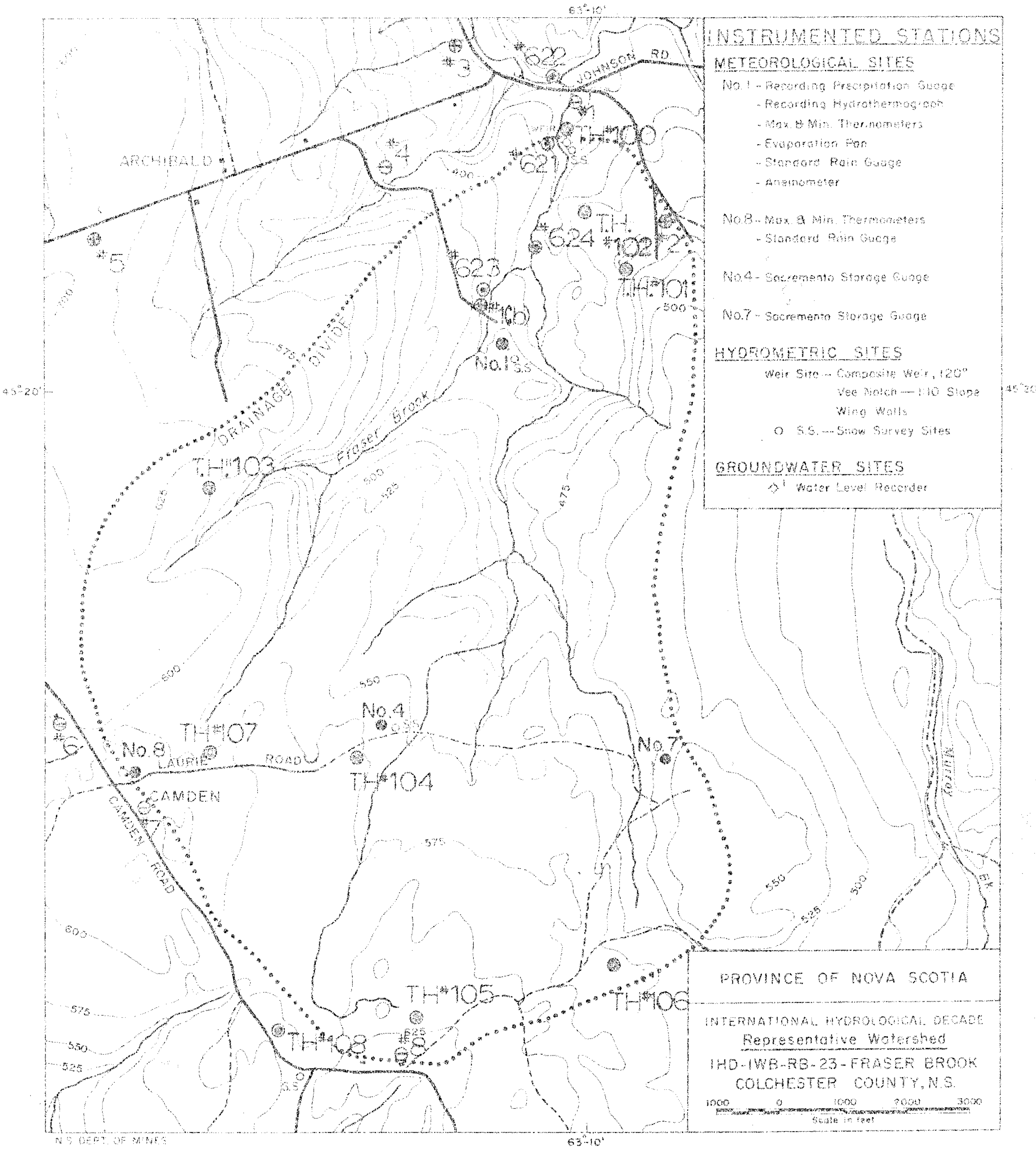
The bulk of the surficial deposits within the Fraser Brook Watershed are of that granular nature which are favourable for a high rate of infiltration of precipitation and surface water to the groundwater table. Over 81% of the surface area is covered with a sand and gravel material which should allow a high rate of recharge to the groundwater flow system within the basin.

TABLE # 2

Test Hole Locations for Drill Logs in Fraser Brook Watershed

Test Hole No.	Location	Collar Elevation	Depth to Bedrock	Elevation to Top of Bedrock
100	11-E-6-A-81-J-NE	350'	2'	348'
101	11-E-6-A-80-E-East	445'	5'	440'
102	11-E-6-A-80-M-SW	420'	17'	403'
103	11-E-6-A-63-J-East	600'	10'	590'
104	11-E-6-A-57-O-Center	590'	18'	572'
105	11-E-6-A-57-B-South	640'	15'	630'
106	11-E-6-A-56-D-East	550'	16'	534'
107	11-E-6-A-40-N-East	615'	10'	605'
108	11-E-6-A-40-N-NW	620'	3'	617'

Figure 4



Test-Hole Locations

Bedrock Water Samples

Surficial " "

Surface " "

A series of test holes drilled across the watershed indicates that the drift cover varies in thickness from about 5 feet to over 45 feet. Drilling also revealed that a thin mantle of till, between 5 and 10 feet thick, covers most of the basin. The deepest cover is found on the South East side of the basin and in the extreme Northwest portion. In the Southeast segment a test hole indicated 16 feet of sandy till overlying the same thickness of clay till. A test hole drilled in the N-W segment revealed 10 feet of sandy till overlying 33 feet of clay till and boulders. These were the only areas where the two types of till were found to occur together. All other test holes showed that the sandy till extended down to bedrock and formed the only drift cover in those areas.

BEDROCK GEOLOGY

Introduction

The geology of the Truro-Fraser Brook area consists entirely of sedimentary rock units composed mainly of terrestial sediments. Major lithologic units of Carboniferous age and Mesozoic age mould the geology of the area. Rocks representing the Horton Group, of Lower Mississippian age, the Canso Group of Upper Mississippian, and the Annapolis Formation of Lower Triassic age outcrop to the east of Truro.

The Horton Group of sediments consists of red and grey sandstones, grit, shale, and conglomerate. These rocks of early Mississippian age are also fossiliferous. Structurally the Horton Group is an eastward extension of the Walton anticline. Horton sediments are overlain by the Macumber formation which consists of grey, sandy, laminated, unfossiliferous limestone. The occurrence of these Horton rocks is confined in the area South of the Horton-Triassic contact running E-W through the South part of the Town of Truro. They are bounded on the East by Canso sediments in the faulted contact running roughly N-S.

Sparsely fossiliferous sandstones and shales of the Canso group of Carboniferous age are exposed along Salmon River and several of its North-flowing tributaries east of Truro. Normal faults, that have obscured the contact between Canso rocks and underlying marine sediments of Windsor age, have brought Canso sediments into contact with lithologically similar sediments of the Horton Group.

Cobequid Bay is bordered on either side by red conglomerate and sandstone of Triassic Age. These sediments were deposited in the eastern end of a synclinal basin that terminates about six miles east of Truro. On the South side of Cobequid Bay, a marked angular unconformity exists between Triassic rocks and sediments of the underlying Horton Group. North of the Bay, Triassic strata are in probably faulted contact with sediments of Pennsylvanian Age. With respect to folding the Triassic sediments are relatively undisturbed.

Canso Group

The age of the Canso sediments whether they are Upper Mississippian or Lower Pennsylvanian is still rather indefinite. Dating with the aid of fauna evidence and floral remains is impractical because of the fragmented nature of the available fossils.

Bell (1944, p. 5) divided the Upper Carboniferous rocks of the Maritime Provinces into four main groups: the Canso Group, the Riversdale Group, the Cumberland Group and the Pictou Group. Of these separate units, the Canso Group is the oldest and the Pictou Group the youngest. Thus Bell considers the Canso sediments to be of Lower Pennsylvanian Age.

Later, however, Bell (1958) places the Canso Group among the Upper Mississippian units and thus indicates that they are of Lower Carboniferous Age. Shea and Wallace (1962) point out that some authors place the Canso Group in the Upper Mississippian and others have called it Lower Pennsylvanian or transitional between Upper and Lower Carboniferous. They refer to it as being Upper Mississippian in age.

I. M. Stevenson (1950) places the Canso Group in Late Mississippian age. From these statements it seems reasonable to assume that the preponderence of opinion today dates the Canso sediments as Upper Mississippian or Lower Carboniferous.

The Truro area falls within the boundaries of the Fundy Basin defined by Bell as a narrow elongated basin that was intermontane in character and received Carboniferous sediments. This basin was bounded by two main contributing areas. To the Northwest, an upland in central New Brunswick, and in the South and Southeast an upland of Pre-Carboniferous rock belonging to the Meguma Group. The Fundy Basin itself was a composite one, being divided into connecting sub-basins by linear uplands arranged more or less in echelon. The largest of these uplands in the Truro area is represented by the Cobequid uplands and these supplied sediments to the Minas sub-basin which lies in the South of the uplands.

The Canso Group is represented in the Minas sub-basin by the West Bay formation which extends from the Stellarton map area westward to areas along the North Shore of the Minas Basin. The sediments of this formation are non-marine or brackish and reach a thickness of over 1800 feet. The Minas sub-basin received fluvial and partly lacustrine deposits under a warm and semi-arid climate, until a pronounced linear uplift of the Cobequid upland resulted in an unconformity which marks the beginning of Pennsylvanian time.

The Minas sub-basin was a tectonically negative area of intermittent subsidence while deposition was proceeding, while the Cobequid uplands are considered to be positive areas of intermittent elevations.

Bell defines the Minas sub-basin of Caroniferous deposition as that part of a basin of deposition that lies south of a Cobequid upland and North of an upland in Southern Nova Scotia, extending from Minas Channel to a Stellarton structural gap between the Cobequid and Pictou-Antigonish uplands. Thus defined the sub-basin includes parts of Cumberland, Hants, Colchester and Pictou Counties.

Carboniferous strata in the Minas sub-basin range in age from early Mississippian to late Pennsylvanian. They are unconformably overlain in Minas Basin area by non-marine later Triassic red sediments.

The West Bay Formation of the Canso Group consists of non-marine, red and grey sandstone, siltstone and shale.

Canso strata outcropping in the western part of the Minas sub-basin are confined to two areas. The smaller is a narrow coastal belt north of Minas Basin, extending from West Bay to Two Islands, the larger an area extending from Valley on the Salmon River eastward to the Stellarton structural gap. The Fraser Brook Watershed being located completely in this larger area. In the eastern portion of the larger area the strata are highly deformed and induration and silicification of the beds precludes expectation of occurrence of strata with high porosity and permeability.

The Canso sediments found within the Fraser Brook Watershed were separated into 8 distinct mapable lithologic units. The strata are separated into three sandstone units, four siltstone units and one shale unit, each being identified by lithology and its position in the geologic section of the area. These are described in order from the bottom of the section, Unit #1, to the top, Unit #8. Proceeding from the South extremity of, or top of the watershed, and moving Northward toward the bottom, one transverses up the section.

The oldestunit (No. 1) consists of a reddish brown sandstone underlying the Southeast corner of the watershed. Since it does not outcrop within the drainage area and was found in a test hole (No. 106) a more detailed description of its extent and variations of its lithology is not possible. The short length of core recovered indicates that it is well indurated containing a high amount of quartz and minor amount of mica.

Continuing up the section the next unit (No. 2) consists of a greyish green siltstone, found by testhole No. 105. This unit lies to the NW of and parallel to Unit No. 1. No outcrop of this siltstone unit was found but the drill cuttings indicate it to be well consolidated, slightly micaceous, and interbedded with thin lenses of red slightly micaceous siltstone.

Overlying the greyish green siltstone is a reddish brown siltstone unit (No. 3) which outcrops at the top of the east tributary of Fraser Brook. This massive and well indurated siltstone is interbedded with thinner components of greyish green siltstone and brick red micaceous siltstone. Nearly 500 feet of outcrop is exposed along which the strike varied from 40° to 52° and the dip remained about 40° North.

Unit No. 4 outcrops on the far east tributary and again just above the weir site. It was also encountered in Test-hole No. 102, drilled at a point 1500 feet SE of the weir site. This unit consists of a medium-grained, massive greenish grey quartzitic sandstone, with variations of a light brownish grey sandstone. It is mainly well cemented and indurated except for the light brown lenses which appear to be quite porous. Near the weir site this unit also has minor stringer inclusions of siltstone and showings of pyrite.

A relatively thin, platy, brick red shale unit (No. 5) overlies the sandstone. It was found overlying the sandstone with a sharp conformable contact at all outcrops and is quite distinct in this respect. This shale unit outcrops on the upper east tributary, on the lower east tributary and in the vicinity of the weir site.

The next unit (No. 6) consists of a reddish brown laminated, micaceous siltstone, showing cross bedding. It contains lenses of brick red siltstone and grey green siltstone. In most areas it was badly fractured and showed well developed bedding plane cleavage. From the bedding - cleavage plane relationships in this unit much of the structure of the section was determined, and is discussed later in this report.

Unit No. 7 consists of a massive, well indurated, fine-grained quartzite sandstone which is mainly greyish brown and green. Variation in colour to Reddish brown and grey occur both vertically and laterally in the unit. Specks of pyrite occur throughout the dark grey-green areas while mica is present in minor amounts within the sample and more abundantly in fracture planes. In the lighter lenses which are also not as well indurated, pebbles of white quartz are included.

The youngest unit (No. 8) at the top of the section exposed within the watershed, consists of a reddish brown, micaceous siltstone. Outcrops of this unit are confined to the center and the NW portions of the basin. Variations in lithology to platy shale lenses, and colour variations to brick red were observed. Most of the unit is massive showing no primary structures, while the thin platy beds possess well defined bedding plane cleavage.

<u>Structure</u>

Within the map area the sediments have been folded giving rise to one complete anticline and two complete synclines trending NE-SW. The anticline, named the central anticline, passes through Camden, the center of the basin and continues North Eastward. Lying to the North West and paralleling the anticline is the Archibald syncline; while the Greenfield syncline lies to the SE and trends in the same direction.

The regional strike of the strata is about 35° deviating as much as 15° over the area. A distinct change in strike occurs in the SW corner of the watershed where the beds strike with less of an azimuth. It is suggested by the author that this phenomena is a result of a North South trending fault which lies some unknown distance (probably within 2 miles) west of the watershed area. The fault is most likely the same one mapped by Stevenson (1950) and the one which brings the Canso sediments into contact with older Horton sediments which lie to the west. It was previously believed that this fault ran through the west portion of the drainage basin, however, a study of the outcrop and core recovered from test holes (Nos. 107, 108) near the Camden road indicate that the rocks just outside the west boundary of the watershed are of the same lithologic character and sequence as the rock units within the basin. Thus the geology is continuous across the watershed and for some distance west of the west boundary.

In order to determine and orient the major structures of the rock units cleavage and bedding plane relationships were used. In the siltstone unit (No. 6), the slaty cleavage was observed to be parallel to the axial planes of the folds which in turn are nearly parallel to the bedding. It was also observed that both bedding and cleavage dip in the same direction, but the former dips less than the latter. According to Billings (1954), if under the above conditions the cleavage dips in the same direction as the bedding but more steeply, the beds are right side up, and the synclinal axis is in the direction in which the beds dip. Thus at this point, in the bottom half of the watershed, the beds are right side up and the folding is quite continuous, with no overturning or faulting. At no other point in the watershed was there other evidence to suggest the contrary.

HYDROLOGY

Instrumentation

There are several federal and provincial government agencies collaborating with one another for the purpose of carrying out various programs within the International Hydrologic Decade. The three agencies responsible for instrumentation within the Fraser Brook Watershed are collecting and recording data for meteorologic, hydrometric, and hydrogeologic studies.

The Meteorological Branch of the Department of Transport have completely installed a network of instruments that will record changes, patterns, trends and other values of various weather and meteorological phenomena. Records and data resulting from this network are also collected, processed and kept on file by the Meteorological Branch at their regional office in Moncton, N. B.

Four different met sites have been set up and instrumented in various parts of the watershed. Instrumentation includes a recording precipitation gauge, a recording hydrothermograph, three sets of maximum and minimum thermometers, three standard rain gauges, an anemometer, and two Sacremento storage gauges. Two seasonal instruments, an evaporation pan and a net radiometer are also installed and operate during the summer months. The net radiometer is located at the met station in Bible Hill.

All hydrometric surveys within the watershed are carried out by the Water Resources Branch of the Dept. of Energy, Mines and Resources. For their measurements a weir site was constructed consisting of a measuring bridge, a stilling well and a composite weir with a 120° 'Vee' notch flanked by wing walls with a 1:10 slope. This enables a continuous measure of the stream stage and discharge rate of the surface water leaving the watershed area. Other work carried out by Water Resources Branch include suspended and bed load sediment studies, and snow surveys to determine depth and density of snow cover.

The hydrogeologic studies are being carried out by the Groundwater Section of the N.S. Department of Mines, which sponsors the I.H.D. program in Nova Scotia. A water level recorder has been installed adjacent to the weir site to monitor fluctuations in the groundwater table. This data will be used to determine the amount of basin outflow which occurs as subsurface flow. Plans are also prepared for the installation of piezometers at various points throughout the watershed which will give data pertinent to estimating changes in groundwater storage within the basin. Hydrochemical surveys are also carried out by this Department in an attempt to determine the chemical characteristics of water as it occurs in the various geologic environments.

Hydrologic Conductivity

The presence of fine-grained, well indurated sediments within the watershed preclude the possibility of expecting high porpsities, or high permeabilities. Thus any high fluid conductivity would be the result of a secondary permeability in the form of fractures, joints, fault zones, etc. L.V. Brandon (1963) states that wells drilled into the sedimentary rocks of the Canso Group may have a water yield range from 5-25 gpm.

Test-hole No. 100 was drilled into rock unit #6 at the weir site as an observation well in which a water level recorder was installed. The well is 6 inches in diameter and 60 feet deep. A 24 hour pump test was carried out at an average pumping rate of 5 Igpm, and resulted in a maximum drawdown of 29.5 feet. From this data the average calculated transmissibility was found to be 354 gpd/ft and the average safe pumping rate is 7 Igpm. A water yield of this amount is quite sufficient to satisfy domestic and small farm demands.

Water Levels

Generally speaking the water table within the watershed is very high. The greatest recorded depth to water was 18 feet, this being measured in a drill hole at the extreme south limit of and at the highest topographic point of the basin. This is in agreement with the theory of groundwater flow where the high lands are areas of recharge, and thus the water table in these regions is not as high as other parts of the drainage system. Several springs and dug wells with high water tables are found in the lower portion of the basin; this portion being the discharge area where groundwater seepage occurs.

Hydrochemistry

As part of a water sample program, 14 samples were collected and analyzed for about 12 different chemical constituents. Each sample was assigned a reference number coinciding with the National Topographic Reference of the point at which the sample was taken. The samples were then divided into three separate groups, each group representing water from a common source area or similar hydrologic or geologic environment. The three source areas may be defined as surface streams, surficial geology deposits, and the bedrock or the Canso Group of sediments.

In order to classify the samples into a particular source area two basic assumptions were required to separate the water samples from the bedrock source area and those samples from the surficial deposits. The first assumption states that any sample collected from a drilled well is considered to be derived from the Canso Group of sediments (bedrock). This is quite a valid assumption because all drilled wells considered are deep, penetrating from about 45 to 75 feet into the bedrock, with all surficial deposits cased off, the casing extending about an average of 10 feet into the bedrock to prevent leakage.

The second assumption states that any water sample collected from a dug well or a spring is assumed to be derived from the surficial deposits overlying the Canso sediments. This is also reasonable since these shallow dug wells occur only in the areas where the water table is high and the wells do not penetrate to the bedrock.

Water samples derived from surface streams were collected at various locations of the Fraser Brook drainage system. All sample locations, including those of the other two source areas are shown on the accompanying map # .

Hem (1965) points out that the chemical composition of natural waters is affected by the soluble products of rock weathering and decomposition. Chemical analyses of representative water samples help indicate the nature and importance of some of the environmental factors to which liquid water may be exposed in the hydrologic cycle. Also the amount of mineral content found in a water is dependent somewhat on the ability of it to dissolve rock constituents and on the length of time it has had to dissolve the material. Water falling through the air comes in contact with and picks up carbon dioxide which lowers the pH of the water and makes it more active as a chemical solvent. As it percolates into the ground and moves through the soil it picks up more free acids and salts which can lower the pH to values below 4.5. Thus it is expected that the further a water travels through an earth material and the longer it is in contact with the soluble matter, the greater will be the amount of chemical constituents dissolved by and present in the water.

The chemical analyses of natural waters within the watershed showed very distinct and definite trends to support this belief. Water samples from the surface streams contained relatively very small concentrations of the various chemical constituents. In contrast to this (Fig. #) water derived from the bedrock source area contained much higher concentrations, while samples derived from the surficial deposits contained intermediate amounts of the chemical constituents. The generally higher pH of the bedrock samples may be contributed to a neutralizing affect from the higher content of total dissolved solids.

It was found that all concentrations of dissolved chemical constituents were greater in bedrock water than those of surficial deposits, which in turn contained higher amounts of total dissolved solids than did the surface water.

The range in values of chemical constituents in water from streams was very narrow. Values for total dissolved solids ranged from 34.0 - 35.0 parts per million (ppm). The widest range of all constituents is represented by total hardness, ranging from 11.1 - 14.6 ppm, a variation of 3.5 ppm. The highest value being found in the area above the East tributary, while the lowest value was recorded at the lowest sample point on the stream, near the mouth.

Values of chemical composition of surficial water vary over a somewhat wider range. Alkalinity for example has the widest range with values from 4.0 - 102.0 ppm. Total hardness is low enough to classify the water as soft with values ranging from 20.1 to 56.1 ppm.

Chemical constituents dissolved in bedrock water were found to be present in varying amounts and covering relatively wide ranges. Alkalinity for example having the widest range gave readings between 22 and 150 ppm. Total hardness varied between a low of 26.1 and a high of 119.2 ppm, which is considered to be only medium hard water in this part of the province. The highest readings of both chloride and nitrate, which are 47.9 and 23.0 ppm respectively, are found in a drilled well located in a barn yard. Based on the background data of this area and the well location it is suggested that these high values are an indication of pollution.

The two main criteria considered when classifying irrigation waters are the soluble sodium percentage (SSP) and the sodium absorption ratio (SAR). Generally speaking the lower these two values are in a water the more suitable the water for irrigation purposes. Waters with high ratios of sodium to calcium and magnesium cause a decrease in permeability of the soil by de-flocculation which results from a base exchange reaction.

TABLE # 2

Data on Groundwater Samples Collected in Fraser Brook Watershed

Sample No.	Location	Type of Well	Depth	Diameter	Static Water Level	Collar Elev.	Source Area	Property Owner
1	11-E-6-A-81-O-SE	Drilled	60'	6"	11.8'	350'	Bedrock	} Harvey Curtis
1(a)	11-E-6-A-81-O-SE	Drilled	60'	6"	11.8'	350'	Bedrock	}
2	11-E-6-A-80-F-NW	Spring	--	--	--	450'	Surficial	John R. Whidden
3	11-E-6-A-88-B-NW	Dug	--	--	--	325'	Surficial	Fulton Langille
4	11-E-6-A-81-L-N	Drilled	67'	4"	--	450'	Bedrock	Weatherby
5	11-E-6-A-82-G-NW	Dug	--	--	--	640'	Surficial	Leonard Reid
6	11-E-6-A-63-E-East	Drilled	63'	4"	8.0'	605'	Bedrock	Albert McMillan
7	11-E-6-A-58-K-East	Drilled	--	--	--	625'	Bedrock	Stanley Rath
8	11-E-6-A-40-O-NE	Drilled	83'	5"	18.0'	630'	Bedrock	Ralph Henderson
1(b)	11-E-6-A-81-G-SE	Dug	--	--	---	390'	Surficial	Merle Smith

TABI # 4

Chemical Analysis of Groundwater from Known Source Areas

Source	Sample No.	Ca	Mg	Na	Fe	Mn	SO_4	Cl	NO_3	Alk	Total Hardness	pH	SSP	SAR	TDS
Canso Bedrock	1	18.8	7.3	11.3	2.0	0.04	12.0	17.7	T	150	77.2	8.8	0.318	0.558	--
	1(a)	19.6	7.1	20.3	0.28	0.03	4.0	31.9	T	132	78.2	8.3	0.570	1.008	--
	4	30.9	4.2	10.2	0.02	T	19.0	16.0	2.0	84	97.2	7.8	0.232	0.452	--
	6	24.0	2.2	10.2	0.02	T	12.0	16.0	8.0	68	91.2	7.2	0.318	0.530	--
	7	30.5	10.3	30.7	0.24	0.04	27.0	47.9	25.0	24	119.2	5.9	0.566	1.230	--
	8	6.4	2.2	9.1	0.22	0.02	22.0	14.2	1.0	22	26.1	6.6	0.835	0.817	--
Surficial Deposits	1(b)	6.4	3.4	5.2	0.65	1.00	2.0	8.0	T	32	34.0	6.9	0.368	0.414	--
	2	6.0	3.0	8.5	0.05	T	11.0	13.3	T	102	28.1	8.3	0.706	0.673	--
	3	21.2	0.4	8.5	0.05	0.03	21.0	13.3	T	56	56.1	7.2	0.339	0.501	--
	5	7.2	2.8	22.1	0.2	T	4.0	34.6	T	4	30.1	5.1	1.627	1.767	--
Fraser Brook at weir)	621	2.8	1.4	2.5	0.09	T	4.7	2.7	0.05	9.9	12.8	6.5	0.30	0.3	35
at mouth)	622	2.3	1.3	2.6	T	T	3.9	2.7	0.08	8.4	11.1	6.8	0.33	0.3	34
above east ributary)	623	3.2	1.6	2.1	T	T	5.6	2.6	0.05	10.7	14.6	6.7	0.23	0.2	35
below east ributary)	624	2.7	1.4	2.5	T	T	4.7	2.7	0.05	9.5	12.5	6.8	0.30	0.3	34

Notes **(1) All values are in parts per million except SSP,** SAR & pH

(2) T denotes a trace amount (less than 0.01 ppm)

TABLE # 5

Range of Chemical Constituents in Water from Streams

(Fraser Brook)

--Fraser Brook Watershed--

Calcium	2. 3 to 3. 2 ppm
Magnesium	1. 3 to 1. 6 ppm
Sodium	2. 1 to 2. 6 ppm
Iron	Trace to 0. 09 ppm
Manganese	Trace to Trace
Sulfate	3. 9 to 5. 6 ppm
Chloride	2. 6 to 2. 7 ppm
Nitrate	Trace to 0. 08 ppm
Alkalinity	8. 4 to 10. 7 ppm
Total Hardness	11. 1 to 14. 6 ppm
Total Dissolved Solids	34. 0 to 35. 0 ppm
SSP	. 23 to . 33
SAR	0. 2 to 0. 3
pH	6. 5 to 6. 8

TABLE # 6

Range of Chemical Constituents in Water from Springs and Dug Wells

(Surficial Water)

--Fraser Brook Watershed--

Calcium	6.0 to 21.2 ppm
Magnesium	0.4 to 3.0 ppm
Sodium	5.2 to 22.1 ppm
Iron	0.05 to 0.65 ppm
Manganese	Trace to 1.0 ppm
Sulfate	3.0 to 21.0 ppm
Chloride	8.0 to 34.6 ppm
Nitrate	Trace to Trace
Alkalinity	4 to 102 ppm
Total Hardness	28.1 to 56.1 ppm
SSP	0.339 to 1.627
SAR	0.414 to 1.767
pH	5.1 to 8.3

Range includes samples 2, 3, 5, 1(b)

TABLE # 7

Range of Chemical Constituents in Water from Drilled Wells
(Bedrock Water)
--Fraser Brook Watershed--

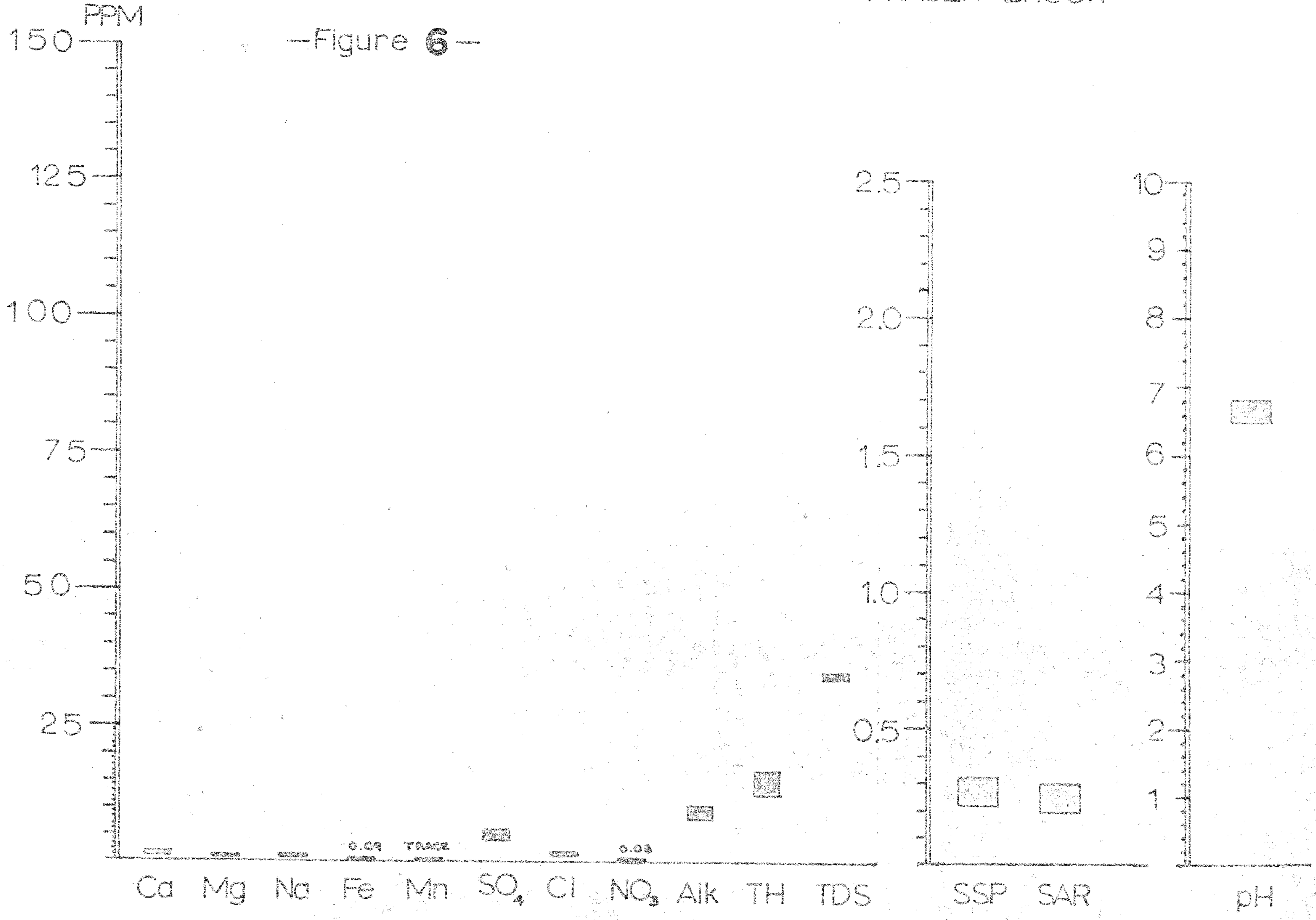
Calcium	6.4 to 30.9 ppm
Magnesium	2.2 to 10.3 ppm
Sodium	9.1 to 30.7 ppm
Iron	0.02 to 2.0 ppm
Manganese	Trace to 0.04 ppm
Sulfates	4.0 to 27.0 ppm
Chloride	14.2 to 47.9 ppm
Nitrate	Trace to 25.0 ppm
Alkalinity	22 to 150 ppm
Total Hardness	26.1 to 119.2 ppm
SSP	0.232 to 0.835
SAR	0.452 to 1.230
pH	5.9 to 8.8

Range includes samples 1, 1a, 4, 6, 7, 8

RANGE OF CHEMICAL CONSTITUENTS IN WATER FROM STREAMS

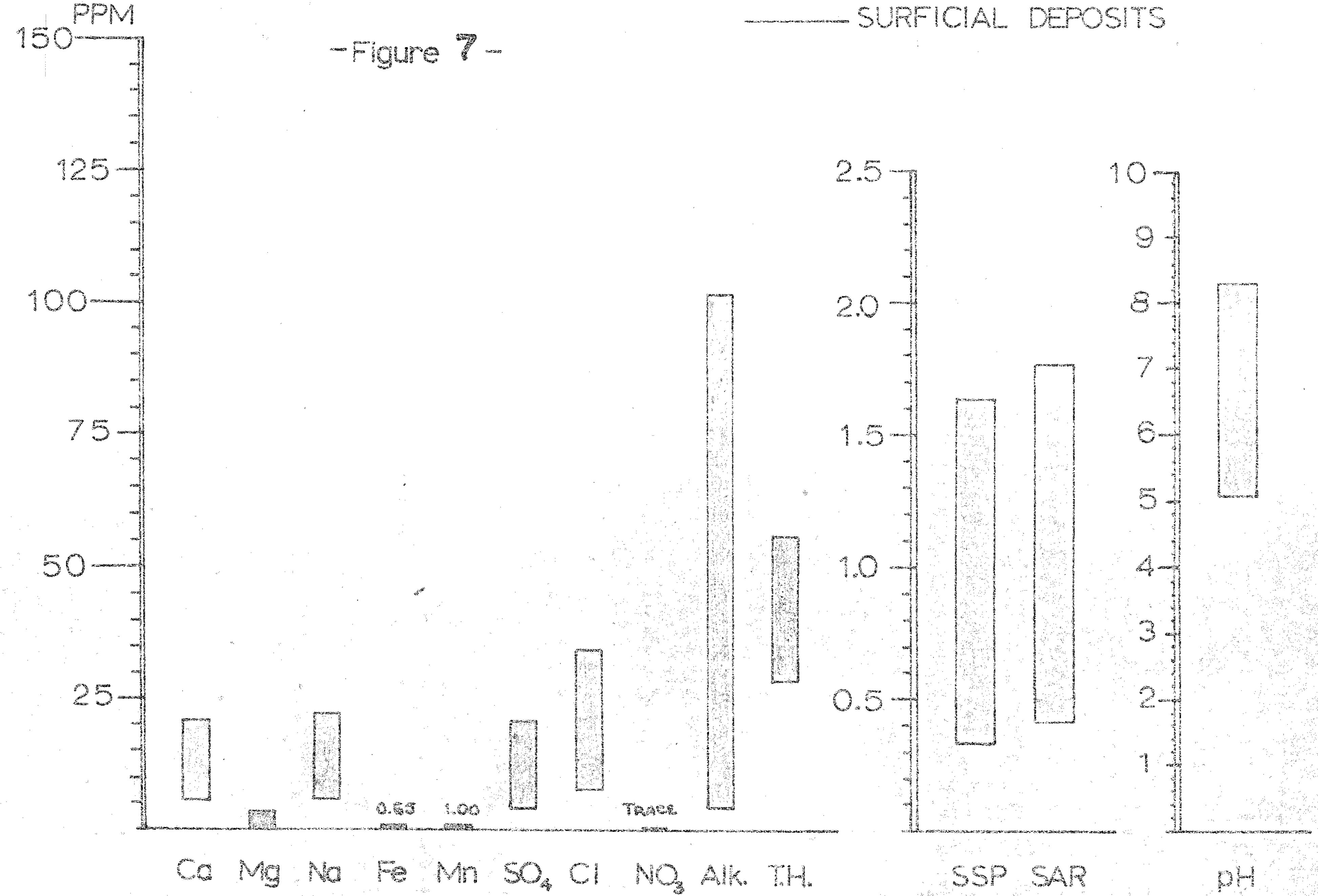
——FRASER BROOK

—Figure 6—



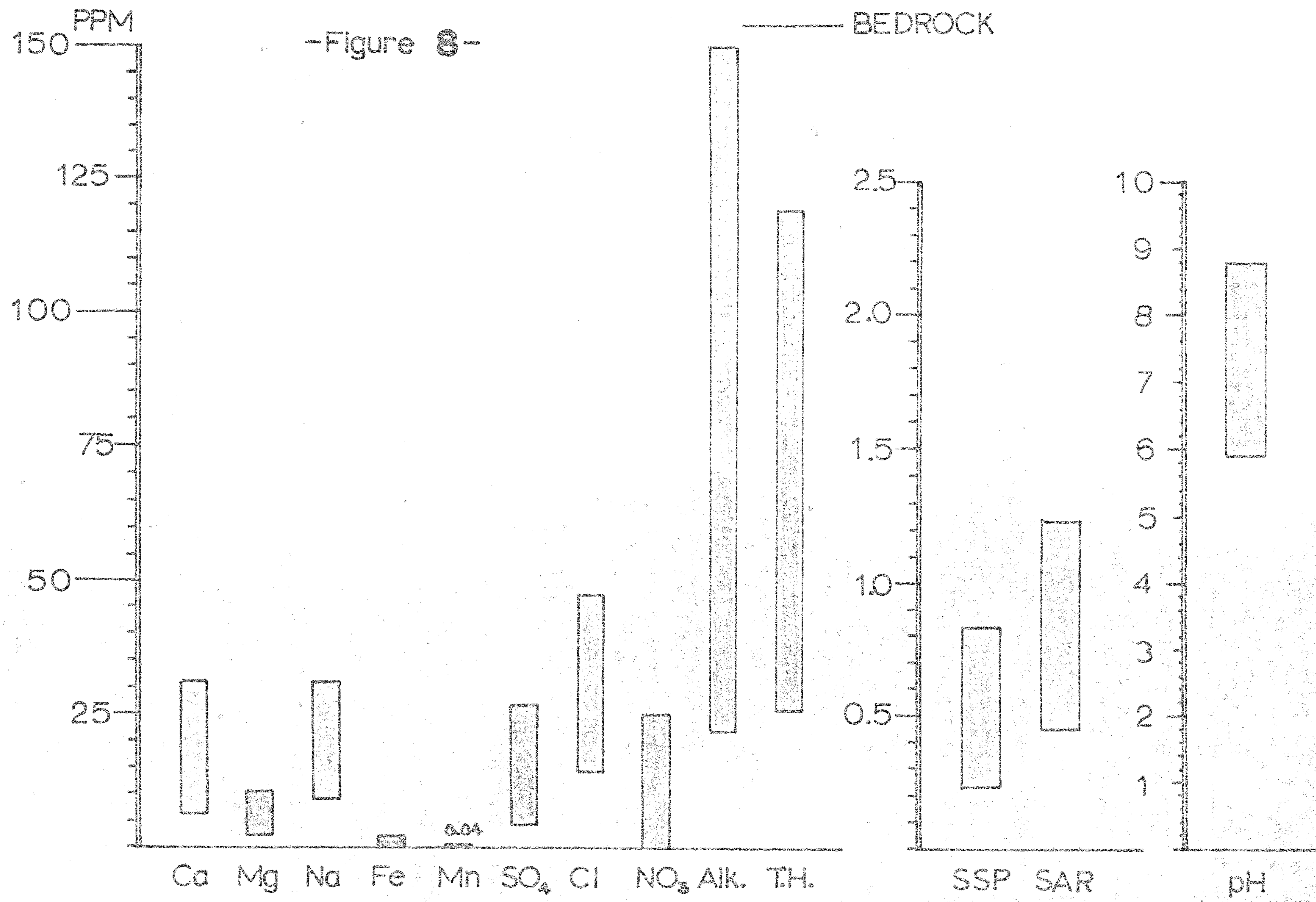
RANGE OF CHEMICAL CONSTITUENTS IN WATER FROM SPRINGS AND DUG WELLS

-Figure 7-

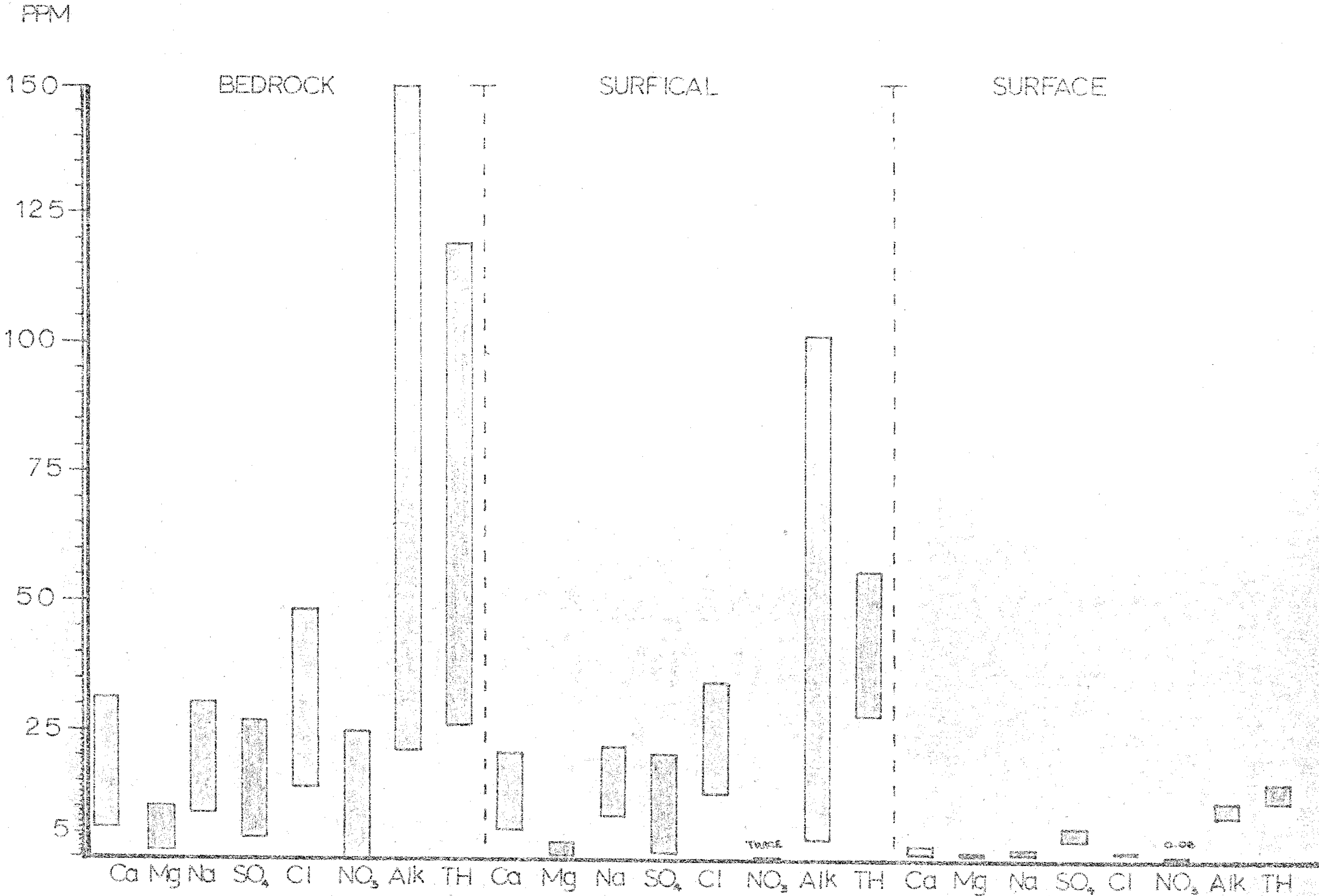


RANGE OF CHEMICAL CONSTITUENTS IN WATER FROM DRILLED WELLS

-Figure 8-



CHARA TERISTIC CHEMICAL RANGES OF WATE FROM DIFFERENT SOURSE AREAS IN THE FRASER BROOK WATERSHED



-Figure 9-

Of all water samples collected within the watershed the highest SSP and SAR values were 1.6 and 1.8 respectively. These readings would indicate that the water is quite suitable for irrigation. However, for a more definite and exact classification of these waters additional factors such as total dissolved solids, boron content and soil types must be considered.

Conclusions

Nova Scotia's first representative watershed, the Fraser Brook Basin selected as part of the I.H.D. program for this area, has been completely instrumented for collecting meteorological and hydrometric data. Ground-water instrumentation will be completed by this summer with the installation of several piezometers. Most surveying and mapping has been undertaken with detailed studies of the forest cover, soil types, surficial and bedrock geology having been completed, and maps prepared.

An inventory has been taken of the surface features and the geology of the basin, and a study is now underway on the behaviour, trends and characteristics of water as it is measured in its various hydrologic environments within the watershed area.

It will be interesting to note, study and interpret the inter-relationships of the various parameters which contribute to the final qualitative and quantitative values of water in this basin.

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