NOSE CREEK WATER QUALITY STUDY

PREPARED BY

PETER H. SCHONEKESS
POLLUTION CONTROL DIVISION
ALBERTA ENVIRONMENT
CALGARY, ALBERTA

FOR

ALBERTA ENVIRONMENT
PLANNING DIVISION
CALGARY, ALBERTA

Calgary, Alberta December, 1981

SYNOPSIS

The Nose Creek Water Quality Study was initiated by the Calgary Branch of the Water Quality Control Branch, Division of Pollution Control as part of a comprehensive Water Management Study for Nose Creek and West Nose Creek undertaken by Planning Division. The study was carried out from April to September of 1980.

Seven creek locations were sampled on a weekly basis for various chemical and bacteriological parameters. During storm periods, storm sewer outfalls were sampled along with several key creek locations. In addition, dry-weather samples were collected from storm sewer outfalls for comparison purposes.

The results of the study indicate that urbanization and associated storm sewer discharges have an appreciable effect on the water quality of Nose Creek and West Nose Creek. Concentrations of chemical parameters in the creeks within the urban area of Calgary can increase by as much as 49 times during storm events as compared to background values at the city boundary.

In comparing the water quality of the creeks with published criteria on the suitability for various water uses, the water within the urban area is unacceptable for use as a public water supply. It is also unacceptable for direct contact recreations. However, secondary contact recreation would be suitable during certain periods (except during storm events). For livestock watering, the results indicate the water in Nose Creek and West Nose Creek would be unsuitable in the urban areas primarily due to pesticide concentrations. The water in the creeks in the rural areas is acceptable for livestock watering. The water at all locations is generally acceptable for irrigation unless it is used to irrigate vegetable crops or other crops consumed directly by man.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Figure | Page

INTRODUCTION

Background

During the past several years considerable attention has been focused on the Nose Creek and West Nose Creek valleys in the urban centers of Calgary and Airdrie because of the rapid growth of both communities and the resultant pressures on lands within and near the valleys. The growth of these communities has also resulted in a deterioration of water quality and affected the aesthetics of adjacent lands. Along with the growth and expansion of the urban areas comes a need for open space and parkland and the Nose Creek valleys have been considered as future park areas.

Because of the various interests within the watershed area, Alberta Environment identified a need to conduct a Water Management Study for Nose Creek and West Nose Creek. As part of this study, the Water Quality Control Branch conducted the Nose Creek Water Quality Study during the summer of 1980.

Purpose of the Study

The purpose of the study was to collect needed water quality information to indicate present conditions of Nose Creek and West Nose Creek and to determine effects of urban storm sewer discharges on water quality.

Scope of the Study

From April 1, 1980 to September 30, 1980, seven creek locations on West Nose Creek and Nose Creek were sampled for chemical and bacteriological parameters on a weekly basis in order to determine general water quality characteristics within and outside of the urban areas of Calgary and Airdrie. A number of creek locations and storm sewer outfalls were sampled during storm periods to provide information on the quality of storm sewer discharges and their effect on creek water quality during storm periods. Samples of storm sewer discharges during dry-weather periods were collected to determine the effects of these discharges compared to storm discharges. The study also presents water quality criteria data to assess the suitability of the water in both creeks for various uses such as recreation, livestock watering, irrigation and as a public water supply. Some conclusions and recommendations are also presented.

Study Limitations

Because of the short duration over which the study was carried out, the data presented should not be interpreted as long-term averages. The data presented, however, are very indicative of situations for the particular time of the study because of the very intensive sampling that was carried out. A study covering seasons and for several years would give a better indication of general water quality over a longer term.

The storm data presented are indicative of particular storms that occurred during the sampling period and, because of the many variables that determine quality of storm run-off, it was impossible to sample enough storm events to get data to incorporate all variables and situations. More storm sampling would be needed to come up with reliable long-term mean values. The data however do indicate some of the magnitudes of the various chemical parameters measured for individual storm events.

GENERAL INFORMATION AND OBSERVATIONS

Drainage Basin Description

Nose Creek and its tributary watersheds cover an area that extends from the Bow River north to the region just north of Crossfield. The east-west extremeties extend west from Highway #2 almost to Cochrane (Figure 1). There are two urban areas within the basin, the Town of Airdrie and the City of Calgary.

The most significant tributary to Nose Creek is West Nose Creek, which joins Nose Creek near the International Airport and the Deerfoot Trail. The entire drainage basin covers an area of 972.6 square kilometers; the West Nose Creek drainage basin covers an area of 323.2 square kilometers.

The Nose Creek profile consists of a relatively steep portion from the Bow River to the West Nose Creek confluence, and from there the creek has a rather flat slope to the head of the watershed. The West Nose Creek profile is generally steeper. The average slope of Nose Creek is 0.0017 and the average slope for West Nose Creek is 0.003 (9).

Topography & Geology

The Nose Creek and West Nose Creek watersheds are primarily treeless. The terrain ranges from flat to moderately undulating in the western portions of the region. The region, other than the urban areas, is used primarily for agricultural activities.

Soils in the region are permeable and surficial. With a relatively treeless watershed, combined with relatively low annual precipitation, run-off co-efficients should be low (9). Because of these factors, very low storm run-off related flows can be expected in the upper watershed areas.

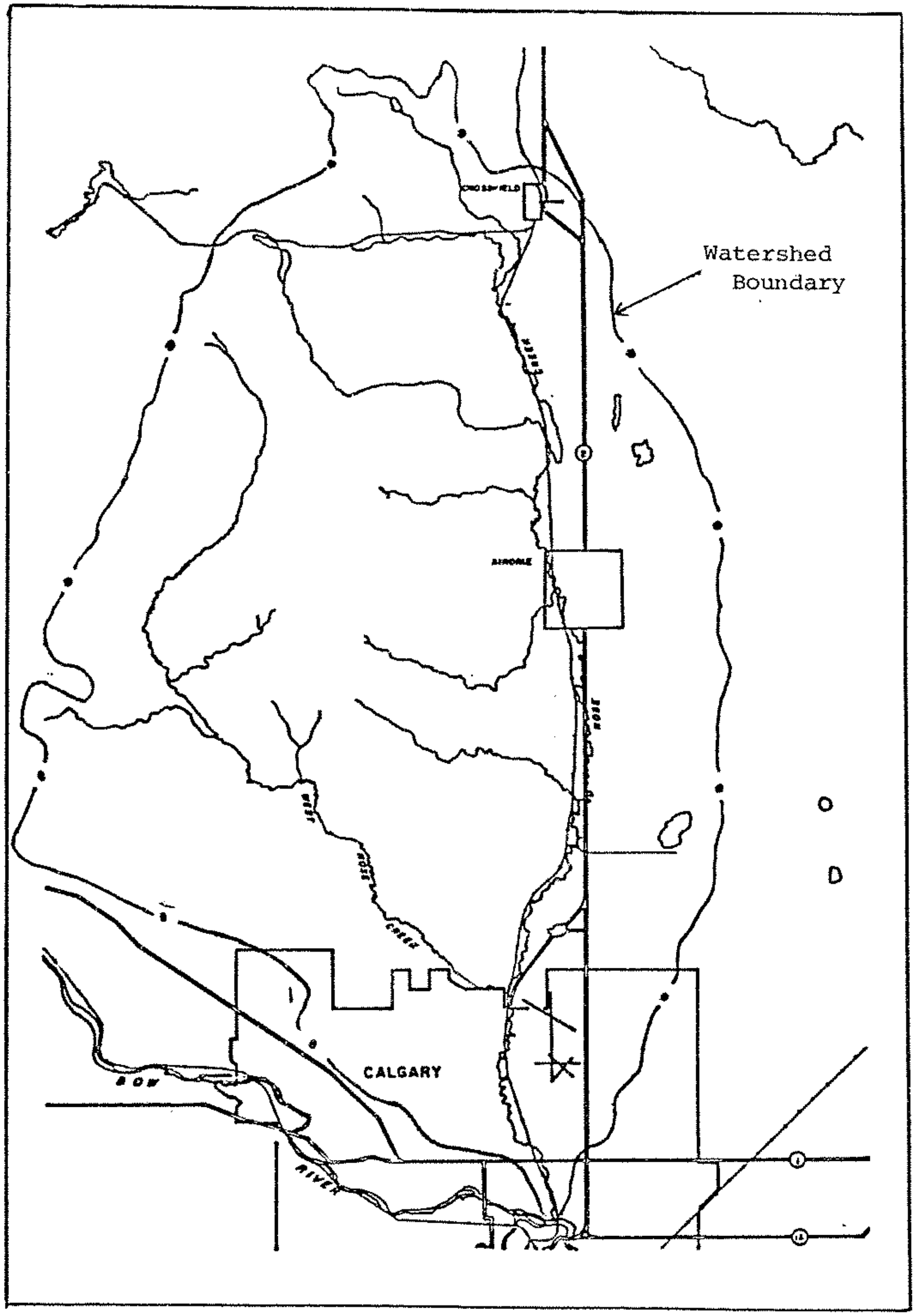


FIGURE 1. NOSE CREEK WATERSHED LOCATION

Alberta
ENVIRONMENT
Pollution Control Division
Water Quality Control Branch

Precipitation

The Nose Creek Water Quality Study was greatly dependent on storm rainfall, and without it the collection of data would not have been possible. In Table 1 a summary of rainfall for the summer of 1980 is presented along with long-term means as determined by Environment Canada (1). The table shows that the heaviest precipitation normally occurs in June; however in 1980, May had the heaviest precipitation. Almost all of the rainfall in May occurred during the last 9 days of the month. Precipitation for June was just below normal (88%), July was 65% of normal, August was 37% of normal and September had 97% of normal precipitation amounts. During the sampling program, it was noticed that many storms did not develop or reach the urban portions of the basin until very late evening or early morning. It was also observed that the Nose Hill in northwest Calgary had an influence on the direction the various storms took as they passed over the City of Calgary.

Creek Flows:

Environment Canada has a recording gauge located on Nose Creek a short distance below the confluence of West Nose Creek. For the purposes of this study, flows from this station were of little value because the gauge records combined flows for Nose Creek and West Nose Creek essentially for an area outside the City of Calgary. Ideally for this study a number of gauges would have been helpful, however, only one gauge was installed by Alberta Environment, Technical Services Division. This gauge was located near the mouth of Nose Creek on June 20, 1980 and in the future will indicate the magnitude of storm inputs between the Environment Canada gauge and the mouth of Nose Creek.

Table 1

Nose Creek Water Quality Study
Rainfall Summary - City of Calgary Gange #18

Day	April	May	June	July	August	September
1			24.0		0.2	
2		0.8	5.0			
3			3.0		0.2	4.0
4			1.6		0.8	
5						
6	1.0				.2	
7		TR			.2	
8					3.2	
9	1.4					
10					2.2	
11			1.8		1.8	
12				17.0	0.4	
13					0.2	13.6
14			6.6	0.8		1.2
15				0.2		
16						
17					0.4	3.2
18				5.8	2.4	
19			10.2	10.0		
20			1.6		4.4	
21						
22			2.4			
23		37.4	0.6			3.6
24		9.0			3.2	1.2
25	TR	15.2	6.8			
26		13.0	8.0			
27		2.2	4.2			
28		6.8	3.2	10.4		
29	0.8	TR				
30					1.0	
31						
Total	3.2	84.4	79.0	44.2	20.8	26.8
Long Term Mean	7.9	40.6	89.4	68.3	55.9	27.7

Note: All values are in mm. and tenths.

During the course of the summer, several conclusions regarding creek flows were made primarily by visual observations. These are listed below:

1. Flows above the Town of Airdrie were very low starting in June whereas flows below Airdrie continued at a slightly higher rate. This was essentially due to storm sewer dry-weather flows.

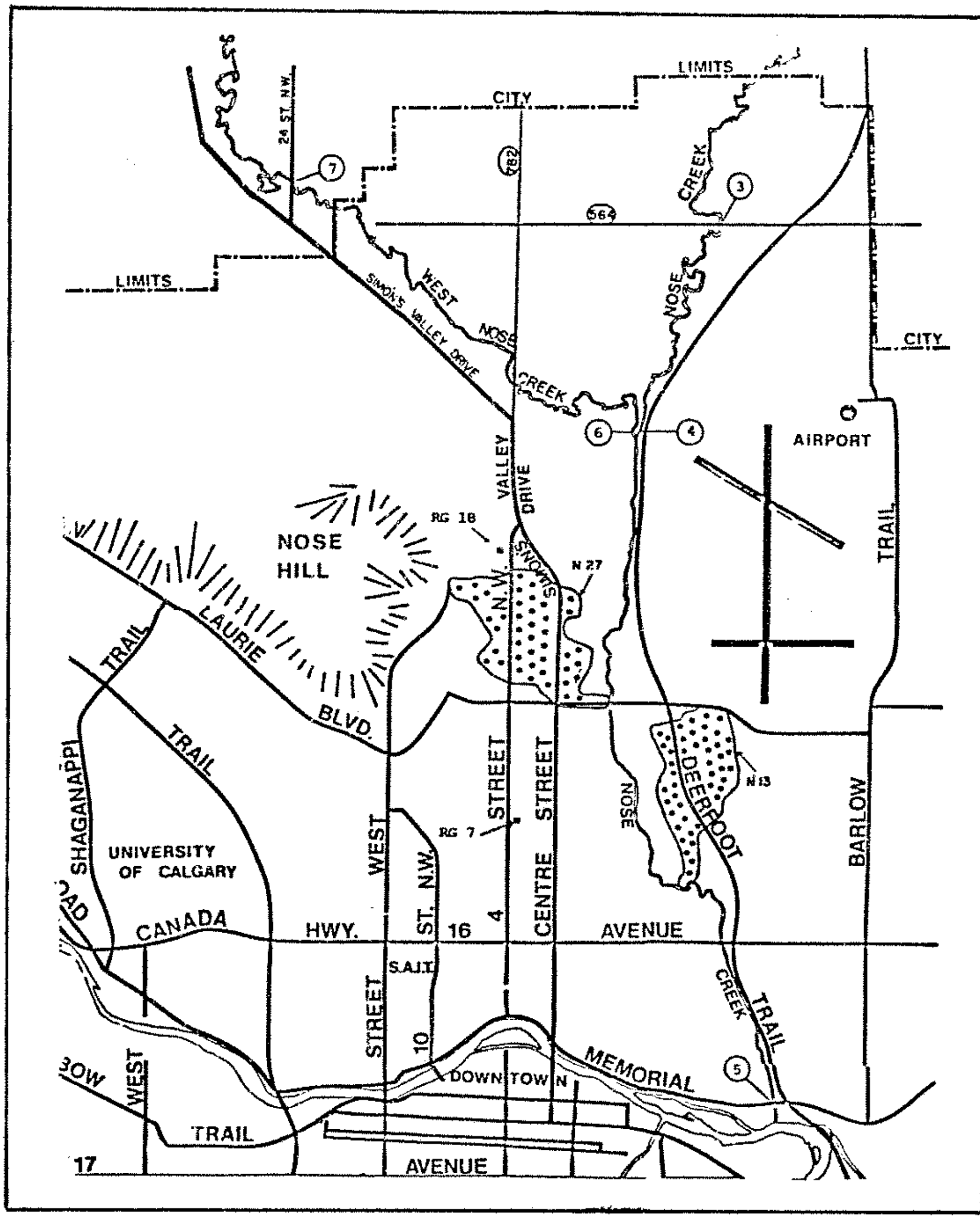
2. Nose Creek seems to have considerably lower dry-weather flows than West Nose Creek. Nose Creek is also a slower moving stream and has more "pond-like" stretches along its reach. (Only 5 major riffles were observed from site 3 to the confluence with West Nose Creek.)

3. Storm precipitation did not visibly affect flows at the Calgary city limits location on West Nose Creek (site 7), however some noticeable increase in flow was noticed on Nose Creek at the city limits (site 3). The increased flow at this location may have been due to the urban run-off from the Town of Airdrie.

Sampling Sites and Locations

In order to monitor routine water quality and to assess the effects of storm run-off in Nose Creek,a number of sampling locations were investigated and eventually seven sites were chosen. These are listed below and indicated in Figure 2.

Site 1	Above the town of Airdrie; at north town boundary
Site 2	Below the Town of Airdrie; located adjacent to Highway #2 about 1/3 mile south of southern town boundary
Site 3	Nose Creek at City limits; located on Highway # 564
Site 4	Nose Creek above confluence with West Nose Creek
Site 5	Nose Creek near the mouth; located below Memorial Drive
Site 6	West Nose Creek above confluence with Nose Creek
Site 7	West Nose Creek at City limits; located at Simmon Valley Road and 24th Street, N.W.



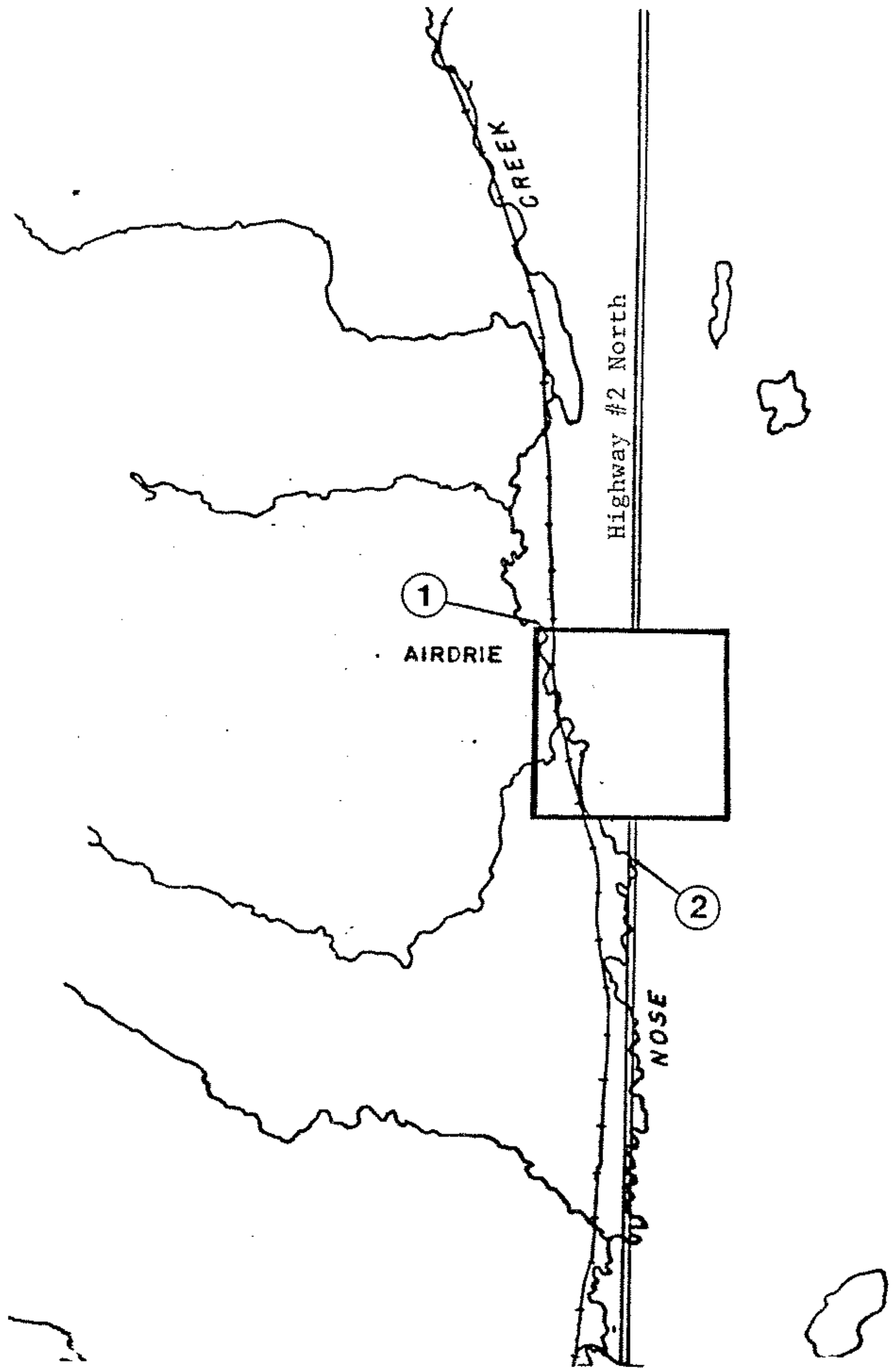
LEGEND:

⑤ Sampling Site Locations

▦ Storm Sewer Drainage Areas

■ City of Calgary Rain Gauges

FIGURE 2. SAMPLING SITE LOCATIONS ON NOSE AND WEST NOSE CREEKS



LEGEND:
① Sampling Site Locations

FIGURE 2. (Cont.) SAMPLING SITE LOCATIONS ON NOSE CREEK AND WEST NOSE CREEK

To determine the quality of storm run-off water, two storm run-off basins were studied. These were essentially different as far as land use was concerned. The two selected basins were basin N-13 and basin N-27 (Figures 2, 3 and 4).

Basin N-13 is located east of the Deerfoot Trail and covers an area of about 226 hectares. The primary land use of the area is warehousing, commerical business and light industrial manufacturing. A portion of the Deerfoot Trail is drained by this basin also.

Basin N-27 is primarily a residential area and covers an area of 199.4 hectares. The area has some parkland and school areas as well as a small portion of commerical development located around the intersection of Centre Street North and McKnight Boulevard.

Aerial and ground photographs of all sampling sites are presented in Appendix C.

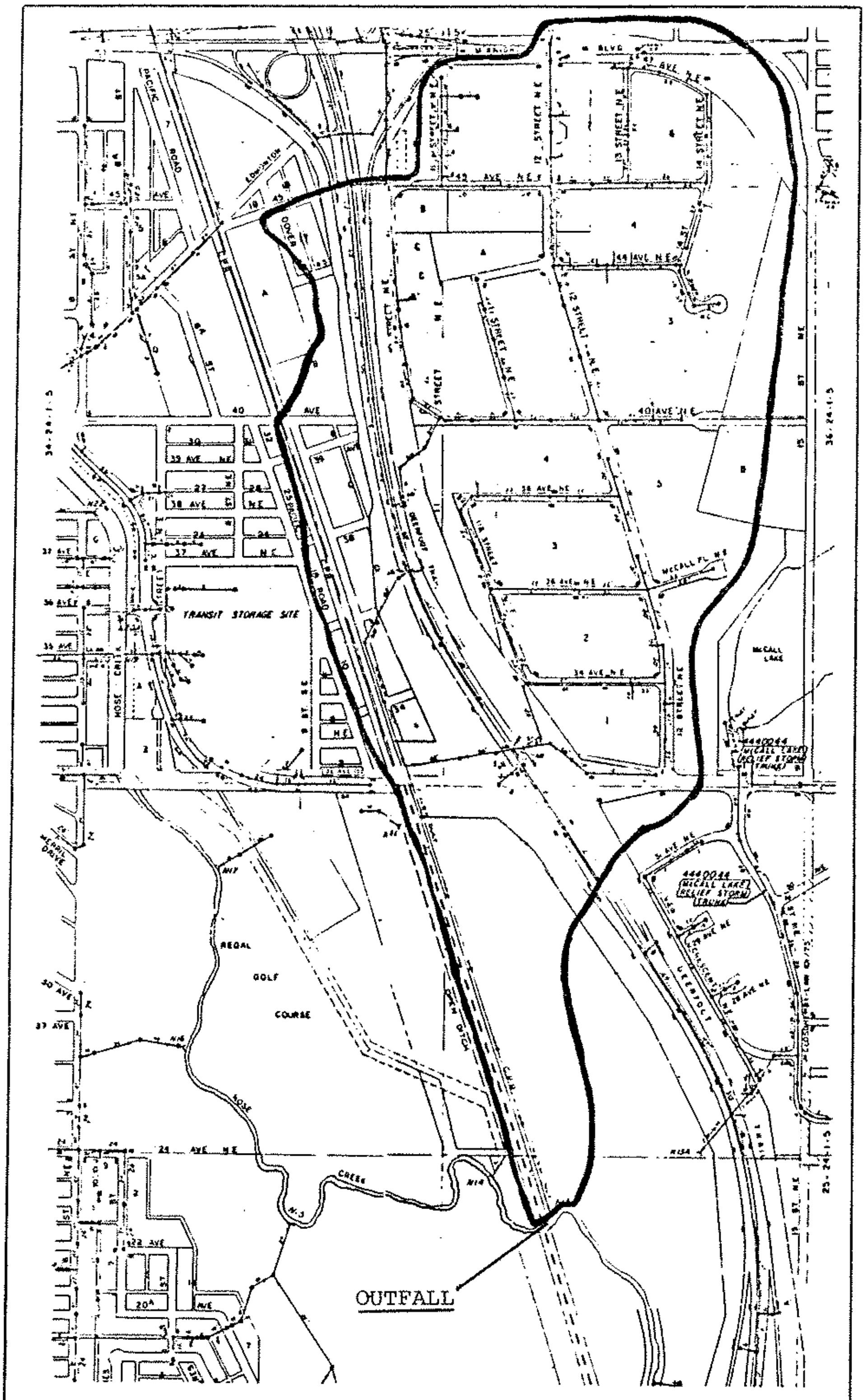


FIGURE 3. STORM SEWER N - 13 DRAINAGE AREA LOCATION

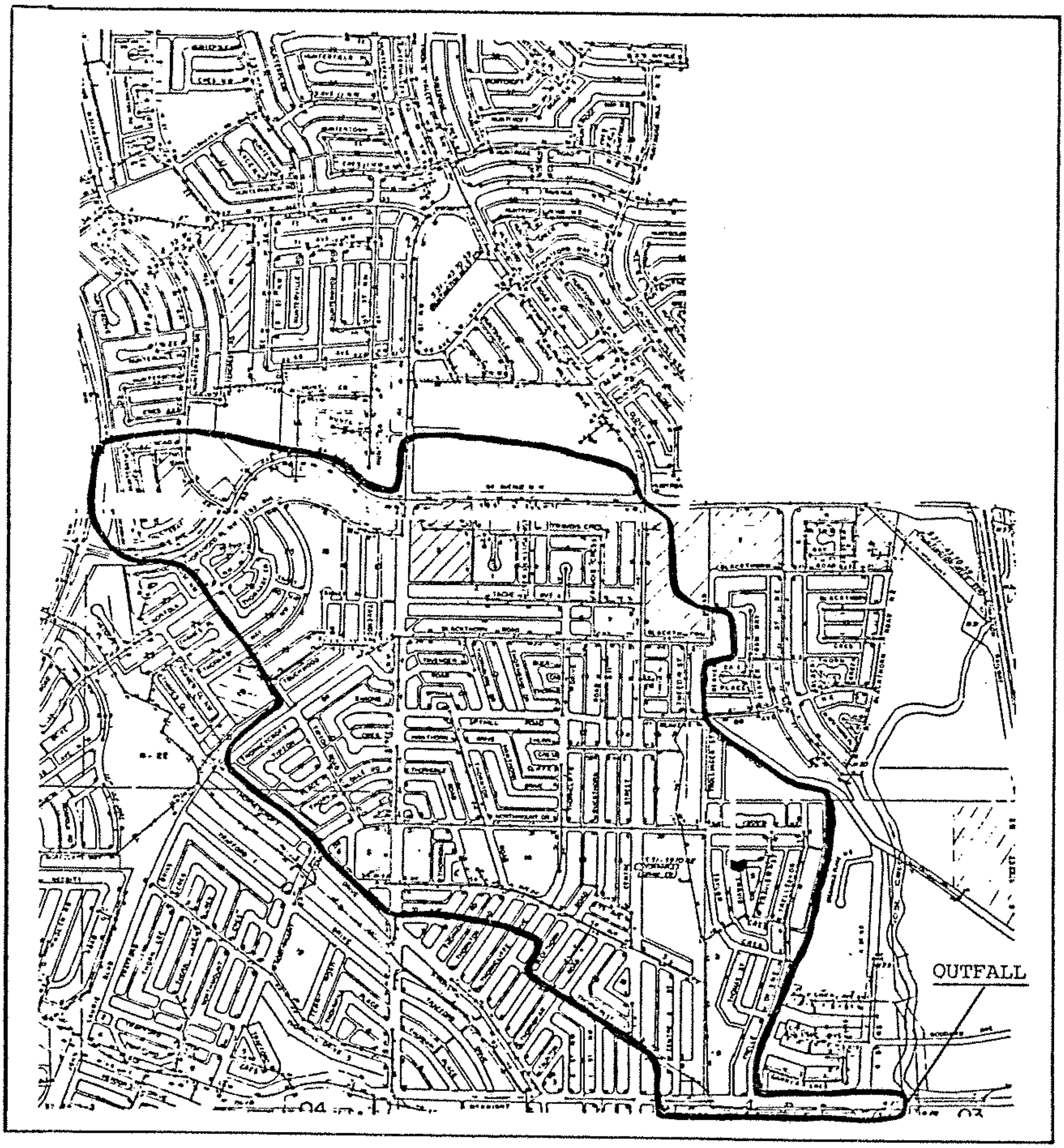


FIGURE 4. STORM SEWER N - 27 DRAINAGE AREA LOCATION

METHODOLOGY

General

The sampling program for the Nose Creek Water Quality Study was designed to establish existing water quality characteristics of Nose and West Nose Creeks and to assess the effects of storm water discharge. This was achieved by comparison of sampling parameters measured at sites located within urbanized Calgary to those same parameters measured at sites located in agricultural settings near the Calgary city limits.

The sampling program consisted of two interrelated components, each of which can be divided into two smaller units as follows:

A) Creek Sampling

- i) weekly sampling of Nose and West Nose Creeks
- ii) monitoring of Nose and West Nose Creeks during storm periods

B) Storm Sewer Sampling

- i) monitoring of dry-weather storm sewer discharges
- ii) monitoring of stormwater discharges

Creek Sampling Program

Weekly sampling on Nose and West Nose Creeks at sites 1 through 7 started on April 9, 1980. For sites 2, 3, 5, 6 and 7 sampling continued every Wednesday morning thereafter until September 24, 1980. Due to decreased flows and stagnant waters, sampling was discontinued on August 27 at site 1 and on September 3 at site 4. (The number of routine samples taken throughout the sampling period is indicated in Table 4.) Each weekly sample consisted of a specified number of chemical parameters and one bacteriological sample. Samples were taken at approximately the same time each week and were submitted not more than 4 hours after the first sample was collected during a sampling run.

Sites 3, 5, 6 and 7 were also monitored during storm periods in conjunction with storm sewer sampling (to be discussed). As shown in Table 2, the majority of creek samples collected during storms were collected from site 5. Site 5 took priority in the study since it is located at the mouth of Nose Creek and therefore reflected pollution sources and upstream conditions of Nose and West Nose Creeks.

The number of samples taken at either site 5 or 6 was dependent on water conditions at the time of sampling. It was desireable to monitor over a period of 3 hours, where samples were taken every half hour for a total of 7 samples.

If the creek was running high and dirty as a result of a previous rainstorm, only a single sample was taken. When this condition existed, a sample was not taken until well after the storm had passed through the Nose Creek Valley since a lag period occurred between storm sewer discharge and the noticeable arrival of that discharge at sites 5 and 6.

Following the sampling of sites 5 and 6, personnel were sent to collect single samples from sites 3 and 7. Again chemical parameters from the specified list were sampled, as were bacteriological samples when the holding-time restriction was not a factor.

For both weekly and storm sampling at the mouth of Nose Creek, accompanying flows were determined by use of a level gauge prior to June 20, 1980, and by use of a recording gauge after that date. Gauge heights were converted to flows in cubic meters per second by Dick Allison of Alberta Environment, Technical Services Division. To determine high flows (5.6 cu.m./sec. and above) a log plot extension was used for constructing a high-water stage discharge curve.

Storm Sewer Sampling Program

Dry-weather discharge was monitored from storm sewer outfalls N-27 and N-13 over the period April to September. As shown in Table 2, 6 dry-weather samples were collected from outfall structure N-27 and 4 from structure N-13.

Storm sewer sampling during storm periods was carried out over 3 hour periods. When a rainstorm was noticed approaching the Nose Creek Valley, personnel were sent to either outfall structure N-27 or N-13 where an initial sample was taken immediately. This sample was essentially a dry-weather sample. Changes in depth and turbidity of flow were then observed closely. When a visible flushing from the outfall occurred, a second sample was taken as soon as possible. Samples were then taken at 15 minute intervals for the first hour, and at half hour intervals for the next two hours, for a total of 9 samples.

Table 2 shows that 95 samples were taken from outfall N-27 while only 29 were taken from N-13. A greater number of samples were taken from the former due to the pattern of storm movements. Whereas rain often fell on the N-27 drainage basin, storms seldom extended to the N-13 drainage basin.

Storm sewer flows were determined by converting water depths within the outfall structures to cubic meters per second by use of the Manning Equation (Appendix B). For storm outfall N-27, both dry-weather and storm flows were obtained, while at N-13 only dry-weather flows could be obtained since during storm periods a significant backflow of storm water resulted causing depth readings to be inaccurate. Formulation used in the determination of storm sewer flows is presented in Appendix B and was made available by Mr. Chow Seng Liu of Alberta Environment.

Table 2

Nose Creek Water Quality Study - 1980

Summary of Samples Collected

Storm Sewer Samples

Sewer	Dry Weather	Storm Period
N-13	4	29
N-27	6	95
Total	10	124

Creek Samples

Creek Site	Routine	Storm Period
1	20	1
2	23	1
3	23	6
4	22	15
5	24	43
6	25	14
7	24	7
Total	161	87

Total (all samples) = 382

RESULTS AND DISCUSSION

Weekly and Storm Creek Sampling Program

The results of this portion of the study have been summarized in Tables 3 to 11 inclusive, Tables 17 and 18 and Figures 5, 6 and 7. A more detailed presentation of the data collected can be found in Appendix A, Tables 1-A, 2-A, 3-A, and 4-A. The chemical parameters which were analyzed are presented in this section on an individual or a similar group basis for discussion purposes.

Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand of water is the amount of oxygen required to oxidize organic or inorganic matter by aerobic microbial decomposition to a more stable form (8). Oxygen-demanding substances that increase the demand are organics derived from natural sources, such as the breakdown of aquatic plants. However, municipal and agricultural wastes can add significant amounts of oxygen demanding material also.

The results in Table 3 indicate that the control sites (3 and 7) generally had lower BOD values than the urban sites (5 and 6). BOD values for the season increased by 58% at site 6 compared to site 7,and by 90% at site 5 compared to site 7. Site 3 values were considerably higher than site 7,possibly due to the physical character of the stream compared to West Nose Creek. On a month-by-month basis, Figure 5 shows that at all sites BOD was high during April because of early spring snow melt. For the remainder of the year, BOD levels decreased except at site 6 where there was a localized increase in September due to dewatering discharges in the Beddington Heights area.

Storm-generated creek samples (Table 8) show trends similar to the weekly sampling results,however the means of peak concentrations were considerably higher than the mean values presented in Table 3. The mean of peak concentrations for storms at site 7 increased from a weekly sampling mean value of 2.42 mg/1 to 2.73 mg/1 indicating very little effect from rural area run-off above the City of Calgary on West Nose Creek. In comparison the value at site 6 increased from a mean of 3.82 mg/1 for weekly sampling to a mean peak value of 7.38 mg/1 indicating input from the urban area during storm events.

An increase of 270% occurred at site 6 when compared to the mean peak concentration during storms between site 6 and site 7.

The BOD mean value of peak concentrations at site 5 (mouth of Nose Creek) increased by 345% when compared to the value at site 7, and by 240% when compared to the value at site 3.

The BOD levels below Airdrie (Table 6) were generally higher than those above Airdrie indicating that storm sewer discharges or overland discharges affect the quality of the water in that area.

Total Organic Carbon (TOC)

Total organic carbon is composed of both dissolved and particulate organic carbon. Total organic carbon bears a direct relationship with both biochemical and chemical oxygen demands and varies with the composition of the organic matter that may be present. The bulk of organic carbon in water is composed of humic substances and degraded plant and animal material. The amounts or organic components can vary with discharge and the growth cycles of vegetation (8).

Table 3 indicates that the mean concentrations for the weekly sampling increased from site 7 to sites 6 and 5 by 16%. Site 3 had the highest concentration due to greater vegetative growth. Table 10 shows the same trend occurred during storm event periods. Site 7 TOC values increased slightly over weekly results due to an increase in the organic or particulate matter from rural area component. Site 5 and 6 values increased due to storm inputs from sewer discharges. Site 3 values decreased due to dilution.

The summary of weekly sampling, as presented in Table 6 for the Airdrie locations, indicates a drop in TOC concentrations below Airdrie due to the reduced amount of vegetative matter in the stream below Airdrie compared to the reach above Airdrie.

Dissolved Oxygen

Oxygen is one of the gases found dissolved in natural surface waters. It is moderately soluble in water. The amount in water will vary depending on temperature, salinity, turbulence and atmospheric pressure. The concentration of oxygen in water is subject also to seasonal and diurnal fluctuations, due in part to variations in temperature, photosynthetic activity and stream flows. Concentrations are controlled primarily by biodepletion and re-aeration processes. The decomposition of organics and the oxidation of inorganic material may reduce oxygen levels considerably (8). Dissolved oxygen in water may be derived from either the atmosphere or from photosynthesis by aquatic plants.

The dissolved oxygen results for the Nose Creek Study (presented in Table 4) indicate that oxygen concentrations at each site generally decreased from April to July and then started to increase. The decrease was due primarily to increased water temperatures, growth of aquatic vegetation and decreased flows. The August and September values show increases primarily due to a decrease in water temperature and reduced aquatic activity. Flows remained about the same in West Nose Creek throughout the sampling period; however, flows were almost zero in Nose Creek above the City of Calgary.

When comparing the various sites, mean values indicate lower concentrations at sites 1, 2, 3 and 4 mainly due to the physical characteristics of the stream itself. Low gradients do not promote re-aeration. Aquatic growth tends to be more prolific in warmer, shallow and slow-moving water. Values at sites 6 and 7 remained higher than at other sites because of little change in the physical characteristics in that reach. There are only 3 or 4 dry-weather storm sewer inputs on West Nose Creek, which may have affected the dissolved oxygen levels within the reach. The net result of increased flows from West Nose Creek and dry-weather storm inputs along Nose Creek, with the resultant oxygen demand, was a decreased oxygen concentration at site 5 when compared to sites 6 and 7. The main difference between the values at sites 3 and 4 when compared to site 5 is that the increased velocity at site 5 resulted in a higher net dissolved oxygen concentration at site 5. As mentioned earlier, Nose Creek has very low stream velocities and flows and many pond-like stretches that tend to deplete the oxygen levels.

Values at site 5 remained comparatively higher than some of the other sites because of a general increase in flow and because of periodic "flushes" from storms which remove a considerable amount of the oxygen demanding material. If these storm flushes did not occur, oxygen utilization as a result of decomposition would have decreased oxygen levels at site 5 considerably.

Total Phosphorus/Dissolved Phosphorus

Phosphorus is a non-metalic element that can appear in organic or inorganic forms. It can be present in water in either a dissolved or particulate form. Phosphorus is an essential plant nutrient and therefore may be a factor limiting plant growth. It is rarely found in significant concentrations in surface waters because it is actively taken up by plants. Sources of phosphorus are the weathering of igneous rocks, decomposition of organic matter and domestic sewage and drainage from fertilized land. When sufficient nitrogen compounds are present, concentrations of phosphorus above 0.1 mg/l in water may prove troublesome by promoting algal growth (8).

Weekly dissolved phosphorus concentrations in Nose Creek and West Nose Creek within the City of Calgary remained fairly constant (as indicated in Table 3). A slight increase occurred from site 7 to site 6 to site 5. Site 3 levels were considerably higher than other sites due to the low flows in that section of Nose Creek which resulted in a concentration of all or most chemical constituents. The increase in total phosphorus at sites 5 and 6 compared to site 7 was due primarily to particulate inputs from storm sewer discharges. The fact that values for total phosphorus and dissolved phosphorus for site 3 were almost identical indicates the total phosphorus at site 3 was entirely in the dissolved form.

Total and dissolved phosphorus concentration above and below Airdrie (Table 6) indicates that above the town, the total phosphorus was almost entirely in the dissolved form. Below Airdrie however, the ratio indicates that only about half was in the dissolved form with the remainder in particulate form.

Table 8 presents data on concentrations during storm events and again, the site 3 values are lower than for the weekly sampling program, indicating a resultant dilution effect during storm periods. Site 7 values increased slightly indicating some small agricultural inputs. The majority of the phosphorus at site 7 was in the dissolved form. Sites 5 and 6 show a considerable increase in total phosphorus indicating that a considerable amount of phosphorus in particulate form entered the creek from storm discharges. During storm events, the increase in total phosphorus from site 7 to site 6 was from 0.11 mg/l to 0.67 mg/l (mean of peak concentrations); from site 7 to site 5 the increase was only from 0.11 mg/l to 0.56 mg/l, indicating some particulate phosphorus was being removed along the way.

On a month-by-month basis (as indicated in Figure 5), total phosphorus concentrations tended to decrease after the spring run-off in April. The exception was site 6 where the phosphorus increased in August and September. This is again a result of particulate inputs from dry-weather storm discharges as a result of a highly active construction project in the area between sites 6 and 7.

Nitrogen

Three nitrogen parameters were examined in the study - total nitrogen, ammonia-nitrogen and nitrate-nitrite nitrogen. Total nitrogen consists of all organic and inorganic forms of nitrogen, ammonia-nitrogen is the most reduced form of organic nitrogen, and nitrate-nitrite nitrogen consists of the oxidized inorganic forms of nitrogen.

Organic nitrogen in surface and groundwater is a major constituent of all living organisms and, in surface waters, exists through normal biological activities. Organic nitrogen results from plant and animal material contained in inflows from surface land drainage as well as sewage effluents.

Ammonia is found in natural water in concentrations less than 0.1 mg/l. Ammonia and ammonium salts are the primary decomposition product of organic nitrogen. Ammonia may enter waters when associated with clay minerals during processes of erosion. It is contained in fertilizers and can be lost rapidly to surface and groundwaters due to high solubility. Precipitation and irrigation water can readily carry ammonified compounds into aquatic systems. Ammonia can be discharged industrially, and atmospheric precipitation and dry fall-out may contain significant ammonia concentrations (8).

As indicated in Table 3, nitrogen parameters showed the highest concentrations at site 5, near the confluence of Nose Creek and the Bow River, reflecting the influence of dry-weather storm sewer discharges on water quality.

Site 3, located on Nose Creek at the Calgary city limits, was also high in nitrogen concentrations. Whereas ammonia nitrogen concentrations were similar at sites 3 and 5, nitrate-nitrite nitrogen and total nitrogen concentrations were significantly higher at site 5. Total nitrogen showed a 32% increase over site 3 - ammonia, a 19% increase and nitrate-nitrite, a 2350% increase. Site 3 nitrogen concentrations were composed primarily of organic and ammonia nitrogen, while at site 5 nitrate-nitrite nitrogen contributed significantly along with the organic and ammonia nitrogen. This would indicate an abundance of organic material in the stream above site 3.

Figure 5 shows that in April, the period of spring run-off, total nitrogen was highest at site 3 in comparison with all other sites. Total nitrogen at site 5 was also high during the spring period when aided by natural run-off and accelerated by the storm sewer networks. Data in Figure 5 indicate nitrate-nitrite nitrogen concentrations continued to increase following the run-off period at site 5. It was found that concentrations in dry-weather flows from storm sewer N-27 were quite high, the mean value for 5 samples being 6.45 mg/l. This indicates that nitrate released into the storm sewer system enhances concentrations in the receiving water. The highly soluble nitrate enters the sewer lines by infiltration of groundwater and is conveyed rapidly and easily into Nose Creek.

Another consideration is that the storm sewer system provides a suitable environment for microbial decomposition of organic material collected between storm periods. The build-up of materials within the storm system is evidenced by the very rapid flush of debris during storm periods. Nitrogen as nitrate-nitrite is available for the stimulation of plant growth and should be considered in the development of storm retention ponds.

Data in Figure 5 also indicate that total nitrogen decreased throughout the summer period at site 3, and increased with the approach of fall. This is indicative of nutrient uptake during the summer period by aquatic vegetation and the release of nitrogen constituents in later months. Site 5 data show a similar pattern, but high nitrogen levels were maintained due to storm water inputs in the summer months.

A comparison of flows at site 3 and site 5 is important when considering the chemical results of the two locations. In a rural setting, Nose Creek is a meandering stream with few areas of high velocity. Above the confluence with West Nose Creek there is considerable ponding of "brown" water. A build-up of organic material was noticed and could account for the high nitrogen concentrations observed at site 3.

When comparing the data for sites 7 and 6 on West Nose Creek with respect to proportions of nitrogen, relationships were similar as between sites 3 and 5. Values were lower at site 7 in all cases. Total nitrogen increased 60% at site 6 over site 7, ammonia-nitrogen 88%, and No_3-No_2-N showed the greatest increase, 160%. Site 6 responded much like site 5 but was characterized by lower concentrations.

Table 3 data show that nitrogen concentrations were significantly higher at site 3 when compared to site 7. This is best explained by examining the stream profiles of both Nose Creek and West Nose Creek. Because of differences in slope between the streams, less build-up of organic matter would occur in West Nose Creek which resulted in a concentration lower at site 7 than at site 3.

Table 8 shows data on concentrations during storm events. Significant inputs to Nose Creek and West Nose Creek occurred via the storm sewer system located upstream of sites 5 and 6. The decreased nitrogen concentrations at site 3 and site 7, when compared to the weekly sampling results, was due to a dilution factor. Ammonia concentration increased slightly indicating some effect of agricultural run-off in the region above site 7.

Residue (Nonfiltrable, Filtrable)

Nonfiltrable residue, or suspended solids, is that portion of the total residue found in water that is retained by a filter. The filtrable residue, or dissolved solids, is that portion of the total residue found in water that passes through the filter.

The data in Table 3 show that during the weekly sampling program, the filtrable portion of the residue found at all four of the major Calgary area sites did not vary significantly from site to site. The nonfiltrable component, however, did increase substantially between sites. The largest increase in mean concentration occurred between sites 6 and 7 indicating the effects of the construction activity in the area. The area below site 6 to site 5 tended to act as a settling basin as shown by the lower mean value at site 5. Mean concentrations for nonfiltrable residue increased by about 13.5 times from site 7 to site 6 and by about 8 times from site 7 to site 5. Site 3 values again were higher than site 7 due to lower velocities of water at site 3 which resulted in a build-up of the residue component. The increased mean concentration of site 3 over site 5 was 117%. Table 6 gives values for sites above and below Airdrie which indicate the effect of that urban area on the creek. The nonfiltrable concentration below Airdrie was higher due to storm sewer dry-weather inputs. The filtrable residue, however, was lower than above Airdrie due to the nature of the dry-weather storm sewer inputs.

Storm event means of peak concentrations are presented in Table 8 and indicate that the filtrable component did not vary too significantly between site 5, 6 and 7; however, the values were somewhat higher than for the weekly monitoring program. The site 3 value decreased from the weekly result indicating a resultant dilution effect as a result of increased flow rather than an input from the area above (Airdrie).

The nonfiltrable component increased greatly, however. There seems to be a progressive build-up of residue downstream which results in an escalation of the concentrations. The value at site 6 was 18 times higher and 49 times higher at site 5 when compared to the value at site 7. Comparing site 3 and site 5, the value at site 5 was also 49 times higher. The storm event results at site 3 were considerably lower than for the weekly results indicating a resultant dilution factor.

The month-to-month analysis shown in Figure 5 indicates an upward trend in the nonfiltrable residue concentration at sites 5 and 6 from April to July illustrating the general effects of dry-weather discharges, precipitation and construction activities. Sites 3 and 7 for the same period increased only for the months of May and June respectively and then decreased for June, July and August.

Bacteriology

As indicated by Table 5, bacteriological densities for the six month sampling period were highest at those sites receiving stormwater inputs. Site 5 showed the highest counts, and the increase over site 6 reflects the increased size of the storm drainage system.

All sites followed the same general trends. From initially low densities in April, increases occurred in the summer months followed by decreasing or stabilizing densities as fall approached.

The control site, site 3 on Nose Creek, generally showed the lowest densities in each month and was characterized by gradual increases until August when densities rose sharply. As discussed, site 3 was characterized as having low velocities and flows throughout most of the sampling season. This could account, in part, for the low densities observed since under such conditions settling of exposed and sediment-bound bacteria would result soon after rainfall run-off.

Matson et al. (7) has demonstrated that densities are consistently higher in the sediment than in the water column, and that an equilibrium exists between settling and resuspension along the stream profile. This may have affected observed densities at site 3 as the gradually increasing densities were interrupted by sharp increases in August when slightly increased flows due to precipitation were apparent.

Although higher than at site 3, spring run-off in April again contained low densities of bacteria at site 5. In the month of June, drastic increases in all bacteriological components were recorded, indicating storm run-off from the urbanized portion of the Nose Creek basin. As Table 1 indicates, rainfall was highest in late May and June, followed by decreases in the fall period. Similarly, monthly bacteriological densities decreased and stabilized in the latter months of the sampling period.

On the basis of the 6-month geometric mean, total coliform densities were 5 times greater at site 5 than at site 3, faecal coliforms more than tripled while faecal streptococci more than doubled. Variations from the norm, however, occurred throughout the sampling period.

Control site 7, on West Nose Creek, showed density trends much like site 5, although values were much lower. Again, due to the large drainage region and mixture of land uses, it would be difficult to pinpoint sources of bacteriological contamination. Sharp increases in June would indicate that run-off from grazed areas occurred causing faecal contamination.

Site 6 showed densities much like site 5, but with lower magnitudes. During the sampling period, only 4 storm sewers drained the area between sites 6 and 7 in comparison with site 5 where water quality was influenced by over 30 storm sewers. Six month geometric means indicate that total coliforms were over twice as great at site 6 in comparison with site 7, faecal coliforms were 3 times greater and faecal streptococci quadrupled. The increases at site 5 over site 6 were similar to those recorded for site 5 over site 3, since both site 7 and site 3 had similar densities for the 6-month sampling period.

During storm periods (as indicated by Table 9) bacteriological densities showed the greatest increases at site 5 where total coliforms increased 17 times over the weekly sampling values, faecal coliforms 5 times and faecal streptococcus 14 times.

The ratio of faecal coliforms to faecal streptococci has been used extensively as an indication of faecal pollution sources. After examination of both stormwater and wastewater, Geildich and Kenner (5) concluded that ratios of less than 0.7 were indicative of non-human animal sources while those greater than 4.0 were indicative of human waste. The ratio does, however, have drawbacks due to the differential die-off rates of faecal coliforms and faecal streptococci. It was found in animal wastes that, at 21°C, faecal coliforms increased by over 300 times within a 48 hour period, thereby increasing the value of the ratio and wrongly indicating human waste (2). Any interpretation of the ratio should take into account this time dependency. Changing values of the ratio has, however, been used by Feachem (4) as an indicator of sources. Based on the following survival rates of faecal components, changing ratios were advantageous in source identification:

Enterococci > Faecal Coliforms > S. bovis, S. equines

(Faecal streptococci component in human faeces) (Faecal streptococci component in animal faeces)

If ratios in fresh faecal material are low, and are subsequently followed by increasing values with time, the indication would be animal sources due to die-off of S. bovis and S. equines and coliform aftergrowth. If ratios are initially high and are followed by decreases, the indication would be human source due to persistance of enterococci.

Based on the six month sampling geometric mean, site 3 showed the lowest FC/FS ratio with a value of .89. The ratio changed little during storm periods (Table 9) to a value of .85. Comparison of monthly values at site 3 shows that the ratio increased significantly through the sampling period from a value of .05 in April to 2.66 in September. Uncertainities usually exist when ratio values are between .7 and 4.0, but because of increases, the indication would be animal contribution.

Site 7 in comparison to 3 shows a weekly sampling ratio of 1.4 which during storm periods increased to 2.2. Due to agricultural practices on the surrounding lands, it is improbable that human contamination caused the increase in the ratio; instead coliform after-growth in contaminated soils occurred.

At site 6 little change in the ratio was observed (1.06-1.02), although both faecal coliforms and faecal streptococci densities increased markedly. Since the area being drained was still under construction during the sampling period, it was expected that animal densities, dogs, cats, etc., would be low such that marked decreases in the ratio would not result during storm periods.

Site 5 clearly showed the impact of animal contamination as the weekly sampling ratio of 1.35 dropped to .48 during storm periods. Resuspension of sediment bound bacteria likely contributed to observed densities during periods of high flow. As Dutka states (3), sediments within storm sewers constitute a reservoir of indicator bacteria that are washed into receiving waters during storm periods.

Metals

To determine concentration of metals found in the water of Nose Creek, weekly samples were collected for the more common of the metals found in natural waters. Analysis was conducted for the metals zinc, lead, copper and chromium.

Zinc is widely used in industry in the manufacture of paints, rubber, textiles and other chemicals. Printing operations, fertilizers, pesticides and the combustion of gasoline and other fuels may contribute zinc to the environment. Lead is a toxic material whose principal natural source is the weathering of sulphide ores. Calcareous bedrock can also contribute lead, while the burning of lead fuels is a major manmade input. Other sources include the production of storage batteries, lead pipes, motor oils and paints. Copper, which is common in natural water, is essential for plant and animal nutrition. Natural copper originates from the weathering of sulphide and carbonate ores. Human inputs are probably more significant and derive from such things as paints, electrical products, mine waters and some fungicides and pesticides. Chromium in waters rarely occurs from natural sources. The major sources are either domestic or industrial uses. It can be found in metal plating, stainless steel, paints and dyes, explosives, ceramics and paper.

Metal concentrations obtained for the Nose Creek study are summarized in Tables 3, 6 and 8. Data in Table 3 show that for the weekly sampling program, concentrations of all metals at all the major sites were very low. Concentrations for metals at site 5 were generally higher than at site 7, except zinc. Concentrations at site 5 were higher than at site 6 except for copper. The concentrations at site 3 were again higher than those at site 7, and for zinc and copper they were higher than those at site 5. This was due again to the higher flows and velocities of water at sites 5 and 7 indicating a dilution effect.

Values in Table 8 indicate that metal concentrations below the town of Airdrie were generally higher than those above the town. This increase is attributed to dry-weather storm inputs from an area of concentrated vehicular traffic and associated residential activities.

Storm generated inputs are summarized in Table 8 and show marked increases for lead, zinc and copper for the urban sites 5 and 6. Lead values at site 6 were 5 times higher than those at site 7 and 52 times higher at site 5. Zinc values were 3 times higher at site 6 and 6 times higher at site 5 than at site 7. Copper values were 4 times higher at site 6 and 3 times higher at site 5 than those at site 7. The large differences in the lead values is possibly due to the lead that originates from combustion of leaded fuel.

The rural sites (3 and 7) showed a general decrease in concentrations of metals during storm periods (Table 8). The decrease was due in part to a dilution factor resulting from slightly increased flows during these periods.

Oil and Grease

The term "oil" can represent a wide variety of substances in the form of hydrocarbons of mineral origin that span the range from gasoline to the heavy fuels and lube oils. The term "grease" refers to a wide variety of organic substances that have a higher molecular weight than the oils. They include some hydrocarbons, esters, oils, fats, waxes, and fatty acids. The origins of these materials are automobile drippings and washing of vehicles, industrial wastes, and indiscriminate dumping into sewer systems (8).

The data collected for the Nose Creek Water Quality Study are summarized in Table 17. For weekly creek samples, the analysis indicated that concentrations were very low. It was noticed, however, on several occasions that a floating "sheen" was visible on the surface of the water. Further investigation revealed the sources as discharges from a storm sewer (dry-weather). The storm samples of June 14 and June 22 indicate that concentrations increased considerably as a result of storm run-off. The high values obtained on June 14 were the result of a diesel oil spill from an overturned tank truck on June 13. It illustrates the maximum concentration in the creek that may be possible as a result of an accident.

Pesticides (Insecticides and Herbicides)

Pesticides are compounds used in the control of most pests that may affect man, crops and animals. In the Nose Creek Study, a periodic analysis was done on creek samples and on one storm event for the herbicide 2,4-D, and the insecticides Temephos (Abate) and Chlorpyrifos (Dursban). The herbicide 2,4-D is one of the most common in use today for weed control. Temephos and Chlorpyrifos are the two most common insecticides in use in the Calgary area.

A summary of the data from weekly samples is presented in Table 18. The data show that concentrations for the two insecticides were below the detection limit of 0.001 mg/l in all cases. The storm sample of May 23, 1980 showed, however, that concentrations increased considerably at sites 5 and 6. The increases indicate that the chemicals were entering the streams as a result of storm run-off. The herbicide 2,4-D was found only at sites 5 and 6 for weekly sampling which shows that the normal watering of lawns causes this chemical to enter the streams via storm sewers directly or by groundwater infiltration. The storm samples on May 23, 1980 indicated concentrations below the detection limit for 2,4-D. Pesticide sampling was discontinued after the May 23 storm because of the very low concentrations found on that date.

Other Parameters

The pH of surface water indicates the balance between acids and bases and is a measure of the hydrogen ion concentration in solution. As an index of the ion concentration, pH is measured on a scale of 0 to 14. A value of 7 indicates a neutral condition, values less than 7 indicate acid conditions and values greater than 7 indicate alkaline conditions (8).

The Nose Creek Study results given in Table 3 indicate the water in West Nose Creek was slightly more alkaline than the water in Nose Creek, however, all sites would be considered to be in the alkaline range.

Table 8 indicates that during storm events, the water in West Nose Creek and Nose Creek at the rural sites (3 and 7) became more alkaline when compared to weekly sampling results. The urban sites however became slightly more "acidic" but values were still on the alkaline side of the scale.

The Airdrie area results in Table 6 indicate the pH of the water below Airdrie was more basic than above Airdrie. This was due to the construction activity in the town and it is thought that the rise in pH was due to alkaline-type soils being eroded into the creek via direct storm sewer run-off or overland flow.

Temperatures for the study were primarily taken during the weekly routine sampling program only. The mean temperatures for the 6 month study period range from a low of 9.7^{o}C at site 7 to a high of 11.5^{o}C at site 5. Site 2 mean temperature was 10.8^{o}C, site 3 was 11^{o}C, site 4 was 10.8^{o}C, site 6 was 10.5^{o}C and site 1 was 10.2^{o}C.

Table 3

Mean Concentrations of Measured Parameters For Weekly Sampling

Parameter (Mg/L)	Site 3	Site 5	Site 6	Site 7
B.O.D.	4.02	4.59	3.82	2.42
T.O.C.	19.67	13.80	13.81	11.91
T-Phos	0.28	0.16	0.19	0.09
D-Phos	0.31	0.09	0.08	0.07
TN	1.77	2.33	1.55	0.97
NH_3-N	0.16	0.19	0.15	0.08
NO_3-NO_2-N	0.04	0.98	0.13	0.05
NFR	25.05	54.34	91.57	6.72
FR	514.7	515.0	500.2	525.4
Zn	0.06	0.02	0.02	0.03
Pb	0.004	0.04	0.006	.003
Cu	0.007	0.006	0.008	0.005
Cr	0.004	0.004	0.003	<0.003
pH	7.90	7.90	8.20	8.20

< : Indicates concentrations " less than "

Table 4

Summary of Dissolved Oxygen Results for Routine Samples

Nose Creek Water Quality Study

Site No. / Month	1	2	3	4	5	6	7
April	9.4	9.2	7.5	8.1	8.5	10.8	11.0
May	5.2	8.2	5.5	7.0	9.8	8.3	9.1
June	4.0	5.5	6.3	5.9	6.0	7.8	8.0
July	2.3	5.0	4.1	5.7	4.9	7.9	6.8
August	2.9	4.2	6.6	6.8	7.4	8.2	7.5
September	-	6.4	8.6	-	9.5	7.2	8.8
Mean	4.8	6.4	6.4	6.7	7.7	8.4	8.5

All values are expressed in mg/l.

Table 5

Monthly Geometric Means for Bacteriological Parameters Sampled Routinely From April to September - Nose Creek Water Quality Study, 1980

Month	Microbiological Parameter (#'s/100 ml)	Site 3	Site 5	Site 6	Site 7
April	Total Coliform	235	518	300	51
	Faecal Coliform	7	186	210	23
	Faecal strep	136	181	75	13
May	Total Coliform	288	500	823	399
	Faecal Coliform	86	180	426	145
	Faecal Strep	59	50	456	35
June	Total Coliform	419	8,106	2,888	1,944
	Faecal Coliform	174	1,212	841	386
	Faecal Strep	216	1,300	1,585	351
July	Total Coliform	564	5,224	2,502	1,108
	Faecal Coliform	345	455	491	395
	Faecal Strep	143	270	580	359
August	Total Coliform	1,777	5,517	2,392	1,214
	Faecal Coliform	985	382	529	420
	Faecal Strep	454	-	178	287
September	Total Coliform	220	2,141	2,719	420
	Faecal Coliform	77	756	1,527	21
	Faecal Strep	29	793	1,673	111
6 month Geometric Mean	Total Coliform	429	2,327	1,244	519
	Faecal Coliform	125	420	555.0	189
	Faecal Strep	140	312	519	137

Table 6

Summary of Water Quality Parameters for Above & Below Airdrie Sites for Weekly Samples

Parameter	Statistic	Units	Site #1 Above Airdrie	Site #2 Below Airdrie
pH	Median	Units	7.67	7.9
Dissolved Oxygen	Mean	mg/1	4.4	6.2
Temperature	Mean	C	10.7	11.3
Total Organic Carbon	Mean	mg/1	28.6	18.6
Biochemical Oxygen Demand	Mean	mg/1	3.23	3.7
Total Phosphorus	Mean	mg/1	.38	.33
Dissolved Phosphorus	Mean	mg/1	.33	.184
Nitrate-Nitrite Nitrogen	Mean	mg/1	.016	.072
Ammonia Nitrogen	Mean	mg/1	.132	.117
Total Nitrogen	Mean	mg/1	1.97	1.34
NFR	Mean	mg/1	16.96	27.26
Filtrable Residue	Mean	mg/1	617.4	446.8
Zinc	Mean	mg/1	.011	.029
Lead	Mean	mg/1	.004	.005
Copper	Mean	mg/1	.007	.008
Chromium	Mean	mg/1	< .003	.003

< : Indicates values " less than "

Table 7

Microbial Densities for Weekly Sampling at Sites 1 and 2

Month	Microbiological Parameter	Site 1 Above Airdrie	Site 2 Below Airdrie
April	Total Coliform	165	142
	Faecal Coliform	5	27
	Faecal Streptococci	16	188
May	Total Coliform	466	454
	Faecal Coliform	120	306
	Faecal Streptococci	44	11
June	Total Coliform	220	602
	Faecal Coliform	67	408
	Faecal Streptococci	199	121
July	Total Coliform	235	690
	Faecal Coliform	78	109
	Faecal Streptococci	60	66
August	Total Coliform	162	967
	Faecal Coliform	90	86
	Faecal Streptococci	62	29
Five Month Geometric Mean			
	Total Coliform	234	482
	Faecal Coliform	49	126
	Faecal Streptococci	55	55

Note: All values shown are geometric means of 4 or 5 values in a 30 day period

Table 8

Means of Peak Measured Concentrations for Storm Generated Creek Samples

Parameter (Mg/L)	Sampling Site No.			
	3	5	6	7
B.O.D.	3.93	9.42	7.38	2.73
T.O.C.	18.57	16.07	14.65	12.50
T-Phos	0.20	0.56	0.67	0.11
D-Phos	0.19	0.16	0.10	0.10
TN	1.15	5.23	1.92	0.88
NH_3-N	0.12	0.55	0.16	0.21
NO_3-NO_2-N	0.02	1.47	.184	0.03
NFR	8.33	417.14	159.85	8.40
FR	484.8	535.6	568.75	554.0
Zn	0.01	0.06	0.03	0.01
Pb	0.003	0.16	0.016	0.003
Cu	0.004	0.01	0.015	0.003
Cr	0.003	0.004	< 0.003	0.003
pH (units)*	8.53	7.51	7.99	8.35

* pH values derived by use of medians rather than means

Table 9

<u>Summary of Microbial Densities For Storm Samples At Creek Sites</u>

Microbiological Parameter	Site 3	Site 5	Site 6	Site7
Total Coliform	558	39,800	19,245	1,600
Faecal Coliform	348	2,150	2,887	1,120
Faecal Streptococci	411	4,475	2,875	500

Note: All values are in no./100ml. and are shown as the 6 month geometric mean of all storm samples collected.

Table 10

Comparison of Peak Measured Concentrations

At Sampling Sites During Storm Periods

Parameter (Mg/L)	June 11, 1980			June 19			June 22		
	Site 5	Site 6	Site 7	Site 3	Site 5	Site 7	Site 3	Site 5	Site 7
B.O.D.	7.10	7.30	2.80	2.40	13.60	2.80		5.00	2.40
T.O.C.	15.80	19.50	15.50	20.50	17.80	13.80		13.00	12.00
T. Phos	.190	.410	.125	.250	1.200	.135	.250	.240	.125
D. Phos	.085	.09	.110	.250	.105	.125	.245	.125	.125
T-N	2.10	2.28	.610	1.71	6.99	1.21	1.61	3.57	.960
NH_3-N		.210	.110	.120	.04	.07	.150	.390	<.002
NO_3-NO_2-N	1.20	.475	.006	.012	1.190	.013	.008	1.270	.014
NFR	52.00	266.0	12.40	6.00	1754.0	2.80	10.40	96.70	14.80
FR	722.0	640.0	640.0	600.	270.0	590.0	634.0	475.0	551.0
Zn	.013	.028	.030	.002	.001	<.001	.011	.045	<.001
Pb	.018	.041	.003	<.002	<.002	.004	.002	.017	<.002
Cu	.004	.021	.002	.002	.002	<.001	.002	.006	<.001
Cr	<.003	<.003	<.003	< .003	.006	<.003	< .003	.003	.003

PARAMETER	June 26, 1980				July 29, 1980			August 20, 1980		
	Site 3	Site 5	Site 6	Site 7	Site 3	Site 5	Site 7	Site 3	Site 5	Site 7
B.O.D.	9.20	6.0	3.20	2.80	1.90	22.50	1.20	3.60	7.70	3.50
T.O.C.	21.00	17.0	14.0	11.50	13.10	13.60	10.30	16.00	12.60	7.60
T-Phos	.178	.580	.476	.094	.165	.800	.075	.105	.180	.055
D-Phos	.160	.252	.080	.084	.150	.160	.075	.085	.085	.050
TKN	1.41	4.60	.476	.610	1.16	3.81	1.03	1.350	10.98	.790
NH_3-N	.090	1.000	.210	1.000	.200	.500	.160	.120	.320	.040
NO_3-NO_2-N	.013	1.300	.110	.013	.028	1.83	.033	.043	1.380	.069
NFR	8.40	478.0	379.0	15.20	98.40	552.0	4.40	19.60	99.00	5.60
FR	642.0	642.0	549.0	523.0	454.0	537.0	501.0	471.0	501.0	429.0
Zn	.012	.081	.045	.017	.056	.140	.026	.017	.035	.011
Pb	.006	.056	.011	<.002	<.002	.260	.006	.005	.280	.004
Cu	.015	.029	.022	.015	<.002	.029	<.001	.004	.015	.002
Cr	.004	.005	.003	<.003	.005	<.003	<.003	.003	.004	< .003

< : Indicates concentrations " less than "

Table 11

Comparison of Pre-and Post-Storm
Values For Measured Parameters at Sites 3 and 7
On August 20, 1980

Parameter (Mg/L)	Site 3		Site 7	
	Pre-Storm	Post-Storm	Pre-Storm	Post-Storm
B.O.D.	2.30	3.50	1.80	3.60
T.O.C.	16.50	16.00	8.00	7.60
T-Phos.	0.115	0.105	0.035	0.055
D-Phos	0.085	0.085	0.035	0.055
TN	1.35	1.35	1.44	0.79
NH_3-N	0.160	0.120	0.100	0.04
NO_3-NO_2-N	0.006	0.043	0.022	0.069
NFR	16.40	19.60	2.40	5.60
FR	475.0	471.0	458.0	429.0
Zn	0.014	0.017	0.300	0.011
Pb	<0.002	0.005	0.005	0.004
Cu	0.012	0.004	0.006	0.002
Cr	0.003	0.003	< 0.003	< 0.003

< Indicates concentrations " less than "

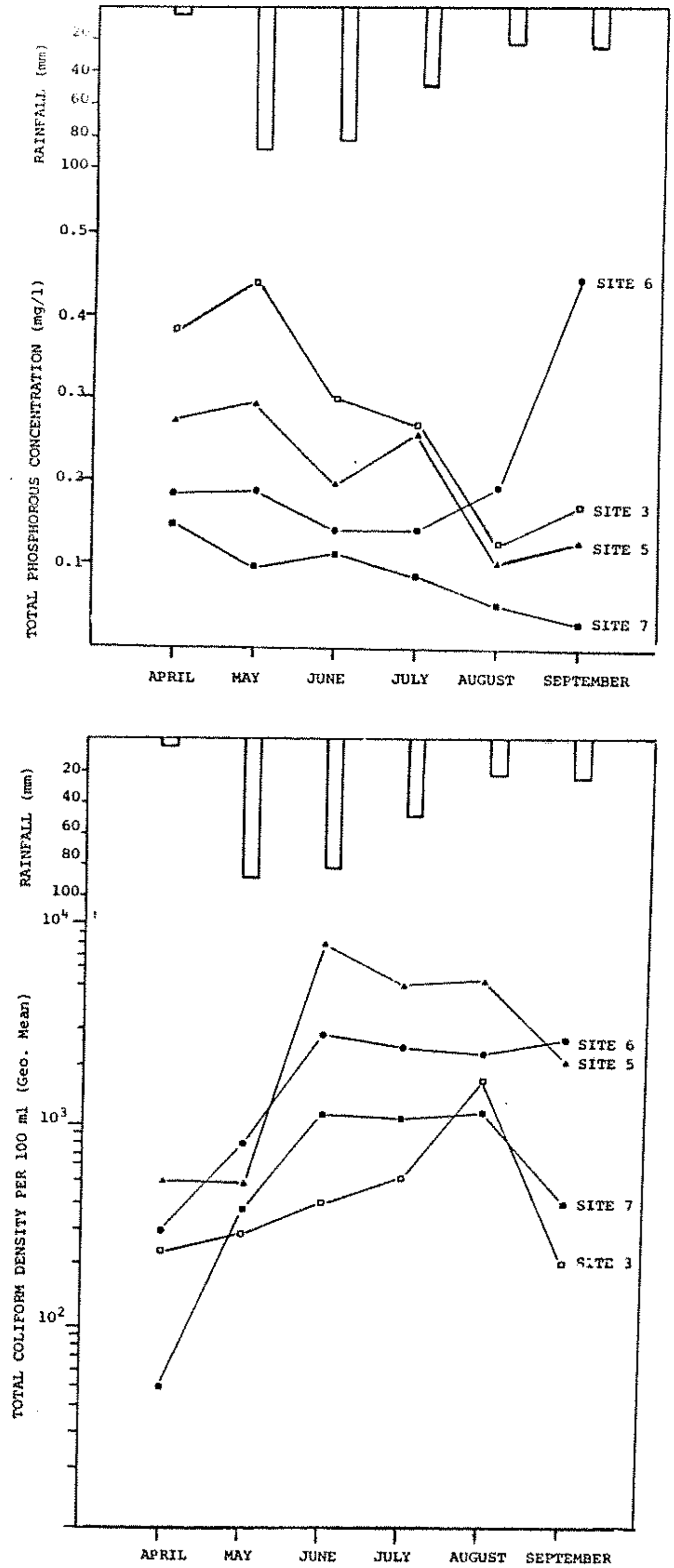


FIGURE 5 MEAN MONTHLY CONCENTRATIOS FOR VARIOUS PARAMETERS AT SITES 3,5,6 AND 7 FOR WEEKLY SAMPLING

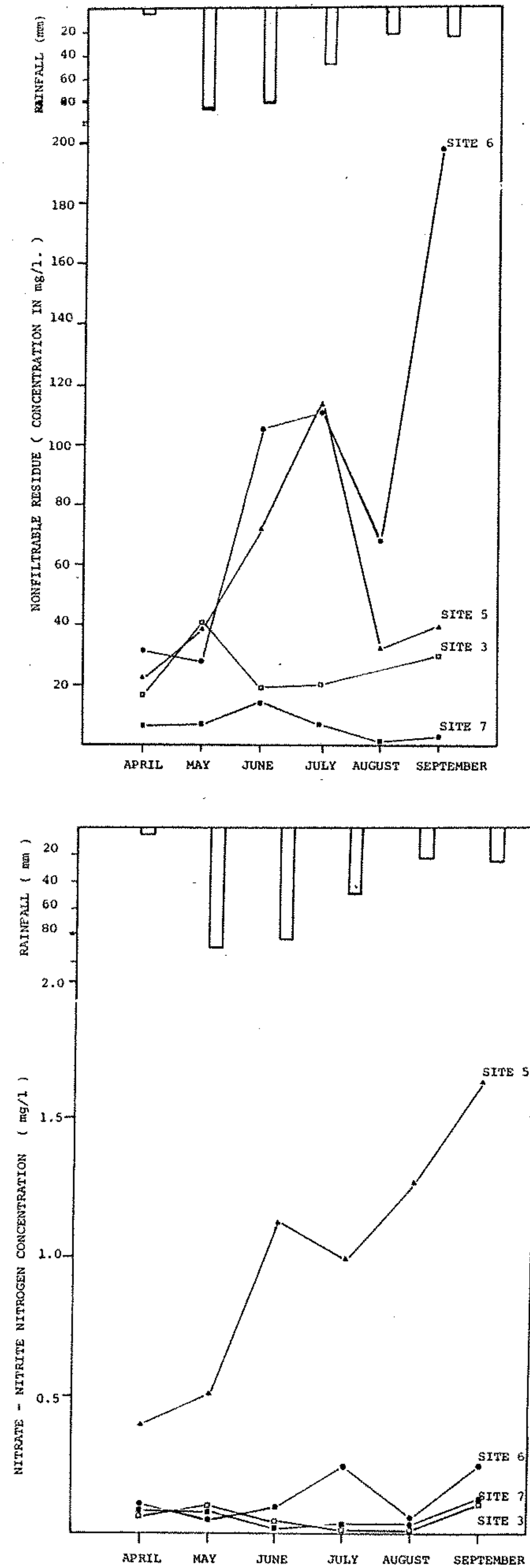


FIGURE 5 (Cont.)

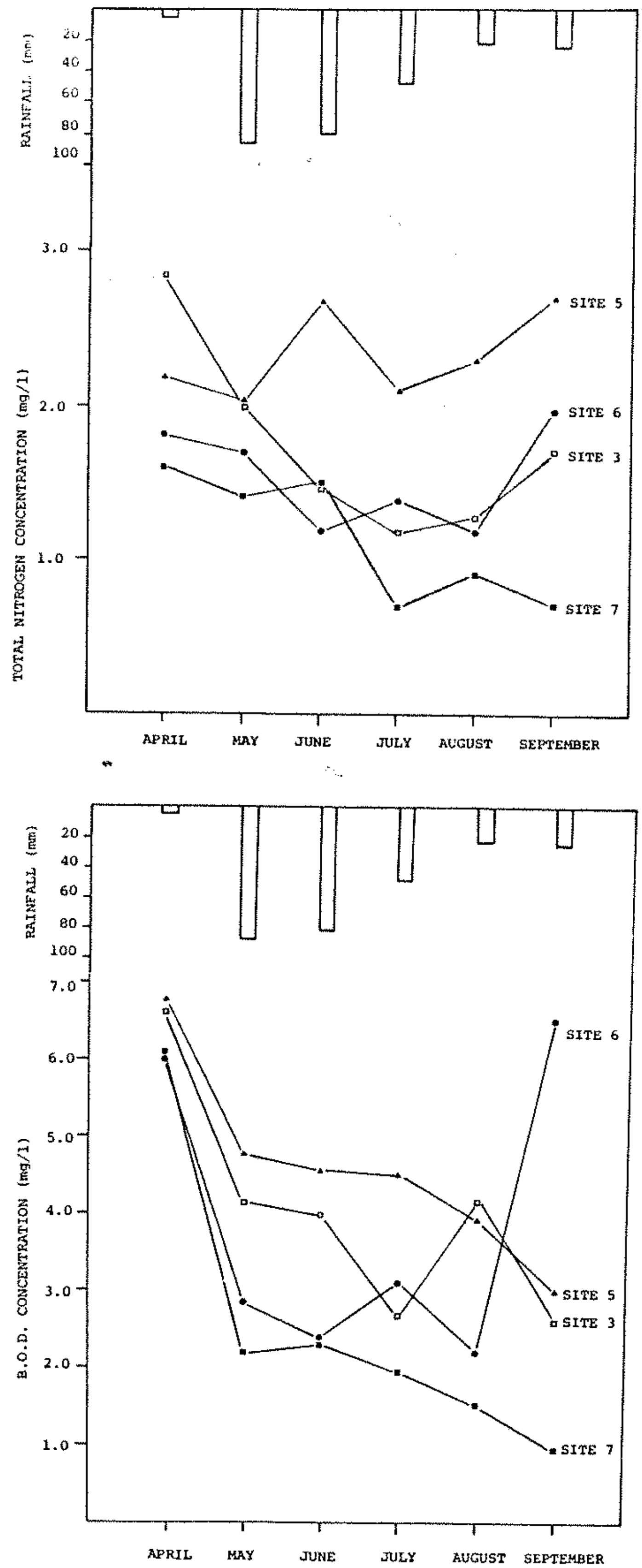


FIGURE 5 (Cont.)

Alberta
ENVIRONMENT
Pollution Control Division
Water Quality Control Branch

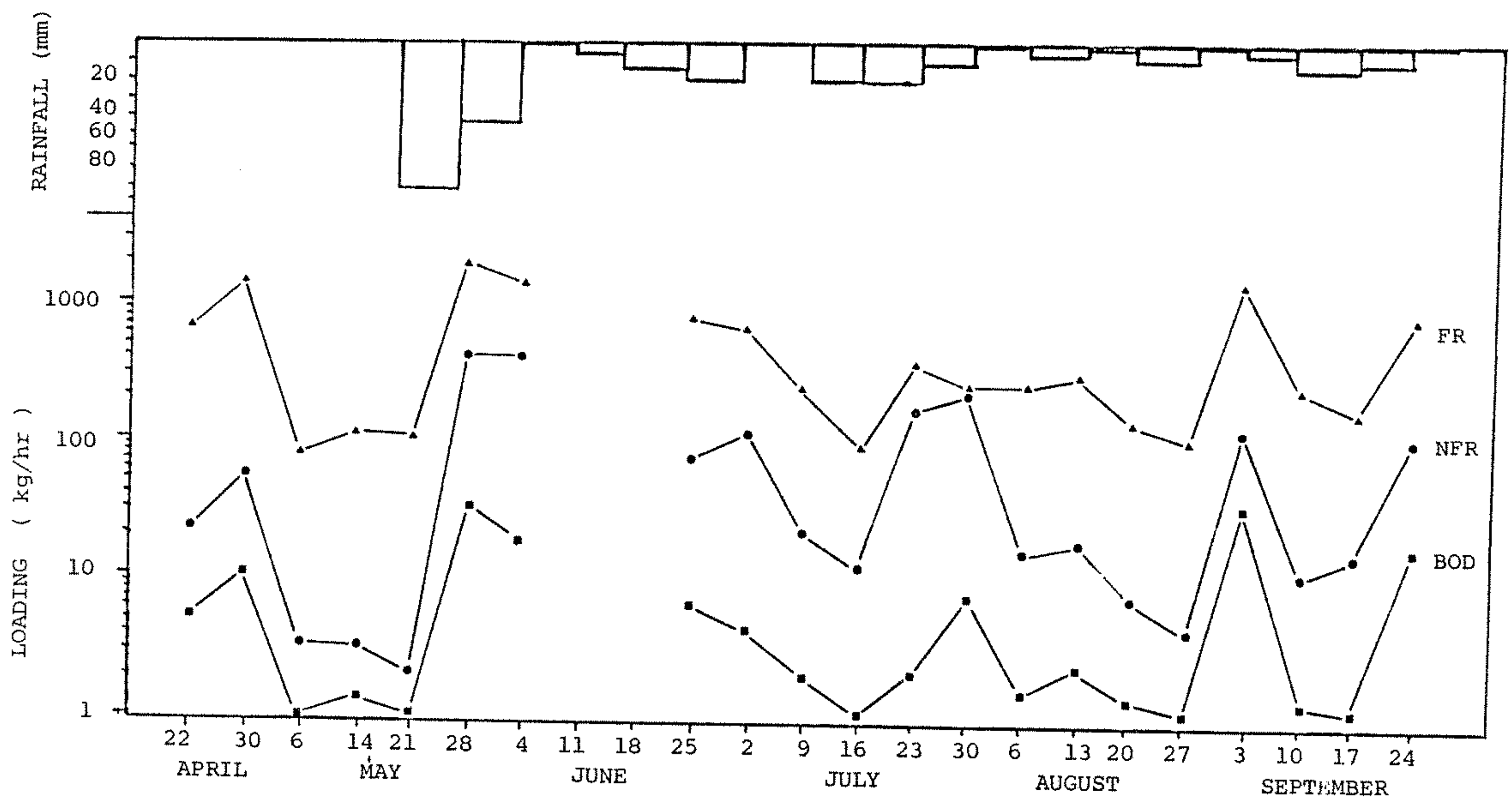


FIGURE 6. LOADINGS AT SITE 5 (NEAR THE MOUTH) FOR ROUTINE SAMPLING

ENVIRONMENT
Pollution Control Division
Water Quality Control Branch

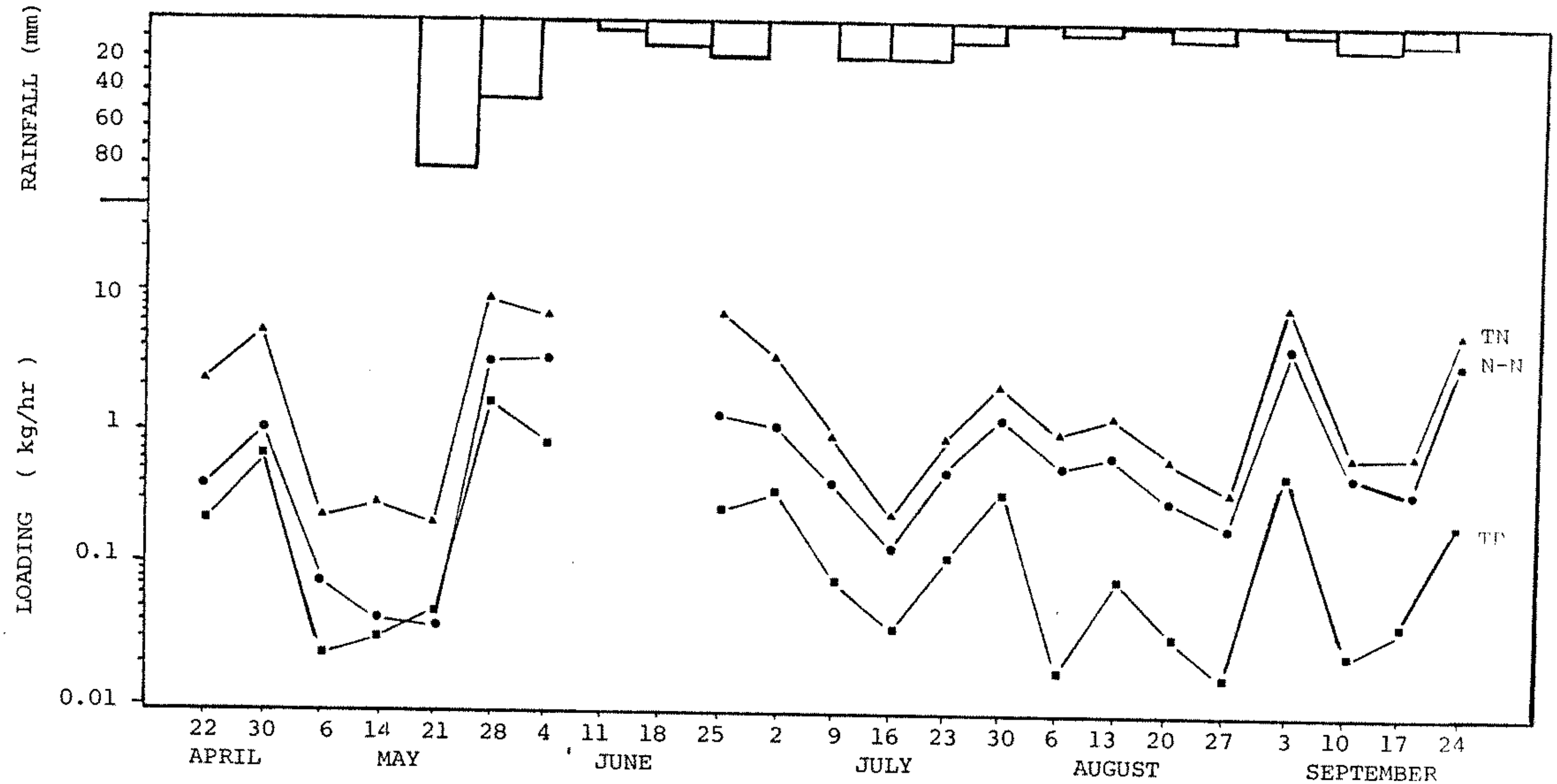


FIGURE 6 (Cont.) LOADINGS AT SITE 5 (NEAR THE MOUTH) FOR ROUTINE SAMPLING

Alberta
ENVIRONMENT
Pollution Control Division
Water Quality Control Branch

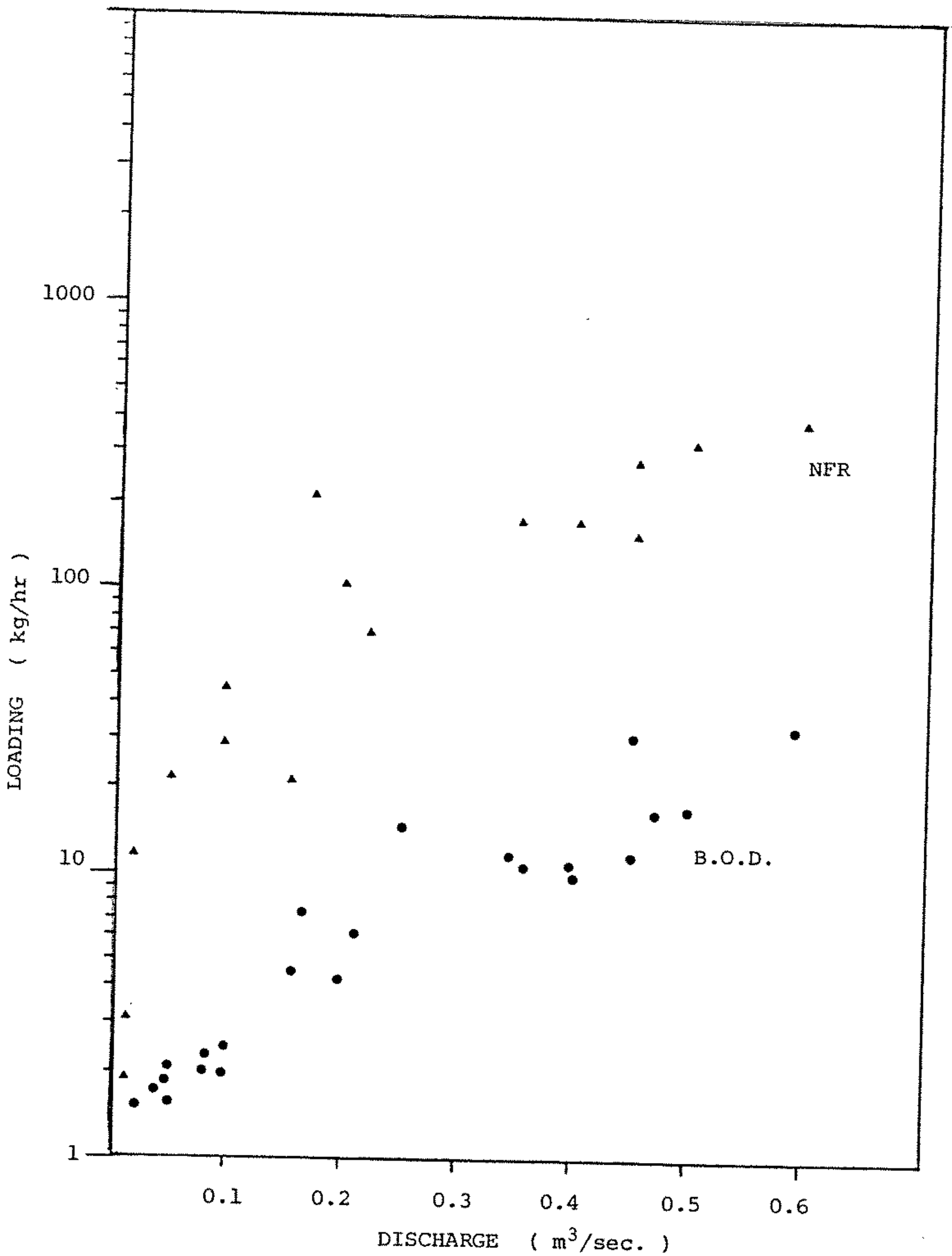


FIGURE 7. LOADING/DISCHARGE RELATIONSHIP AT SITE 5 FOR N.F.R. AND B.O.D.

Storm Sewer Sampling Program

General

As indicated in previous sections of this report, the water quality characteristics of both West Nose Creek and Nose Creek were influenced by storm sewer discharges. This section assesses the storm water discharge itself by examining magnitudes of the measured parameters in both dry-weather and storm sampling periods.

A summary of the data collected on storm sewer discharges is presented in Tables 12 to 18 inclusive and in Figures 8, 9 and 10. A detailed presentation of the data can be found in Appendix A, Tables 5-A, 6-A and 7-A.

Dry-Weather Storm Discharges

The data presented in Table 12 show that only nitrogen parameters vary significantly when sewer N-27 is compared with sewer N-13. This indicates the extensive use of nitrogenous fertilizers in the residential area, and subsequent infiltration of groundwater high in nitrogen into the storm lines.

B.O.D. shows increased concentrations at N-27 in relation to the increases noted for both nitrogen and total organic carbon.

In accordance with comparably low suspended solids from both outfall structures, particulate phosphorus levels were also low. At N-27 all phosphorus was dissolved, while at N-13, 79% was dissolved.

Metals concentrations were low for both storm sewers. Zinc showed a somewhat higher concentration at N-27. Instantaneous loadings at both locations were less than our detection limit. Again, B.O.D., T.O.C. and the nitrogen parameters showed higher loadings at N-27 in accordance with higher concentrations. Dry-weather flows were found to be higher at N-27 and accounted for the increased loadings of NFR since concentrations were quite similar at both sites. The dry-weather flow for N-27 was calculated to be 0.71 l/sec. and for sewer N-13 the flow was 0.23 litres/sec.

Table 12

Storm Sewer Discharge Mean Concentrations and Loadings for Dry-Weather Samples

Parameter	Statistic	Storm Sewer N-27	Storm Sewer N-13
B.O.D.	Mg/L	2.94	1.78
	Kg/Hr	.007	<0.001
T.O.C.	Mg/L	8.32	5.84
	Kg/Hr	0.02	0.004
T-Phos.	Mg/L	0.14	0.19
	Kg/Hr	<.001	<0.001
D-Phos.	Mg/L	0.14	0.15
	Kg/Hr	<.001	<0.001
TN	Mg/L	8.03	1.59
	Kg/Hr	0.02	<0.001
NH_3-N	Mg/L	.342	0.05
	Kg/Hr	<.001	<0.001
NO_3-NO_2-N	Mg/L	6.45	0.73
	Kg/Hr	0.02	<0.001
NFR	Mg/L	4.16	4.00
	Kg/Hr	0.01	<0.001
FR	Mg/L	798.8	666.8
	Kg/Hr	2.04	0.408
Zn	Mg/L	0.06	0.02
	Kg/Hr	< 0.001	<0.001
Pb	Mg/L	.004	.006
	Kg/Hr	<.001	<0.001
Cu	Mg/L	0.01	0.01
	Kg/Hr	<.001	<0.001
Cr	Mg/L	<.003	<.003
	Kg/Hr	<.001	<0.001

< :Indicates concentrations " less than "

Storm Discharges

The initial flush of stormwater during all sampling events was dark brown to black in colour with a visible oily sheen. With subsequent discharge, the stormwater became clearer although water levels within the outfall did not necessarily decrease. It was noted on occasion that the initial flushing had considerably lower flows but higher particulates than were observed at later times, indicating the large amounts of sedimentary material within the storm system.

The significant increases in concentrations of storm discharge over dry weather discharge are shown in Table 13. Exceptions are noted for those parameters which show a dilution effect due to increased discharge, namely total nitrogen, NO_3-NO_2-N and FR. Significantly higher nitrogen concentrations were observed at N-27, reflecting run-off of nitrogenous fertilizers and washout of particulate material such as grass clippings. This material was observed in discharges where the color would change to green. Lower values at N-13 would indicate a greater degree of paved surfaces in the industrial area.

B.O.D. and T.O.C. concentrations were similar at the 2 locations, however, T.O.C. values at N-27 were higher.

The mean value for nonfiltrable residues was higher at N-27 possibly reflecting greater inputs of organic debris from grassed areas and parkland. Metals, with the exception of zinc, showed similar mean concentrations at the two sewer outfalls. Table 13 shows that a substantial increase in lead occurred from both discharges. This would be the result of lead particles being washed into the storm system from the combustion of fuels.

Overall decreases in pH were noted in stormwater discharges when compared with dry-weather discharges. The usual trend found in storms was for pH to drop when the initial flush occurred, with values increasing over time as further washout occurred.

Phosphorus values at sewer N-27 were higher than those at sewer N-13. This was due to particulate inputs from the residential area being higher because of less paved surfaces.

Table 13.

Comparison of Concentrations of Measured Parameters in Dry Weather And Storm Discharges

Parameter (Mg/L)	Statistic	Storm Sewer N-27		Storm Sewer N-13	
		Dry Weather Sampling	Storm Sampling	Dry Weather Sampling	Storm Sampling
B.O.D.	Mean Mean Max	2.94 -	13.57 26.30	1.78 -	13.87 22.17
T.O.C.	Mean Mean Max.	8.32 -	26.24 39.29	5.84 -	22.96 38.33
T-Phos	Mean Mean Max.	0.14 -	0.93 1.64	0.19 -	0.67 1.94
D-Phos	Mean Mean Max.	0.14 -	0.17 0.28	0.15 -	0.19 0.55
TN	Mean Mean Max.	8.03	6.11 11.30	1.59 -	3.65 6.53
NH_3-N	Mean Mean Max.	0.342 -	0.59 1.10	.05 -	0.34 0.45
NO_3-NO_2-N	Mean Mean Max.	6.45 -	2.56 4.99	0.73 -	0.58 1.15
NFR	Mean Mean Max.	4.16 -	966.6 1829.9	4.00 -	636.2 1879.7
FR	Mean Mean Max.	798.8 -	327.7 626.9	666.8 -	240.1 599.0
Zn	Mean Mean Max.	0.06 -	0.17 0.41	0.02 -	0.27 0.74
Pb	Mean Mean Max.	.004 -	0.51 1.50	0.006 -	0.55 1.92
Cu	Mean Mean Max.	0.01 -	0.08 0.47	0.01 -	0.07 0.20
Cr	Mean Mean Max.	<.003 -	.005 0.010	<.003 -	.004 .008
pH (units)	Median range	7.85 7.75-8.10	7.37 6.20-8.50	7.81 7.46-8.00	7.24 6.65-7.92

Table 14

Comparison of Instantaneous Loadings of Measured Parameters in Dry-Weather and Storm Discharges from Storm Sewer N-27

Parameter	Statistic (Kg/Hr)	Dry Weather Samples	Storm Discharge Samples
B.O.D.	Mean	0.007	20.39
	Mean Max.	-	34.89
T.O.C.	Mean	0.020	11.68
	Mean Max.	-	38.58
T-Phos.	Mean	<0.001	.54
	Mean Max.	-	1.80
D-Phos	Mean	<0.001	0.06
	Mean Max.	-	0.19
T N	Mean	0.020	2.79
	Mean Max.	-	7.63
NH_3-N	Mean	<0.001	.364
	Mean Max.	-	1.29
NO_3-NO_2-N	Mean	0.020	0.693
	Mean Max.	-	1.66
NFR	Mean	0.010	701.00
	Mean Max.	-	2013.00
FR	Mean	2.04	104.98
	Mean Max.	-	254.83
Zn	Mean	<0.001	0.12
	Mean Max.	-	0.47
Pb	Mean	<0.001	0.19
	Mean Max.	-	0.88
Cu	Mean	<0.001	0.16 (.013)
	Mean Max.	-	1.24 (.035)
Cr	Mean	<0.001	<.001

< : Indicates values " less than "

Note: Values in brackets are obtained if the high Aug. 20 storm values are deleted from the mean calculation

Table 14 compares dry weather loadings to storm loadings. All parameters are shown to contribute significantly to the receiving waters. Loadings for nonfiltrable residue were very high and caused considerable siltation of the Nose Creek water course. In addition, many of the measured parameters were associated with this material. Depending on discharges, much of this material may be resuspended, resulting in a flushing of Nose Creek itself.

Table 15 and Figures 8 and 9 present data on microbial densities found from storm sewer discharges. In Figure 8 individual variations from storms are presented. Figure 9 illustrates the trend from the beginning of a storm to the end for two separate storm discharges. Table 15 shows that densities from storm sewer discharges were very high. The high faecal coliform/faecal streptococci ratio at N-27 indicates human contamination. This would indicate some sanitary sewage infiltration into the storm system. Storm sewer N-13 indicates animal inputs because of a low faecal coliform/faecal streptococci ratio. The expectation, however, would be that there should be less animal input from that area.

Table 15

Microbial Density Summary for Discharges From Storm Sewers

Microbial Parameter	Storm Sewer	
	N-27	N-13
Total Coliform	* 169,489	163,335
Faecal Coliform	33,397	6,192
Faecal Streptococci	9,780	48,676

Note: All values are in no./100ml. and are geometric means of all samples collected from the storm sewers

* : Indicates values "greater than" because certain samples had densities too numerous to count.

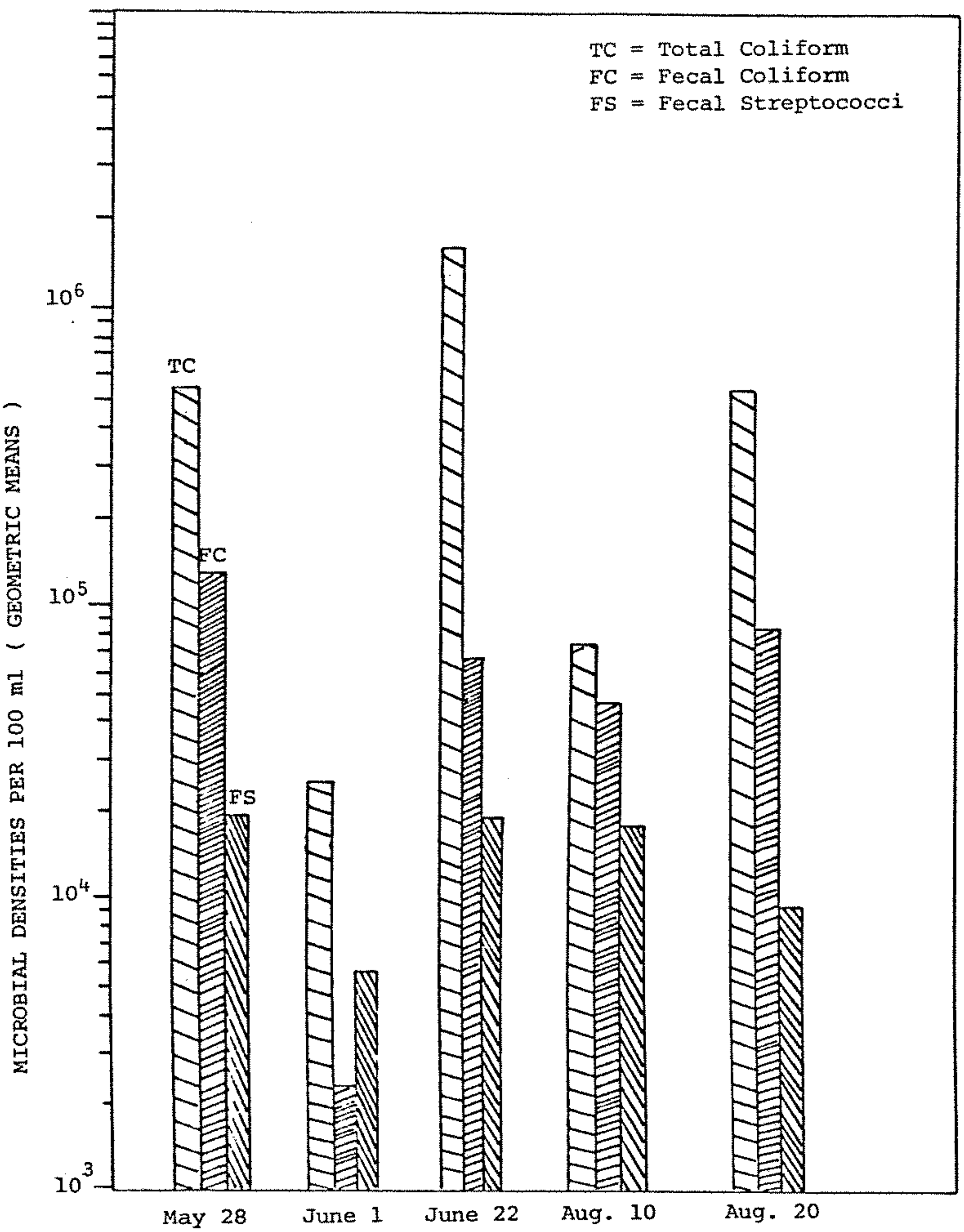


FIGURE 8. MICROBIAL POPULATIONS IN DISCHARGES FROM FIVE STORM EVENTS AT STORM SEWER N - 27

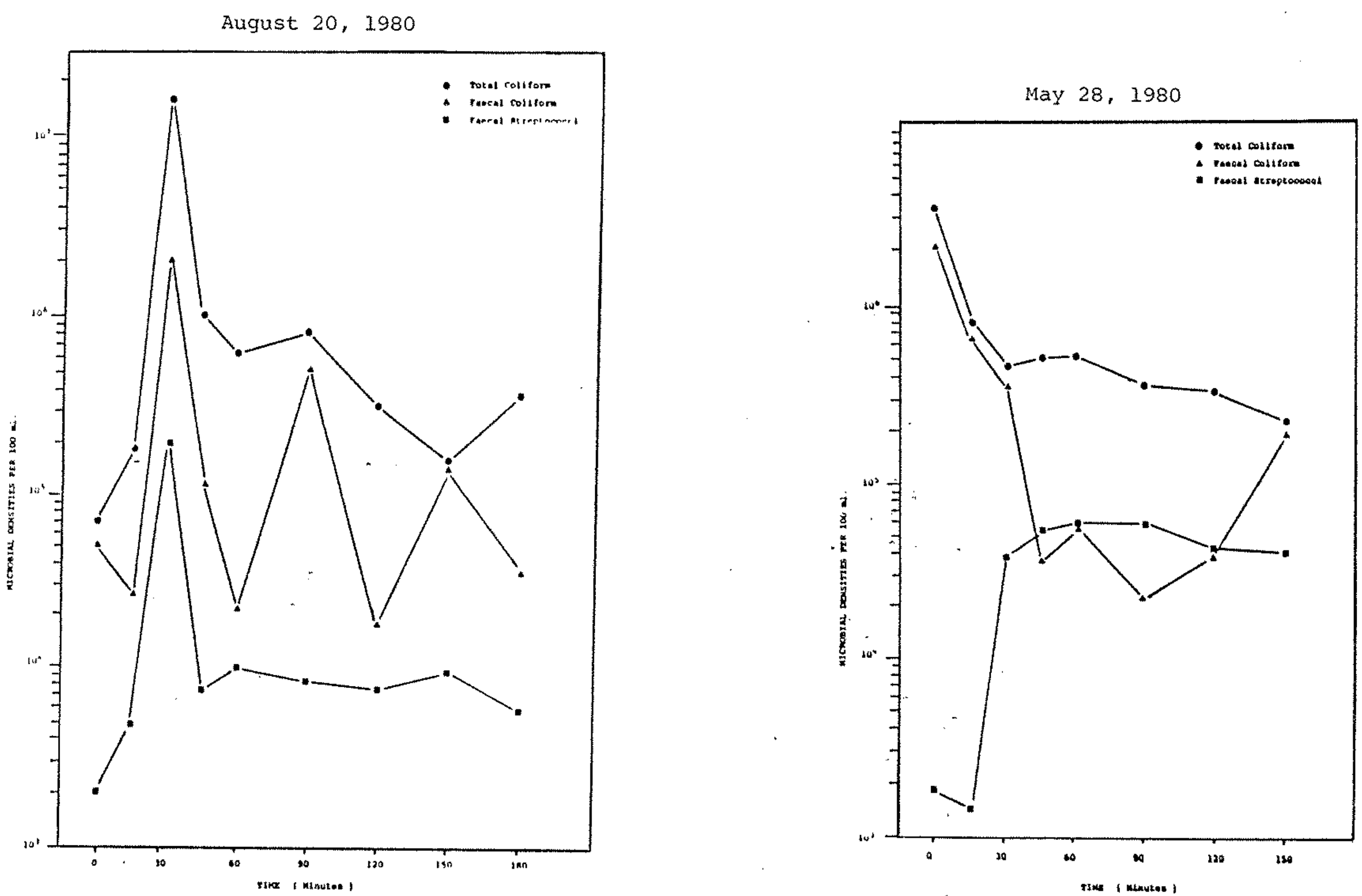


FIGURE 9. MICROBIAL DENSITY RESULTS FOR STORM SEWER N-27 FOR STORMS ON MAY 28,1980 AND AUGUST 20,1980

Alberta
ENVIRONMENT
Pollution Control Division
Water Quality Control Branch

Dutka (3) noted that there seems to be no distinct trends in discharged bacteria results. Our results, however, do show some correlation with flow. When flows are high, densities are lower indicating a dilution effect. Figure 9 indicates the magnitudes of microbial densities that can occur for individual storm events. No seasonal trends seem to be apparent.

Table 16 shows data on a loadings (total) for a 3 hour duration from storm sewer N-27 for given rainfall characteristics. They could be used to estimate loadings from a drainage area for various chemical parameters if certain meteorlogical facts are known.

Table 17 indicates that storm sewers discharge varying amounts of "oil and grease" to the watershed. The amounts will vary with the vehicular density and traffic patterns in a particular area.

Table 18 shows that the source of 2,4-D in the stream was due to storm sewer discharges. Indications are that storm sewer dry-weather flows also contributed pesticides to the stream. The pesticide 2,4-D originated from applications to control weeds predominantly in the residential areas.

For each storm event, similar trends were observed for concentrations and loadings during the 3 hr. sampling periods. Figure 8 presents a loading graph of 12 measured parameters boserved in storm discharge on June 14.

Large increases in flush concentrations and loadings can be seen, although the two did not necessarily peak together. Filtrable residue and nitrate-nitrite nitrogen concentrations decreased whereas loadings increased. Dissolved phosphorus concentrations showed only slight changes throughout the sampling period, however, significant loadings occurred early in the discharge.

Following the 3 hr. period it can be seen that for the most part concentrations and loadings have returned to levels noted previously in the dry-weather flow (sample 1).

Table 16

Total Loadings for 3 hour Storm Sampling Periods at Storm Sewer N-27, With Accompanying Rainfall Characteristics

Parameter	May 25	May 28	June 14	June 22	July 18	Aug. 10	Aug. 20
B.O.D.	30.40 (0.152*)	9.59 (0.048)	21.12 (0.100)	23.77 (0.119)	3.65 (0.018)	13.55 (0.680)	52.20 (0.262)
T. Phos	6.02 (0.030)	1.27 (0.006)	4.68 (0.023)	0.72 (0.004)	0.12 (0.0006)	0.18 (0.0009)	15.8 (0.008)
TN	22.72 (0.114)	9.26 (0.05)	19.74 (0.099)	6.36 (0.037)	0.73 (0.004)	(0.017) 2.33	5.16 (0.026)
NO_3-NO_2-N	5.48 (0.027)	3.99 (0.020)	3.06 (0.015)	2.31 (0.016)	0.15 (0.0008)	754 (0.004)	1.399 (0.007)
NFR	4863.6 (24.39)	1199.2 (6.01)	7450.1 (37.36)	1651.0 (8.78)	212.4 (1.106)	233.84 (1.17)	1289.29 (6.47)

* Values in brackets indicate loading in kg/hectare

Rainfall Characteristic	May 25	May 28	June 14	June 22	July 18	Aug. 10	Aug. 20
Total for storm (mm)	10.4	0.7	6.6	2.4	5.8	2.2	4.0
Intensity (mm/hr)	6.1	0.3	6.6	2.4	1.2	1.1	4.0
Days or hrs since previous rainfall	7.25 hrs.	1 day	3 days	2 days	6 days	2 days	2 days
Am't of previous rainfall (mm)	4.6	10	1.8	1.6	17.0	3.20	2.4
Intensity of previous rainfall (mm/hr)	0.8	9.0	0.45	9.6	2.60	3.20	0.50

Table 17

Oil and Grease Concentrations
Nose Creek Water Quality Study

	Site	Date	Sampling Event	Concentrations (mg/l) and sampling sequences
Storm Sewer Samples	N-27	June 1	Storm	2, 11, 2
	N-27	June 14	Storm	5, 2, 3, 1,
	N-13	June 19	Storm	10
	N-27	June 22	Storm	13, 4, 41
Creek Samples	5	June 14	Storm	1, 4, 4, 34, 29, 323
	7	June 14	Storm	2
	6	June 18	Routine	1.0
	5	June 22	Storm	1, 3, 4
	6	June 22	Storm	13
	2	Sept. 24	Routine	1.0
	3	Sept. 24	Routine	1.0
	5	Sept. 24	Routine	1.0
	6	Sept. 24	Routine	1.0
	7	Sept. 24	Routine	0.0

Table 18

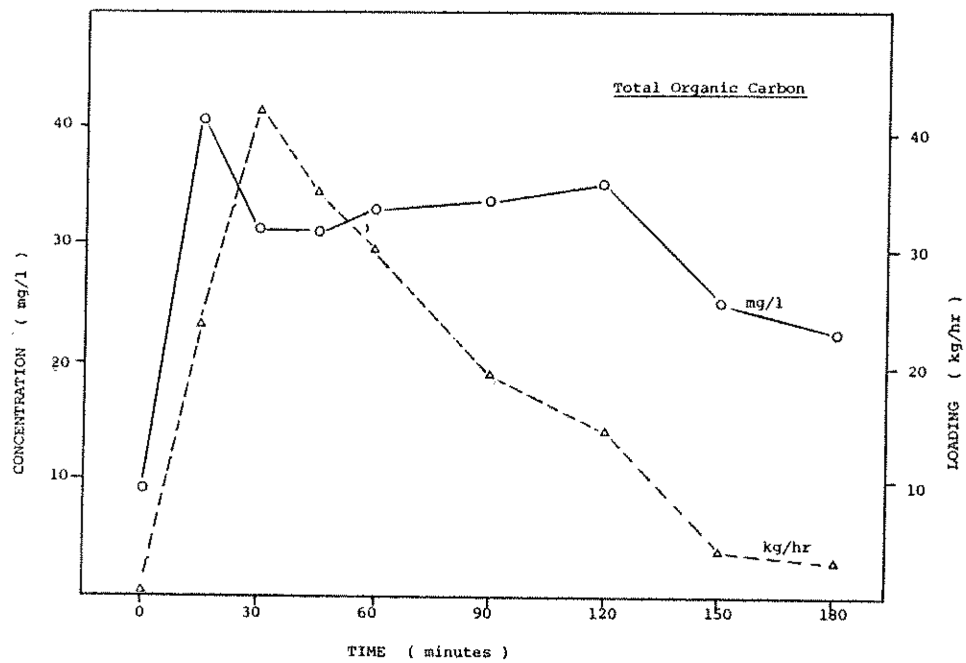
Summary of Concentrations of Herbicide and Pesticide Samples
From Routine Creek and Storm Sewer Discharge Samples

Pesticide/ Herbicides (mg/L)	May 6				May 21				May 23*	
	Site 3	Site 5	Site 6	Site 7	Site 3	Site 5	Site 6	Site 7	Site 5	Site 6
2,4 - D	< 0.001	0.81	0.19	<0.001	< 0.001	0.36	<0.001	<0.001	<0.001	<0.001
Temephos	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.26	.30
Chlorpyrifos	ALL SAMPLES - <0.001 mg/1.									

* Storm Samples

Pesticide/ Herbicide	Storm Sewer N-27 Sampling dates								Storm Sewer N-13
	May 8*	May 23	May 25	May 26	June 1	June 14	June 22	June 26	May 26
2,4 -D	0.39	0.43	< 0.001	0.19	0.63	0.21	0.17	< 0.001	< 0.001
Temephos	ALL SAMPLES < 0.001 mg/1.								
Chlorpyrifos	ALL SAMPLES < 0.001 mg/1.								

* Dry-weather samples
< Indicates values " less than "



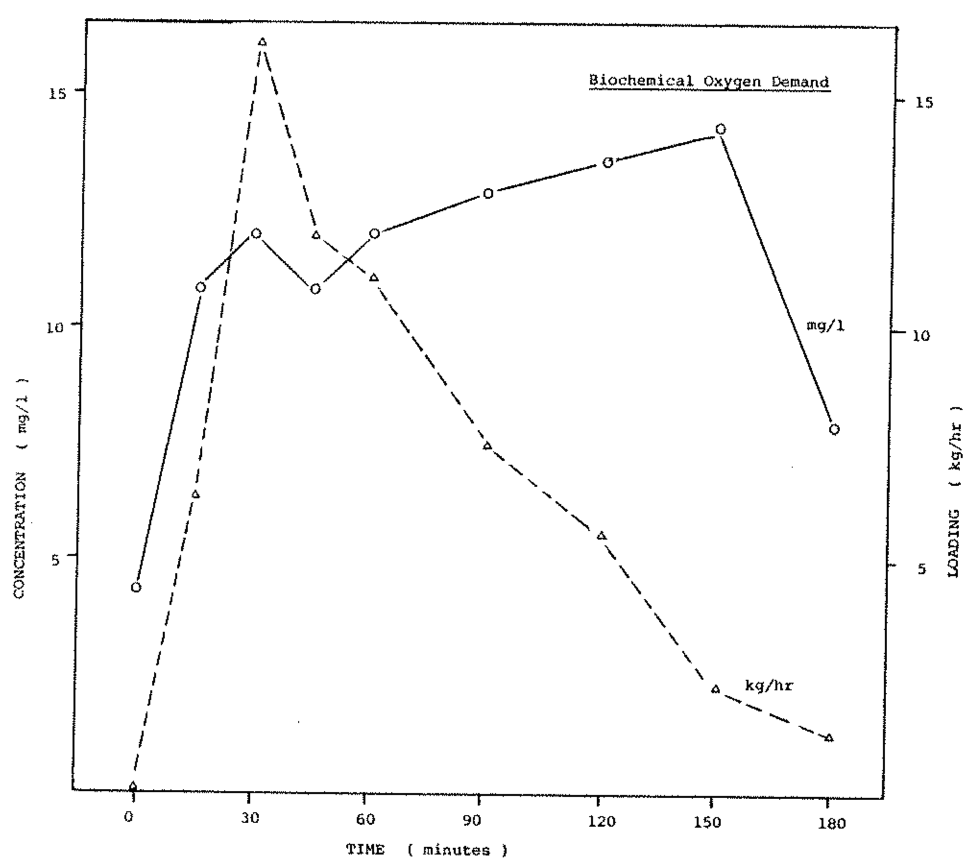
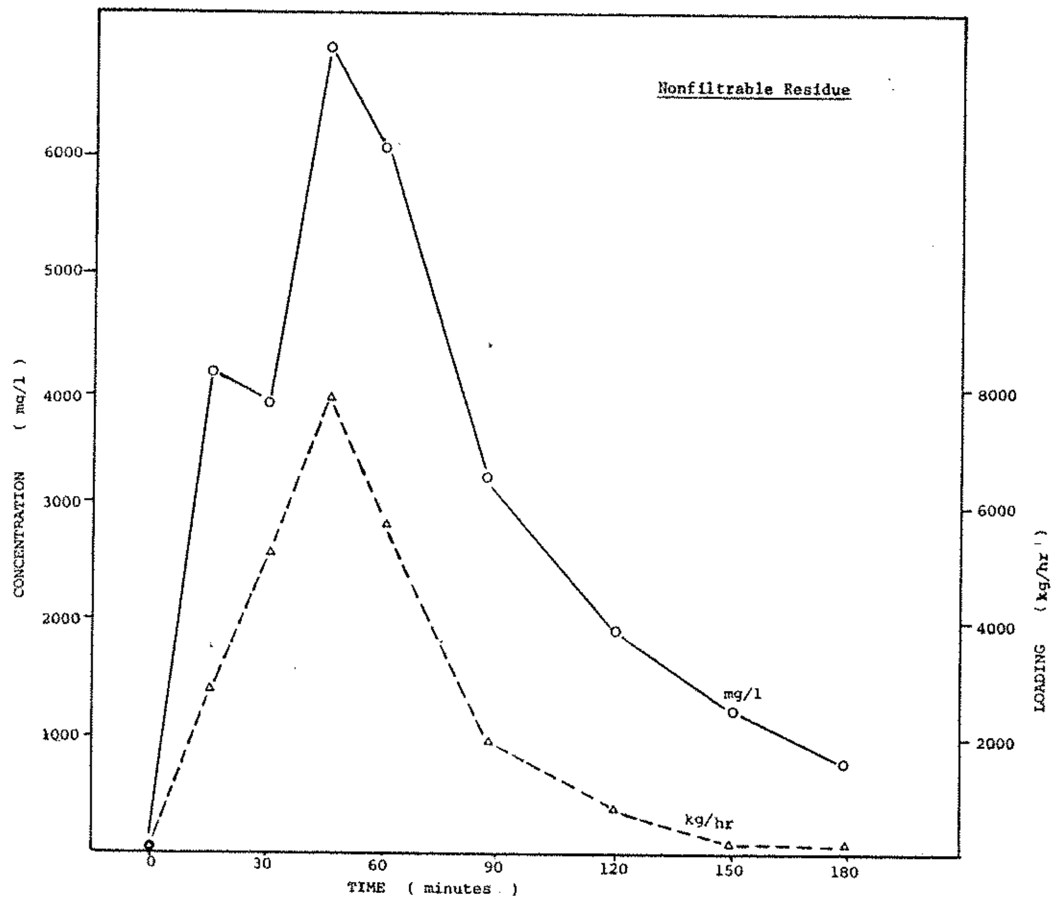


FIGURE 10. LOADING AND CONCENTRATION RELATIONSHIP OF MEASURED PARAMETERS IN STORM SEWER N-27 DISCHARGE FOR JUNE 14, 1980



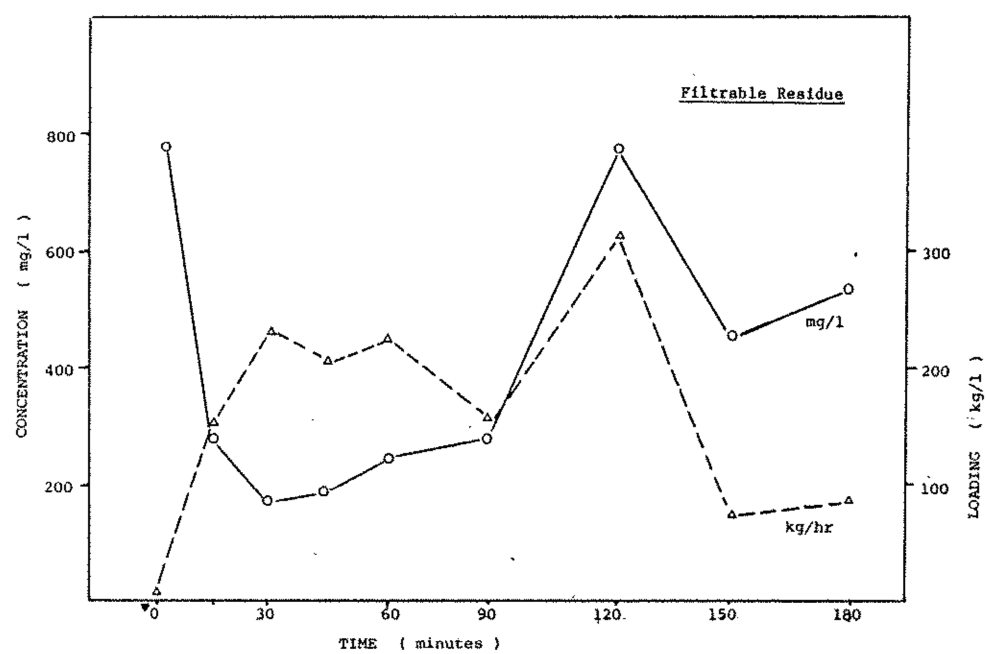
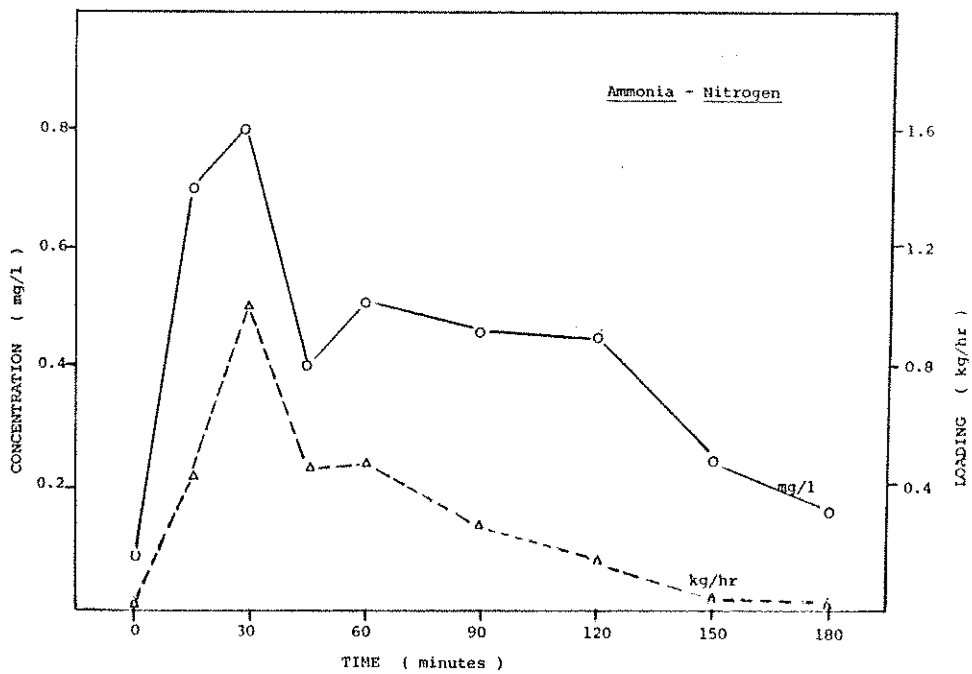


FIGURE 10. (Cont.) LOADING AND CONCENTRATION RELATIONSHIP OF MEASURED PARAMETERS IN STORM SEWER N-27 DISCHARGE FOR JUNE 14,1980



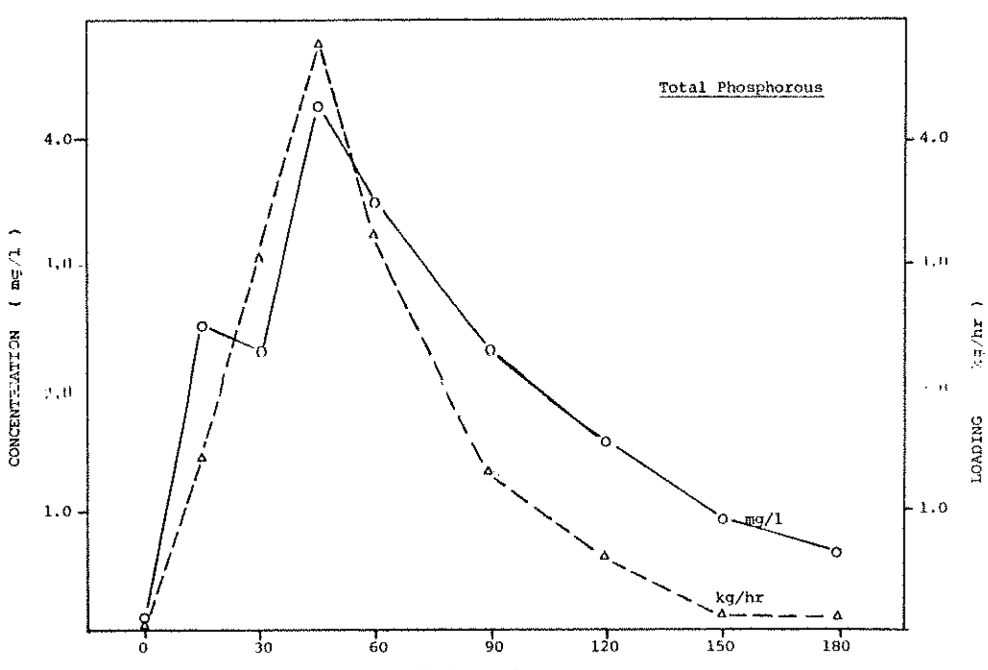
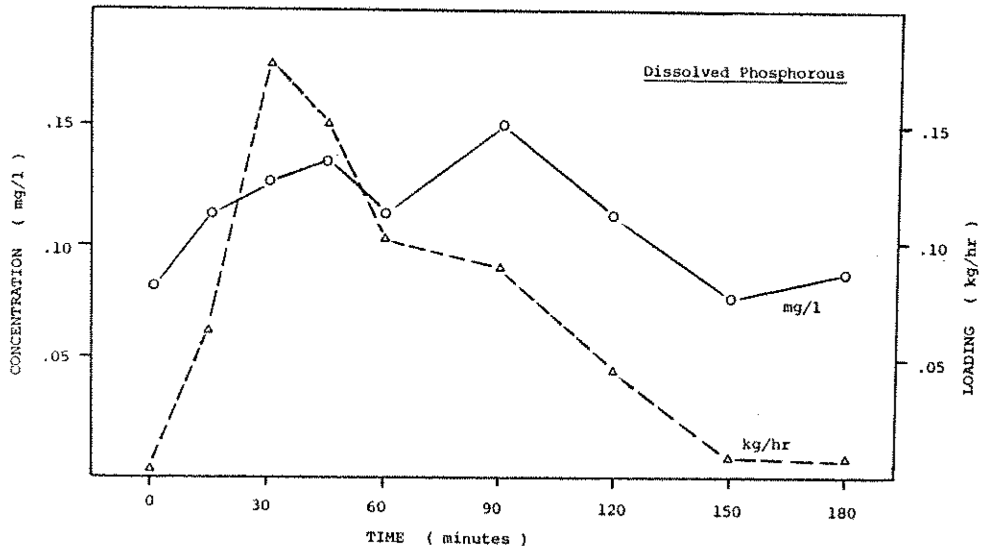


FIGURE 10. (Cont.) LOADING AND CONCENTRATION RELATIONSHIP OF MEASURED PARAMETERS IN STORM SEWER N-27 FOR JUNE 14,1980



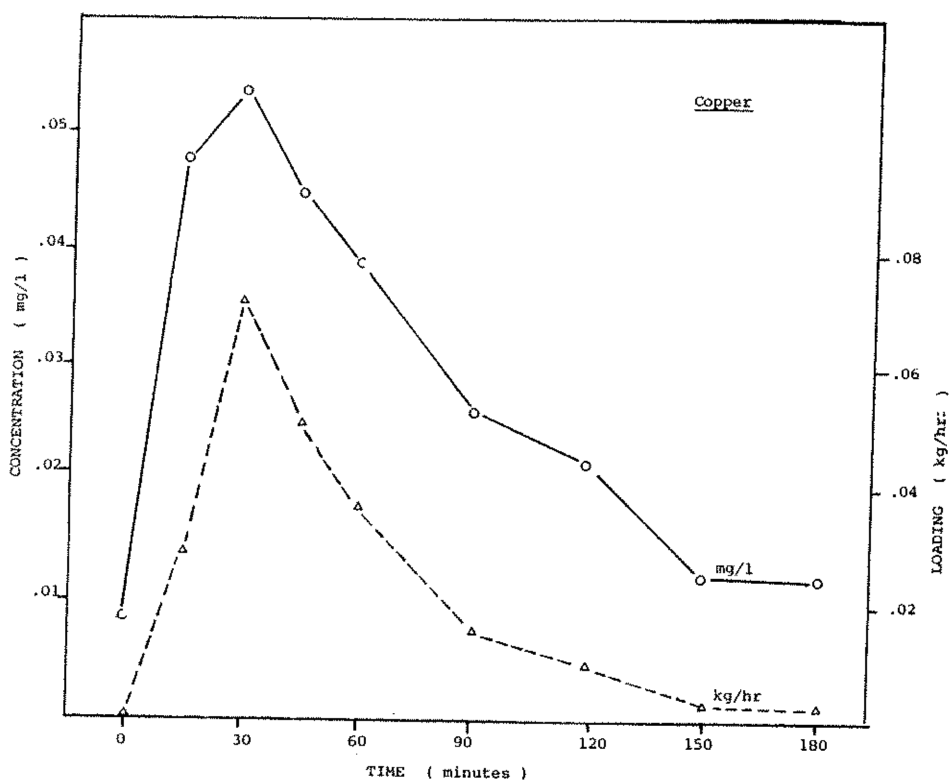
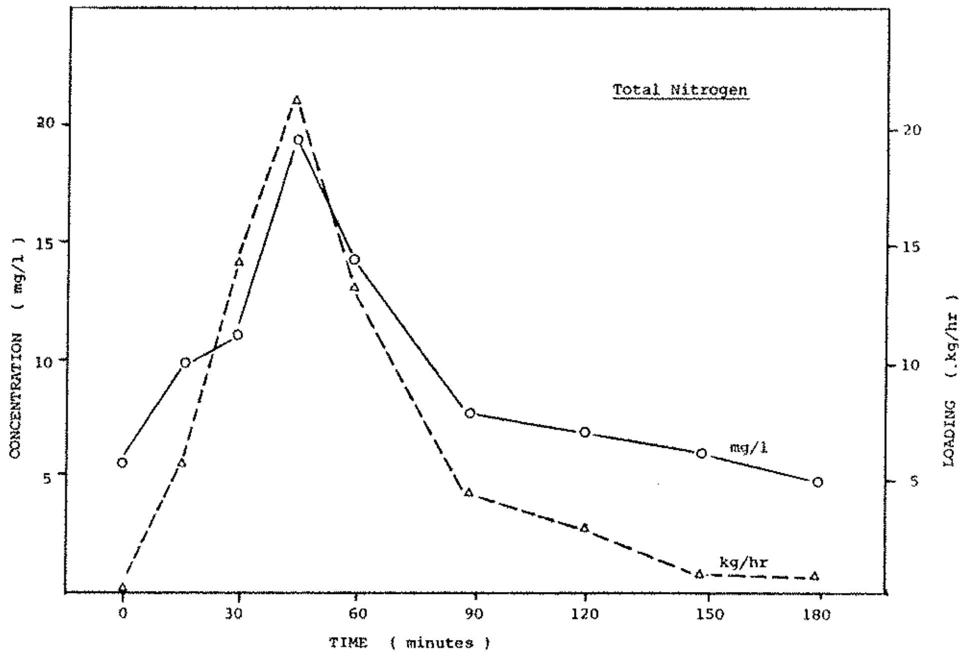


FIGURE 10.(Cont.) LOADING AND CONCENTRATION RELATIONSHIP OF MEASURED PARAMETERS IN STORM SEWER N-27 FOR JUNE 14,1980



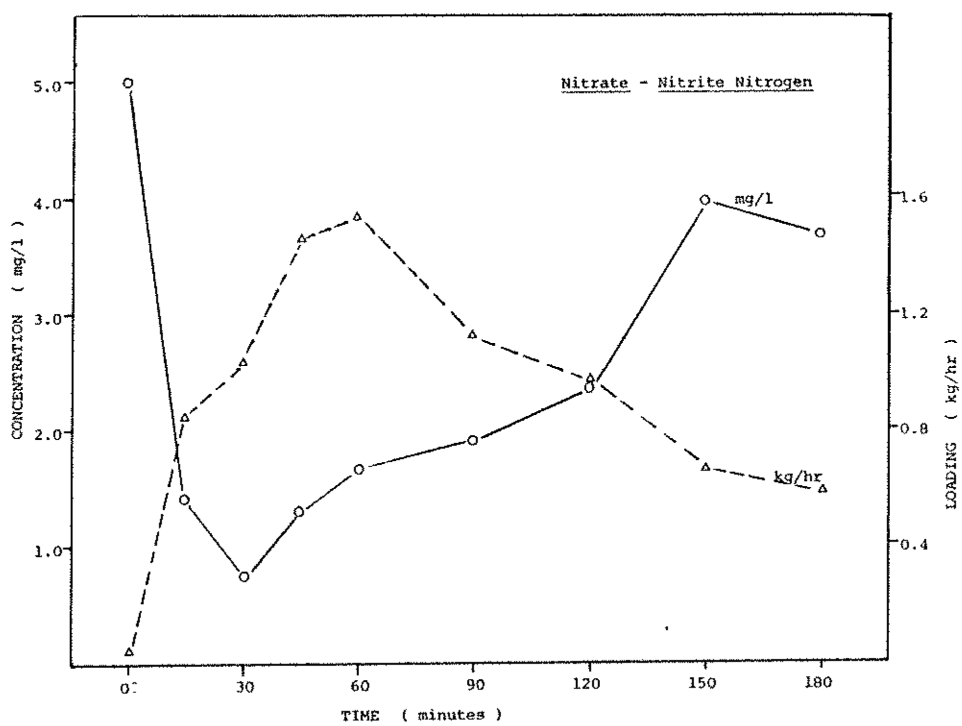
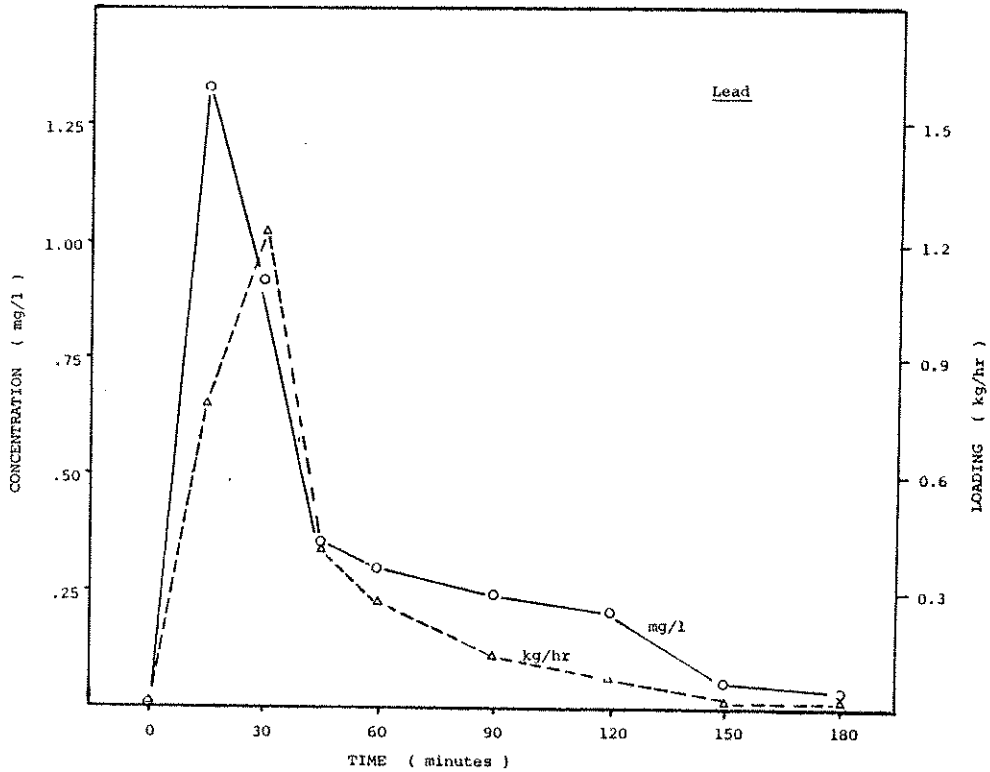


FIGURE 10. (Cont.) LOADING AND CONCENTRATION RELATIONSHIP OF MEASURED PARAMETERS IN STORM SEWER N-27 FOR JUNE 14,1980



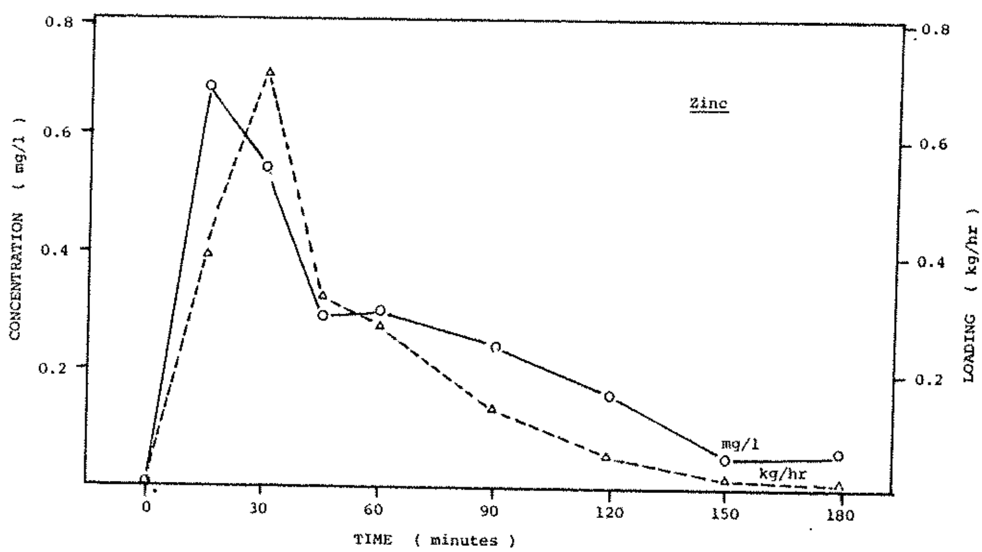


FIGURE 10. (Cont.) LOADING AND CONCENTRATION RELATIONSHIP OF MEASURED PARAMETERS IN STORM SEWER N-27 FOR JUNE 14,1980

SUITABILITY FOR WATER USES

General

In order to determine whether the water quality of West Nose Creek and Nose Creek was suitable for a variety of uses, a quick survey of present use and possible future uses was made. This survey revealed four present and possible future uses of the water in the basin. These uses are livestock watering, irrigation, recreation and the possibility of using the source as a public water supply. If more than one source for the criteria is presented in Tables 19 to 22, the most stringent criteria was used to indicate suitability for the various uses.

The Alberta Surface Water Quality Objectives (Table 19) (Alberta Environment, 1977) indicate objectives for water quality to meet a number of simultaneous uses such as public water supply, agricultural, fish and wildlife, recreational and aesthetics. Since natural water varies considerably from site to site, some locations may not meet the requirements.

Some of the parameters in the sampling program are not considered in the Alberta Objectives and therefore specific-use criteria are presented in Tables 20, 21 and 22. Table 21 presents criteria for the recreational use of water. It presents the Alberta Objectives along with the Environment Canada Guidelines for Water Quality Objectives and Standards, 1972 for comparison. Table 20 presents criteria for public water supply and provides a comparison of three different sources of which the Canadian Drinking Water Standards, 1978 seem to be the most stringent. Table 22 presents use-specific criteria for irrigation and livestock watering. The Ontario Ministry of Environment criteria and the United States Academy of Science (U.S. N.A.S.) and Engineering (U.S. N.A.E.) are presented for comparison purposes.

All the criteria presented in the tables are applicable over a wide range of conditions and therefore more information may be required to determine site-specific suitability for a particular use.

Public Water Supply

The criteria for evaluating Nose Creek water suitability as a potential source of drinking water is presented in Tables 19 and 20. When these criteria are compared to the routine sampling results in Table 3, 5, 6, 7, 17 and 18, it is evident that a number of parameters did not meet the criteria. Total phosphorus, non-filtrable residue, filtrable residue, zinc, total coliform, faecal coliform and pesticides did not meet the criteria at all sites.

Total phosphorus value exceeded both the Ablerta objectives and the federal standards at all sites.

Nonfiltrable residue concentrations exceeded the Alberta objectives only. If Site 7 is to be considered as a background value for the Calgary locations, sites 3, 5 and 6 do not adhere to the criteria. For the Airdrie sites, the same holds true except that the increase in concentration is only slightly higher than the 10 mg/l. allowed.

Filtrable residue concentrations did not meet the federal objectives at sites 3, 5, 6 and 7. Values, however, were only slightly higher than the allowable 500 mg/l. The value at site 1 (above Airdrie) exceeded the criteria for filtrable residues but the site 2 (below Airdrie) value was acceptable.

Zinc concentrations were excessive only at site 3 and again the increase over the acceptable limit was not very great.

Total coliform and faecal coliform values for the six month period did not exceed the limits set out in the Alberta objectives but they were in excess of the Canadian Drinking Water Standards, 1978 and therefore all sites would have to be classified as unacceptable. The Airdrie sites would also be unacceptable as a drinking water supply.

Pesticide concentrations did not meet federal standards at sites 5 and 6.

It should be noted that when the results compared to published criteria, only the mean sampling results are compared and therefore in some cases individual samples may or may not be within criteria limits. The final mean value will indicate specific-use suitability over the entire period.

Data on creek samples collected during storm events are presented in Tables 8, 9, 17 and 18, and when compared to criteria in Tables 19 and 20, similar excursions as for the weekly results are indicated. Magnitudes however differ. Total phosphorus values exceeded the Alberta criteria again at all sites. The value at site 7 was twice the standard of 0.05 mg/l. The value at site 6, the highest recorded mean, was 13 times the standard. Nonfiltrable residue concentrations exceeded the criteria at sites 5 and 6. Values ranged from 20 to 50 times the background value. The background value is considered to be the site 7 concentration. Filtrable residue concentrations exceeded the Canadian Drinking Water Standards, 1978 at sites 5, 6 and 7. Lead and zinc concentrations exceeded the Alberta Standard of 0.05 mg/l at site 5 only. Total coliform and faecal coliform densities exceeded the Alberta and the federal standards at site 5, 6 and 7. Pesticide concentrations at the sites measured exceeded the federal criteria during storm events by about 3 times the allowable limit.

In summary, the Nose Creek and West Nose Creek water is not suitable for use as a public water supply. The rural sites indicate somewhat better suitability but only because of lower mean concentrations of the chemical parameters in excess of the criteria.

Table 19

Alberta Surface Water Quality Limits

BOD	DO must be kept at 5.0 mg/l
TOC	-
Suspended Solids (NFR)	Not more than 10 mg/l over background
pH	6.5 - 8.5
DO	Not < 5.0
Oil & Grease	No sheen
Chromium	.05
Lead	.05
Zinc	.05
Phosphorus (PO_4)	.15

	Outdoor Recreation/ Potable Supply	Direct Contact/ Crop Irrigation
Total Coliform	5000/100 ml	1000/100 ml
Faecal Coliform	1000/100 ml	200/ml or 2400/100 ml on any day

Note: Bacteriological values are based on 90% of the samples, of not less than 5 samples in any consecutive 30 day period.

Table 20

Surface Water Quality Limits for Public Water Supply

Sources & Objectives

Parameter	(2) Canada, 1972	(3) US NAS/NAE, 1973	Canadian Drinking Water (1 Standards, 1978 (Max.)
BOD	-	-	-
TOC	-	-	-
Total phosphorus	.2 (PO_4)	-	-
Total Nitrogen	-	-	-
Ammonia	0.5	.5	-
Nitrate-Nitrite-N	10.	10.0	10.0
Filterable Residue (TDS)	1000	-	500
Zinc	5.0	5.0	5.0
Lead	.05	.05	.05
Copper	1.0	1.0	1.0
Chromium	.05 ($Cr.^{+6}$)	0.05 (total)	.05
Oil & Grease	-	Undetectable	
24-D		.02	.1 (1)
Temephos	.1 (total)	-	.1 (1)
Chlorpyrifos	-	.1 (total)	.1 (1)
Total Coliform Number/ 100 ml	5000	20,000	10 (single sample)
Faecal Coliform	1000	2000	None detected
pH	6.5 - 8.3	5.0 - 9.0	6.5 - 8.5

(1) Concentrations obtained from Canadian Drinking Water Standards, 1978

(2) Canada, 1972 - Guidelines for Water Quality Objectives and Standards, Department of Environment Inland Waters Directorate, Ottawa Technical Bulletin 67

(3) US NAS/NAE, 1973 - Water Quality Criteria 1972, Environmental Protection Agency, Washington, D.C. Pub. EPA-RB 73-33

Recreation

Objectives and criteria for recreation are presented in Tables 19 and 21. The limiting factors that determine the suitability of the water in the Nose Creek watershed for recreation are total and faecal coliform. The standards present data on a number of other factors. The majority of them were acceptable except for oil and grease.

The standards present data on acceptable concentrations of various parameters for direct and secondary contact recreation. Direct contact involves activities such as swimming and water skiing. Secondary contact includes activities such as fishing, boating and other activities that involve less frequent body contact. For comparison the more restrictive Alberta Standards are used.

Data presented in Table 5 indicate, based on weekly sampling, that direct contact recreation is allowable at sites 3 and 7 but would not be allowable for the urban areas (sites 5 and 6). Site 5 data indicate that that location may be acceptable for the months of April and May only. The data show that although the rural sites are generally acceptable, the months of June, July and August could be unsuitable due to high microbial densities. Secondary contact recreation would be generally allowable at all sites throughout the period but would not be allowable for the months of June, July and August at site 5 due to high coliform densities.

The data in Table 7 indicate that for weekly sampling, the water in Nose Creek above and below the town of Airdrie is generally acceptable for direct and secondary recreation. The site below Airdrie (site 2) for May and June would be unacceptable for direct contact recreation due to high faecal coliform densities.

Table 9 presents data on microbial densities in creek water during storm periods, and when compared to the Alberta criteria, all sites are unsuitable for direct contact recreation. The rural sites would be the only sites of the four major Calgary sites suitable for secondary contact.

Table 21

Water Quality Objectives and Criteria for Recreation

Sources and Objectives

Parameter	Alberta Environment Water Quality Objectives, 1977	Environment Canada, Guidelines For Water Quality Objectives & Standards, 1972
1. Direct Contact		
Color (true color units)	-	100.0
Odor (T.O.N)	-	16
Temperature (°C)	-	15 - 30
Turbidity	-	5 - 50
Oil & Grease (mg/l)	-	5
pH (units)	-	6.0 - 9.0
Total Coliform (MPN/100ml)	2400 (single sample)	500 (Median)
	1000 (Geometric mean)	-
Feacal Coliform (MPN/100ml)	200 (Geometric mean)	200 (Median)
2. Secondary Contact		
Faecal Coliforms (MPN/100ml)	1000 at least 90% of samples (not less than 5 in any consecutive 30 day period)	-
Total Coliforms (MPN/100ml)	5000 (same frequency as above)	-

Table 17 data show oil and grease concentrations during routine and storm sampling. The weekly sampling results show that the concentrations are acceptable. During storm events, however, with increased concentrations and a visible sheen on the surface of the water, the waters within the urban area would be unsuitable for recreation.

In summary, weekly data indicate that the urban sites are unsuitable for direct contact recreation but secondary contact recreation would be permissible during certain periods. Microbial densities and oil and grease concentrations are the limiting factors within the urban areas. The data indicate that the rural areas are generally acceptable for both types of recreation, however, microbial densities may limit direct contact recreation during certain times. During storm events ,and under run-off conditions, all Calgary area sites indicated concentrations generally unacceptable for direct or secondary recreation.

Nose Creek quality above and below Airdrie is generally suitable for both types of recreation based on weekly sampling but there may be violations of criteria at the site below Airdrie during certain periods.

Livestock Watering and Irrigation

Criteria for quality of water suitable for livestock watering and irrigation are presented in Tables 19 and 22.

In reviewing the summary data in Tables 3, 6 and 8, and comparing this data to the criteria in Table 22, the water in Nose Creek and West Nose Creek is generally acceptable for livestock watering in the area covered by the study. However, pesticide values as shown in Table 20, are in excess of the published criteria within the urban area. This water would be unsuitable for livestock watering.

Criteria for irrigation depend on a number of factors such as the nature of the soil and the type of crop being irrigated. The values in Tables 19 and 22 are the maximum acceptable concentrations for continuous use on all types of soils.

Table 22

Surface Water Quality Limits for Livestock Watering and Irrigation

	Source and Objectives			
	U.S. NAS/NAE 1973		Ontario Environment 1979	
Parameter	Livestock Watering	Irrigation	Livestock Watering	Irrigation
pH	-	-	-	4.8-9.0
BOD	-	High values deplete oxygen	-	-
Total Organic Carbon	-	-	-	-
Suspended Solids	-	-	-	-
Nitrate Nitrite-N	100.	-	20.0	-
Dissolved Oxygen	-	-	-	-
FR(Filt. Residue)	3000.	500.0	2500.	500.
Oil & Grease	-	-	-	-
Chromium	1.0	.1	.05(+6)	20.0
Lead	.1	5.0	.05	20.0
Copper	.5	.2	-	5.0
Zinc	25.	2.0	-	5.0
Phosphorus	-	-	-	-
Total Coliform MPN/100 ml	Avoid Contaminated areas	-	-	-
Faecal Coliform MPN/100 ml	Avoid Contaminated areas	1000.	-	100.
24D	.02	No toxic effects	-	-
Temephos	.1 (total)	No toxic effects	-	-
Chlorpyrifos	-	No toxic effects	-	-

The weekly sampling results in Tables 5 and 8 when compared to the criteria, indicate general acceptability of the water for irrigation at all the sites in the Calgary and Airdrie area. Storm sampling results in Table 10 indicate general acceptability also except for the concentration of filtrable residue at sites 5, 6 and 7.

Coliform levels at all sites will be a restricting factor if the water will be used to irrigate vegetable crops or other crops consumed directly by man.

In summary, Nose Creek and West Nose Creek water quality data indicate the water is unsuitable for livestock watering in the urban area. This is primarily due to high pesticide concentrations. The water at all locations is generally acceptable for irrigation, however, if the water is used to irrigate vegetable crops or other crops consumed directly by man, all areas except above Airdrie would be unsuitable for irrigation because of high microbial densities.

Biological Considerations

Nitrogen and phosphorus have been cited as the two plant nutrients responsible for excessive amounts of aquatic plants, particularly in lakes or reservoirs. The Alberta Objective of 1.0 mg/l for total nitrogen and 0.15 mg/l total phosphorus as PO_4 (equivalent to about 0.05 mg/l as phosphorus) are the best available estimates of levels at which plant and algal growth would not be excessive.

In reviewing the data from the Nose Creek study the concentration of total phosphorus (as P) exceeded the Alberta Standard of 0.05 mg/l at all sites including the Airdrie locations. Total nitrogen concentrations also exceeded the objective of 1.0 mg/l at all sites except site 7. As a result, the availability of nitrogen and phosphorus would not limit plant and algal growth in the Nose Creek watershed except in the reach above site 7. Other physical factors, however, are presently limiting growth. These include a combination of factors such as base flow rate, depth of water, sudden flow fluctuations (as during storm events), sunlight penetration and temperature. A change in any one or more of these factors could promote increased aquatic growth.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

As a result of the study carried out in the Nose Creek watershed from April to September of 1980, the following conclusions pertaining to water quality are presented:

1. Nose Hill seems to affect the meteorology within the Calgary area resulting in erratic movement of storms.
2. Concentrations of the various chemical parameters at the rural sites are generally lower than at the urban sites for dry-weather or weekly sampling.
3. Concentrations for the various chemical parameters during storm periods generally increase greatly at the urban sites and only slightly at rural sites. In some cases concentrations at the rural sites decreased indicating a dilution effect because of slightly elevated flows.
4. Storm discharges from the Town of Airdrie have little adverse effect on water quality at the Calgary city limits.
5. Agricultural run-off above the City of Calgary on West Nose Creek and Nose Creek has little effect on water quality when compared to storm sewer discharges within the urban areas.
6. Run-off from the Beddington Heights area, which is in various stages of construction, has a marked effect on the quality of water in West Nose Creek considering that only a few storm sewers direct run-off water to it.
7. Concentration of measured parameters of dry-weather discharges are generally higher than concentrations found in the creek. The difference becomes greater during storm events.
8. The concentration of chemical parameters in storm sewer waters are generally higher from a primarily residential area than from a commercial or business area. This holds for both dry-weather and storm conditions.
9. Storm sewer discharge concentrations during storm events are generally highest during the initial flush, however, there may be exceptions where the maximum concentration for some parameters can occur after the flush.

10. Flows in Nose Creek at the Calgary city limits were low but somewhat higher than below Airdrie.

11. Flows in West Nose when compared to Nose Creek remained fairly high and steady throughout the sampling period.

12. During storm events, flows in the creek at the rural sites increase only slightly whereas flows in the urban areas, increase from 10 to 60 times normal dry-weather flow.

13. Water quality of Nose Creek and West Nose Creek is unsuitable for use as a public water supply.

14. Urban areas are generally unsuitable for direct contact recreation,however, secondary contact recreation could be allowed during certain times of the year. Rural sites are generally acceptable for both types of recreation but microbial densities will limit direct contact recreation during certain times.

15. The water in Nose Creek and West Nose Creek is generally acceptable for irrigation as long as the water is not used to irrigate crops consumed directly by man.

ACKNOWLEDGEMENTS

The writer would like to thank the following people and organizations for their assistance in carrying out this study:

John McCulloch,Pollution Control Division, Alberta Environment, for field work, data compilation and report writing.

City of Calgary, Sewer Division, for maps and precipitation data.

Chow Seng Liu, Pollution Control Division, Alberta Environment, for assistance in measuring flows at storm sewer outfalls.

Dick Allison, Technical Services Division, Alberta Environment, for supplying creek flow data.

REFERENCES

1. Annual Meteorological Summary, Environment Canada, Atmospheric Environment Service, 1979.

2. Doran, J.W. and D.M. Linn, "Bacteriological Quality of Runoff Water from Pastureland", Applied and Environmental Microbiology, vol. 37, 1979.

3. Dutka, B.J. and I. Rybakowski, Microbiological Study of Some Canadian Storm Water Runoff at Burlington and Brucewood, (Report to Urban Drainage Subcommittee), Canada-Ontario Agreement in Great Lakes Water Quality, Project 75-3-24, 1976.

4. Feachem, R., "An Improved Role for Faecal Coliform to Faecal Streptococci Ratios in the Differentiation Between Human and Non-Human Pollution Sources", Water Res., vol. 9, 1975, pp 689-90.

5. Geldreich, E.E. and B.A. Kenner, "Concepts of Faecal Streptococci in Stream Pollution", Journal Water Pollution Control Federation, CH: R336-R352, 1969.

6. Kerr, W.E., Analysis of Floods - Nose Creek, Alberta Environment, Hydrology Branch, 1980.

7. Matsen, A. et al., "Pollution Indicators and Other Microorganisms in River Sediment", Journal Water Pollution Control Federation, January 1978, pp 13-18.

8. McNeely, R.N., V.P. Neimanis and L. Dwyer, Water Quality Sourcebook - A Guide to Water Quality Parameters, Environment Canada, Inland Waters Directorate, 1979.

9. Nose Creek Interim Storm Water Management Study, M.M. Dillan Ltd., November 1979.

10. Qureshi, A.A. and B.J. Dutka, "Microbiological Studies on the Quality of Urban Stormwater Runoff in Southern Ontario, Canada", Water Research (G.B.), vol. 13, 1979, pp 977-85.

APPENDIX A

Detailed Results of Creek and Storm Sewer Sampling

Nose Creek Water Quality Study

NOSE CREEK WATER QUALITY STUDY - ROUTINE SAMPLING FOR APRIL

PARAMETER	STATISTIC	SAMPLING SITE						
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
pH	Range	7.9-8.3	7.69-8.25	7.8-8.3	7.7-8.15	7.67-8.15	7.66-8.30	7.61-8.30
	Mean	8.0	8.13	7.95	7.9	7.98	8.03	8.1
D.O.	Range	8.3-10.6	8.9-9.5	6.5-8.5	7.6-8.6	7.2-9.7	10.0-11.6	10.1-11.9
	Mean	9.4	9.2	7.5	8.1	8.5	10.8	11.0
Temp.	Range	7-10	7-9	7-9	6-10	-	-	7-9
	Mean	8.3	7.7	7.7	8.0	-	-	8.0
T.O.C.	Range	21.5-26.7	21.5-22.0	20.6-24.0	20.0-22.4	15.5-20.0	12.2-23.0	11.0-21.0
	Mean	24.0	21.8	21.9	21.2	16.9	15.5	14.3
B.O.D.	Range	3.1-3.6	4.5-5.7	3.1-13.2	2.0-11.8	3.8-13.8	2.6-14.5	2.1-15.8
	Mean	3.4	4.9	6.65	5.62	6.8	6.0	6.08
T-Phos.	Range	.330-.590	.310-.420	.310-.510	.290-.460	.200-.360	.097-.290	.080-.260
	Mean	.473	.383	.385	.350	.274	.184	.148
D-Phos.	Range	.254-.560	.262-.340	.212-.363	.226-.340	.133-.220	.062-.121	.059-.129
	Mean	.435	.314	.291	.285	.180	.091	.092
NO_3-NO_2-N	Range	<.003-.003	.003-.006	<.003-.230	<.003-.210	.340-.480	.021-.230	.004-.246
	Mean	.003	.004	.061	.055	.392	.104	.087
NH_3-N	Range	.006-.155	.014-.380	.006-.450	.007-.450	.072-.620	.028-.470	<.002-.320
	Mean	.056	.137	.139	.164	.240	.202	.144
T-N	Range	1.94-2.02	.640-2.05	1.56-3.05	1.80-2.92	1.74-2.85	1.16-2.79	.70-2.52
	Mean	1.97	1.54	2.84	2.12	2.18	1.82	1.60
N.F.R.	Range	0.8-10.0	14.8-34.4	2.4-26.0	2.0-22.0	16.8-26.0	10.8-49.0	2.4-11.2
	Mean	4.5	24.0	16.2	11.0	22.4	31.5	7.2
F.R.	Range	290-523	291-473	314-526	275-562	321-600	301-596	290-593
	Mean	396.7	372.3	408.5	396.8	434.3	424	409

NOSE CREEK WATER QUALITY STUDY - ROUTINE SAMPLING FOR MAY

PARAMETER	STATISTIC	SAMPLING SITE						
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
pH	Range	7.1-7.9	7.6-8.4	7.3-7.9	7.3-8.1	7.4-8.4	7.8-8.1	7.7-8.4
	Mean	7.8	8.2	7.8	8.1	8.2	8.0	8.1
D.O.	Range	3.3-7.2	7.5-8.9	5.1-6.2	6.6-7.3	7.4-11.7	6.3-9.6	8.3-10.0
	Mean	5.2	8.2	5.5	7.0	9.8	8.3	9.1
Temp.	Range	9-13	9-18	9-12	13-15	7-13	9-12	9-13
	Mean	12	13	11	14	11	10	11
T.O.C.	Range	30.5-40.0	12.0-22.5	15.5-26.0	16.0-24.5	11.5-15.3	10.0-24.5	8.0-22.5
	Mean	34.0	19.9	22.2	21.4	13.2	14.4	12.6
B.O.D.	Range	o.4-4.1	0.8-4.2	0.8-6.3	0.4-2.9	0.8-8.3	2.0-3.4	1.9-2.6
	Mean	3.1	3.0	4.1	2.2	4.8	2.8	2.2
T-Phos.	Range	.315-.660	.301-2.45	.410-.470	.253-.340	.182-.405	.136-.250	.068-.160
	Mean	.514	.865	.444	.302	.295	.189	.099
D-Phos.	Range	.295-.630	.215-.300	.145-.361	.135-.300	.034-.108	.073-.142	.053-.105
	Mean	.448	.262	.294	.205	.068	.100	.075
NO_3-NO_2-N	Range	<.003-.088	<.003-.720	<.003-.380	<.003-.330	.265-.890	<.003-.166	<.003-.063
	Mean	.030	.188	.098	.086	.510	.068	.028
NH_3-N	Range	.110-.270	.082-.450	.058-.280	.100-.300	.054-.400	.072-.370	.026-.180
	Mean	.170	.184	.124	.186	.226	.162	.073
T-N	Range	2.46-2.92	1.72-2.27	1.80-2.21	1.63-2.62	1.56-2.49	.76-4.17	.55-1.81
	Mean	2.79	1.95	2.03	2.03	2.00	1.73	.92
N.F.R.	Range	6.0-35.6	6.0-186.	5.6-101.	1.2-45.5	24-96	10.4-48.5	2.8-16.8
	Mean	23.4	53.5	40.3	14.4	38.2	27.4	7.4
F.R.	Range	570-786	248-564	408-744	429-726	527-690	580-704	574-666
	Mean	698.3	463.3	609	609.3	616	614.8	604.3

Note: All values are in "mg/l" except pH values which are in "units" and Temperature which are in " ^{o}C "

< : Indicates values "less than"

TABLE 1-A NOSE CREEK WATER QUALITY STUDY ROUTINE MONITORING RESULTS

NOSE CREEK WATER QUALITY STUDY - ROUTINE SAMPLING FOR JUNE

PARAMETER	STATISTIC	SAMPLING SITE						
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
PH	Range Mean	7.5-8.1 7.8	7.4-8.4 7.9	7.4-8.3 7.9	7.4-8.1 7.8	7.2-7.8 7.3	7.9-8.3 8.2	8.0-8.2 8.2
D.O.	Range Mean	3.3-4.9 4.0	3.7-7.1 5.5	5.0-8.2 6.3	5.7-6.4 5.9	4.5-7.6 6.0	7.6-8.3 7.8	7.3-8.5 8.0
Temp.	Range Mean	9-10 9	9-13 12	8-15 12	8-11 10	- 13	8-12 11	8-10 9
T.O.C.	Range Mean	25.0-30.0 28.1	18.0-24.3 22.0	18.8-21.5 20.7	17.3-21.5 19.3	11.5-15.5 13.6	12.0-16.0 14.3	9.8-16.5 13.4
B.O.D.	Range Mean	2.7-3.8 3.0	2.7-4.1 3.4	3.1-5.6 4.0	2.3-3.5 2.9	4.2-5.0 4.5	1.8-2.5 2.3	1.5-2.2 1.9
T-Phos.	Range Mean	.186-.490 .355	.154-.395 .261	.270-.370 .300	.265-.355 .311	.135-.260 .198	.115-.180 .140	.091-.145 .144
D-Phos.	Range Mean	.183-.410 .317	.137-.240 .194	.183-.290 .242	.255-.345 .287	.060-.125 .084	.064-.115 .086	.075-.145 .100
NO_3-NO_2-N	Range Mean	<.003-.040 .016	.011-.585 .173	.006-.129 .041	.003-.122 .050	.970-1.33 1.123	.018-.235 .098	.003-.043 .019
NH_3-N	Range Mean	.080-.340 .205	.080-.370 .180	.120-.290 .172	.090-.460 .232	.160-.290 .207	.110-.370 .200	.020-.090 .063
T-N	Range Mean	1.41-2.54 1.97	1.12-1.68 1.45	1.01-1.90 1.47	1.00-1.71 1.42	2.07-3.37 2.69	.82-1.34 1.18	.60-1.24 0.98
N.F.R.	Range Mean	6.0-63.6 29.2	5.2-97.2 33.4	6.4-38.4 19.6	2.8-29.0 12.2	45.5-115.0 69.2	3.2-372. 105.6	1.6-24.0 14.0
F.R.	Range Mean	465-865 690	325-585 509	436-634 538	416-670 542	403-660 515	518-640 583	537-615 579

NOSE CREEK WATER QUALITY STUDY - ROUTINE SAMPLING FOR JULY

PARAMETER	STATISTIC	SAMPLING SITE						
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
pH	Range Mean	7.2-7.7 7.5	7.2-8.0 7.7	7.4-7.9 7.6	7.5-8.3 7.9	7.4-8.2 7.7	7.4-8.3 7.9	7.6-8.4 8.3
D.O.	Range Mean	1.6-3.4 2.3	3.4-7.5 5.0	3.0-5.1 4.1	4.6-6.1 5.7	4.1-6.1 4.9	5.5-9.4 7.9	3.9-10.2 6.8
Temp.	Range Mean	10-16 12	10-16 12	11-16 13	10-15 13	12-14 13	10-13 12	8-11 10
T.O.C.	Range Mean	19.5-80.0 32.9	14.0-35.0 18.9	11.8-25.0 17.7	12.0-35.0 19.3	8.7-4.0 17.3	11.0-35.0 16.0	8.3-35.0 15.9
B.O.D.	Range Mean	1.3-4.0 2.5	2.0-3.7 2.6	1.8-3.7 2.7	1.3-3.4 2.4	2.9-6.5 4.5	2.0-5.5 3.1	1.5-3.0 1.9
T-Phos.	Range Mean	.295-.860 .438	.085-.800 .270	.170-.440 .271	.200-.371 .248	.205-.335 .260	.115-.185 .145	.070-.115 .086
D-Phos.	Range Mean	.290-.840 .429	.075-.730 .235	.135-.402 .225	.165-.317 .220	.090-.154 .113	.075-.102 .088	.065-.097 .078
NO_3-NO_2-N	Range Mean	.006-.050 .019	.015-.067 .032	.005-.015 .012	.005-.022 .014	.790-1.20 .987	.022-.880 .234	.007-.040 .024
NH_3-N	Range Mean	.060-.330 .128	.030-.340 .108	.050-.510 .202	.040-.450 .150	.150-.540 .282	.090-.240 .132	.040-.350 .132
T-N	Range Mean	.91-1.88 1.54	.43-2.03 1.04	1.11-1.91 1.19	.56-2.12 1.18	1.56-2.67 2.10	.47-4.28 1.39	.51-.95 .69
N.F.R.	Range Mean	2.4-13.6 6.0	6.8-47.6 17.6	12.2-32.0 20.1	3.2-19.6 9.1	56.4-191. 114.7	8.8-450. 113.9	3.6-15.6 7.3
F.R.	Range Mean	393-657 572	240-410 349	365-450 419	243-430 380	201-610 476	229-550 446	449-565 518

Note: All values are in "mg/l" except pH values which are in "units" and Temperature which are in "°C"

< : Indicates values " less than "

TABLE 1-A (Cont.) NOSE CREEK WATER QUALITY STUDY ROUTINE MONITORING RESULTS

NOSE CREEK WATER QUALITY STUDY - ROUTINE SAMPLING FOR AUGUST

PARAMETER	STATISTIC	SAMPLING SITE						
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
pH	Range	7.46-8.58	7.72-8.50	8.15- 9.18	7.82-8.62	7.52- 8.30	7.9-8.36	7.78-8.55
	Median	7.66	7.73	8.40	8.28	7.85	8.2	8.1
D.O.	Range	2.6-3.3	3.3-5.0	5.5-7.5	6.8-6.9	6.0-8.7	8.2-8.3	6.7-8.4
	Mean	2.9	4.2	6.6	6.8	7.4	8.2	7.5
Temp.	Range	9-13	10-13	10-13.3	11-13	11-14	-	10-13
	Mean	10.7	11.3	11.75	12	12.5	-	11.3
T.O.C.	Range	20.7-22.0	13.9-16.8	13.7-17.8	12.6-16.0	11.3-13.0	9.2-11.1	8.0-9.0
	Mean	21.48	15.00	16.13	14.90	11.95	10.33	8.45
B.O.D.	Range	2.2-9.6	1.5-7.2	2.3-8.8	1.2-2.8	3.1-4.8	1.5-2.6	.6-1.9
	Mean	4.35	3.40	4.13	2.13	3.9	2.2	1.5
T-Phos.	Range	.071-.155	.075-.235	.080-.158	.080-.116	.045-.153	.115-.345	.034-.100
	Mean	.129	.106	.127	.102	.104	.194	.051
D-Phos.	Range	.050-.118	.050-.083	.080-.10	.080-.113	.043-.061	.050-.052	.028-.035
	Mean	.080	.065	.086	.095	.051	.051	.032
NO_3-NO_2-N	Range	.003-.012	.003-.018	<.003-.024	<.003-.008	1.08-1.50	<.003-.080	.004-.025
	Mean	.009	.009	.012	.006	1.26	.057	.016
NH_3-N	Range	.04-.120	.04-.08	.06-.16	.03-.08	.12-.16	.08-.18	.01-.10
	Mean	.083	.053	.093	.045	.15	.127	.038
T-N	Range	1.42-2.17	.96-1.35	.97-1.51	1.0-1.17	2.13-2.52	.90-1.78	.69-1.44
	Mean	1.72	1.08	1.27	1.10	2.31	1.19	.91
N.F.R.	Range	5.2-59.6	8.8-38.8	12-48	2.4-4.4	21.6-47.6	18-154	0.8-2.4
	Mean	21.3	16.5	23.7	3.6	33.4	68	1.5
F.R.	Range	637-740	429-500	475-504	457-483	471-638	468-526	458-537
	Mean	686	469	489	473	532	503	505

NOSE CREEK WATER QUALITY STUDY - ROUTINE SAMPLING FOR SEPTEMBER

PARAMETER	STATISTIC	SAMPLING SITE						
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
pH	Range	-	7.72-8.36	8.75-8.97	8.04	7.56-8.43	7.63-8.51	8.02-8.55
	Mean	-	8.07	8.79	-	7.91	8.12	8.44
D.O.	Range	-	4.9-9.3	6.0-9.7	6.8	6.9-14.8	6.7-8.2	7.7-9.4
	Mean	-	6.4	8.6	-	9.5	7.2	8.8
Temp.	Range	N O D A T A A V A I L A B L E						
	Mean							
T.O.C.	Range	-	13.5-15.5	18.5-20.3	15.8	8.1-11.3	9.3-17.3	6.0-7.8
	Mean	-	14.65	19.43	-	9.83	12.40	6.93
B.O.D.	Range	-	3.2-6.8	1.0-4.8	2.0	.4-9.6	3.4-10.0	0.6-1.3
	Mean	-	5.55	2.57	-	3.03	6.50	0.98
T-Phos.	Range	-	.077-.194	.095-.260	.118	.056-.184	.101-.780	.019-.034
	Mean	-	.127	.172	-	.130	.450	.030
D-Phos.	Range	-	.035-.073	.063-.123	.097	.028-.086	.035-.146	.018-.030
	Mean	-	.054	.098	-	.057	.080	.026
NO_3-NO_2-N	Range	-	.007-.025	.003-.055	<.003	.940-3.10	.017-.430	.012-.430
	Mean	-	.016	.024	-	1.62	.245	.121
NH_3-N	Range	-	.03-.07	.04-.67	.02	< .002-.170	.04-.06	<.002-.020
	Mean	-	.05	.25	-	.053	.05	.009
T-N	Range	-	.49-1.35	1.7-1.93	1.25	1.71-4.38	1.13-3.04	.57-.99
	Mean	-	1.13	1.80	-	2.72	1.97	0.7
N.F.R.	Range	-	11.0-30.8	8.0-71.2	10.40	25.6-52.0	38.8-347.	2.0-3.6
	Mean	-	20.2	30.4	-	39.1	203.	2.95
F.R.	Range	-	500-553	537-722	544	428-636	267-491	511-564
	Mean	-	524.8	624.7	-	517.3	430.5	537.3

Note: All values are in mg/l except pH values which are in " units " and Temperature which are in °C

< : Indicates concentrations "less than"

Table 2-A

Microbial Densities at Creek Sites for Various Storm Events

Site No.	Date	Total Coliform	Faecal Coliform	Faecal Streptococci
3	June 19	150	112	148
	June 22	-	-	-
	June 26	280	140	1400
	July 29	3200	1500	200
	Aug. 20	720	620	690
Site 3 Geometric Mean		558	347	411
5	June 1	83000	1280	28300
	June 11	2600	220	530
	June 19	63000	28000	10000
	June 22	43000	2300	2800
	June 26	27000	3500	12000
	July 29	250000	6600	33000
	Aug. 10	84000	310	1400
	Aug. 20	19000	3500	690
Site 5 Geometric Mean		39802	2149	4475
6	June 11	67000	2200	1600
	June 19	4300	4100	2800
	June 22	-	-	-
	June 26	17000	3500	12000
	Aug. 10	28000	2200	1270
Site 6 Geometric Mean		19244	2887	2875
7	June 11	3700	570	204
	June 14	-	-	-
	June 19	3400	3100	1100
	June 22	5000	1340	850
	June 26	2500	1070	2300
	July 29	5800	1200	2000
	Aug. 20	1600	1120	500
Site 7 Geometric Mean		3368	1227	872

TABLE 3-A. MAXIMUM MEASURED CONCENTRATIONS FOR STORM GENERATED CREEK SAMPLES FOR INDIVIDUAL STORMS

Site	Date	Chemical Parameters													
		B.O.D.	T.O.C.	T-Phos.	D-Phos.	T-N	NH_3 - N	NO_3-NO_2-N	NFR	FR	Zn	Pb	Cu	Cr	pH *
3	June 14	4.40	20.80	0.235	0.230	0.83	0.060	0.026	5.60	.562.0	0.005	<0.002	0.003	<0.003	8.00
	June 19	2.40	20.50	0.250	0.250	1.71	0.120	0.012	6.00	600.0	0.002	<0.002	0.002	<0.003	8.60
	June 22	3.00	20.00	0.250	0.245	1.61	0.150	0.008	10.40	634.0	0.011	0.002	0.002	<0.003	8.80
	June 26	9.20	21.00	0.178	0.160	1.41	0.090	0.013	8.40	642.0	0.012	0.006	0.015	0.004	8.45
	July 29	1.90	13.10	0.165	0.150	0.02	0.200	0.028	-	-	-	-	-	-	8.20
	Aug. 20	3.60	16.00	0.105	0.085	1.35	0.120	0.043	19.60	471.0	0.017	0.005	0.004	0.003	8.89
Site 3 Mean		3.93	18.57	0.197	0.187	1.16	0.123	0.022	8.33	484.8	0.008	0.003	0.004	0.003	8.53
5	May 23	11.80	27.00	0.518	0.201	5.15	1.400	1.850	100.00	522.0	0.043	0.075	0.010	<0.003	7.34
	June 1	6.50	16.50	0.850	0.295	6.67	0.950	1.470	556.00	688.0	0.110	0.680	0.017	0.010	7.50
	June 11	7.10	15.80	0.190	0.085	2.10	0.130	1.200	52.00	722.0	0.013	0.018	0.004	<0.003	7.76
	June 19	13.60	17.80	1.200	0.105	6.99	0.040	1.190	1754.0	270.0	0.001	<0.002	0.002	0.006	7.40
	June 22	5.00	13.00	0.240	0.125	3.57	0.390	1.270	96.70	475.0	0.045	0.017	0.006	<0.003	7.44
	June 26	6.00	17.00	0.580	0.252	4.60	1.000	1.300	478.00	642.0	0.081	0.056	0.029	0.005	7.42
	July 29	22.00	13.60	0.800	0.160	4.15	0.500	1.830	552.00	537.0	0.140	0.260	0.029	<0.003	7.54
	Aug. 10	5.10	11.30	0.440	0.110	2.84	0.180	1.700	66.60	463.0	0.024	0.019	0.009	0.003	7.62
	Aug. 20	7.70	11.60	0.180	0.085	10.98	0.320	1.380	99.00	501.0	0.035	0.280	0.015	0.004	7.53
Site 5 Mean		9.42	16.07	0.555	0.158	5.23	0.550	1.470	417.14	535.6	0.055	0.160	0.013	0.004	7.51
6	June 11	7.30	19.50	0.410	0.090	2.28	0.210	0.475	266.00	640.0	0.028	0.044	0.021	0.003	8.00
	June 22	13.00	14.00	0.230	0.125	1.77	0.150	0.067	97.50	572.0	0.023	<0.002	0.004	<0.003	8.20
	June 26	3.20	14.00	0.480	0.080	2.21	0.210	0.110	37.90	549.0	0.045	0.011	0.022	0.003	7.90
	Aug. 10	6.00	11.10	1.550	0.090	1.40	0.070	0.084	238.00	514.0	0.024	0.007	0.012	0.003	7.60
Site 6 Mean		7.38	14.65	0.670	0.100	1.92	0.160	0.184	159.85	568.8	0.030	0.016	0.015	0.003	7.95
7	June 11	2.80	15.50	0.125	0.110	0.61	0.110	0.006	12.4	640.0	0.030	0.003	0.002	<0.003	8.10
	June 14	3.60	16.80	0.150	0.115	0.93	0.060	0.034	3.6	644.0	<0.001	<0.002	0.001	<0.003	8.10
	June 19	2.80	13.80	0.135	0.125	1.21	0.070	0.013	2.8	590.0	<0.001	0.004	<0.001	<0.003	8.20
	June 22	2.40	12.00	0.125	0.125	0.96	<0.002	0.014	14.8	551.0	<0.001	<0.002	<0.001	<0.003	8.50
	June 26	2.80	11.50	0.094	0.084	0.61	1.000	0.013	15.2	523.0	0.017	<0.002	0.015	<0.003	8.35
	July 29	1.20	10.30	0.075	0.075	1.03	0.160	0.033	4.4	501.0	0.026	0.006	<0.001	<0.003	8.40
	Aug. 20	3.50	7.60	0.055	0.050	0.79	0.040	0.069	5.6	429.0	0.011	0.004	0.002	<0.003	8.83
Site 7 Mean		2.73	12.50	0.108	0.098	0.88	0.206	0.026	8.4	554.0	0.012	0.003	0.003	<0.003	8.35

* - Indicates pH in " units "

Note : All concentrations are in mg/l except pH

Table 4-A. Comparison of Pre and Post Storm Values Measured at Sites 3 and 7

Parameter (Mg/L)	Storm - June 26				Storm - June 19				Storm - Aug. 20			
	Site 3		Site 7		Site 3		Site 7		Site 3		Site 7	
	June 25	June 26	June 25	June 26	June 18	June 19	June 18	June 19	Aug. 20	Aug. 20	Aug. 20	Aug. 20
B.O.D.	5.60	9.20	1.9	2.80	3.10	2.40	1.50	2.80	2.30	3.50	1.80	8
T.O.C.	21.50	21.00	9.8	11.50	21.00	20.50	13.80	13.80	16.50	16.00	8.00	7.60
Total Phos	.275	.178	.091	.094	.285	.250	.145	.135	.115	.105	.035	.055
Diss Phos	.183	.160	.08	.084	.250	.250	.145	.125	.085	.085	.035	.055
TKN	1.62	1.41	1.24	.61	1.90	1.71	1.11	1.21	1.35	1.35	1.44	.790
NH_3-N	.120	.09	.02	1.00	.290	.120	.090	.070	.160	.120	.100	.040
NO_3-NO_2-N	.016	.013	.043	.013	.006	.012	.010	.013	.006	.043	.022	.069
NFR	22.80	28.0	24.00	15.20	6.40	6.00	1.60	2.80	16.40	19.60	2.40	5.60
FR	634.0	642.0	537.0	523.0	620.	600.	585.0	590.0	475.0	471.0	458.0	429.0
Zn	.005	.012	< .001	.017	.005	.002	.102	<.001	.014	.017	.300	.011
Pb	<.002	.005	< .002	<.002	< .002	<.002	<.002	.004	<.002	.005	.005	.004
Cu	.016	.015	.001	.015	.004	.002	.001	<.001	.012	.004	.006	.002
Cr	.007	.004	.003	<.003	< .003	<.003	<.003	<.003	.003	.003	<.003	< .003

TABLE 5-A STORM SEWER DRY WEATHER DISCHARGE CONCENTRATIONS AND LOADINGS

PARAMETER	STATISTIC	STORM SEWER N - 27					STORM SEWER N - 13				
		May 8	May 24	July 9	July 31	Aug. 20	June 11	June 26	July 9	July 31	Aug. 20
B.O.D.	mg/l	2.80	7.00	1.30	1.20	2.40	0.50	4.40	1.50	0.60	1.90
	kg/hr	0.007	0.018	0.003	0.003	0.006	<0.001	0.003	<0.001	<0.001	0.001
T.O.C.	mg/l	6.5	15.3	6.5	6.0	7.3	4.5	11.5	4.5	3.5	5.2
	kg/hr	0.017	0.039	0.017	0.015	0.019	0.003	0.007	0.003	0.002	0.003
T-Phos.	mg/l	0.12	0.25	0.09	0.17	0.09	0.16	0.25	0.11	0.32	0.10
	kg/hr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
D-Phos.	mg/l	0.120	0.247	0.083	0.165	0.085	0.150	0.227	0.092	0.315	0.090
	kg/hr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
T-N	mg/l	7.43	11.60	5.49	6.83	8.78	1.02	1.40	1.32	0.96	3.24
	kg/hr	0.019	0.03	0.014	0.018	0.022	<0.001	<0.001	<0.001	<0.001	<0.001
NH_3-N	mg/l	0.41	0.29	0.09	0.08	0.84	0.08	0.08	0.06	0.05	<0.002
	kg/hr	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
NO_3-NO_2 - N	mg/l	4.75	10.00	4.90	6.10	6.50	0.83	0.78	0.99	0.71	0.34
	kg/hr	0.012	0.026	0.013	0.016	0.017	<0.001	<0.001	<0.001	<0.001	<0.001
NFR	mg/l	2.80	10.80	4.40	2.00	0.80	1.60	16.00	1.20	0.80	0.40
	kg/hr	0.007	0.028	0.011	0.005	0.002	0.001	0.01	<0.001	<0.001	<0.001
FR	mg/l	715.0	717.0	865.0	917.0	780.0	650.0	578.0	710.0	811.0	585.0
	kg/hr	1.83	1.83	2.21	2.34	1.99	0.398	0.354	0.435	0.496	0.358
Zn	mg/l	0.003	0.013	0.016	0.024	0.22	0.005	0.015	0.019	0.008	0.062
	kg/hr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	mg/l	<0.002	0.006	0.003	0.004	0.005	0.006	0.016	<0.002	0.004	<0.002
	kg/hr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/l	0.002	0.014	0.008	0.010	0.015	0.003	0.016	0.012	0.004	0.018
	kg/hr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/l	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
	kg/hr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

< : Indicates values " less than "

TABLE [illegible]-A STORM SEWER DISCHARGE MEAN AND MAXIMUM CONCENTRATIONS FOR INDIVIDUAL STORM PERIODS

PARAMETER	STATISTIC (mg/l)	STORM SEWER N - 27										STORM SEWER N - 13		
		May 23	May 25	May 26	May 28	June 1	June 14	June 22	July 18	Aug. 10	Aug. 20	May 26	June 19	June 26
T.O.C.	Mean	33.83	14.79	20.23	24.12	14.44	29.11	23.78	62.00	14.07	26.04	21.33	27.57	20.08
	Maximum	55.00	19.80	32.50	30.50	38.00	40.50	39.30	95.00	19.80	55.00	43.00	37.50	34.50
B.O.D.	Mean	13.40	8.16	3.31	6.27	9.67	10.94	16.48	19.06	17.27	31.12	6.20	20.17	15.24
	Maximum	14.50	11.40	8.80	10.10	15.00	14.4	28.80	38.00	46.00	76.00	14.10	25.60	26.80
T - Phos.	Mean	1.01	1.30	1.00	0.88	0.87	2.03	0.45	0.74	0.21	0.83	0.86	0.07	1.06
	Maximum	1.13	1.79	1.40	1.05	1.30	4.30	1.05	1.55	0.43	2.40	1.60	1.75	2.47
D - Phos.	Mean	0.37	0.27	0.23	0.14	0.14	0.10	0.13	0.13	0.10	0.09	0.30	0.15	0.12
	Maximum	0.96	0.40	0.28	0.18	0.24	0.14	0.19	0.18	0.14	0.12	0.94	0.49	0.23
T - N	Mean	4.00	7.45	4.14	7.41	4.98	9.45	6.00	6.68	4.58	6.41	3.68	3.40	3.88
	Maximum	8.50	11.10	7.10	9.45	8.27	19.32	8.75	14.70	10.53	15.50	6.00	5.50	8.08
NH_3 - N	Mean	0.82	0.42	0.41	0.94	0.57	0.41	0.44	0.46	0.21	1.22	0.37	0.41	0.25
	Maximum	1.60	0.90	0.49	1.65	1.00	0.80	0.90	0.98	0.43	2.22	0.49	0.50	0.35
NO_3-NO_2 - N	Mean	1.67	3.33	2.14	3.71	1.48	2.47	3.06	2.74	2.52	2.45	0.96	0.27	0.50
	Maximum	1.90	8.20	4.30	7.65	2.27	5.00	4.85	5.70	5.80	4.90	2.20	0.46	0.78
NFR	Mean	683.00	956.8	976.5	719.3	794.0	3097.6	566.14	1062.0	179.28	631.47	522.90	563.30	822.50
	Maximum	864.00	1628.	1584.	1210.	1380.	6950.0	2320.	2750.0	418.00	1506.0	980.00	2527.0	2132.0
FR	Mean	208.30	310.9	205.4	487.1	210.2	408.3	415.4	430.0	274.80	327.0	206.0	280.0	234.2
	Maximum	287.00	949.0	339.0	1079.	292.0	774.0	676.0	754.0	629.0	699.0	374.0	845.0	578.0
Zn	Mean	0.25	0.11	-	0.16	0.13	0.26	0.15	0.19	0.06	0.26	0.15	0.26	0.39
	Maximum	0.40	0.25	-	0.35	0.32	0.68	0.45	0.52	0.14	0.74	0.29	1.07	0.87
Pb	Mean	0.62	1.75	0.28	0.30	0.89	0.38	0.19	0.23	0.08	0.41	0.80	0.35	0.50
	Maximum	0.94	4.77	0.42	0.87	3.90	1.33	0.83	0.61	0.23	1.60	2.54	1.77	1.46
Cu	Mean	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.55	0.03	0.07	0.10
	Maximum	0.04	0.04	0.03	0.04	0.04	0.05	0.03	0.07	0.04	4.30	0.05	0.39	0.16
Cr	Mean	0.003	0.007	0.006	0.006	0.007	0.004	0.003	0.003	0.003	<0.003	0.004	0.004	0.005
	Maximum	0.005	0.014	0.013	0.027	0.016	0.007	0.005	0.005	0.005	0.003	0.007	0.011	0.007

< : Indicates values "less than "

APPENDIX B

Equation For Storm Sewer Flow Calculations

Nose Creek Water Quality Study

Table 7-A

Microbial Densities for Discharges From Storm Sewers

Storm Sewer No.	Date	Microbial Parameter (No./100ml.) Total Coliform	Faecal Coliform	Faecal Streptococci
N-27	May 25	28,450	11,635	5,038
	May 28	558,590	129,561	19,891
	June 1	25,286	2,323	5,884
	June 22	>211,401	67,409	18,662
	Aug. 10	>542,967	67,712	8,675
	Aug. 20	513,929	86,809	9,167
N-27 Geometric Mean		>169,489	33,397	9,780
N-13	May 26	36,688	3,526	12,235
	June 19	749,154	16,636	153,454
	June 26	158,541	4,048	61,428
N-13 Geometric Mean		163,335	6,192	48,676

> : Indicates values " greater than " as certain samples were too numerous to count

Note : Values indicated are the geometric mean of samples collected during each storm

APPENDIX C

Photographs

Sampling Site Locations

Nose Creek Water Quality Study

Site 1. Nose Creek Above Airdrie, Aerial View Looking North

Site 1. Nose Creek Above Airdrie, Ground View

Site 2. Nose Creek Below Airdrie, Adjacent to Highway #2,
Aerial View Looking North

Site 2. Nose Creek Below Airdrie, Closer Aerial View

Site 3. Nose Creek At Calgary City Limits, On Secondary Highway #564, Aerial View Looking East

Site 3. Nose Creek At Calgary City Limits, Ground View

Sites 4 and 6. Nose Creek Above Confluence of West Nose Creek (4) And West Nose Creek Above Confluence of Nose Creek (6), Aerial View Looking North

Sites 4 and 6. Aerial View Looking South

Site 6. West Nose Creek Above Confluence of Nose Creek, Ground View Looking North

Sites 4 and 6. Confluence Area of Nose Creek and West Nose Creek, Ground View Looking North (Upstream)

Site 5. Nose Creek Near The Mouth, Below Memorial Drive In Calgary, Aerial View Looking Northeast

Site 5. Nose Creek Near The Mouth, Ground View Looking Upstream

Site 7. West Nose Creek At The City Limits, On 24 St. N.W., Aerial View Looking South

Storm Sewer N-13. Outfall Location on Nose Creek, Aerial View Looking North

Storm Sewer N-27. Outfall Location on Nose Creek, Aerial View Looking Northeast