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SEDIMENT-HERBICIDE STUDY FOR THE BIG CREEK WATERSHED AND RONDEAU BAY AREA, SOUTHERN ONTARIO

Prepared For

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1.0 INTRODUCTION

Studies have been carried out over several decades to determine the nature, extent and importance of rural non-point pollution sources in the Great Lakes Basin (IJC 1980). Although initial studies focused on the reduction of phosphorous to the lakes, more recently, concerns have focused on the movement and loading of other contaminants to the basin's ecosystem.

Within the basin, pesticides are regularly applied to agricultural crops. These products which include herbicides, insecticides and fungicides, are used on a wide range of crop types and physiographic conditions, and are generally regarded as a form of non-point source pollution. Like phosphorous, following application these products are frequently transported via sediment, groundwater or surface water flow, from the agricultural land into the aquatic ecosystem.

In earlier studies, Coleman (1982) described a method for reducing the long term average loading of total phosphorous and soluble phosphorous to the Great Lakes. The method, which utilizes the universal soil loss equation, focuses on the estimation and mapping of factors such as rainfall, soil erodability, slope length and percent, and crop cover. Through a combined analysis of these factors, areas of potentially high, moderate and low soil loss can be identified and action taken to ameliorate the movement of sediment contaminated nutrients from moving into water-courses. Although originally developed for estimating the rate and movement of phosphorous, since pesticides and herbicides also have an affinity for sediment, similar principles would apply for the estimation and movement of some of these products.

Mapping of the various universal soil loss equation factors has recently been carried out over much of southern and southwestern Ontario. In addition wetlands, which are considered important components in the overall maintenance of water quality within watersheds, have also been identified and mapped as part of a more broadly-based program to estimate the loss of wetlands throughout southern Ontario.

Since much of the information required to initiate a study on the evaluation of the potential impact of pesticides and herbicides on the aquatic environment is generally available, a number of areas in southern Ontario have been identified as potentially significant contributors of these non-point contaminants to the Great Lakes Basin. The purpose of this study is to examine available sediment source area mapping and wetland mapping together with other information for two areas in southern Ontario, the Big Creek and Rondeau areas near Lake Erie. Using the available information several sub-basins are to be identified as potential locations for establishing a long-term water quality monitoring program designed to measure the impacts of pesticides.

In addition to identifying potential sub-basins for long term pesticide monitoring, and as background to the proposed monitoring program, a summary of the type and use of pesticides, water quality, water flow and climatological information for the two study areas is required.

The purpose of this report is to identify selected basins within the Big Creek and Rondeau Bay areas which might serve as potential water quality monitoring locations and to summarize existing water quality, water flow, climatological and pesticide use for the two areas.

2.0 STUDY OBJECTIVES

To achieve the general objectives outlined in section 1.0, the following more specific tasks were identified:

2.1 Map, at a scale of 1:50,000, sediment-herbicide-wetland areas in the Big Creek and Rondeau areas using existing wetland, land use, soil erosion potential and hydrological information;

2.2 Using the information from 2.1, identify potential sediment-herbicide-wetland monitoring sub-basins;

2.3 Assemble existing water quality, water flow and climatological data for the study areas, presenting the information in tabular/graphical formats; and

2.4 Conduct an inventory of pesticide use in the Big Creek and Rondeau Bay areas including: type of pesticide/herbicide, time of application, rate of application and crop(s) affected.

3.0 STUDY AREA

The two areas selected for study include the Big Creek Watershed, and the marshes bordering Rondeau Bay along Lake Erie (Figure 3.1).

Big Creek

The Big Creek basin has an area of approximately 728 km^2, centered on Big Creek which has a north-south length of 56 km and a width which varies between 13 and 23 km in an east-west direction. The headwaters of Big Creek rise in Oxford County just north of Burgessville and south of Oriel (Figure 3.2). At first the stream flows in an easterly direction and then turns south between Harley and Northfield Centre. From there it follows a southerly direction to discharge into a broad marsh at the west end of Long Point Bay on Lake Erie.

Topography of the basin is characterized by a broad, flat plain, with scattered prominant ridges and deeply-incised stream valleys. The topography results from deposition and erosion during glacial and post-glacial times.

The Norfolk Sand Plain dominates the surficial geology of the watershed (Figure 3.3). The plain is a broad, flat, shallow sandy lacustrine feature formed as a large lacustrine delta in one of the post-glacial lakes (Whittlesey ans Warren) which covered most of the basin during deglaciation (Chapman and Putnam 1973). Depth of the sand varies across the area, however thicknesses of 5-15 m are not uncommon (Yakutchik and Lammers 1970). Post-glacial wind erosion of the sand deposits resulted in the formation of sand dunes. Extensive dune fields are found in the Scotland and Langton areas of the watershed, with other dunes scattered randomly throughout the remaining area of the watershed.

Four morainic ridges are found in the basin: St. Thomas, Norwich, Tillsonburg and Paris moraines. Of these, the Tillsonburg and Paris moraine are the best developed (Figure 3.3). The Tillsonburg moraine extends from Harley in the north to Summerville in the west. The Paris moraine extends from near Scotland in the north to Delhi in the south. A large till plain occupies the extreme northwest area of the watershed.

Lacustrine deposits are scattered throughout southern reaches of the watershed, and consist primarily of well-bedded silt and clay, with some fine sands also present.

Alluvial sand deposits are found along the southern reaches of Big Creek.

As the glacial lakes receded from the basin to their present levels, drainage patterns developed on the land surface and deep, V-shaped stream valleys were eroded. Several different levels of stream terraces along the Big Creek channel between Delhi and Lake Erie probably reflect changing drainage conditions during post-glacial

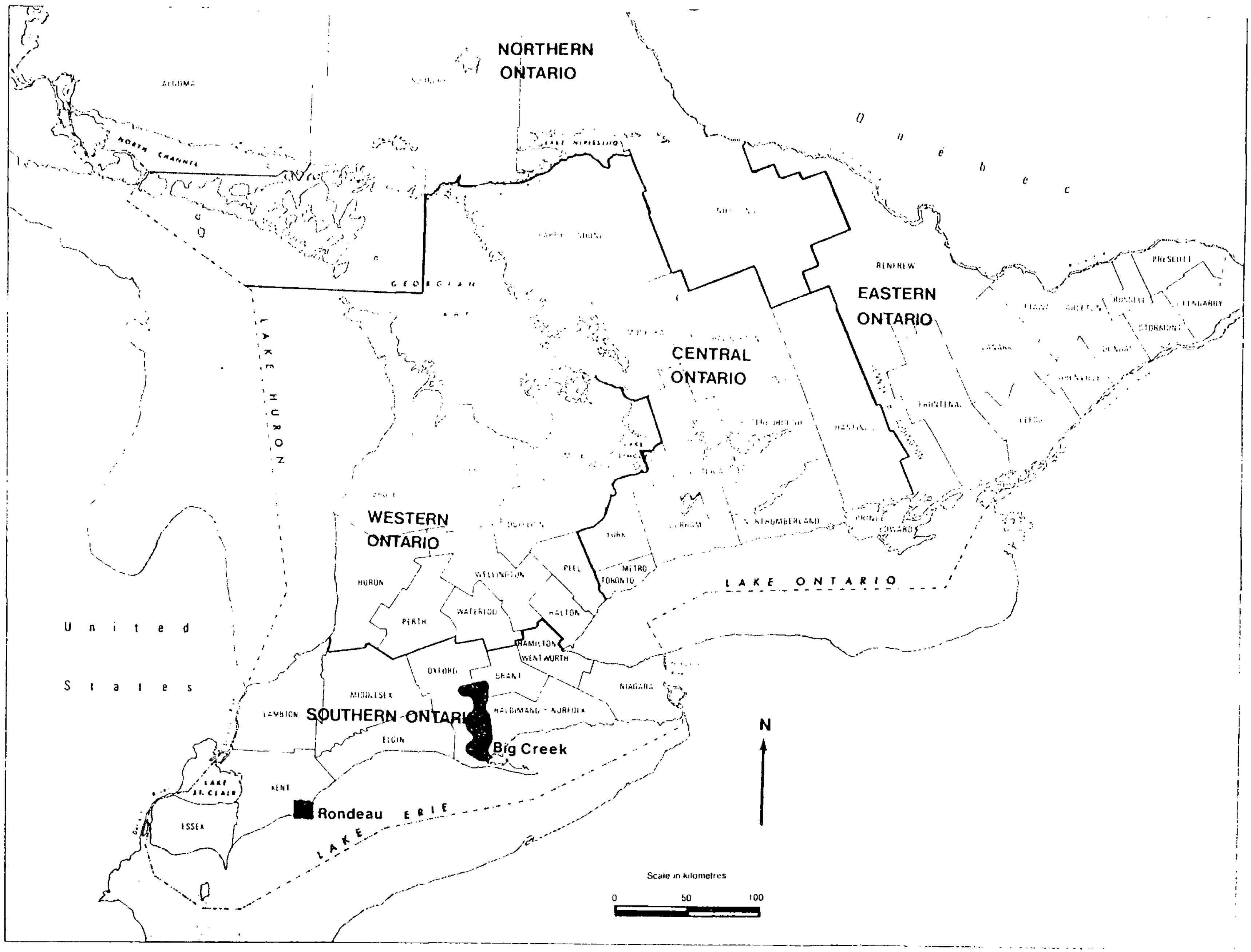
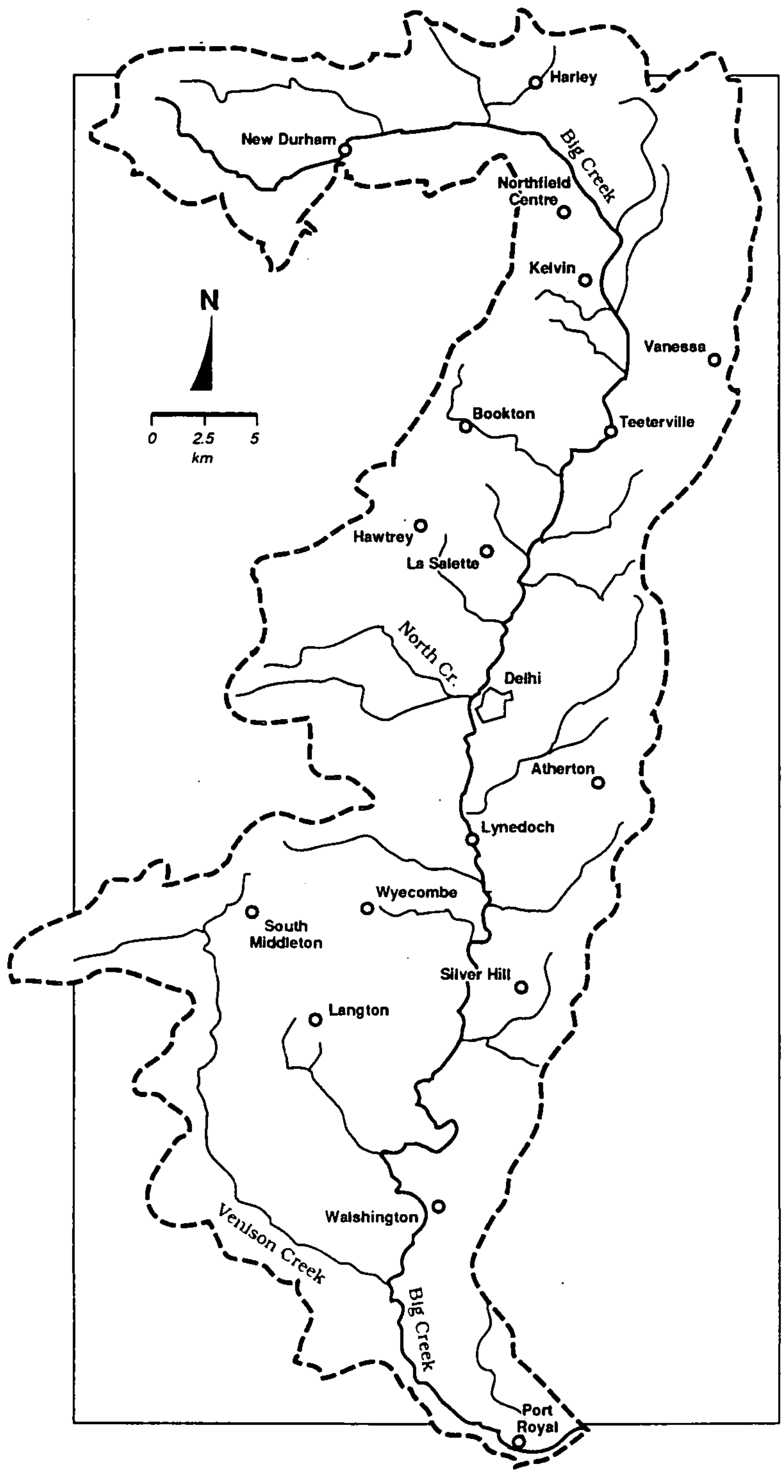
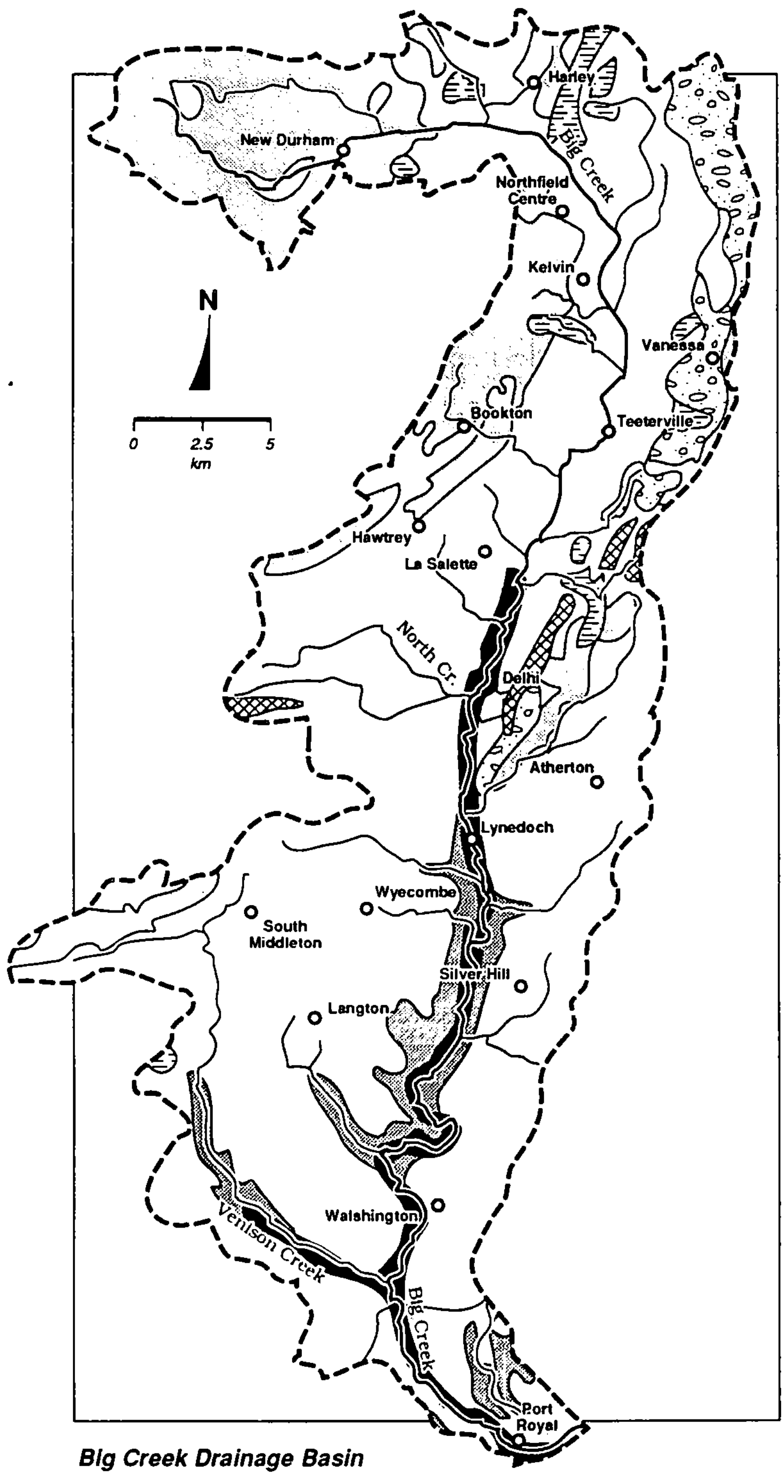


Figure 3.1. Location of the Big Creek and Rondeau areas in southern Ontario.



Big Creek Drainage Basin



Big Creek Drainage Basin

Surficial Geology

- *Alluvial deposits*
- *Lacustrine deposits*
- *Moranic deposits*
- *shallow Lacustrine and Fluvial deposits*
- *outwash deposits*
- *marsh - swamp deposits*
- *beach deposits*

times (Yakutchik and Lammers 1970).

Swamps and other wetlands occur as relatively small pockets, but occupy in total approximately 5% of the basin (Yakutchik and Lammers 1970). Many of these occur in the northern parts of the basin where drainage is generally poor.

Bedrock of the watershed is primarily Devonian age limestone of the Delaware Formation (Yakutchik and Lammers 1970), and is typically covered by 15 to 100 m of overburden (Figure 3.4).

Groundwater is generally abundant and easily obtained over most of the watershed (LPRCA 1979). With an average porosity of 20%, the amount of groundwater present in the overburden is equivalent to 9 m of water over the entire watershed. The natural quality of the groundwater is acceptable, although availability is occasionally constrained by low permeability. This constraint generally applies to the agricultural irrigational demands placed on the sand plains region of the watershed (LPRCA 1979). Groundwater flow is generally toward Big Creek where it discharges into the Creek. Approximately 46% of the total stream runoff from the Big Creek Watershed is estimated to originate with groundwater discharge as base flow (Yakutchik and Lammers 1970).

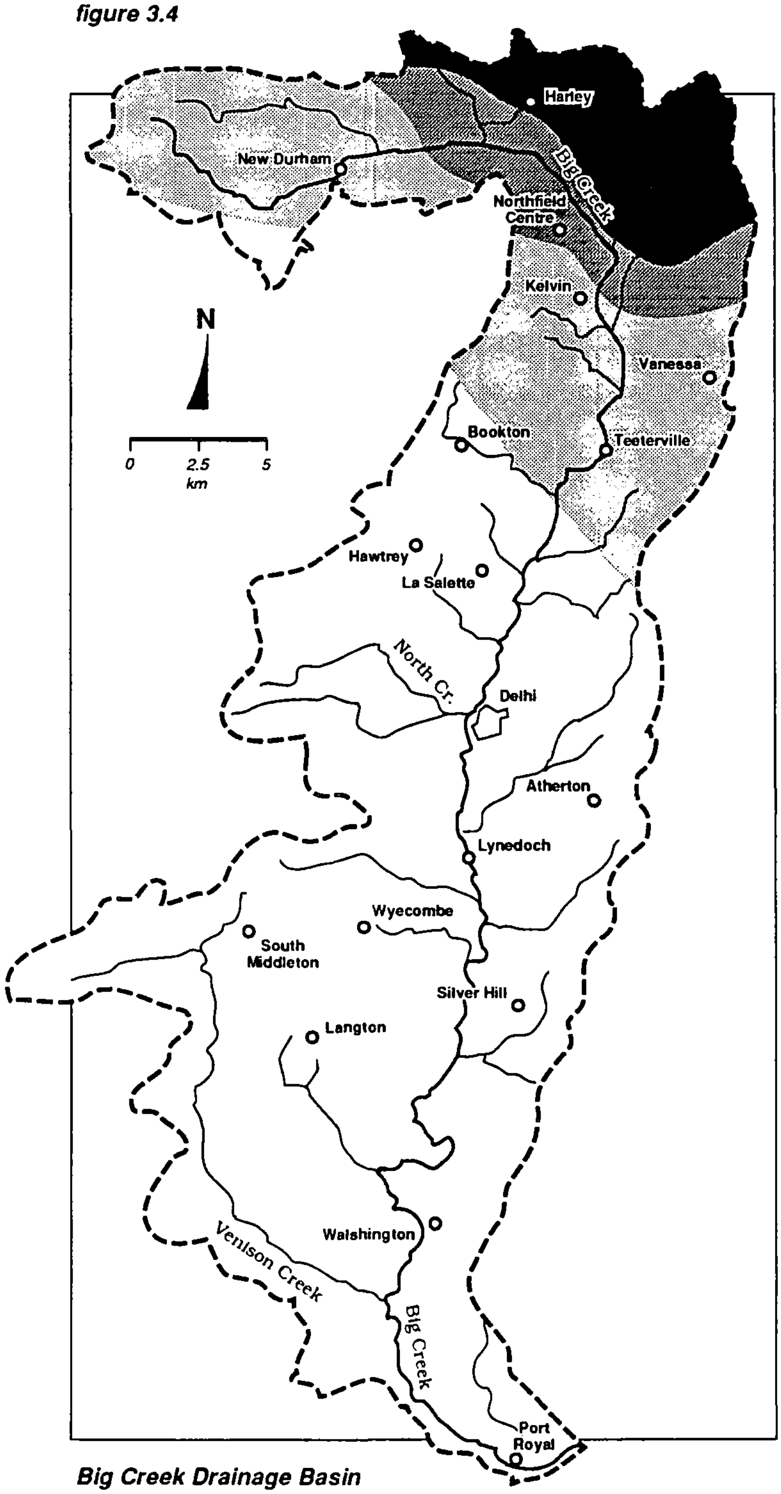
Water quality from the bedrock is generally not considered acceptable for either drinking or irrigation purposes. Hydrogen sulphide, sulphate and chloride concentrations increase with depth in the bedrock, particularly in the Salina Formation (LPRCA 1979). Most of the water used in the watershed is taken from surface water or from aquifers in the overburden material.

Land use in the basin (Figure 3.5) is dominated by tobacco and corn, and is associated with the sandy lacustrine deposits characteristic of the southern and central portions of the watershed. On the morainal deposits in the northern part of the watershed, corn, grains, hay and pasture represent the dominant land use. Rich, hardwood forests occupy bottomlands and floodplains along major creeks and streams.

Rondeau Marshes

The Rondeau Bay area (Figure 3.1), is characterized as a poorly drained, very gently undulating clay plain. Organic soils dominate the shoreline areas of Lake Erie (Rondeau Marshes). Within the clay plain, a relatively dense parallel drainage network has developed. These streams, each defining a small sub-basin, all drain into the wetlands bordering Rondeau Harbour and are characterized along their margins by high annual soil loss potential (i.e. >10 tonnes/ha/yr.), and high to moderate potential for sediment transport to a stream.

figure 3.4



Big Creek Drainage Basin

Bedrock Geology

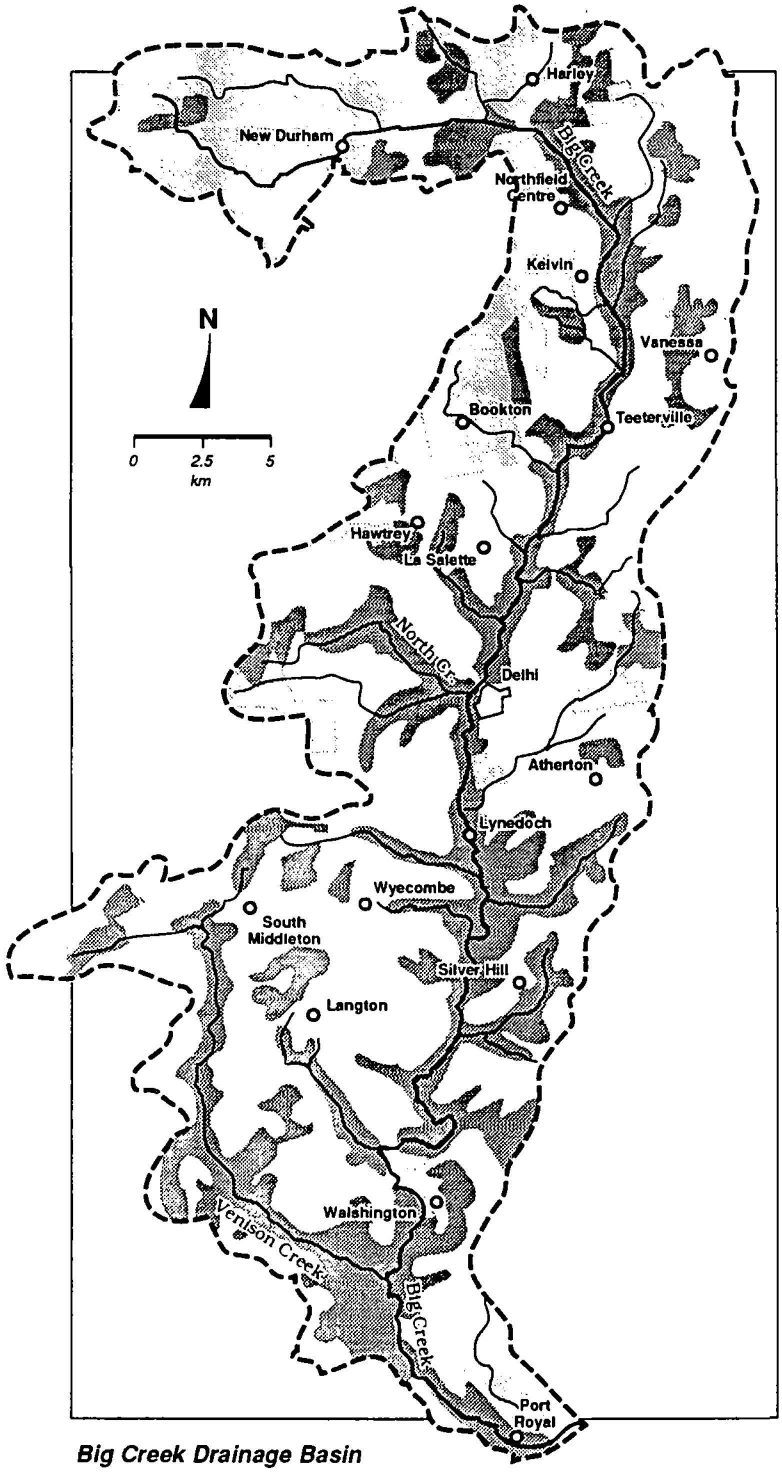
Devonian

Delaware formation — *Detroit River group* — *Bois Blanc formation*

Silurian

Bass Island formation — *Salina formation*

figure 3.5



Big Creek Drainage Basin

Land Use

tobacco / corn · *corn, grains, hay, pasture* · *forest cover*

Organic soils on the clay plain are predominantly small, and relatively isolated characterized by hardwood swamps. The marshes along Rondeau harbour are extensive and dominate the entire shoreline area. Most are cultivated for onions or carrots.

4.0 METHODS

4.1 Small Watershed Mapping/Wetlands

In order to identify several sub-basins within the Big Creek watershed and Rondeau Bay areas suitable for long-term monitoring of pesticide/herbicide impacts on water quality and wetlands, available mapped information on wetland location, agricultural land use system, potential average annual soil loss, terrain capability to transport sediment to a stream and basin hydrology were examined. This information is available as a separate map overlay at a nominal scale of 1:50,000.

Through a series of manual overlay procedures, the aforementioned map information was synthesized and mapped onto a 1:50,000 map overlay which could then be used to evaluate all sub-basins. The synthesis procedures were as follows:

1. all wetlands mapped on the "wetland mapping series" as "current wetlands" or "wetlands gained: 1967 -1982" were delineated on a 1:50,00 scale map of the Big Creek Watershed, and a 1:50,000 NTS map for Rondeau. Ontario Ministry of Natural Resources, and Long Point Region Conservation Authority (LPRCA) staff assisted in identifying additional wetlands, and in providing wetland inventory information for major wetlands in the Big Creek basin. This information is appended to the report.

2. Using paper copy 1:50,000 scale NTS maps, all hydrological features of the two areas were drafted. These features included: shoreline of Lake Erie, rivers, creeks, streams, lakes, ponds and drainage ditches;

3. Agricultural land use systems impinging on each wetland were identified and mapped;

4. Each wetland was annotated with the following information: soil type (i.e. Organic or Mineral), Potential Average Annual Soil Loss (High, Medium, or Low) and Terrain Capability to Transport Sediment to a Stream (High, Moderate or Low). The latter two information categories were taken from similarly named maps.

5. The manually drawn map was digitized in DLG format for later input and use with a GIS.

Resultant maps were evaluated using appropriate criteria and sub-basins potentially suitable for a monitoring program identified.

Together with staff of the Inland Waters Directorate, field reconnaissance in the watershed was carried out to evaluate each of the potential water quality monitoring locations. A number of sites, including several well locations for groundwater monitoring, were selected for long-term pesticide monitoring.

4.2 Water Quality Data

Water quality data for the period 1970-1988 was obtained through the Ministry of Environment, Hydrology and Networks Unit, Water Resources Branch. Three monitoring stations in the Big Creek Watershed (Figure 4.1) include:

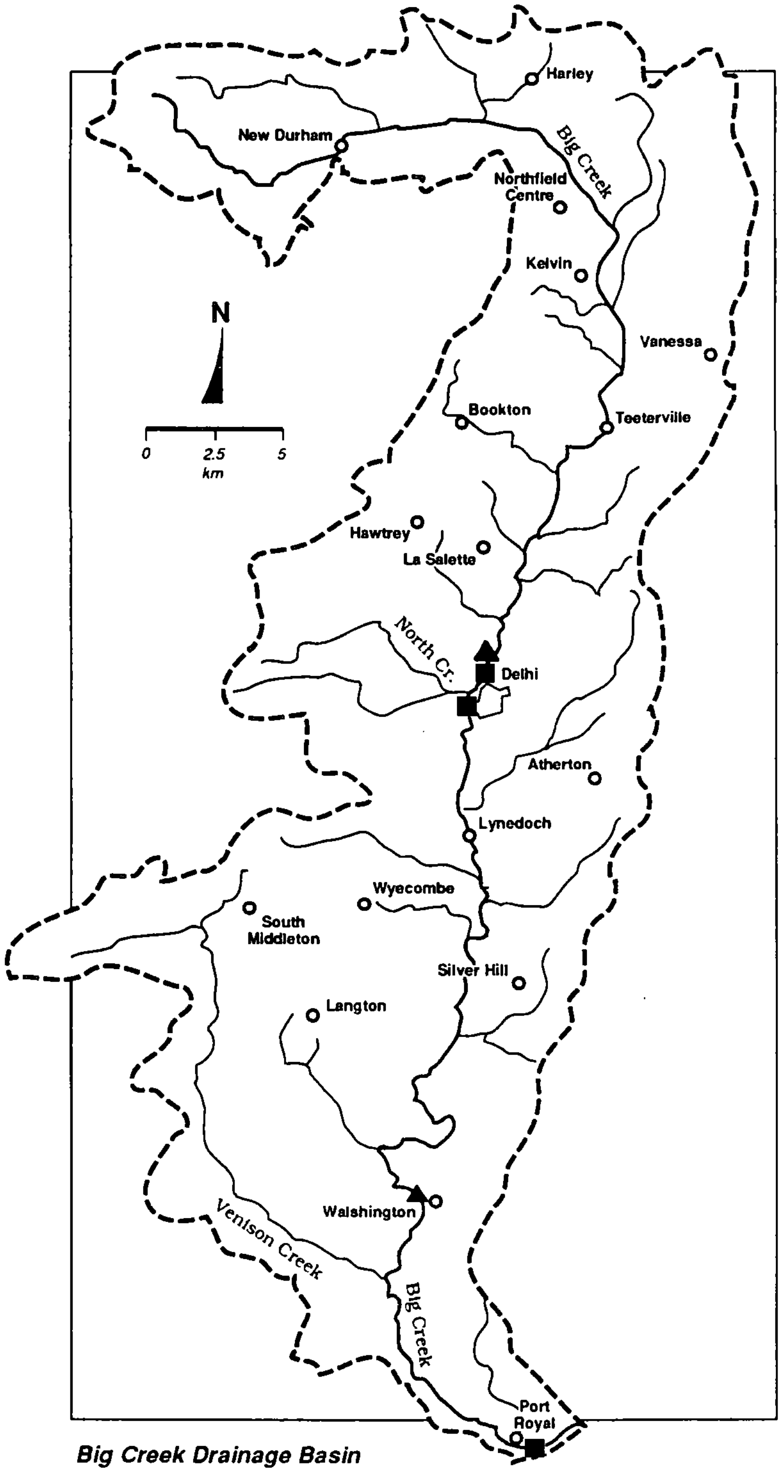
- o Big Creek at William Street, Delhi;
- o Big Creek at Western Ave., Delhi; and
- o Big Creek at Norfolk County Road 42.

Water quality sampling at the William Street station commenced in 1979 and continues to the present. Sampling at the Western Ave. station began in 1982 and discontinued in 1987. Sampling at the Norfolk County Road 42 station has been continuous since 1972.

Although water quality information for all three sites is included in the appendix of the report, only information from the William Street station in Delhi, and the Norfolk County Road 42 station have been examined during this study. The William Street location in Delhi represents the upper watershed, the Norfolk station represents the lower watershed and is the last water monitoring location prior to export from the basin.

Data on water quality parameters for each of the stations was downloaded from the MOE data base onto 5 1/4" floppy disks and made available to Wickware & Associates. Sampling frequency for individual parameters is variable. As a result, a sub-set of the entire data base was selected for analysis and graphical presentation. Those variables selected are found in Table 4.1.

figure 4.1



Big Creek Drainage Basin

Monitoring Stations

▲ *Water Discharge Stations* ■ *Water Quality Stations*

Table 4.1. Parameters selected for analysis in the Big Creek Watershed.

pH	Total Nitrogen
Total Phosphorous	Ammonia
Dissolved Oxygen	Total Nitrogen (TKN)
Turbidity	Conductivity

Hardcopy output obtained through MOE and a Lotus 123 spreadsheet form of the data is appended to the report. All variables, including those not summarized in this study, are included on the electronic media for use as required at some future time.

Water quality information on Organic parameters i.e. for study of herbicide and pesticide residues is not available from MOE.

Water quality information for rivers or creeks draining into the Rondeau study area was not available. Data for the nearest available stations, (Rodney and West Lorne) are east of the Rondeau Bay study area and although data for these stations were obtained from MOE have not been summarized for this study. Hardcopy output of the MOE files and Lotus 123 spreadsheet form of the data is appended to the report.

4.3 Water Flow Data

Water flow information for Big Creek for the 1980-1987 period was obtained through the Water Resource Branch of Environment Canada in Guelph, Ontario. Two monitoring stations (Figure 4.1) located on Big Creek include stations at:

o South Wallsingham; and

o Town of Delhi

Water flow data for the Rondeau Bay area is not available. Information was made available on 5 1/4" floppy disks in Lotus 123 format. The data structure was modified slightly for export into STATGRAPHICS and subsequent analysis.

4.4 Climatological Data

Climatological data for the Big Creek Watershed was obtained from the Canadian Climate Centre, Atmospheric Environment Service, Environment Canada, Downsview from two stations:

- o St. Williams Agricultural Research Station; and
- o Town of Delhi

The information is available in both raw and summarized format. For this study, information was obtained in both formats. Raw data was made available on 5 1/4" floppy disks, and is appended to the report for further evaluation as required.

Information over the past 10 years includes: Daily Maximum Temperature, Daily Minimum Temperature, Daily Mean Temperature, Total Snowfall, Total Precipitation, Snow on Ground.

Biogeoclimatological profiles for each of the stations have been prepared and summarize the major climatological data.

Additional climatological information for the Big Creek watershed is available through the LPRCA, however observations are sporadic and limited to the summer months. No summary of the information is available, and the value of the observations are limited. Climatological information is not recorded by the Ministry of Natural Resources.

Climate records for the Rondeau area are not available, however records from the nearest station (Ridgetown) were obtained.

4.5 Pesticide Use

Information on pesticide and herbicide use in the study areas was obtained through various sources. Published material prepared by the Ontario Ministry of Agriculture and Food (OMAF) includes annual documents on various crop production recommendations, as well as A Guide to Weed Control (OMAF 1989) which lists information on recommended application rates of various pesticides used in the province.

In addition to this published material, interviews with Agricultural Crop Specialists at: Simcoe Agricultural Research Station, Delhi Research Station, Harrow Research Station, Bradford Research Station, College of Agricultural Technology in Ridgetown and the Guelph Agricultural Centre were undertaken. Information on local use and application of herbicides and pesticides was obtained through these individuals. A list of those contacted is appended to the report.

Other individuals and agencies which potentially use pesticides were contacted. These agencies included: County and Regional Roads, MTO Southwestern Region, Conrail (Buffalo, U.S.A.), CN Rail (London), Ontario Hydro, and Union Gas (Chatam). A list of individuals contacted is appended to the report.

5.0 RESULTS

5.1 Watershed Selection

Following the mapping of all wetlands and land use/sediment erosion potential around each of the wetlands, a number of potential watersheds that could be used for monitoring were identified. The selection of potential watersheds involved consideration of several factors: 1) each watershed should be in the range of 1000-1500 acres, 2) each of the watersheds should contain or drain into a wetland, and 3) monitoring sites within the watershed should maximize the amount of the monitored area within a single sediment ranking class (High, Medium, or Low).

Watersheds meeting those general criteria are shown on the 1:50,000 NTS map overlay accompanying this report. Although there are numerous small watersheds throughout the Big Creek Basin which are relatively uniform with respect to land use and erosion potential, there are few that also meet the wetland requirement. One small watershed in the Delhi area was identified as meeting all the requirements and was selected for intensive monitoring.

Following field examination, a number of sites within the basin were identified for monitoring (including several groundwater sites) and sampling initiated in the spring of 1989 (Figure 5.1).

Several additional monitoring locations in the lower parts of the watershed were also selected for monitoring including Big Creek at Concession Road 8, and within the marshes along Long Point Bay (Figure 5.1).

5.2 Summary of Water Quality

Surface water quality data from two stations in the Big Creek basin was obtained through the Ontario Ministry of Environment. Although data are potentially available for 38 variables, most are sampled and analysed only sporadically, and information is of limited value when evaluating long term trends in water quality. For this study eight variables have been statisitically summarized. Since it is not the purpose of this study to undertake an in-depth analysis of water quality data but rather to evaluate general long-term trends or changes in water quality, only simple descriptive summaries of the available data are attempted. For each variable, available raw data observations have been plotted as a time series analysis (missing values excluded from the analysis), and then subjected to a general trend analysis (missing values again excluded) in order to identify general improvements or degradation in quality over the monitored time period. Mean and median values for each variable over the total sampling period has also been calculated for long term comparative purposes (Table 5.1).

The data are subject to a number of inherent limitations including:

. data are not normally distributed and include significant gaps in the data base;

. data is frequently collected (or reported) inconsistently during the year with the result that the data collection is skewed;

. collections are taken monthly at approximately the same time. Data may therefore be "event" influenced during certain sampling periods but not others. This is of particular concern for sediment-associated variables such as turbidity or phosphorous which are significantly influenced by stormfall events, floods, industrial discharges etc.

. The data are not flow or seasonally adjusted.

Following is a brief summary of for these selected variables:

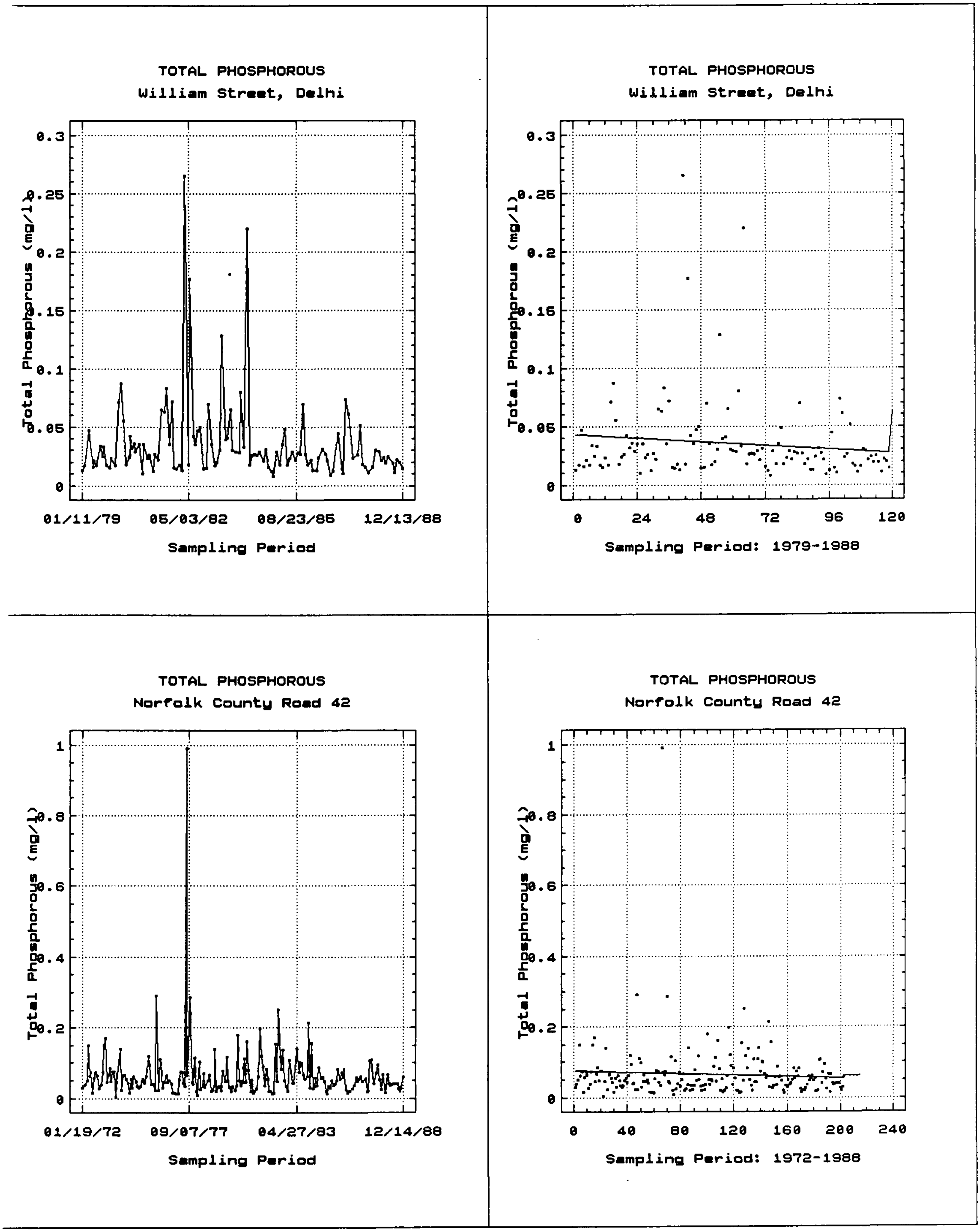
5.2.1 Total Phosphorous

Concentrations of total phosphorous at each of the two sampling stations is shown in Figure 5.2. Median and mean phosphorous concentrations are provided in Table 5.1. Concentrations are relatively low and uniform throughout the basin. Median concentrations are in the 0.03-0.04 mg/l range reflecting the sandy nature of the surficial deposits throughout most of the basin, the relative stability of stream banks, and the generally low relief in the watershed which reduces the amount of sediment transported to water courses.

Table 5.1. Median and mean concentrations for nine major water quality variables at Delhi (1979 - 1988) and Walsingham (1972 - 1988) along Big Creek.

STATION	DO (mg/l)	TURBIDITY (FTU)	PH	CONDUCTIVITY (umho/cm)	ALKALINITY (mg/l)	TOTAL PHOSPHOROUS (mg/l)	NH3-N (mg/l)	TKN (mg/l)	FECAL COLIFORM (cnt/100ml)
DELHI									
Median	10.3	3.4	8.3	550	205.5	0.03	0.06	0.05	93
Mean	10.5	5.7	8.3	542	203.6	0.04	0.09	0.05	206.8
no. samples	115	116	114	118	90	119	119	119	80
NORFOLK									
Median	9.8	10.0	8.2	498	192.3	0.04	0.03	0.43	40
Mean	10.0	14.2	8.2	497	190.3	0.06	0.04	0.46	91.7
no. samples	196	185	153	201	92	203	203	203	157

igure 5.2 Total phosphorous at two sampling locations in the Big Creek watershed.



Trend analysis suggests that in both the upper and lower parts of the watershed concentrations have been generally stable or slightly declining throughout the 1980's. Mean concentration in 1972 was 0.05 mg/l and 0.03 mg/l in 1988 which is also the concentration recommended in the Canadian Water Quality Guideline.

5.2.2 Ammonia (NH3-N)

Ammonia sources in the watershed are primarily associated with low level applications of fertilizers used in the production of row crops such as corn, and from livestock activities such as manure application and cattle access to stream courses. Ammonia concentrations for the two study areas is shown in Figure 5.3, while mean and median concentrations are shown in Table 5.1.

Seasonal fluctuations in the concentrations are clearly evident in Figure 5.3. Concentrations tend to be higher in the upper part of the basin (median concentration 0.06 mg/l) where row crops such as corn, and livestock activities greatest. Concentration in the lower basin is 0.03 mg/l). A generally declining trend in ammonia concentrations suggest some improvement in water quality, although water quality guidelines for aquatic life are consistently met at both stations.

5.2.3 Total Kjeldahl Nitrogen (TKN)

TKN concentrations for each of the monitoring stations are shown in Figure 5.4. Mean and median concentrations in Table 5.1. Concentrations are significantly higher in the lower basin where the median concentration of 0.43 mg/l is almost 10 times greater than in the upper basin (0.05 mg/l). All values are less than the drinking water quality guideline of 10 mg/l. Figure 5.4 (Trend Analysis), suggests that TKN has shown slight improvement since 1972.

5.2.4 Dissolved Oxygen

Dissolved oxygen concentrations for the two monitoring stations are shown in Figure 5.5. Mean and median concentrations are provided in Table 5.1. Concentrations are relatively uniform throughout the basin with the median concentration in the upper basin being 10.3 mg/l, and 9.8 mg/l in the lower basin.

Trends in dissolved oxygen in the basin have been relatively stable over the past decade, particularly in the lower basin where no change is observed. A slight improvement has occurred in the upper basin, although the change has been slight. In general, dissolved oxygen concentrations satisfy the water quality guidelines for aquatic life gure 5.3 Ammonia (NH_3-N) concentrations at two sampling locations in the Big Creek watershed.

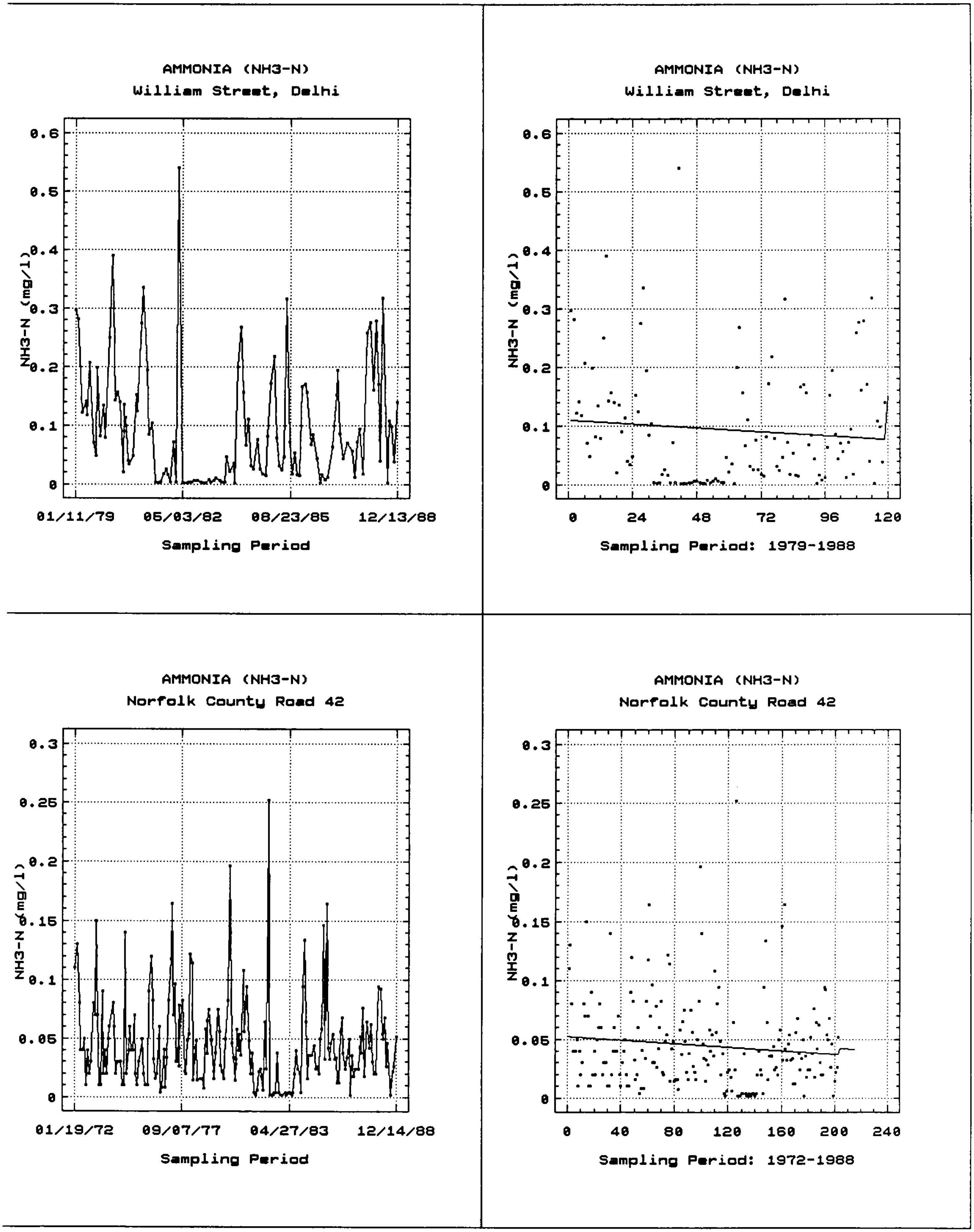


Figure 5.4 TKN at two sampling locations in the Big Creek watershed.

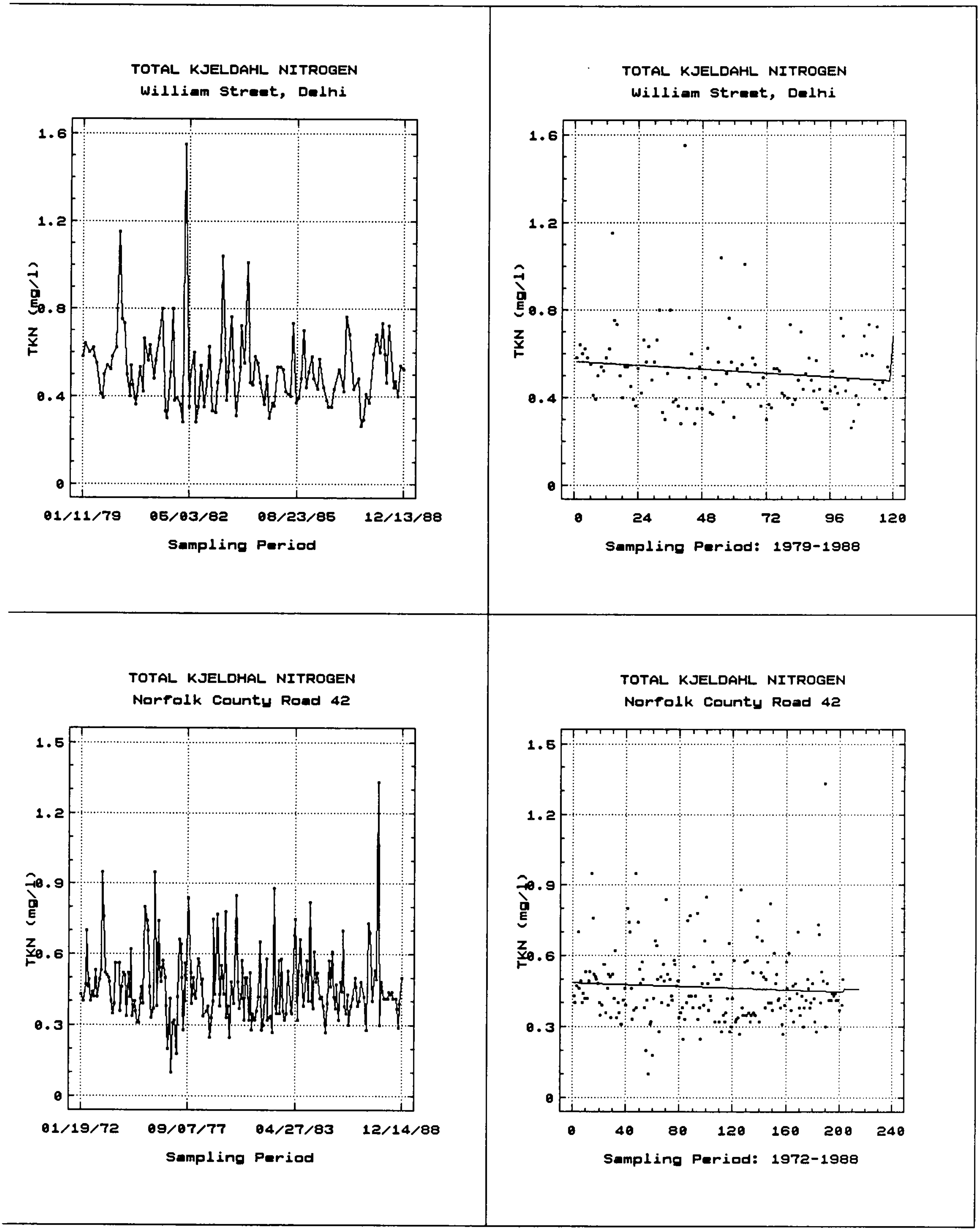
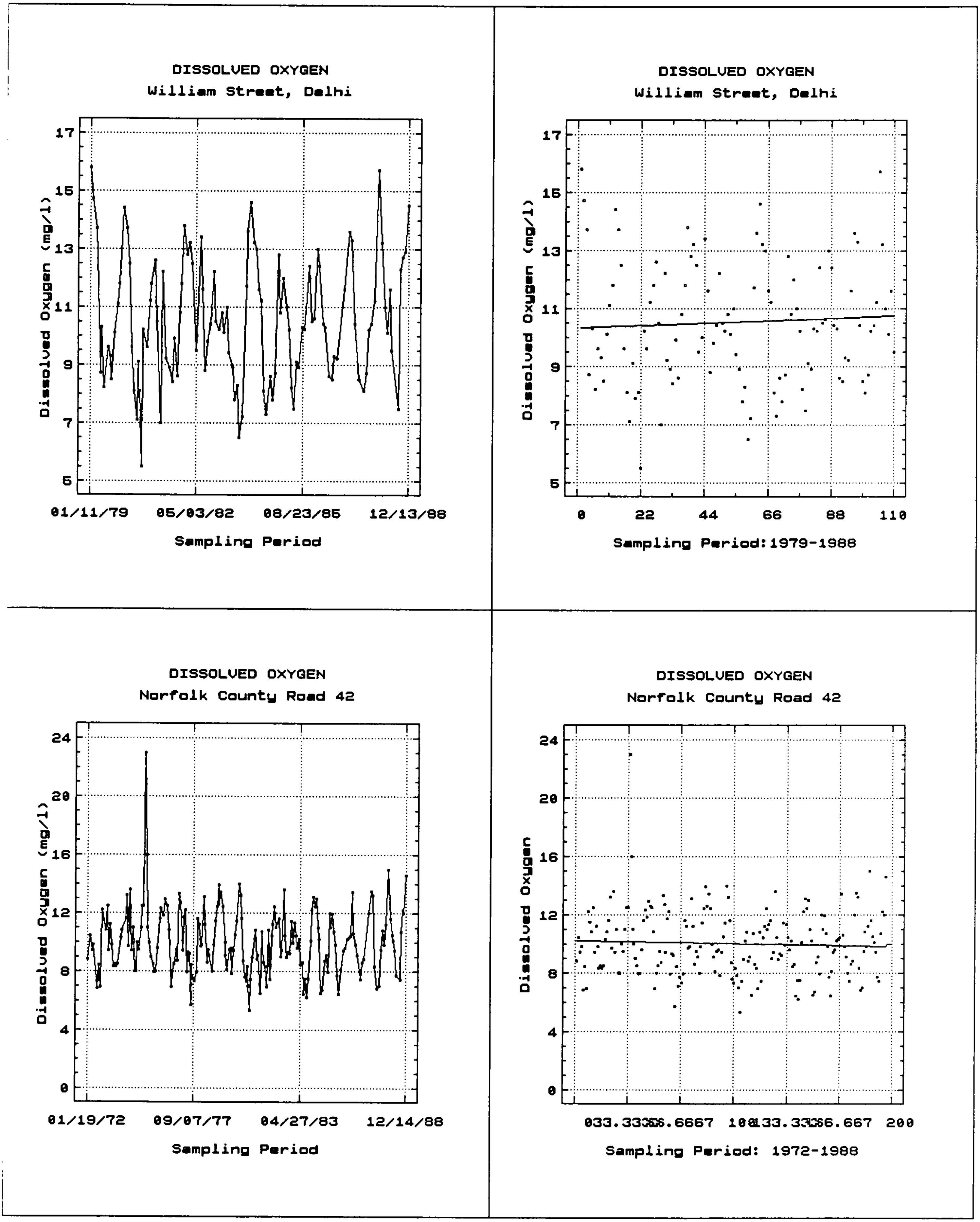


Figure 5.5 Dissolved oxygen at two sampling locations in the Big Creek watershed.



(6.5 mg/l) in both areas of the watershed.

5.2.5 Alkalinity

Alkalinity concentrations for the two stations are shown in Figure 5.6. Mean and median concentrations are shown in Table 5.1. In general, the basin is well buffered, with median alkalinity concentrations ranging from 205 mg/l in the upper basin to 192 mg/l in the lower basin. Slightly increasing trends are observed over the sampling period.

5.2.6 pH

pH for the two monitoring stations are shown in Figure 5.7. Mean and median values are presented in Table 5.1. pH values in both the upper and lower watershed areas have shown increases in pH over the past 10-15 years. Mean pH has increased in the upper basin from 8.2 in 1979 to 8.4 in 1988. In the lower basin the increase has been from 8.2 in 1976, to 8.3 in 1988.

Canadian Water Quality Guidelines (1987) suggest that the acceptable range for pH is between 5.0 and 9.0 for recreational uses, and 6.5-8.5 for aquatic life. At or near the extremes of this range the buffering capacity is low. The pH of Big Creek is apparently approaching the upper extreme for both aquatic and recreational uses, with trends (Figure 5.7) indicating a continuing upward movement.

5.2.7 Conductivity

Conductivity concentrations for the basin are shown in Figure 5.8. Mean and median concnetrations are presented in Table 5.1. Conductivity has remained relatively stable over the sampling period with median concentrations in the upper basin being 542 uhmo/cm and 498 uhmo/cm in the lower basin.

5.2.8 Turbidity

Turbidity concentrations for the basin are shown in Figure 5.9. Mean and median concentrations are presented in Table 5.1. The relatively low concentrations (3.4 FTU in the upper basin and 8.2 FTU) in the lower basin reflect the generally sandy nature of the surficial deposits in the basin. The slightly higher concentrations in the lower basin reflect not only the occurrence of lacustrine silts and clays along Big Creek in the lower basin, but

Figure 5.6 Total alkalinity at two sampling locations in the Big Creek watershed.

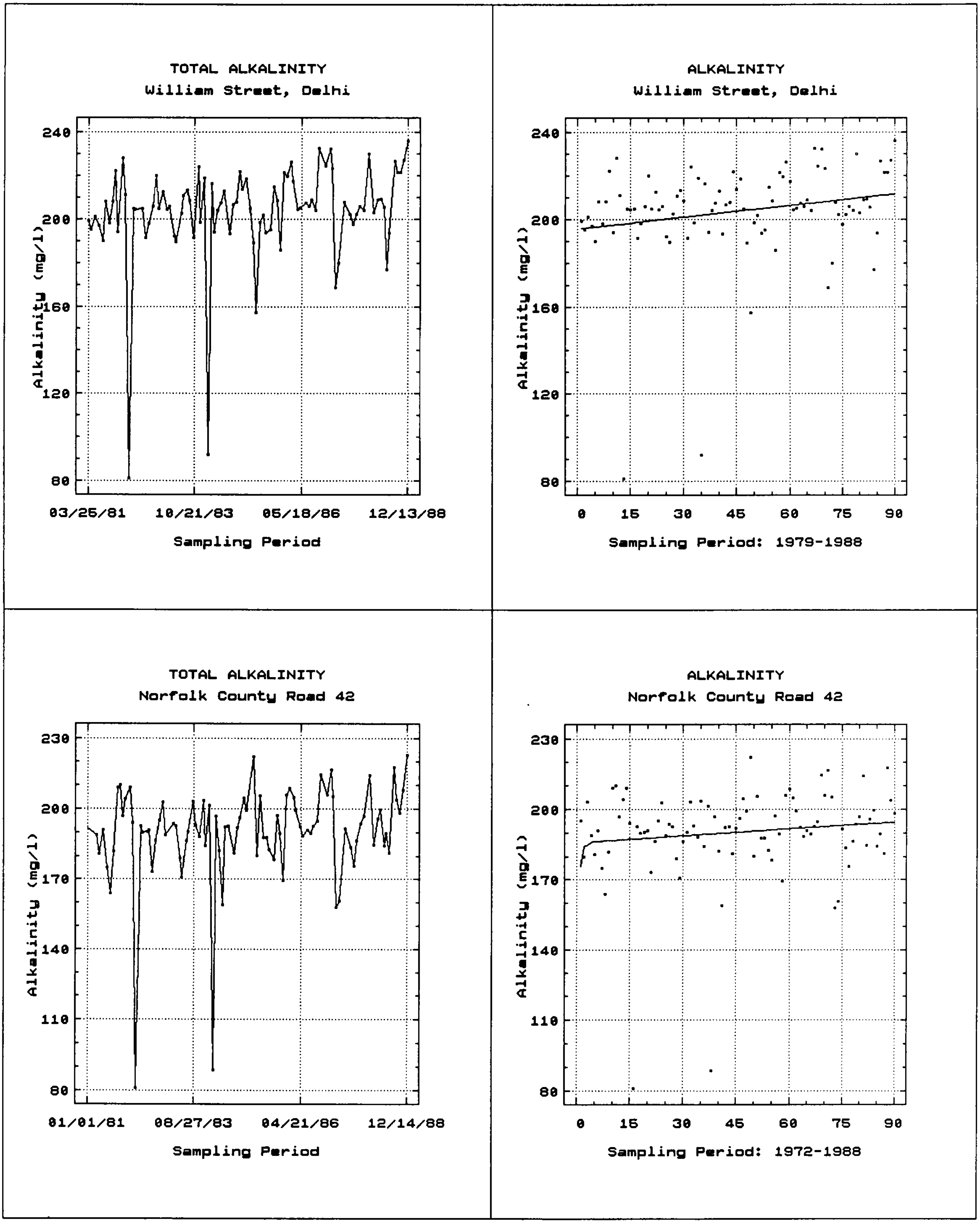


Figure 5.7 pH at two sampling locations in the Big Creek watershed.

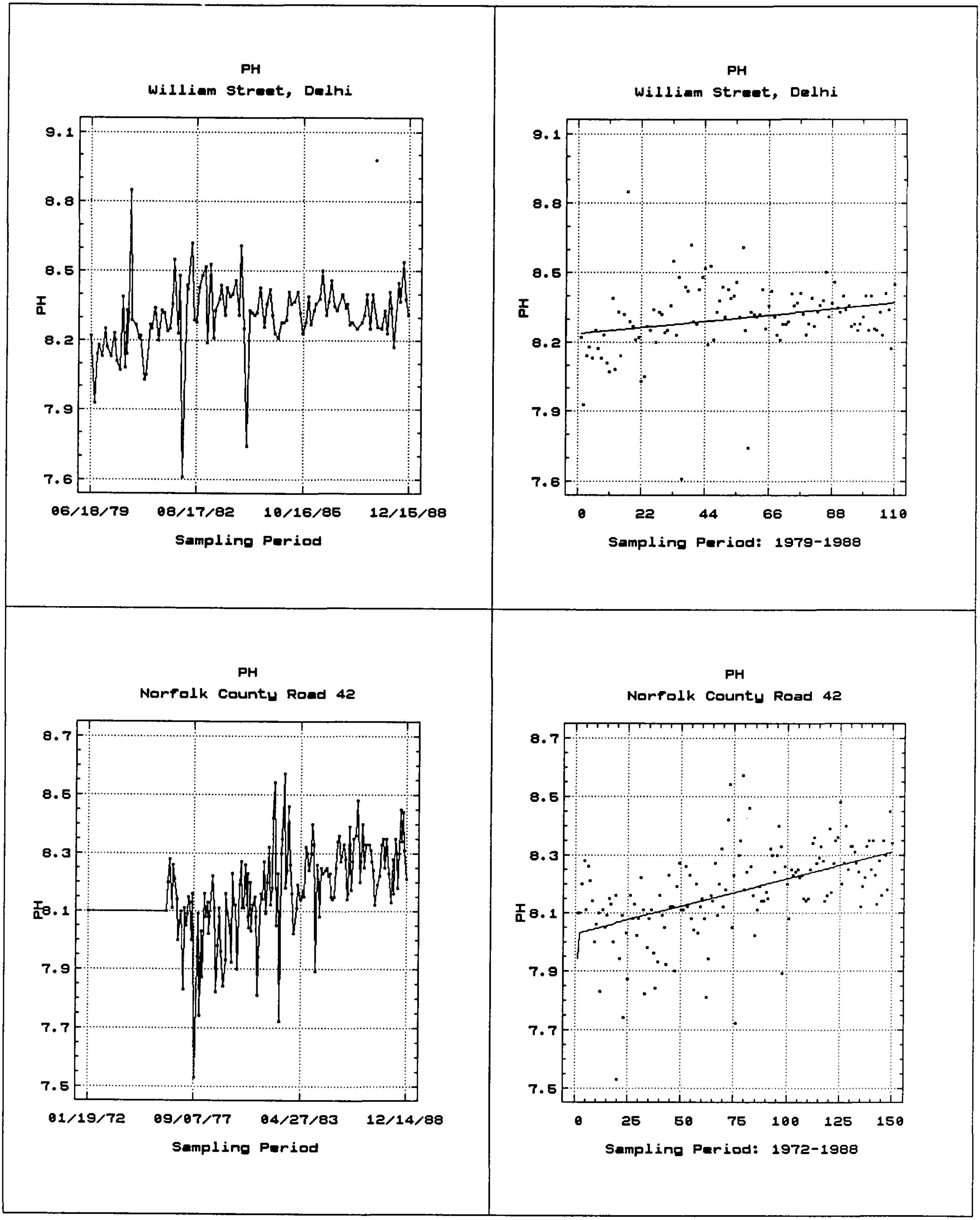
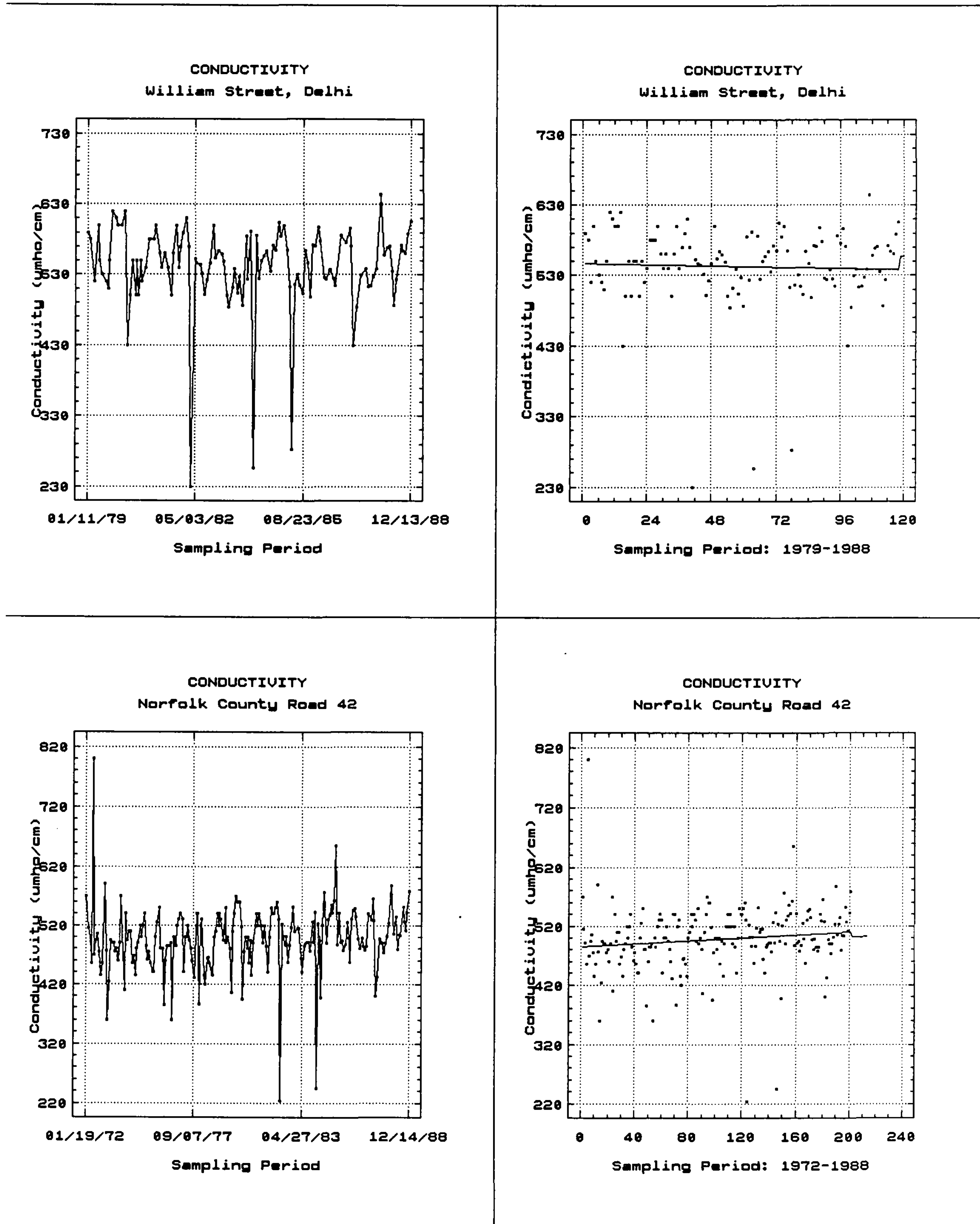
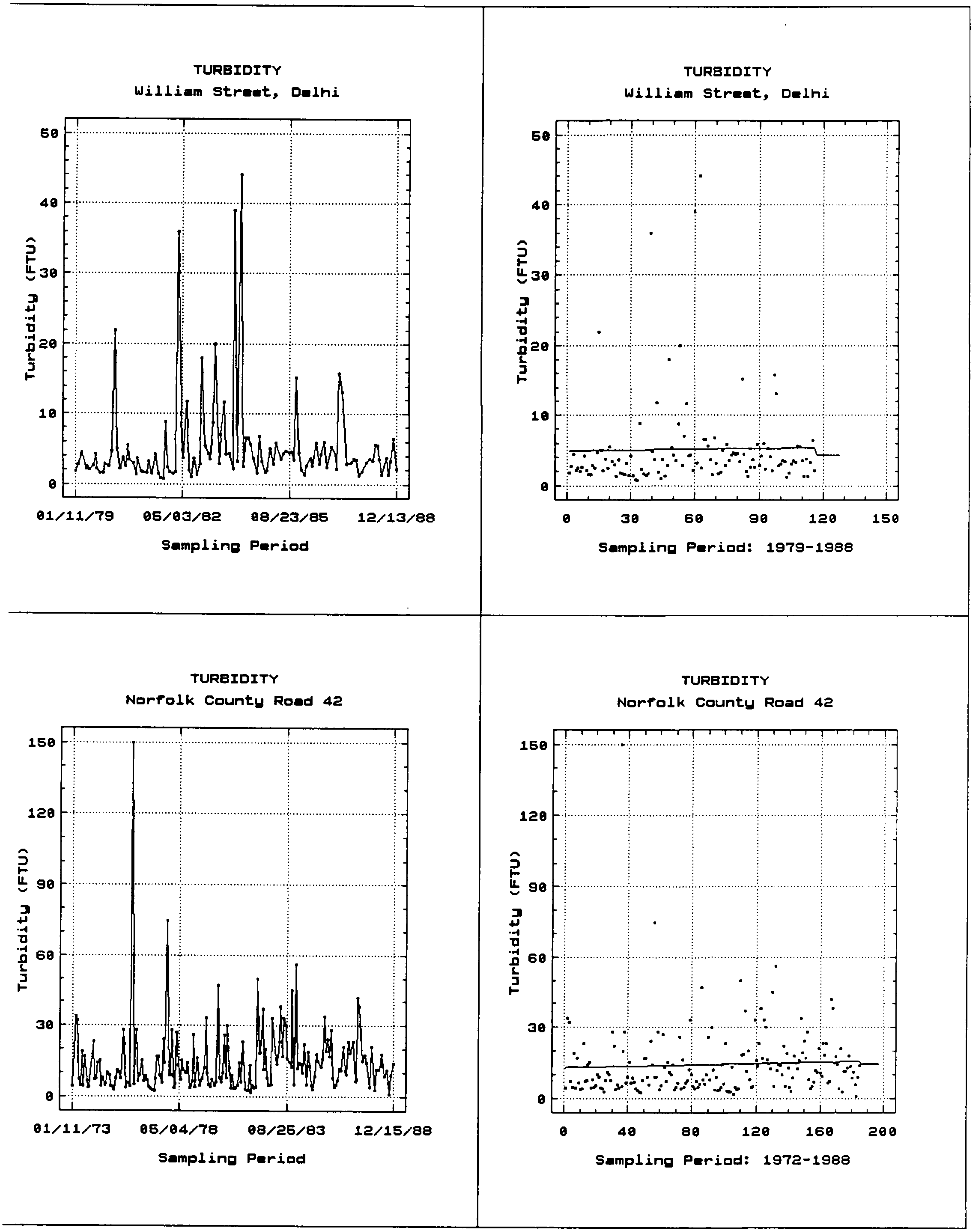


Figure 5.8 Conductivity at two sampling locations in the Big Creek watershed.



gure 5.9 Turbidity at two sampling locations in the Big Creek watershed.



also their low erodability.

5.3 Summary of Water Flow

Water flow data have been summarized for two stations in the watershed. The upper basin is represented by a station in Delhi, and the lower basin by a station near Wallsingham. Tables 5.2 and 5.3 summarize mean monthly discharges on Big Creek at each of these locations for the period 1980-1987. Mean monthly discharge for each year are also presented.

Seasonal stream flow summaries are presented for the sampling period for each of the two monitoring stations. Figures 5.10 - 5.13 summarize the information for Big Creek at Delhi, Figures 5.14 - 5.17 summarize the information from Wallsingham.

Finally, daily stream discharge for each station, for the May-August period in each of the sampling years is presented in order to better observe the natural variability associated with stream discharge data (Figures 5.18 - 25). All data is appended to the report and can be examined/manipulated as required.

As expected, mean flow on Big Creek is highest in the lower basin, the mean annual discharge being 7.73 m^3/sec. Mean annual discharge in the upper basin is 4.96 m^3/sec. Highest flows in both parts of the basin are recorded during March and April, lowest flow during July and August (Tables 5.2 and 5.3). Daily discharges are influenced by individual storm events, however as the daily discharge figures illustrate, trends from May through August are to lower flow conditions (Figures 5.18 - 5.25).

5.4 Climate Summary

Two long term climate recording stations for Big Creek are located at St. Williams and the Canada Department of Agriculture station in Delhi. Biogeoclimatological profiles for each of these two stations are presented in Figures 5.26 and 5.27. St. Williams located just outside the Big Creek watershed near the north shore of Lake Erie, represents the southern part of the area, whereas Delhi represents the northern portion. Climatologically, the watershed appears to be quite similar throughout. The moderating effect of Lake Erie is evident in the data. For example mean annual temperature in the south is 8°C and 7.9°C in the north. Total annual precipitation at St. Williams is 1028.2 mm and 966.4 at Delhi. Growing degree days are 188 at St. Williams and 189 at Delhi, reflecting the cooling influence of Lake Erie in the spring and summer.

Table 5.2 Mean Monthly Discharges on Big Creek at Delhi, 1980-1987.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	6.03	2.43	8.05	10.18	4.99	3.21	2.11	2.07	2.67	3.53	3.00	4.28
1981	2.45	10.03	5.47	5.09	3.80	2.37	1.03	1.97	5.44	4.77	4.16	3.27
1982	3.39	2.03	14.03	11.52	3.70	6.06	1.75	1.65	2.06	2.27	5.38	8.90
1983	5.10	6.20	4.94	6.55	6.76	3.44	2.01	7.55	2.76	2.67	3.86	8.12
1984	3.54	13.26	8.26	9.33	5.92	7.26	3.45	1.58	2.42	1.77	3.22	4.29
1985	4.82	8.56	16.52	10.38	3.93	2.91	1.68	1.62	3.09	6.24	14.24	8.76
1986	5.99	4.71	12.60	7.55	5.51	3.53	2.26	2.03	2.56	5.68	4.04	7.64
1987	5.06	3.37	6.73	7.85	2.75	1.89	1.43	1.36	1.43	1.64	2.08	4.10
MEAN	4.55	6.32	9.58	8.56	4.67	3.83	1.97	2.48	2.80	3.57	5.00	6.17

Table 5.3 Mean Monthly Discharges on Big Creek near Wallsingham, 1980-1987.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	8.74	4.27	12.04	13.95	7.98	5.83	5.09	4.09	5.12	5.77	5.61	6.87
1981	3.64	13.73	8.45	7.87	6.44	4.90	3.19	3.62	7.50	7.65	6.92	5.99
1982	5.31	3.60	20.67	16.19	6.89	9.70	4.04	3.34	3.66	4.21	8.26	13.62
1983	8.54	9.83	7.68	9.87	10.35	5.51	3.58	10.25	4.81	4.54	6.08	11.74
1984	4.46	19.79	12.48	14.69	9.19	8.96	5.15	3.92	5.54	4.48	5.39	6.14
1985	7.80	11.92	21.65	14.59	6.03	5.38	3.64	3.36	4.69	7.57	18.85	11.45
1986	7.95	6.52	16.41	10.80	7.80	5.71	4.08	3.85	4.59	10.26	7.21	13.20
1987	8.52	5.73	10.21	12.45	5.22	3.68	2.76	2.67	2.75	3.21	4.15	7.62
MEAN	6.87	9.42	13.70	12.55	7.49	6.21	3.94	4.39	4.83	5.96	7.81	9.58

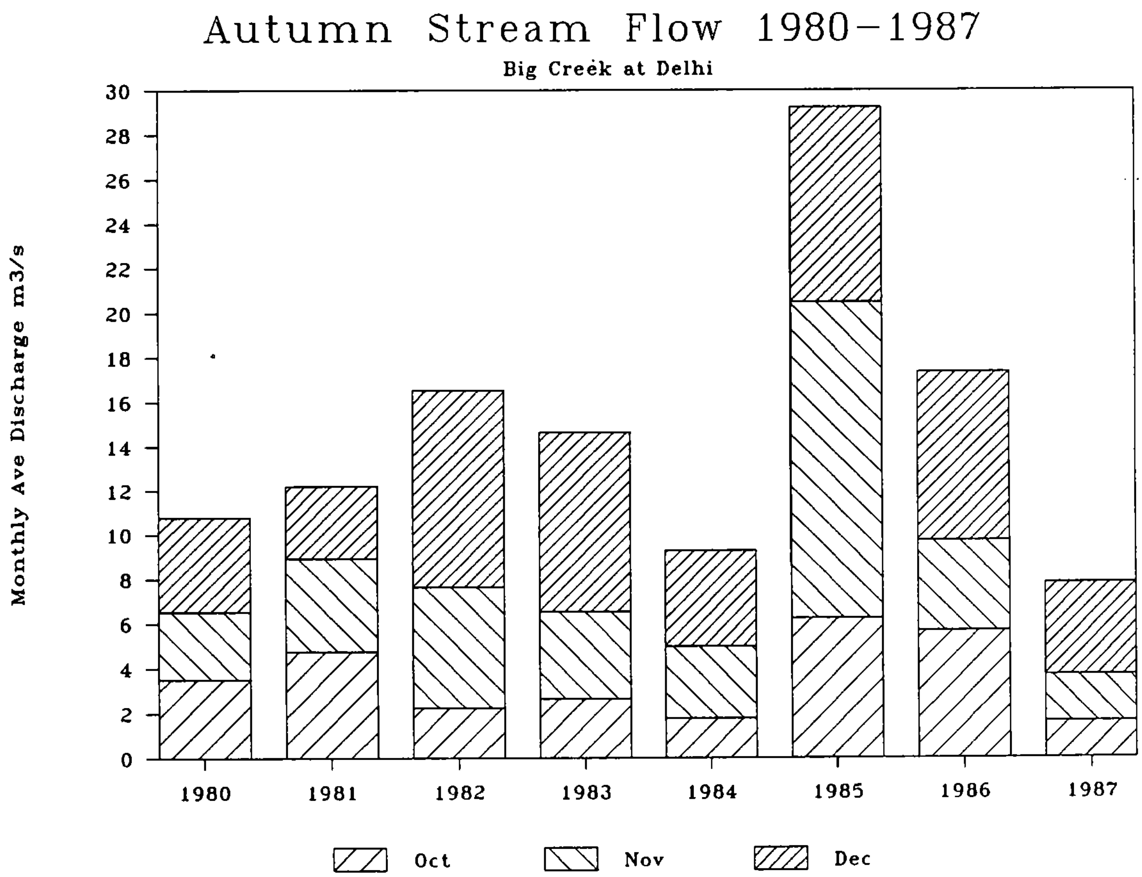


Figure 5.10 Autumn streamflow (1980 - 1987) in Big Creek at Delhi.

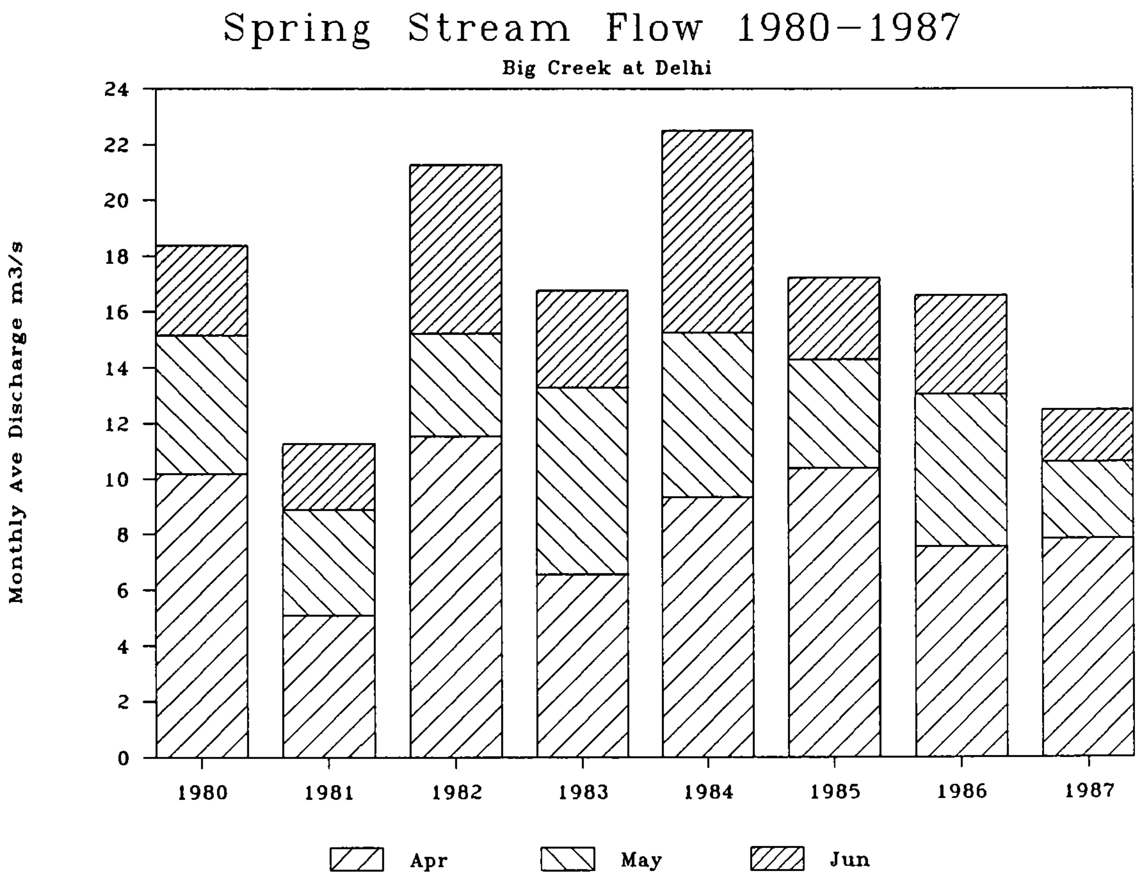


Figure 5.11 Spring streamflow (1980 - 1987) in Big Creek at Delhi.

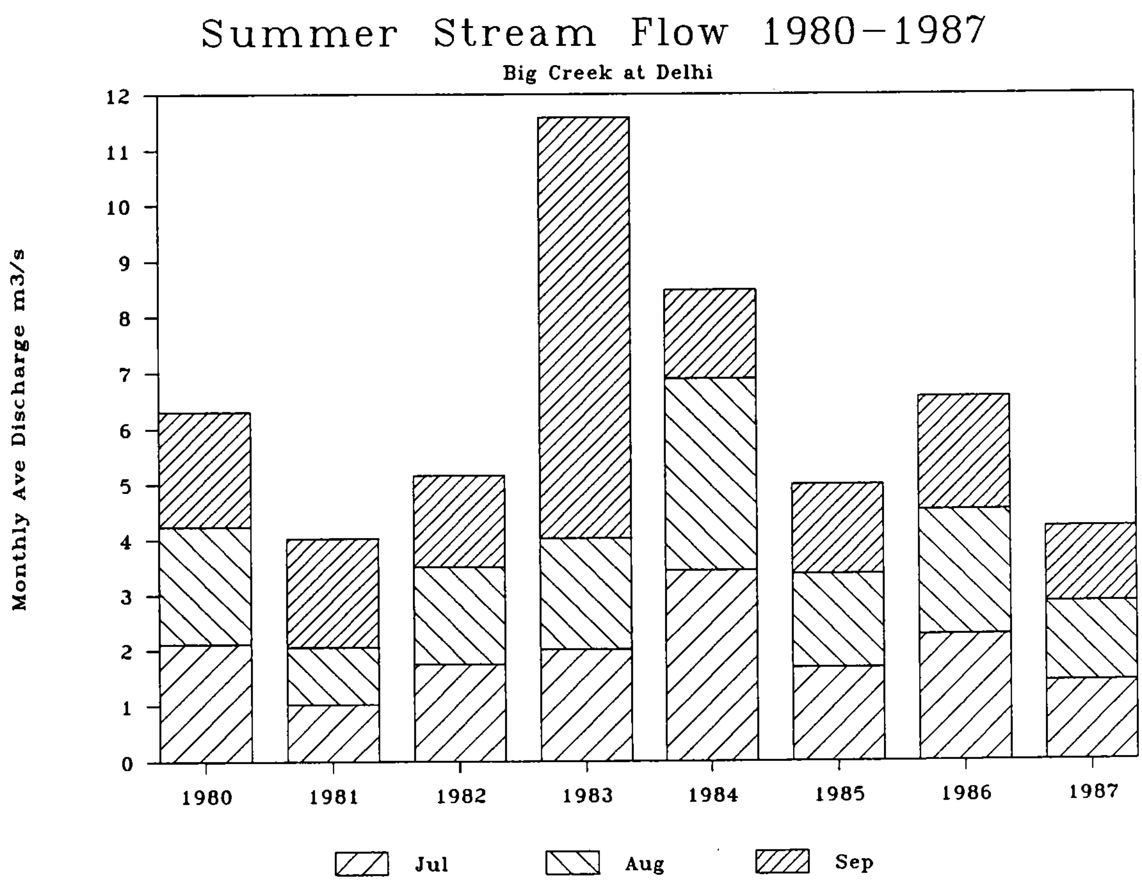


Figure 5.12 Summer streamflow (1980 - 1987) in Big Creek at Delhi.

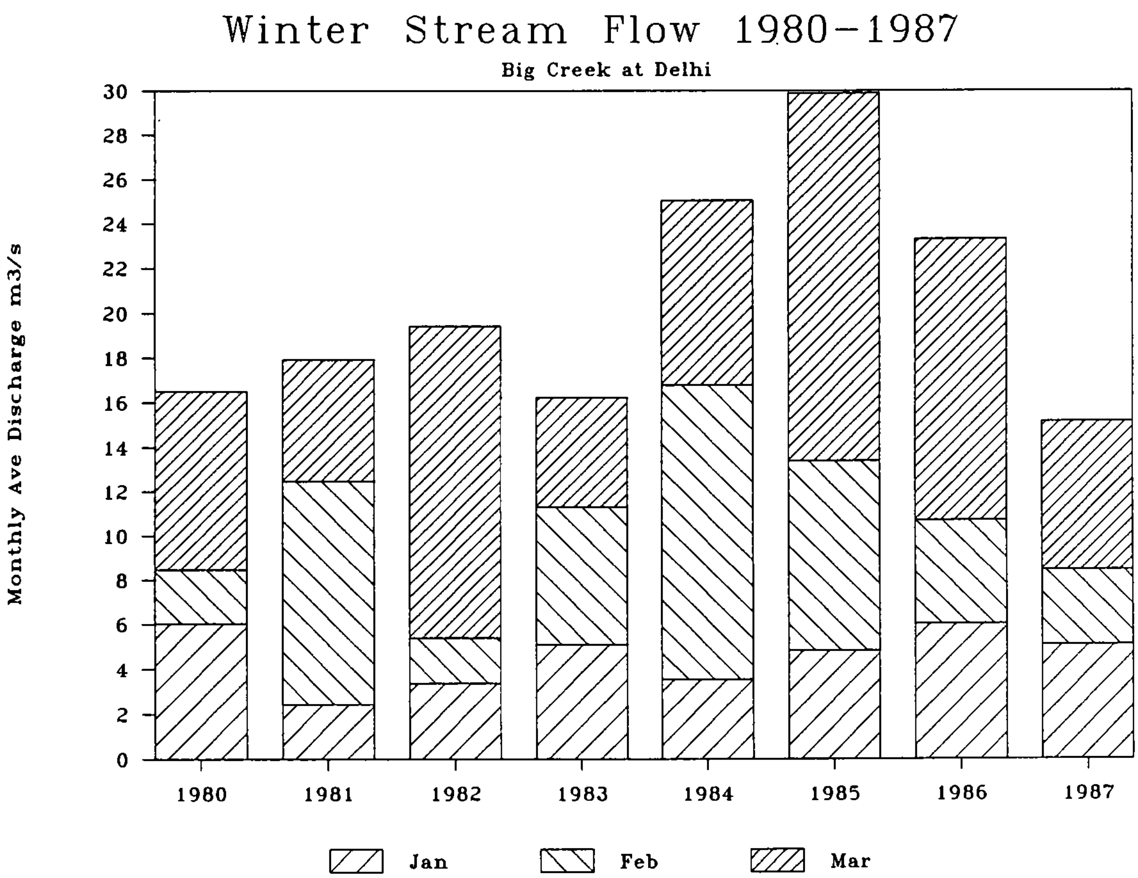


Figure 5.13 Winter streamflow (1980 - 1987) in Big Creek at Delhi.

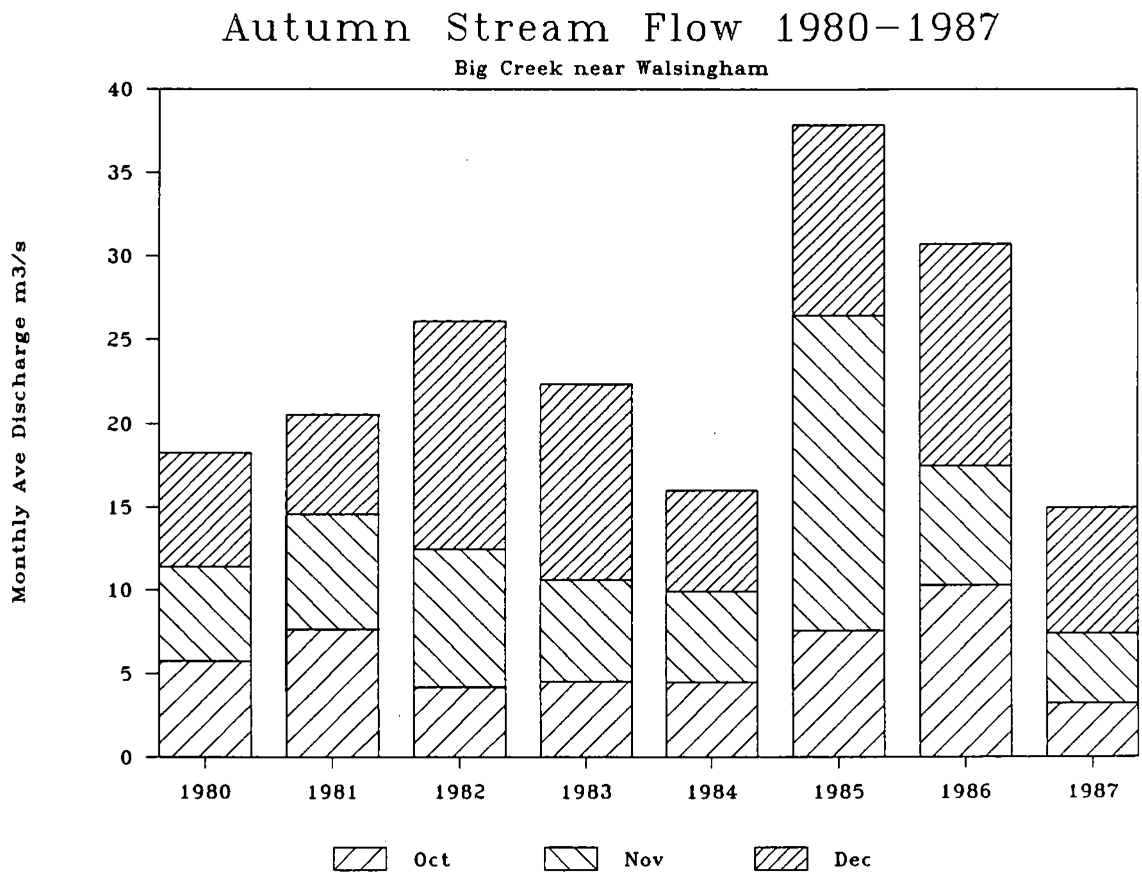


Figure 5.14 Autumn streamflow (1980 - 1987) in Big Creek at Walsingham.

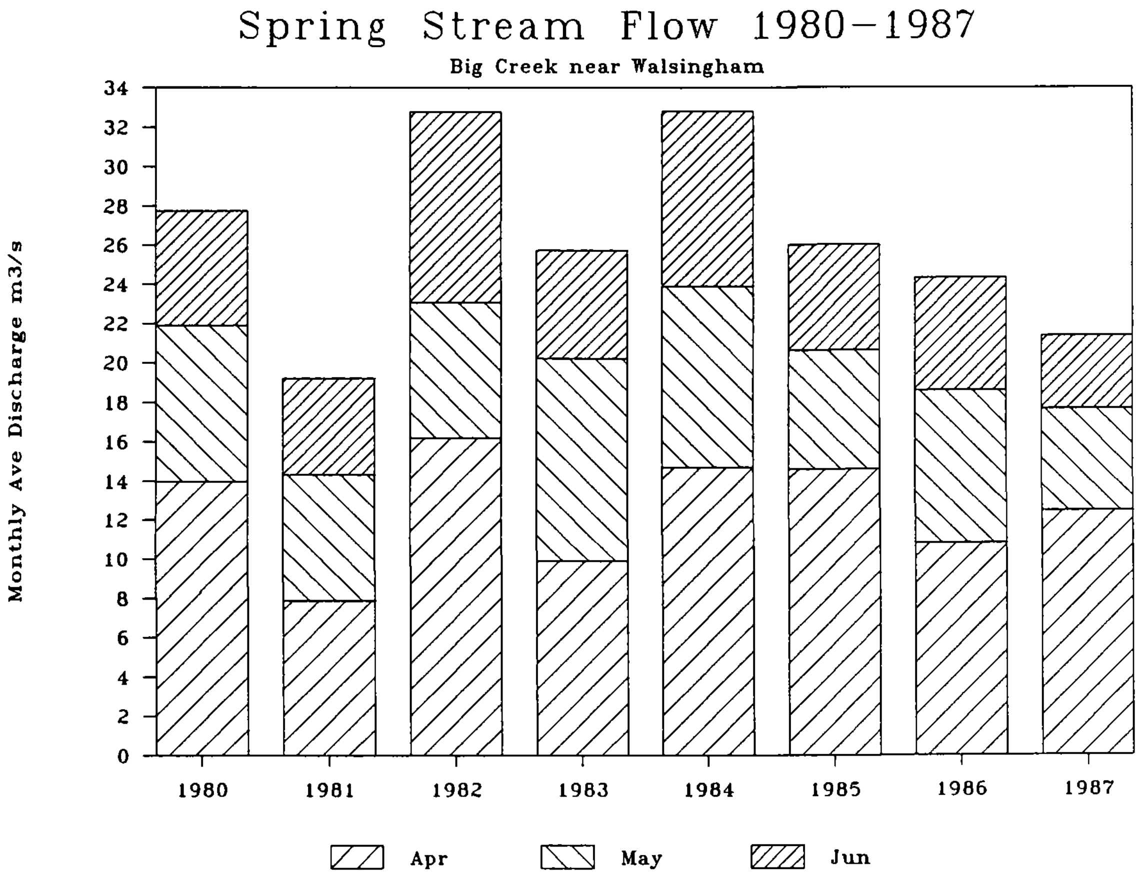


Figure 5.15 Spring streamflow (1980 - 1987) in Big Creek at Walsingham.

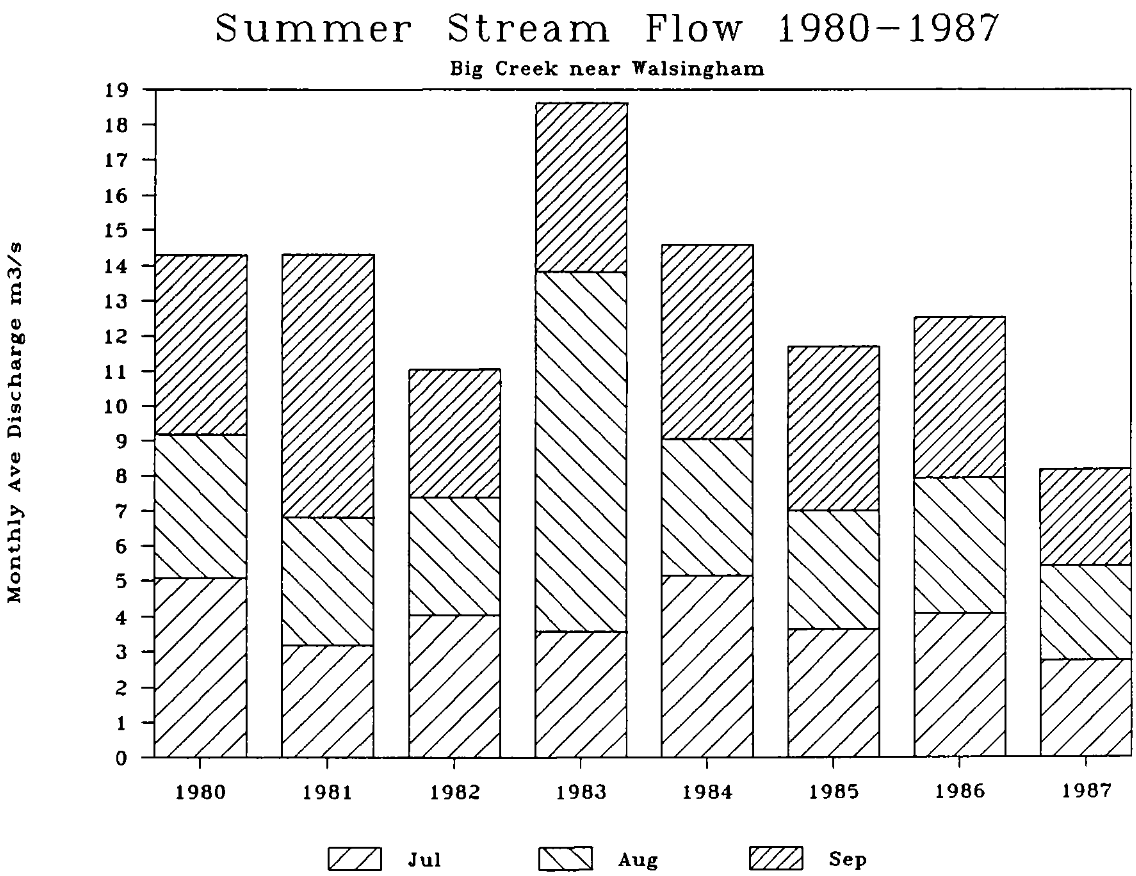


Figure 5.16 Summer streamflow (1980 - 1987) in Big Creek at Walsingham.

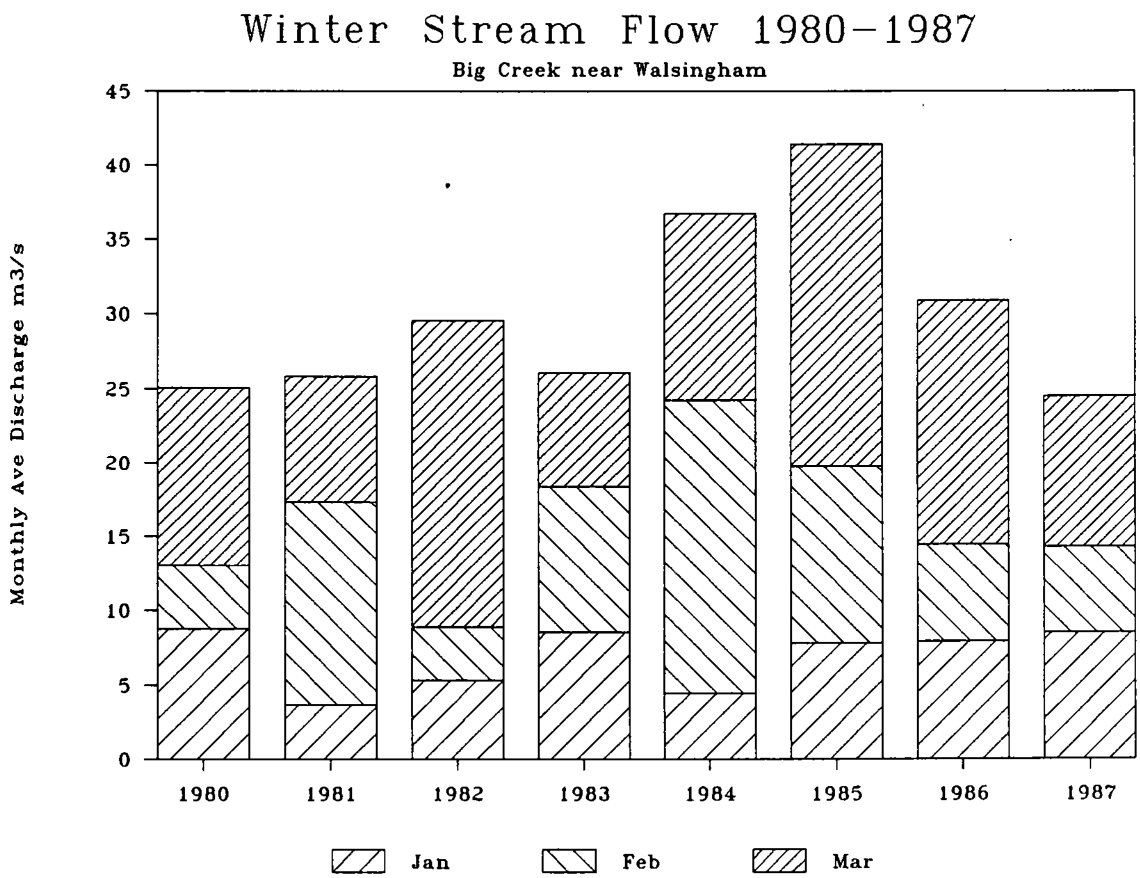
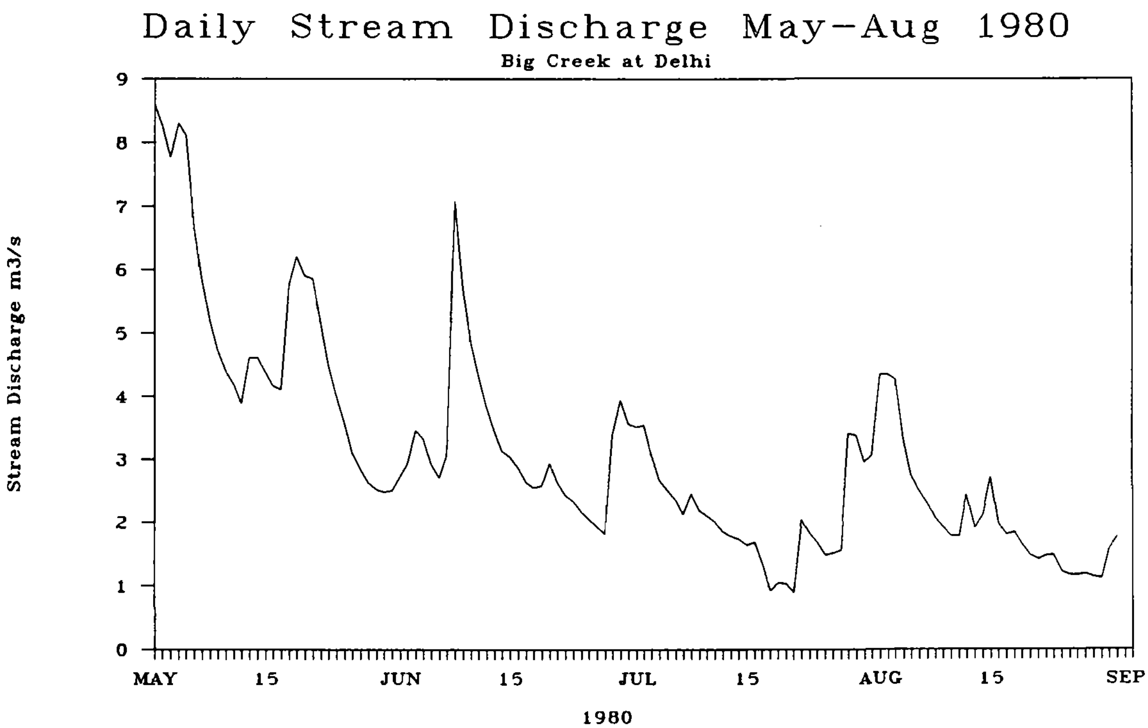


Figure 5.17 Winter streamflow (1980 - 1987) in Big Creek at Walsingham.



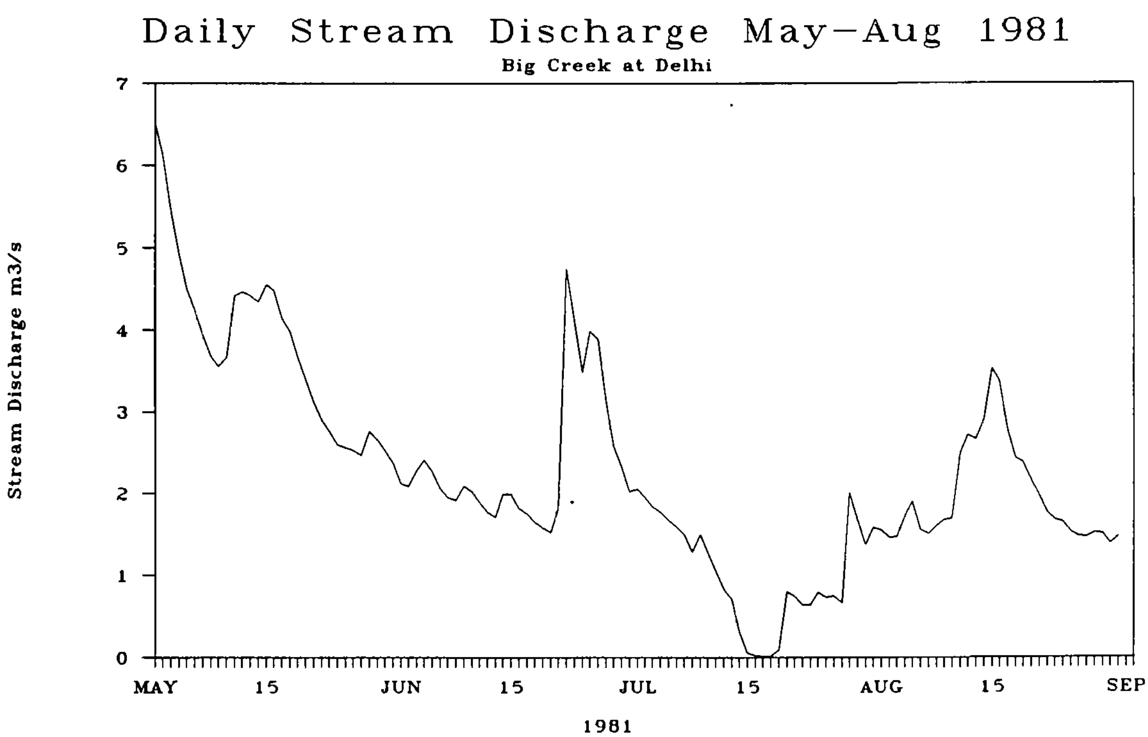


Figure 5.18 Daily stream discharge (May - August, 1980) in Big Creek at Delhi.

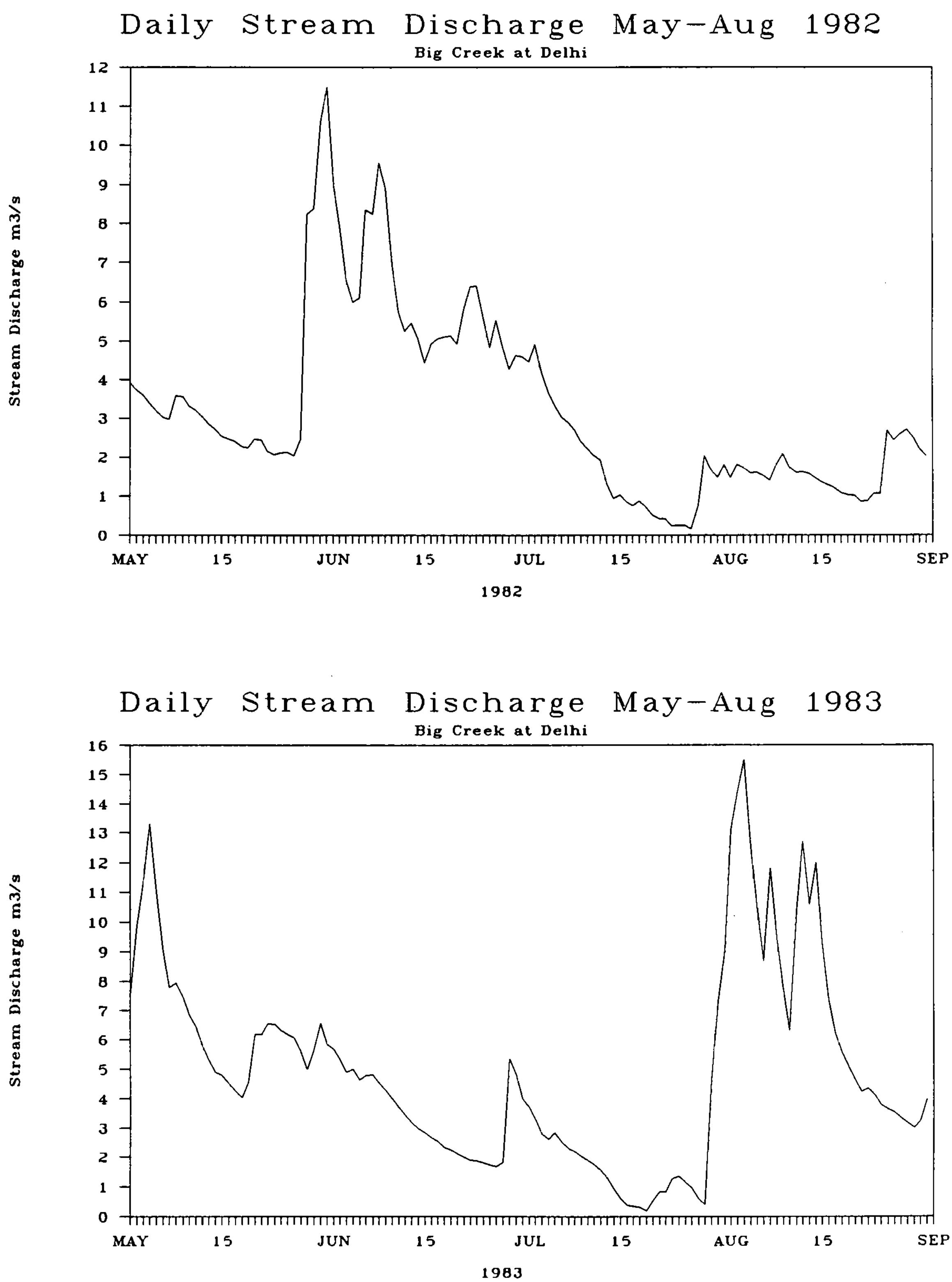
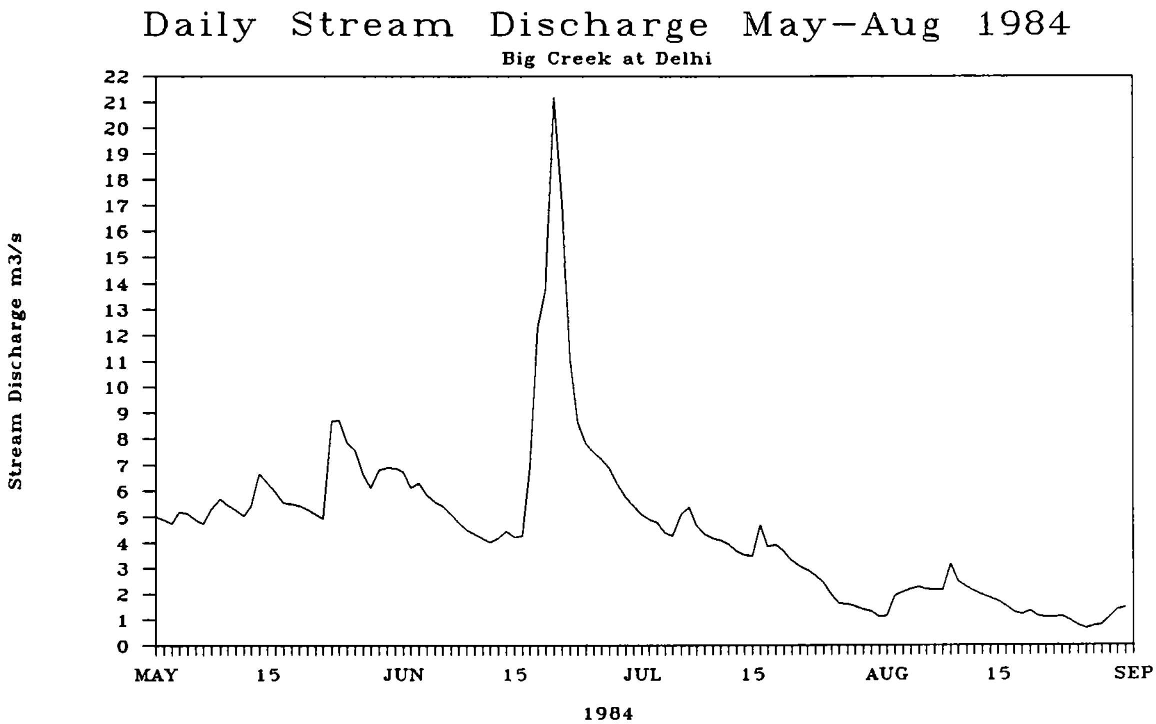


Figure 5.19 Daily stream discharge (May - August, 1982) in Big Creek at Delhi.



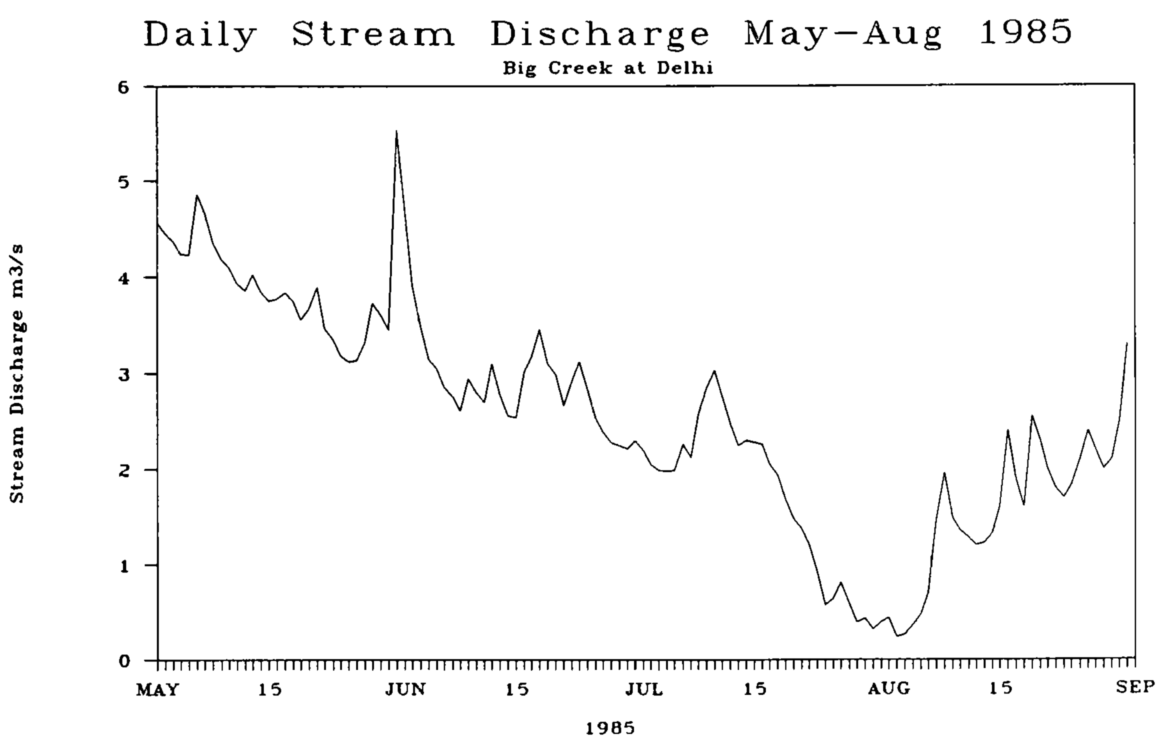
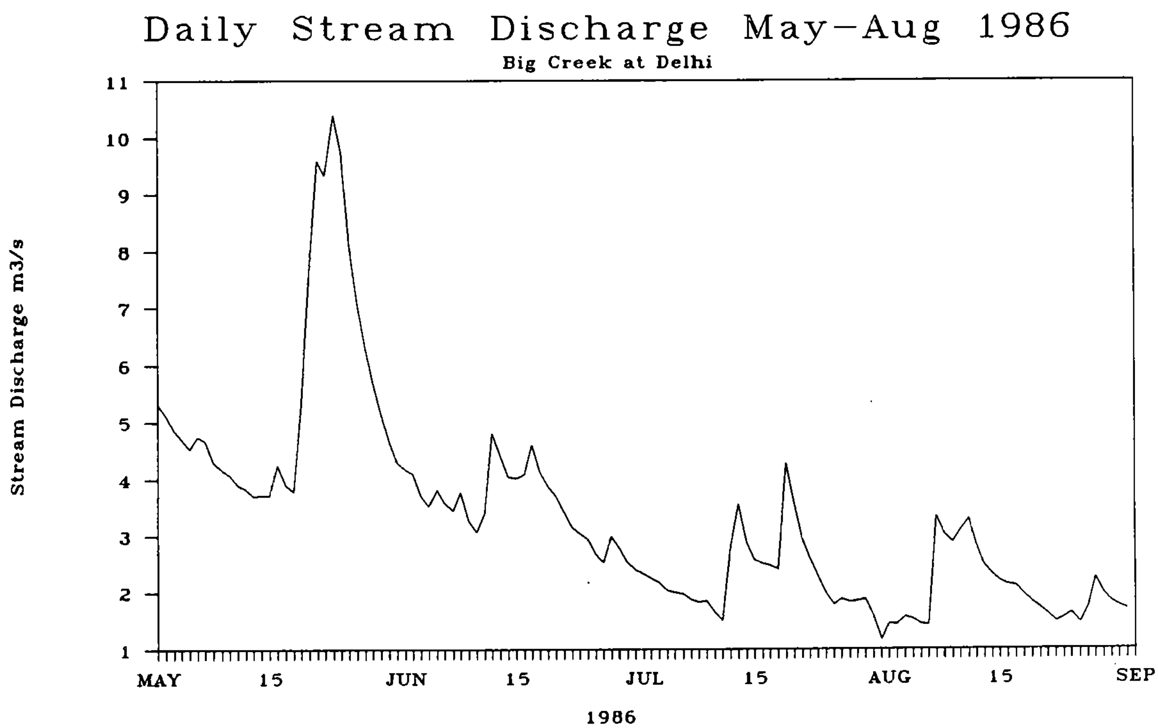


Figure 5.20 Daily stream discharge (May - August, 1984) in Big Creek at Delhi.



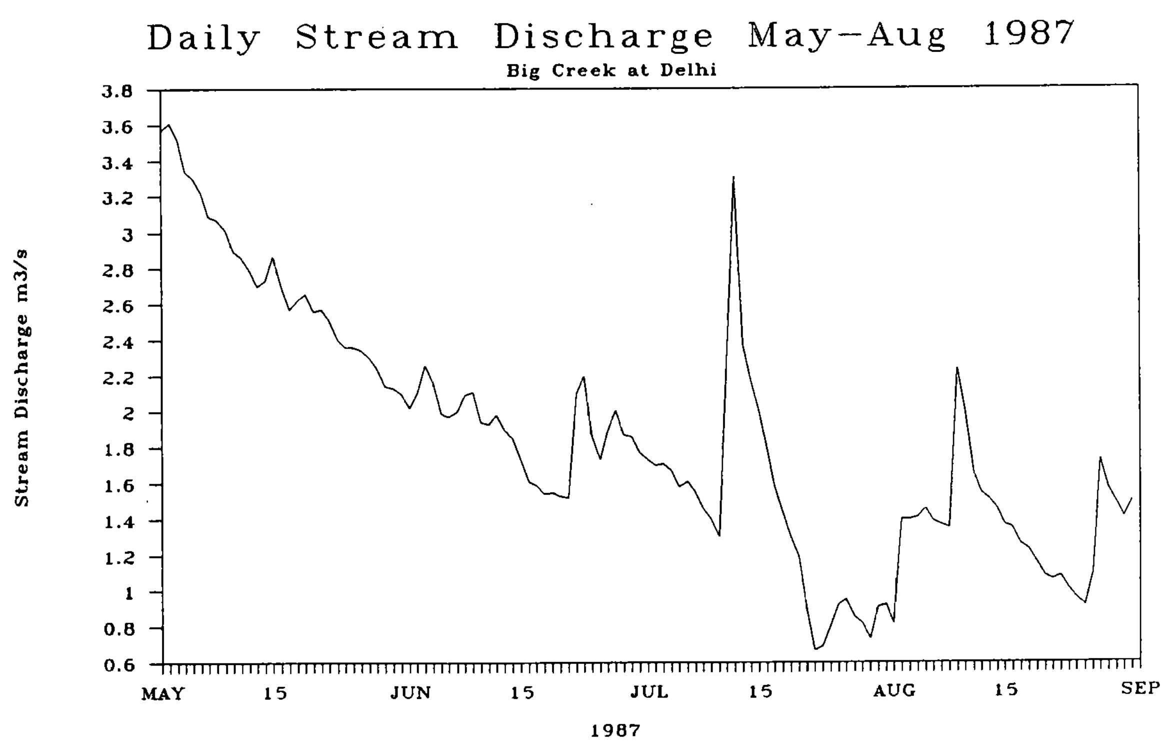
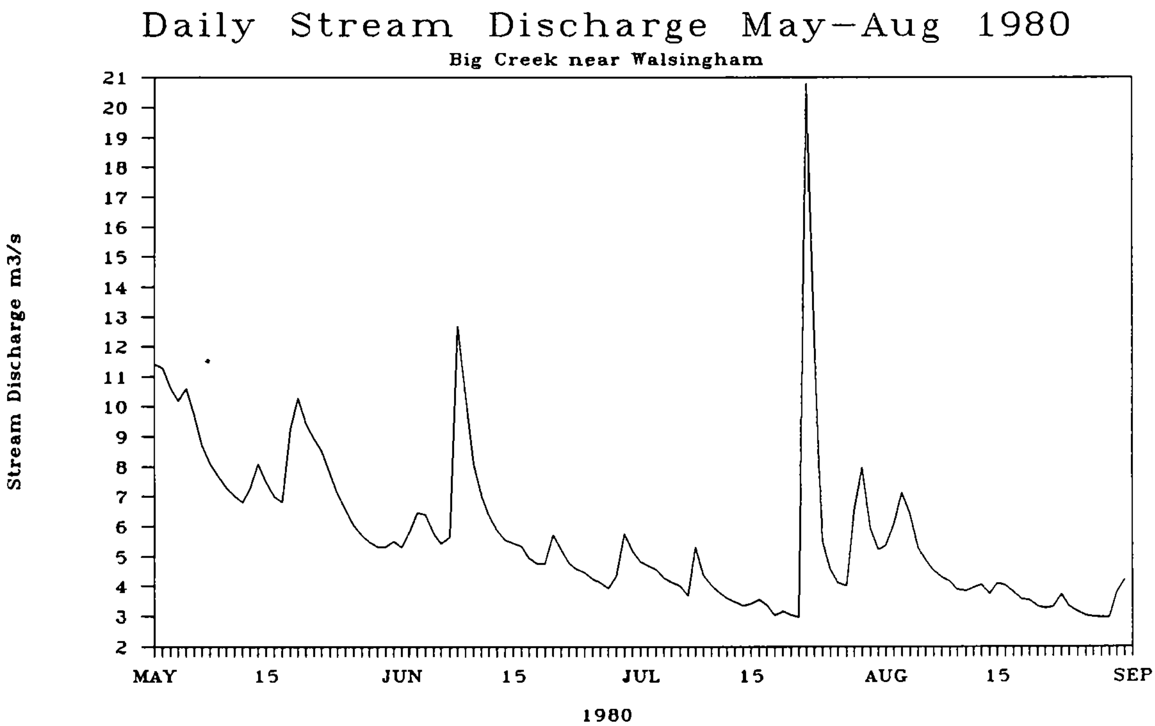


Figure 5.21 Daily stream discharge (May - August, 1986) in Big Creek at Delhi.



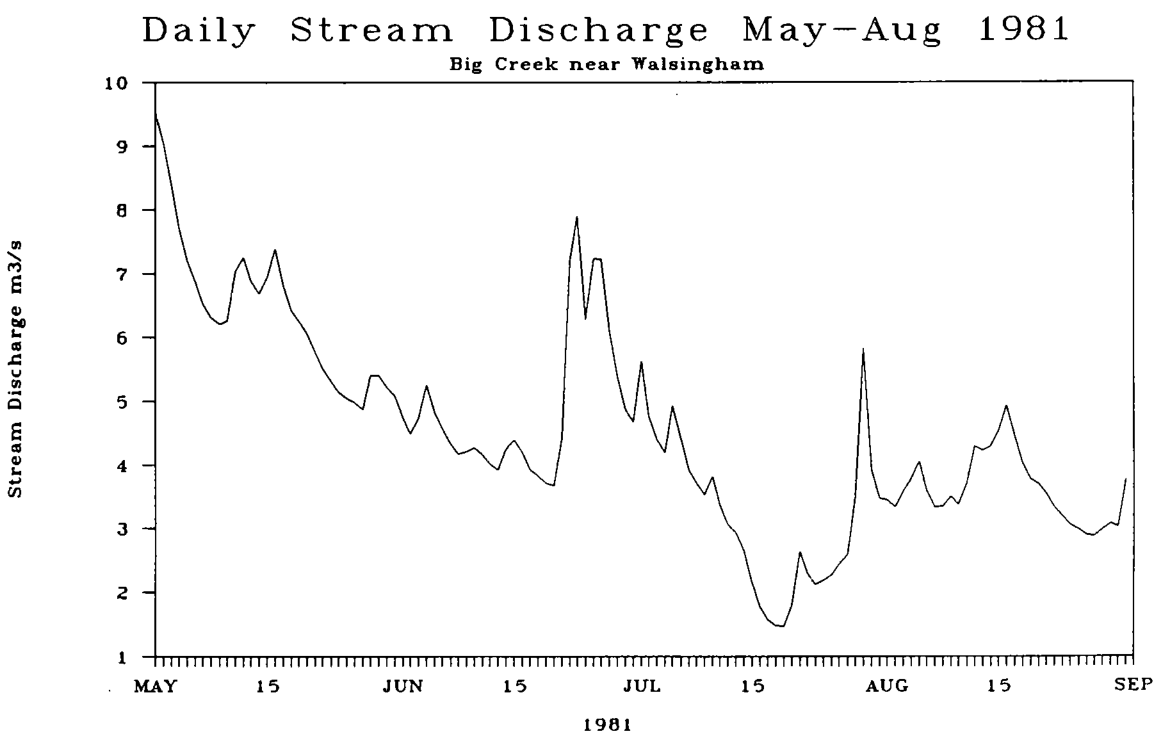
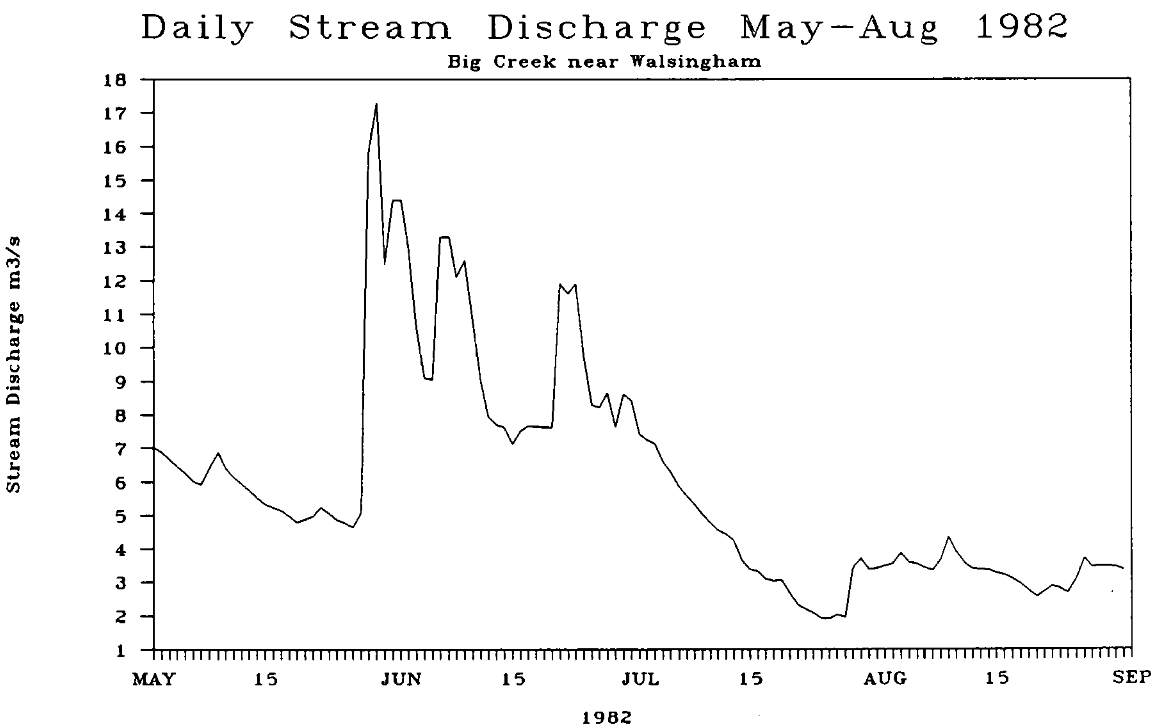


Figure 5.22 Daily stream discharge (May - August, 1980) in Big Creek at Walsingham.



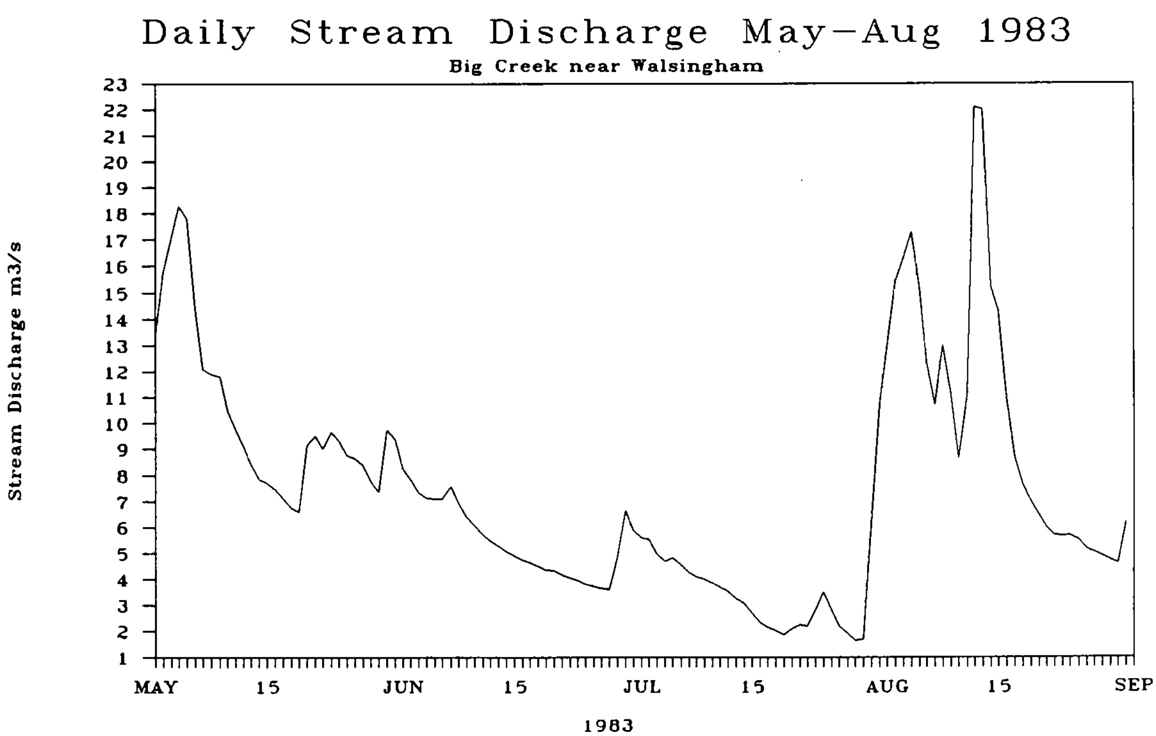
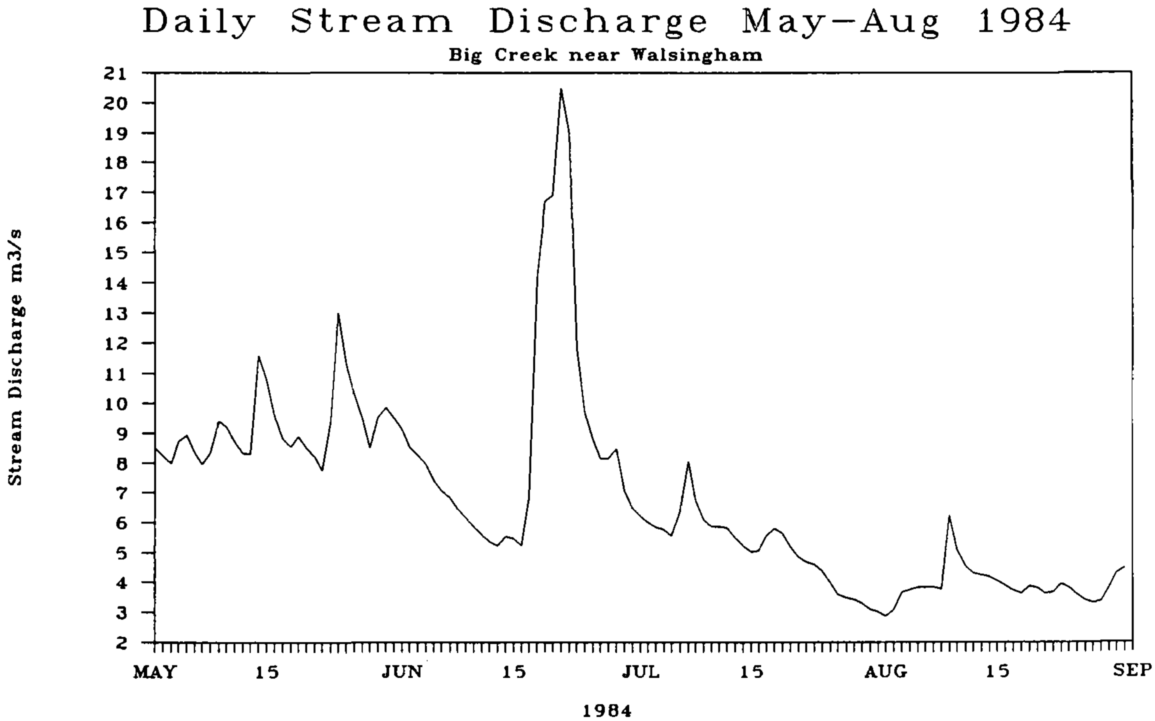


Figure 5.23 Daily stream discharge (May - August, 1982) in Big Creek at Walsingham.



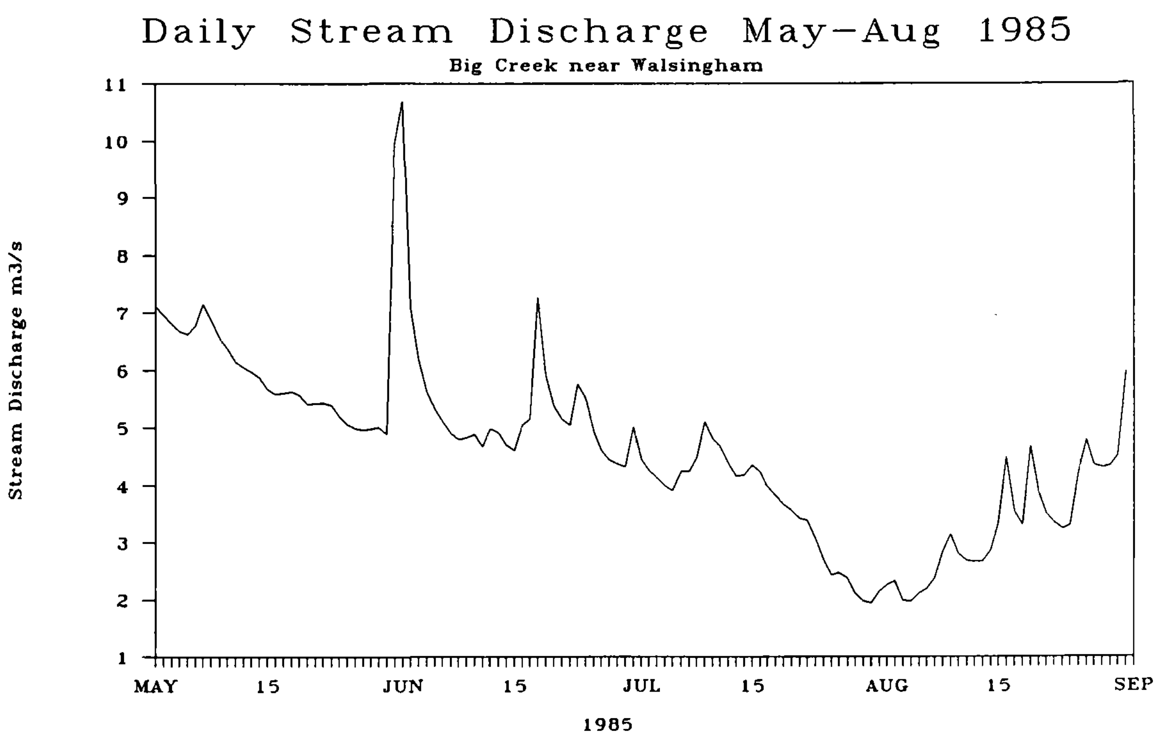
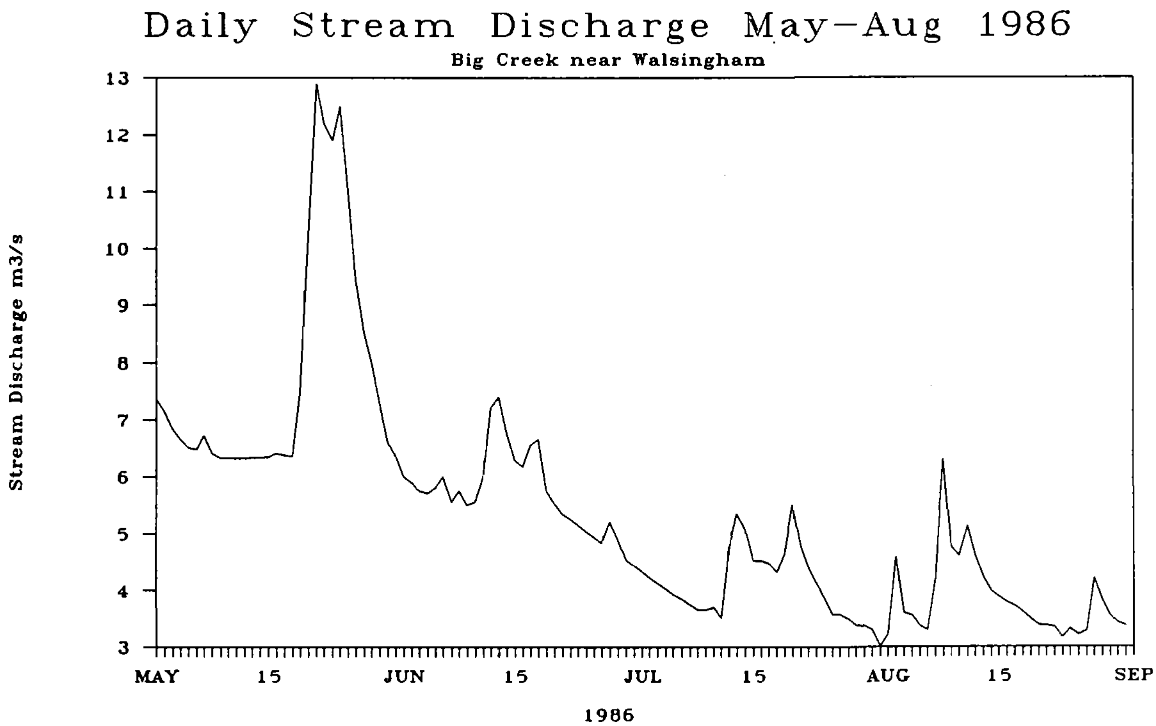


Figure 5.24 Daily stream discharge (May - August, 1984) in Big Creek at Walsingham.



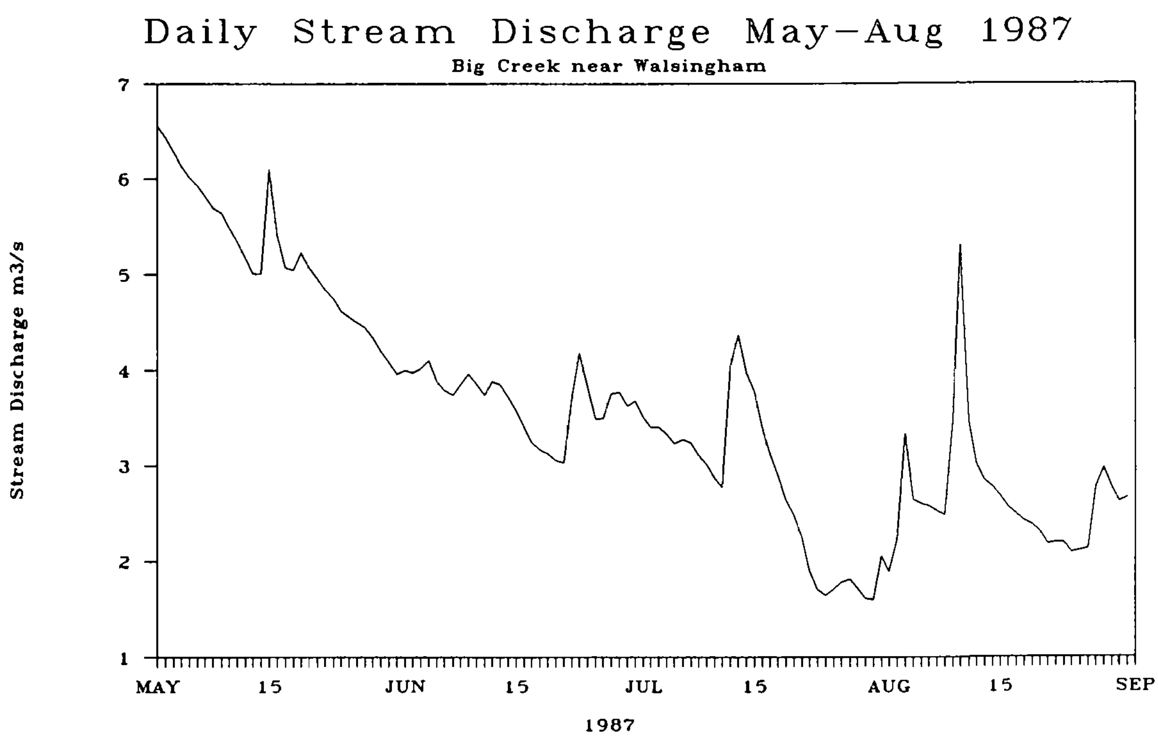
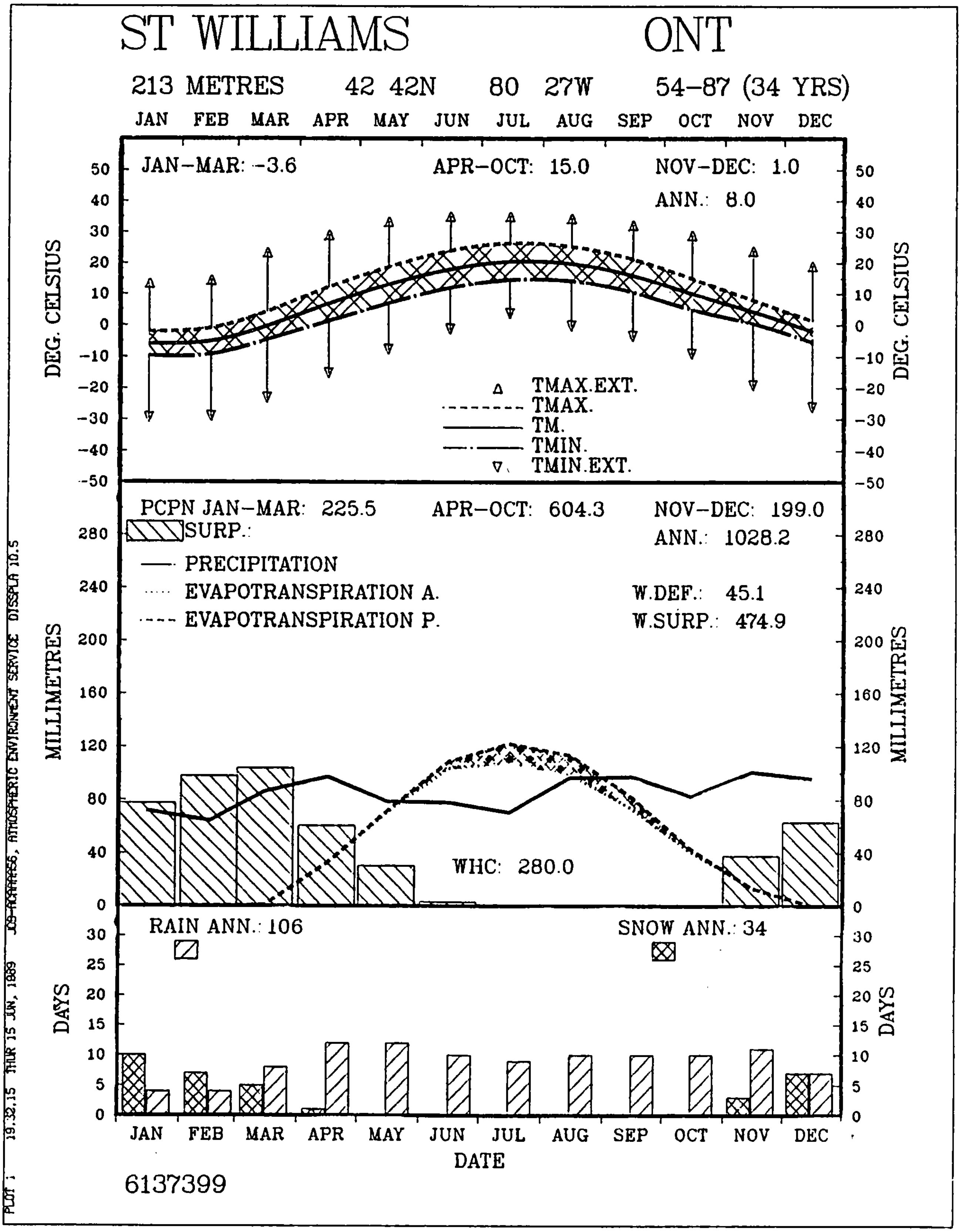


Figure 5.25 Daily stream discharge (May - August, 1986) in Big Creek at Walsingham.

Figure 5.26 Biogeoclimatic profile for St. Williams, Ontario.



ST WILLIAMS ONT

213 METRES 42 42N 80 27W 54–87 (34 YRS)

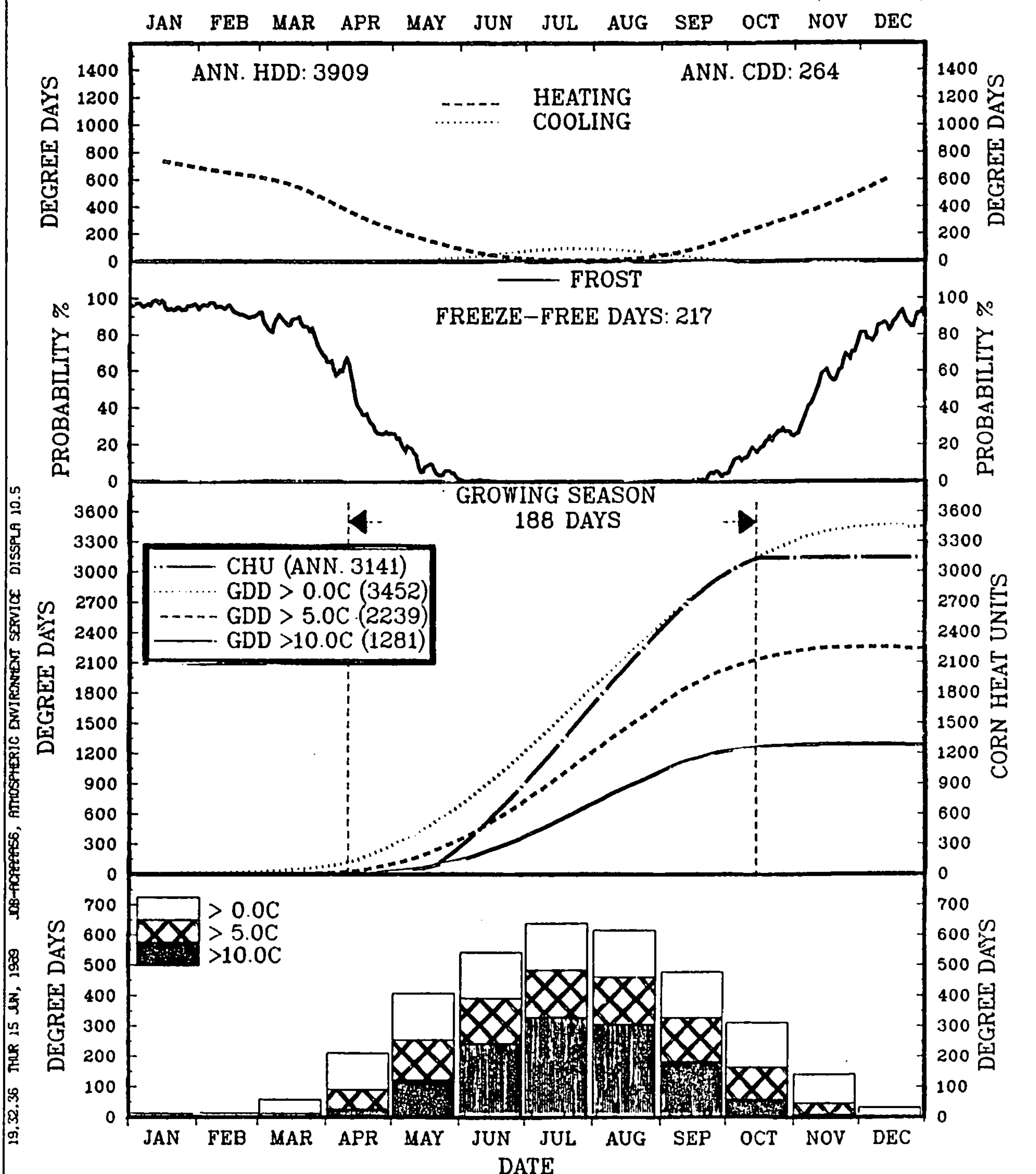


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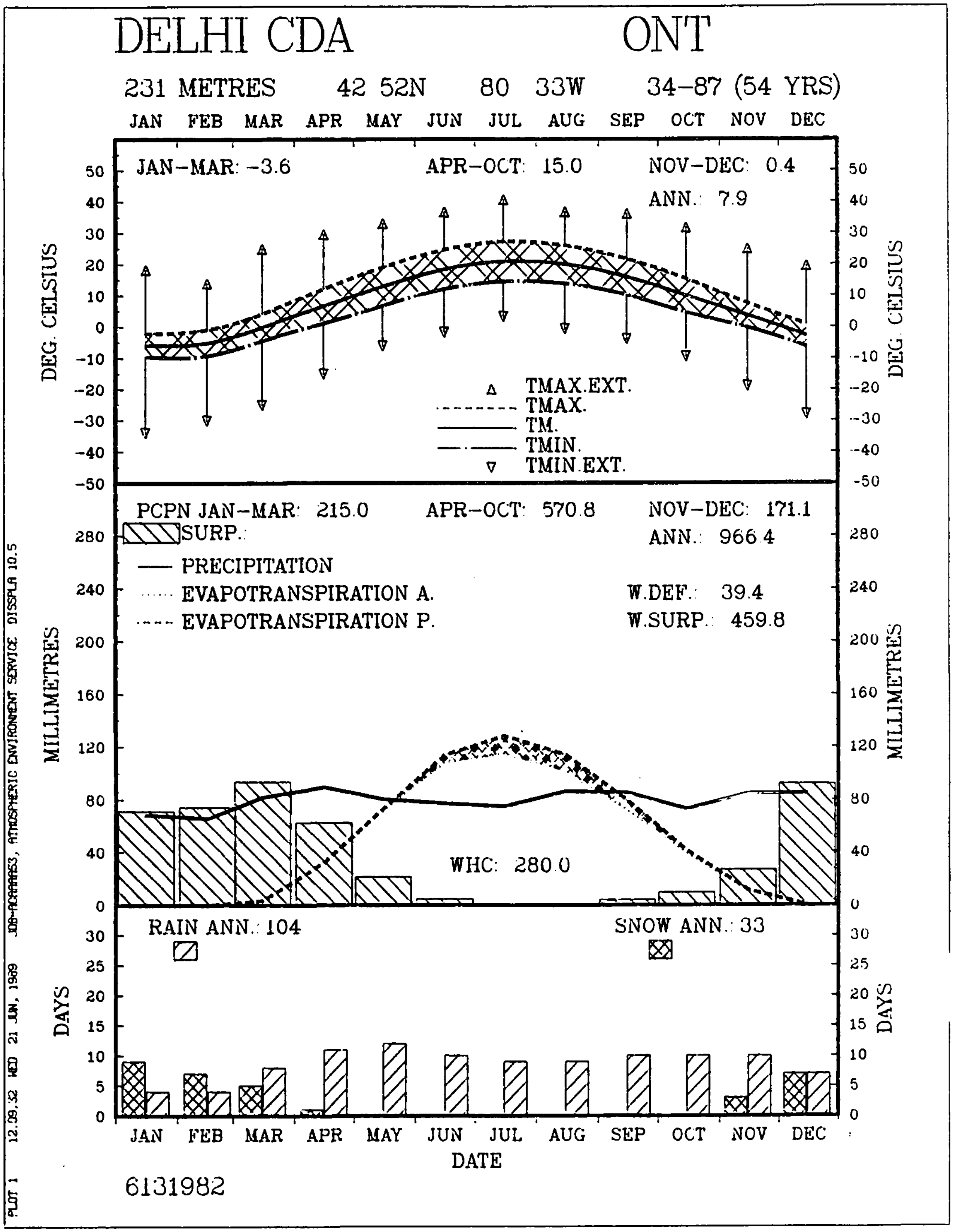
Figure 5.27 Biogeoclimatic profile for Delhi CDA, Ontario.



DELHI CDA ONT

231 METRES 42 52N 80 33W 34–87 (54 YRS)

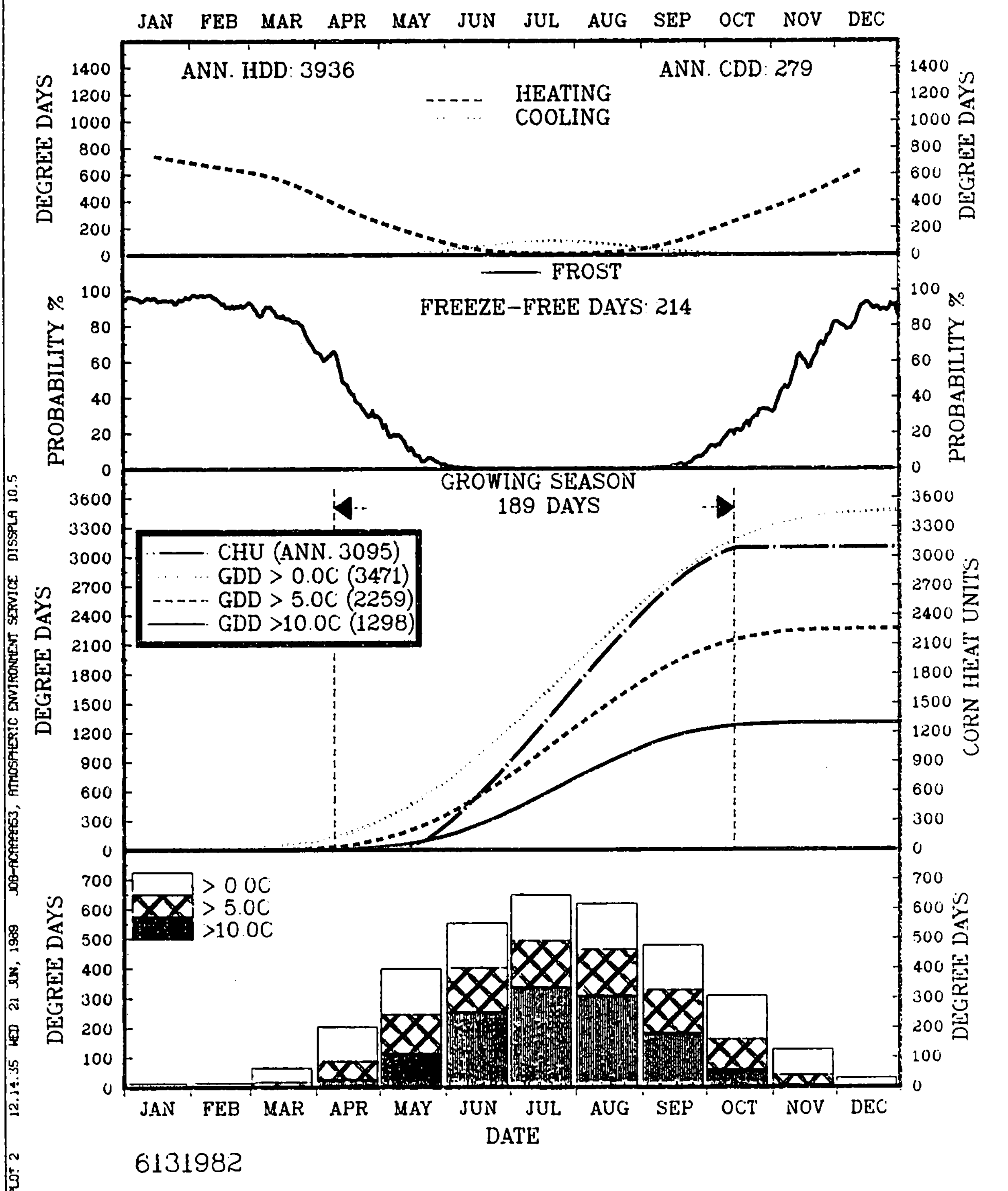


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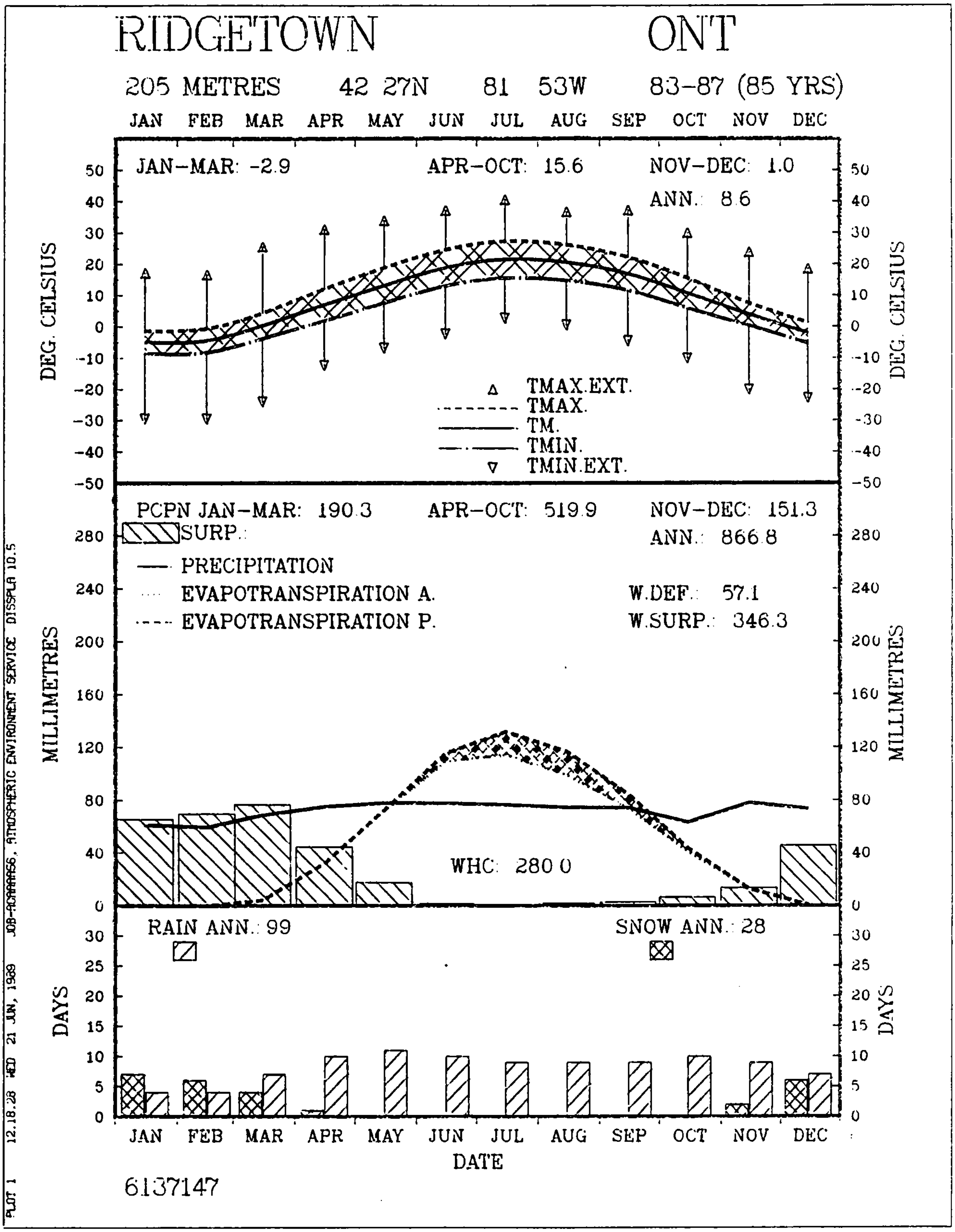
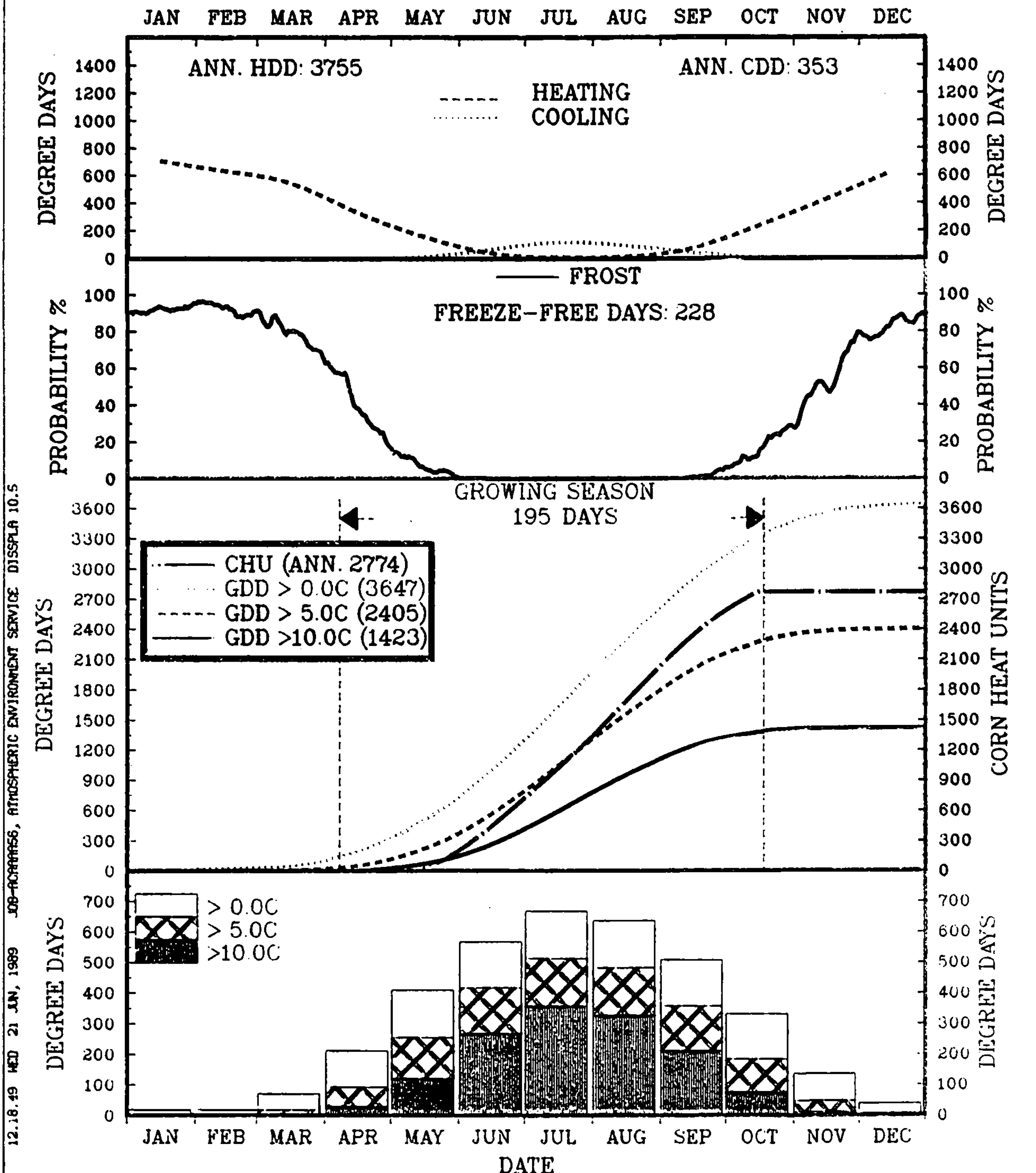
Figure 5.28 Biogeoclimatic profile for Ridgetown, Ontario.



RIDGETOWN ONT

205 METRES 42 27N 81 53W 83-87 (85 YRS)



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The Rondeau area is represented by the nearest climate monitoring station at Ridgetown (Figure 5.28). Mean annual temperature at Ridgetown is 8.6°C with mean annual precipitation of 866.8 mm.

5.3 Summary of Pesticide Use

5.3.1 Big Creek Watershed

Tables 5.4 and 5.5 summarize pesticide and herbicide use in Big Creek and Rondeau Bay areas. Information is presented by crop type, period of application, product applied and application rate. Following is a summary by crop type of the information assembled in each of the aforementioned tables.

5.3.1.1 Flue-cured Tobacco

Tobacco forms a significant acreage of cropland in the Big Creek watershed, being in the centre of Ontario's most important tobacco growing region. The light loamy sands on which this crop is most successful, requires extensive treatment prior to planting in late May/early June. Herbicides such as glyphosate or pebulate are applied before fumigation and is followed by a spraying of diphenamid at planting time. A second spraying is usually applied in a 30 cm band over the row. Soil fumigants, notably 1,3 dichloro-propene (Vorlex Plus) are applied in early May to control nematodes and black root rot. Row application of fumigants (injection 42" apart) is now used over broadcast application (injection 8" apart) which required twice as much material. The active ingredient currently used in 1,3 dichloropropene is able to biodegrade fairly quickly.

Fatty alcohol is used as for sucker control from mid July to mid August. Normally two applications are made during the year. Insecticides are used for cutworms, maggots, hornworms and aphids. Cutworms are the most serious pest to tobacco production in this area. Three options are available to the grower; 1) cover crop treatment in late April (15% growers), 2) soil treatment in mid May (35% growers) and 3) post planting in late May/early June (50% growers). A number of products are used in all three options including cypermethrin, deltamethrin, permethrin and chlorpyrifos. A fourth option, not a registered treatment, involves the diluting of acephate into the planting water. Treatment for maggots by diluting diazinon in planting water is used on about 20% of Ontario's tobacco crop. Hornworms and aphids are contolled by the same treatment, the most popular material being the application of acephate from mid July to mid August. Other pests such as wireworm are not a problem in this area. Fungicides have not been used since the last outbreak of blue mold in 1981.

TABLE 5.4

BIG CREEK WATERSHED:

PESTICIDE USE ON VARIOUS AGRICULTURAL

AND UTILITY LAND USES

1) **Flue-cured Tobacco**

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Nematode/Black Root Rot (fumigant)	First 2 weeks in May	1,3-dichloro-propene	Vorlex Plus	28 L/ha. (107 cm. rows) Note: Growers use low rate is calculation of application
		1,3-dichloro-propene	Telone II	75 L/ha. (107 cm. row)
Weed Control	1) Late April/early May	pebulate	Tillam	6.3 - 7.7 L/ha.
	(before fumigation)	glyphosate	Roundup	2.35 L/ha.
	2) Late May/early June (planting time)	diphenamid	Enide	9.0 - 13.0 kg/ha. (applied to 12" band over row - rates given per treated ha. Multiply by a factor of 4 for actual hectarage)
Sucker Control	Mid July - mid August (normally 2 applications)	fatty alcohol	Emtrol or	17 L/ha before topping 19 L/ha after topping
		fatty alcohol	Delete or	17 L/ha (before) 20 L/ha (after)
		fatty alcohol	Pfizol 10	17 L/ha (before) 20 L/ha (after)
Cutworm Control	Three options (grower chooses one)			
	1) Cover crop (15%) (mid - late April)	deltamethrin	Decis	2.5 EC - 200 mL/ha
		cypermethrin	Ripcord	400 EC- 90mL/ha
		permethrin	Ambush	500 EC- 140mL/ha
		chlorpyrifos	Lorsban	4 E - 1.2 L/ha

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
	2) Soil treatment (35%) (mid May)	deltamethrin	Decis	2.5 EC (400-800 mL/ha)
		cypermethrin	Ripcord	400 EC (175-350 mL/ha)
		permethrin	Ambush	500 EC (140-275mL/ha)
	3) Post planting (50%) (late May/early June)	deltamethrin	Decis	2,5 EC - 400 mL/ha
		cypermethrin	Ripcord	400 EC - 175 mL/ha
		acephate	Orthene	75% SP - 1.5 kg/ha
		permethrin	Ambush	500 EC - 140 mL/ha
Maggots	Late May/early June (planting time)	diazinon	Basudin	42 g/180 L water (< 20% of Ont. crop treated)
Hornworms/ Aphids	Mid July - mid August	acephate	Orthene	75% SP, 725 g/ha

2) **Fruit Crops**

a) Apples

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED Generic Name	MATERIAL USED Commercial Product	APPLICATION RATE
Scale Insects, Mites	Late April/early May (Silver tip to 1/2" green to tight cluster)		Superior Oil (60-70 vis.)	50 L/ha (trees 4.5 - 5.5 m. high)
Scab	Late April - early July Also July/August if necessary (6-10 applications/year according to rainfall and tree development)	metiram (fungicide)	Polyram	6.0 kg/ha
Tentiform Leaf Miner	Early to mid May	deltamethrin	Decis	2.5 EC 500 mL/ha (70% of growers)
		azinphos methyl	Guthion APM	2.1 kg/ha (30% of growers)
Mullein Bug and/or Plum curculio	Early June	diazinon	Diazinon	3.25 kg/ha (30% of growers)
		azinphos methyl	Guthion	2.1 kg/ha (70% of growers)
First Codling Moth Spray	Early to mid June	azinphos methyl	Guthion	2.1 kg/ha
		phosmet	Imidan	3.75 kg/ha (100% of growers)
Codling Moth, Apple Maggot	July and August	phosmet	Imidan	3.75 kg/ha
		phosalone	Zolone	5.0 kg/ha
Fireblight	May, June	streptomycin sulfate	Agri-Mycin 17	600 g/1000l (30% of growers)
Weeds	May (1 - 2 applications/year)	paraquat	Gramoxone	5.5 L/ha
		terbacil	Sinbar	2.25 - 4.5 kg/ha
		napropamide	Devrinol	9.0 kg/ha
		simazine	Princep Nine-T	2.5 - 5.0 kg/ha
		glyphosate	Roundup	2.25 - 12 L/ha (depending on type of weed)

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
b) Strawberries				
First Year:				
Site preparation	Fall or early spring (October or April)	trifluralin	Treflan	1.1 - 2.1 L/ha
Weed control - post planting (First year)	Several weeks after planting	terbacil	Sinbar	275 - 550 g/ha
Second Year:				
Strawberry Clipper Weevil	Late April (after straw taken off)	carbofuran	Furadan	1.1 L/ha
Fruit Rot	Late April - June (5 fungicide sprays a year)	captan benomyl iprodione	Captan 80% WP Benlate Rovral 50% WP	4.25 kg/ha 2.0 kg/ha (Grower has choice of one)
Weed control - post harvest	Fall (after mowing and prior to mulching)	terbacil	Sinbar (80 WP)	700 - 850 g/ha

3) **Field Crops**

a) Corn

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Weeds	First two weeks of May	metolachlor	Dual (960 g/L) (principle product used)	2 - 2.75 L/ha Lowest rate used on sand due to sensitivity (no clay colloids to tie up chemicals in
		or		
		cyanazine	Bladex (480 g/L)	3.75 - 5.5 L/ha
			Bladex (80 WP)	2.25 - 3.25 kg/ha (Used in combination - Lowest rate of application on sand)
		or		
		atrazine	Atrazine (500 g/L)	2.25 - 3.75 L/ha
			Atrazine	1.2 - 1.94 L/ha (Being used less frequently because of problem in rotation, i.e. carry over in succedding years)

b) Soybeans

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Weeds	Last two weeks of May	metoachlor	Dual (960 g/L)	1.75 - 2.75 L/ha
		linuron	Afolan (450g/L)	1.9 - 2.5 L/ha
			Lorox (50 DF)	1.38 - 2.29 kg/ha

c) Rye

No herbicide applied to this crop. It is not normally harvested due to its low commercial value. Almost all rye planted in the Big Creek watershed is plowed under as green manure.

d) Mixed grains (oats, barley)

Acerage too small in watershed to be of significance. Generally no herbicides are used on this field crop.

4) **Vegetable Crops**

a) Tomatoes

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Bacterial Spot, Bacterial Speck, Bacterial Canker, Anthracnose, Early Blight, Late Blight	Mid June - mid August (5 applications a season)	chlorothanlonil mancozeb	Bravo Mancozeb 80 WP	2.8 - 3.2 L 3.25 kg (2 1/2 of each fungicide)
Weeds	Early May (once)	trifluralin metribuzin	Treflan Sencor	1.1 - 2.1 L/ha 0.5 - 1.4 L/ha (often used together)

5) **Specialty Crops**

a) Ginseng

	May - late August	mancozeb	Dithane M-45	25 lbs/ac
Weeds	No applications made			

b) Peanuts

Very little pesticide used as there are few pests in this particular area. In Ontario there are no large single genotype crops which tend to be susceptible to disease. Peanuts are grown on former tobacco land which is usually clean.

5) Utility Corridors

a) Union Gas

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Weed control at stations (gravel) (annual grasses and broadleaf weeds)	April/May (one application)	paraquat/ simazine	Terraklene	25 L (liquid) used for 170 stations in area (Port Dover-Waterford-Norwich-Tillsonburg) No spraying along easement lines. Seldom near a stream. Hand weed in stations near streams.

b) Regional Roads/Township Roads

Herbicides are not generally applied to both Regional and Township roads in the Region of Haldimand-Norfolk. The Tp. of Delhi and Tp. of Norfolk do not spray because of the potential risk to tobacco crops.

TABLE 5.5

RONDEAU MARSH WATERSHED

PESTICIDE USE ON VARIOUS AGRICULTURAL

AND UTILITY LAND USES

1) Onions

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Weed Control :				
1) Pre-emergence (stale seedbed)	Last 2 weeks in April	glyphosate or paraquat	Roundup Gramoxone	7.0 - 12.0 L/ha (perennial weeds) 3 - 5.5 L/ha (seedling weeds)
2) Pre-emergence (germinating annuals and seedling grasses)	Last week of April	chlorpropham	CIPC	9.45 - 18.9 L/ha
3) Post-emergence				
a) broadleaf weeds	First 2 weeks of June (Once started, spraying occurs every 7-10 days. Last spray 52 days before harvest)	oxyfluorfen	Goal	0.62 L/ha (Most growers spray 1/5 of recommended rate)
b) annual grasses and grassy windbreaks	Applied 1 - 2 times a season	sethoxydim	Poast plus Assist	0.8 - 1.6 L/ha (rate higher on rye and barley windbreaks)

Onion Maggot and Thrips:

a) First period (onions seeded with granular insecticide)	Last 2 weeks of April	fonofos	Dyfonate	22.5 kg/ha
			or	
		chlorpyrifos	Lorsban	8 - 16 kg/ha
b) Second period	Mid June to first 2 weeks of September (Average of 6 applications. One to two sprays likely of parathion)	cypermethrin	Ripcord	175 mL/ha
		or		
		diazinon	Diazinon	(50% WP) 1.0 kg/ha
		parathion	Parathion	2.25 kg/ha

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Smut :				
a) Time of seeding	Last week of April	carbathiin + thiram	Pro-Gro	60 g. per 2.3 kg of seeds
Botrytis Leaf Spot	First 2 weeks of July (sprayed every 7-10 days weather dependent. 4 - dry years 8 - wet years	maneb or	Maneb	80% WP 2.25 kg/ha
		mancozeb or	Mancozeb	80% WP 22.25-3.25 kg/ha
		iprodione	Rovral	1.5 kg/ha
Sprout inhibitor	One application in August	maleic hydrazide	Royal MH 60 SG	No inforamtion in OMAF Pub. 363 (not always applied to entire crop)

2) Carrots

CONTROL OBJECTIVE	APPLICATION PERIOD	MATERIAL USED		APPLICATION RATE
		Generic Name	Commercial Product	
Weed Control :				
1) Pre-emergence	End of April - mid June (dependent on time of planting)	glyphosate	Roundup	2.4 - 3.5 L/ha (annual) 7/0 - 12.0 L/ha (perennial)
		or		
		paraquat	Gramoxone	3 - 5.5 L/ha
2) Pre-emergence	Applied after above herbicide used	linuron	Lorox	1.25 - 2.25 kg/ha
		or		
		prometrye	Gesagard	2.25 - 4.25 kg/ha
3) Post-emergence	One application - period dependent growth stage	herbicidal oil		600 - 800 L/ha (overall spray) 300 - 400 L/ha (rows only)
		diclofop-methyl	Hoe-Grass	3.5 L/ha (if problem with grassy weeds)
Carrot Rust Fly	Late May - Sept. (6 - 8 sprays/year however average would be less even if pest present)	diazinon	Diazinon	50% WP 1.1 kg/ha
		or		
		parathion	Parathion	15% WP 2.25 kg/ha
Carrot Weevil	Two applications just after emergence	phosmet	Imidan	50% WP 2.25 kg/ha
Carrot Leaf Blight (maintain healthy carrot tops)	Early - mid August within 1 - 2 weeks of harvest (4 - 7 sprays/year)	manocezeb	Diathane M-45	2.25 kg/ha
		or	Manzate 200	2.55 kg/ha
		or		
		chlorothalanil	Bravo 500	2.4 - 3.2 L/ha

5.3.1.2 Fruit Crops

Apples

Orchard acreage in the Big Creek watershed region is concentrated somewhat to the east of the drainage basin in the vicinity of Vittoria and Walsh and to the west around Clear Creek. Only a small proportion of the Big Creek drainage basin is in apple orchard and most it concentrated in the southern portions of the watershed.

Of all crop types that occur within the watershed, apples would appear to receive the greater amount of pesticide use and the largest variety of materials. The first spraying occurs in late April and early May during the silver tip to tight cluster stage of bud development. Superior oil, a non-toxic biological control for scale insects and mites, is used. From early to mid May (tight cluster pink to full pink) a synthetic pyrethroid spray is applied to control tentiform leaf miner with deltamethrin being the most commonly used commercial product (70% of growers in area) followed by azinphos methyl (30% of growers). During the calyx stage, (early June or after most petals have fallen), diazinon or azinphos methyl is sprayed for mullein leaf bug and/or plun curculio caterpillars followed 7 to 10 days later by a first codling moth spray of either azinphos methyl or phosmet. Successive sprays for both codling moth and apple maggot is performed in July and August. The number of times an orchard will need to be sprayed will depend on the severity of the codling moth infestation and precipitation patterns. Special sprays are occasionally used by growers in the area for such things as aphids, European red mites and white apple leafhopper. The major commercial products include Sevin, Pirimor, Phosalone, Omite and Kelthane. Aphids, mites and leafhoppers are not a significant problem in the Norfolk region hence these products represent only a very small proportion of all insecticide sprays used.

Fungicides are widely used for scale and fireblight. Polygam, the most commonly used fungicide, is applied from late April to early July to control apple scab. On average 6 to 10 applications are made a year according to rainfall and tree development. Although not a major problem it is estimated that about 30% of growers in the area spray for fireblight during May and June. The most commonly used material is streptomycin sulfate (Agri-Mycin 17).

A number of herbicides are used by growers to control weeds around young trees. Commercial products used by growers include Glyphosate, Sinbar, Devrinol, Princep Nine-T and Gramoxone. The application rates of some such as Glyphosate will largely depend on the type of weed that is being controlled. Generally one to two applications a year are made to control emerged annual and perennial weeds that otherwise will compete for the resources needed by the fruit tree.

Strawberries

Stawberries are an important fruit crop in the Norfolk sand plain area. Much of the acreage is located in the northern portions of the watershed towards Scotland and to the east near Vittoria (which is outside of the watershed basin). This is a short cycle perennial crop that requires site preparation before planting. Herbicides are used exclusively during the first year. Treflane is applied either in the fall (October) or early spring (April) to prepare the site for planting. Approximately four to six weeks after planting, Sinbar is applied at a low rate to control germinating and seedling weeds. Weed control for the balance of the first year is through cultivation and howing. Insecticides are not generally applied during the first year in this particular strawberry growing area of Ontario.

During the second year the plants will begin to bear fruit. An insecticide, Furadan, is applied in late April after the straw is taken off the plants to control the strawberry clipper weevil. An average of five fungicide sprays a year are made to control fruit rot (botrytis). Growers will choose one of the following materials; Captan, Benlate and Rovral, and spray during the following periods; 1) first spray - when buds are visible in crown, 2) when buds show white, 3) first bloom, 4) 7 to 10 days later, 5) end of harvest. After the harvest the plants are mowed.

After mowing but prior to mulching, the herbicide Sinbar is applied to control winter annuals and weeds germinating in early spring. Sinbar may be applied the following spring immediately after the mulch straw is removed, however lower rates would have to be applied in the preceding fall.

5.3.1.3 Field Crops

Corn

Field corn has increased in acreage within the watershed area as cash crops like tobacco experience decline caused by the setting of lower quotas. In this particular area, corn diseases are not considered a problem hence few, if any insecticides are used. Moreover, corn seed used today is treated for fungus. Herbicides are used extensively to control annual grass and broadleaf weeds. Herbicides are generally applied to the soil during the first two weeks of May before the corn is planted. Dual (metalachlor) is the principal herbicide product currently used on corn. The lowest rates given in the Guide to Weed Control (OMAF 1989) would be used on the light sands found in the Big Creek watershed as there are no clay colloids to bind the chemicals. Atrazine was once the main product, however today it is being used less frequently. Atrazine creates problems in rotation as there is usually a carry over of the material within the soil in succeeding years causing the risk of damage to other crops. Bladex (cyanazine) is also a popular herbicide where the soils contain a higher loam content. This product does not have residual problems associated with Atrazine.

Soybeans

Soybeans is another crop which has replaced some of the lost tobacco acreage in the Big Creek watershed. A large number of herbicides are used on soybeans as outlined in the Guide to Weed Control (OMAF 1989) however, the principal herbicides used to control broadleaf weeds in this region include Dual and Linuron which includes the products Afolan and Lorox. Generally these herbicides are applied to the soil during the last two weeks of May just prior to planting.

Rye

No herbicide is applied to this crop. Rye grown in this region is not normally harvested due to its low commercial value. Almost all rye planted in the Big Creek watershed is rotational with tobacco and corn and is plowed under as green manure.

Mixed Grains (oats, barley)

Acreages of mixed grain is localized to the northern portions of the watershed and are too small to be of significance. Generally no herbicides are used on this field crop.

5.3.1.4 Vegetable Crops

Tomatoes

Approximately 1200 acres of tomatoes are grown in an area from Port Rowan to Clear Creek in the southern part of the watershed. Much of this occurs on the Port Rowan clay plain, however tomatoes are also found on the loamier sands as well. A number of bacterial and fungus diseases (Bacterial Spot, Bacterial Speck, Bacterial Cancer, Anthracnose, Early Blight, Late Blight) that commonly attack tomato plants are largely controlled through the application of Bravo or Mancozeb. Spraying occurs over a period from mid June to mid August with an average of 5 applications a season. Both fungicides are used by growers with about half of each being used on the total seasonal application.

A single application of herbicide is given to the soil each year before the tomato plants are transplanted into the field. Treflan and Sencor are most commonly used and are frequently used together to control germinating annual grases and annual broadleaf weeds. The application is made in early May.

5.3.1.5 Specialty Crops

Ginseng

The light loamy sands of this particular region have in more recent years become a centre for ginseng production. The areas of concentration occur just outside the Big Creek watershed, i.e. Waterford, Scotland and Vanessa. Total production area in this region is approximately 245 ha making it a relatively minor component in overall cash cropping. In the Big Creek watershed small amounts of ginseng acreage are found. No published OMAF guidelines can be found on pesticide use for this crop. The fungicide Dithane M-45 is applied periodically from May to late August. Herbicides are not applied as ginseng plants are very susceptible to damage from these products. Weeds are controlled with straw mulch and hand removal.

Peanuts

Peanuts are a specialty crop which were originally experimental and now have become established on a modest scale. Very little pesticide material is required on peanuts in this particular area. Unlike southern U.S. states there are no large single genotype peanut crops which tend to be susceptible to disease. Peanuts are grown on former tobacco land which is usually clean of weeds and fungus diseases.

5.3.2 Rondeau Bay Marsh

5.3.2.1 Vegetable Crops

Onions

Onions are the predominant vegetable crop on the muck soils to the north and west of Rondeau Bay. Herbicide use is extensive from early spring to harvest. Two pre-emergent sprays are made beginning with a single application of Glyphosate or Gramoxone in the last two weeks of April followed by an application of CIPC (chlorpropham) shortly thereafter. Post emergent herbicides begin the first two weeks of June with the application of Goal (oxyfluorfen). Once started, this material is sprayed every 7 to 10 days to control broadleaf weeds with the last spray occuring around 52 days before harvest. Annual grasses and grassy windbreaks planted between the rows are killed with a product called Poast plus Assist, the latter being an adjuvant that makes the herbicide more effective. This is applied once or twice a season.

Insecticide applications to control onion maggot and thirps begin in the last 2 weeks of April during seeding time. Dyfonate or Chlorpyrifos is in granular form and incorporated with the onion seed at the time of planting. A second period involving an average of six applications extends from mid June to harvest (first two weeks of September). Products used include either Cypermethrin, Diazinon or Parathion. It is not known which of the three is the most predominantly used. It is known that one or two sprays is probably of parathion.

Fungicides are used to control smut and botrytis leaf spot. Seeds are treated with Pro-Gro, a mixture of carbathiin and thiram either through coating or pelleting. The seeds are planted during the last week in April. Beginning in the first two weeks of July fungicides such as Maneb, Mancozeb or Rovral are sprayed every 7 to 10 days to control botrytis leaf spot. In dry years as few as four applications will be made while in wet years up to 8 sprayings may occur.

Maleic hydrazide sprays such as Royal MH 60 SG are used to improve the storage life and quality of onions by inhibiting sproutage in storage. One application is usually made in August. This sprout inhibitor is not always applied to the entire crop as some onions will be sold or processed soon after havesting.

Carrots

Carrots are the second most important vegetable grown on muck soils in Ontario. Due to the similar soil and moisture conditions, carrots share many of the same weed problems as onions and hence require similar treatment with herbicides. Unlike onions, spray periods are quite variable as they are dependent upon planting time. Carrots may be planted anytime between the end of April and mid June. Two pre-emergent sprays are applied, the first being Glyphosate or Gramoxone, the second Lorox or Gesagard shortly thereafter. Post-emergent herbicide spraying includes one application of herbicidal oil as soon as the true leaves develop and an application of Hoe-Grass to control annual grassy weeds.

The main insect problem is carrot rust fly. This is controlled either through Diazinon or Parathion. It is recommended that the insecticide is sprayed six to eight times a year beginning in late May and ending in September, however the average tends to be less. If carrot weevil is present two applications of Phosmet are made just after emergence of the leaves. It is important to maintain healthy carrot tops in order to reduce desication during storage. Carrot leaf blight, a fungus which attacks the tops is controlled with the fungicide product Bravo. Four to seven sprays a year are made commencing in early to mid August and ending one to two weeks before harvest. The number of applications will also depend on how long the carrots are left in the field and the amount of precipitation.

6.0 REFERENCES

Chapman, L.J. and D.F. Putnam. 1973. The physiography of southern Ontario. Ont. Res. Foundation, Univ. Toronto Press. Toronto, Ontario.

Coleman, D.E. 1982. Stratford-Avon Environmental Management Study. Technical Report No. 4. Ontario Min. Env. Toronto, Ontario.

International Joint Commission. 1980. Pollution in the Great Lakes Basin from land use activities. An IJC report to the governments of the U.S. and Canada. Windsor, Ontario. 1980.

Long Point Region Conservation Authority. 1979. Big Creek Watershed Background Study. Draft #1. Long Point Region Conservation Authority, Simcoe, Ontario.

Ontario Ministry of Agriculture and Food. 1987. Agricultural Statistics for Ontario, 1987. Statistical Services Unit, Economics and Policy Coordination Branch, August 1988. Publication 20. Toronto, Ontario.

Ontario Ministry of Agriculture and Food. 1989. Guide to weed control. Publication 75. Toronto, Ontario.

Yakutchik, T.J. and W. Lammers. 1970. Water resources of the Big Creek Drainage Basin. Ont. Wat. Res. Comm., Water Resources Rep. 2. Toronto, Ontario.

APPENDIX I

INDIVIDUALS AND AGENCIES CONTACTED

Big Creek Watershed

1.0 Agricultural Land Use

1.1 Simcoe Research Station: 1-519-426-7120
Pam Fisher: Fruit Specialist
Steve Rowe/Craig Hunter: Vegetable Crop Specialists
Henriette Plas: Field Crop Specialist

1.2 Delhi Research Station: 1-519-582-1950
Milt Watson: Tobacco Specialist

2.0 Regional Roads: 1-519-426-1523
Paul Swic: Main Garage, Simcoe

3.0 Union Gas: 1-800-265-8403
Bert Smith: Simcoe

4.0 MTO, Southwestern Region: 1-519-681-1441
Doug Hohnsten: Engineering Services (knows Norfolk region)

5.0 Ontario Hydro: 1-800-668-8500 (ask for 592-4323)
Bryan Allen: Environment Specialist
Pesticides and Biology Control

Rondeau Marshes

1.0 County Roads: 1-800-265-0553
Mac Allison: Maintainance Supervisor

2.0 Agricultural Use

2.1 Harrow Research Station: 1-519-738-2251

Todd Leuty: tree fruits and grapes specialist

Leslie Huffman: vegetable crop specialist

2.2 College of Agricultural Technology (Ridgetown): 1-519-674-5456

Henry Oleochowski and Ed. Tomecek: soils and crop specialists

2.3 Bradford Research Station: 1-416-775-3783

Matt Volk: Field Crop Specialist

Mary Ruth MacDonald: Specialist in pesticide use on muck vegetables