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FRASER RIVER ESTUARY STUDY, WATER QUALITY, DRY WEATHER STORM SEWER DISCHARGES

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SUMMARY

Water quality in the Fraser River Estuary has been described in a summary report, and in a set of eleven background reports. The present report is one in a short series of technical additions, which supply information too detailed to incorporate in the background reports.

Approximately 180 storm sewer discharges to the Fraser River in the Greater Vancouver Regional District (GVRD) have been catalogued. The majority of these storm drains were found to discharge even during a prolonged period of dry weather, and a dry pipe was an exception rather than a rule. The discharge of storm water averaged 0.015 m^3/s through pipes and 0.12 m^3/s through drainage ditches during the dry weather period. It was found that nothing was known of these sewers for dry weather conditions. Therefore a series of elementary surveys were initiated, intended to serve as a basis for design of more comprehensive surveys at some later date.

Preliminary sampling was carried out in 1978 to determine mean contaminant concentrations in storm water during dry weather flow. Samples from thirty-two representative sites were analyzed for metals, nutrients and fecal coliforms. Iron was found to have the highest metal concentration (0.20 mg/L-50.0 mg/L), followed by aluminum (0.02 mg/l to 2.8 mg/L) and manganese (<0.02 mg/L - 4.85 mg/L). Nutrient levels were highest in agricultural areas or near landfills. Nitrogen levels were extremely high (0.02 mg/L - 41.0 mg/L) at specific outfalls. Fecal coliforms were generally high ranging from <20 to 240 000 MPN/100 mL. Several discharges near public parks were observed to have high levels of coliform bacteria.

Storm drain effluent samples were collected in late October to November 1978 and analyzed for pesticides previously detected in Fraser River sediment. Pesticide concentrations in the effluent samples were below the detection limit with the exception of samples from a ditch adjacent to a former pesticide manufacturing company. Six of the twelve compounds detected in this sample exceeded safe limits for the protection of aquatic life.

The pH of dry weather storm water ranged from 5.9 to 12.4. The influence of storm water on the buffering capacity of the river was measured on nine river samples collected between Barnston Island and the Oak Street

Bridge on the North Arm and Nelson Road on the Main Arm. To change the pH of river water by one unit required a dilution of river water with acidic stormwater of between thirty and fifty percent. A dilution with basic (i.e., high pH) storm water, of only one to thirteen percent, also gave the same result. This shows that the river is more sensitive to basic discharges than to acidic discharges.

The flow of storm water is influenced by storm events and the twice daily fluctuations of tides. The tidal reversal of river flow with corresponding rise in water level stopped or reversed flow in approximately 70% of the storm drains in the study area. The impoundment caused by this tidal action persisted for up to six hours with a subsequent release of effluent at ebb tide and resuspension of particulate matter, resulting in an effluent flush. During an effluent flush, the dissolved oxygen level was observed to drop from 7.9 mg/L to 1.9 mg/L. Concentrations of other parameters were also observed to change during the flush period. Storm sewer monitoring programs within the estuary should therefore allow for the effects of tidal changes.

During the 1978 monitoring program, a simple, portable automated system was developed for sampling a storm flush. Four factors important to developing such an automated system were found to be selection of sampling site, proximity of a source of electrical power, a reliable method of sensing increased flow, and collection of correct sample size.

Some agricultural land in the Fraser River Delta is irrigated by ditch through the dry weather season. Adequate supply and water quality are two areas of concern.

ACKNOWLEDGEMENTS

This study was funded jointly by the Waste Management and the Aquatic Studies Branch. Data presented in this report were collected by the authors, and also by Mr. Kai W. Hui and Mr. R. Cain. All calculations and graphs were prepared by Mr. Krahn and verified by Mr. Walker. The assistance of Mr. Keith Ferguson of the Environmental Protection Service, Mr. G. Gough and Mr. P. Bardal of the Waste Management Branch and Mr. R. Rocchini of the Aquatic Studies Branch is gratefully acknowledged.

Two of the authors, Mr. Krahn and Mr. Walker have left government employment.

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Copies of this report may be obtained from the Ministry of Environment, Parliament Buildings, Victoria, B.C.

PREFACE

The Fraser River Estuary Study was set up by the Federal and Provincial Governments to develop a management plan for the area.

The area under study is the Fraser River downstream from Kanaka Creek to Roberts Bank and Sturgeon Bank. The Banks are included between Point Grey and the U.S. Border. Boundary Bay and Semiahmoo Bay are also included but Burrard Inlet is not in the study area.

The study examined land use, recreation, habitat and water quality, and reports were issued on each of these subjects.

Supplementary to the initial water quality report, a more detailed analysis of the information was undertaken by members of the water quality work group. As a result, eleven background technical reports are being published. The background reports are entitled as follows:

- Municipal effluents.
- Industrial effluents.
- Storm water discharges.
- Impact of landfills.
- Acute toxicity of effluents.
- Trace organic constituents in discharges.
- Toxic organic contaminants.
- Water chemistry; 1970-1978.
- Microbial water quality; 1970-1977.
- Aquatic biota and sediments.
- Boundary Bay.

Each of the background reports contains conclusions and recommendations based on the technical findings in the report. The recommendations do not necessarily reflect the policy of government agencies funding the work. Copies of these reports will be available at all main branches of the public libraries in the lower mainland.

Five auxiliary reports, of which this is one, are also being published in further support of the study. These cover the following subjects:

- Site registry of storm water outfalls.
- Dry weather storm sewer discharges.
- Data report on water quality.
- Survey of fecal coliforms in 1978.
- Survey of dissolved oxygen in 1978.

Copies of these reports will be available from the Ministry of Environment, Parliament Buildings, Victoria, British Columbia.

To bring this work together the water quality work group has published a summary report. This document summarizes the background reports, analyzes their main findings and presents final recommendations. Some of the recommendations from the background reports may be omitted or modified in the summary report, due to the effect of integrating conclusions on related topics. Copies of the summary report have been placed in public libraries, and extra copies are available to interested parties from the Ministry of Environment in Victoria.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

Figure		Page

1. INTRODUCTION

This report presents data gathered during a preliminary investigation in 1978 of dry weather discharges of storm drain effluents. An inventory of municipal storm water outfalls to the Fraser River and estuary was carried out concurrently. Both projects were ancillary to a more comprehensive examination of storm sewers and urban runoff by Mr. K. Ferguson of the Environmental Protection Service and Dr. K. Hall of the Westwater Research Centre. Their results are published as a separate report(1).

The locations, descriptions, and photographs of the storm water outfalls located during the inventory are published in a separate report(2). The approximate position of storm water outfalls catalogued in EQUIS are indicated in Figure 1. To date, only discharges from municipal systems have been catalogued.

The objectives of this study were to:

- observe the discharge pattern as influenced by tide for a typical storm sewer
- monitor a selected sub-set of representative storm sewers in order to estimate dry weather loadings to the estuary from these sources
- ascertain whether storm runoff could be responsible for low pH values observed in the Fraser, as reported elsewhere(3).

For convenience, the study was divided into seven projects as noted below. The results of each project are presented and discussed in separate sections and appendices of this report.

List of Projects

- Metal and Nutrient Survey
- Coliform Survey
- Pesticide Survey
- Acidity/Alkalinity Survey
- Tidal Influence Study
- Instrument Design for Storm Water Monitoring
- Irrigation in the Estuary Study Area

The data in this report may vary slightly from those presented in other background reports or the summary report for this study. The reason for this is overlapping stages of preparation in the different reports; however, overall conclusions are not affected. Note that this report deliberately does not contain a Recommendations section, since it is intended to be ancillary to the Ferguson and Hall Report.

2. METAL AND NUTRIENT SURVEY

2.1 Method

The objective of the Metal and Nutrient Survey was to estimate dry weather loadings for various metals and nutrients of importance to the Fraser estuary. Thirty-three sites were chosen within the study area, and each site was sampled at least twice between July and October, 1978. Six of the 32 sites were selected because the physical appearance of the discharge suggested possible contamination by domestic or industrial wastes. The remaining 27 sites were selected as being typical of a general type of land use. The sites, categorized by land use, are tabulated in Table 2.1. Nine sites were chosen in agricultural areas, eight in commercial, five in industrial, one near a landfill and nine in residential areas.

Laboratory analyses were performed by the Provincial Environmental Laboratory. The sampling, preservation and storage procedures were performed in accordance with methodology outlined in the Environmental Laboratory publication concerning Water and Waste Water Sample Handling and Preservation Procedures[4]. The following parameters were monitored.

1)* Air Temperature
2)* Alkalinity
3) Aluminum (Total)
4) Arsenic (Total)
5) Biochemical Oxygen Demand
6) Chromium (Total)
7) Colour (T.A.C.)
8) Copper (Total)
9)* Dissolved Oxygen
10) Filterable Residue
11)* Flow
12) Iron (Total)
13) Lead (Total)
14) Manganese (Total)
15) Mercury (Total)
16) Nickel (Total)
17) Nitrogen, Total Kjeldahl
18) Nitrate + Nitrite
19) Non-Filterable Residue
20) Oil and Grease
21)* pH
22) Phenolics
23) Phosphate (Total Filtered)
24) Phosphate (Total Unfiltered)
25)* Salinity
26)* Specific Conductivity
27) Tannin and Lignin
28) Total Inorganic Carbon (TIC)
29) Total Nitrogen
30) Total Organic Carbon (TOC)
31) Total Residue (By Calculation)
32)* Water Temperature
33) Zinc (Total)

* Measurements made in the field.

2.2 Results and Discussion

The results of all laboratory and field analyses are tabulated in Table 2.1 and the preparation methods are recorded in Table 2.2. (These values have been stored in the provincial data base, EQUIS, for future reference). Mean and median parameter values for each land use category are tabulated in Table 2.3 but the variability of results tabulated in Table 2.1 and the small sample size should be kept in mind. These results thus represent a preliminary indication of storm water quality.

Nutrient concentrations appeared to be relatively high in agricultural areas. Metal concentrations were not as high as had been anticipated; iron had the highest metal concentration within all land use categories.

Flow estimates were used as follows: Total mean dry weather flows for non-tidal storm sewers, tidal storm sewers and tidal ditches or sloughs were calculated as tabulated in Table 2.4. Daily volumes of storm water entering various parts or reaches of the lower Fraser River were estimated, as tabulated in Table 2.5. (For all tidal sites, flow was assumed to occur for only 12 hours per day). Finally, mean flows were multiplied by parameter concentrations to estimate dry weather loadings for various nutrients and metals. The results are tabulated in Table 2.6.

It must be emphasized that these results are based on small sample sizes, and must be considered rough estimates at best. Other data are virtually non-existent. These first estimates are intended to help plan future monitoring programs.

3. COLIFORM SURVEY

3.1 Method

An attempt was made to characterize dry weather bacteriological contaminants in storm water, using the indicator organism, fecal coliform. All samples were analyzed by the Provincial Health Laboratory. Forty-two sites were chosen to cover the study, thirteen located in residential areas, twelve in agricultural, thirteen in industrial, two near waste landfills, and two in commercial areas.

The 42 sites include the 32 sites sampled in the Metal and Nutrient Survey. A total of 100 samples was obtained in this preliminary survey. Most sites were sampled at least twice, and several (with high levels) three times.

3.2 Results and Discussion

Results are tabulated in Tables 3.1 to 3.5, and summarized in Table 3.6 and Figure 6.

The highest concentrations of bacteria occurred in storm drains flowing from residential areas, with seven values greater than 24 000/100 mL and two values greater than 240 000/100 mL. The public has easy access to these discharges. For example: Sites XE03126-01, -02 are located adjacent to the Fraser-View Golf Course in South Vancouver. A well used trail leading to the outfall was evident and school children have been observed in the area on several occasions (see Figure 7). Both outfalls had fecal coliform counts in excess of 240 000/100 mL. High coliform levels also were measured at Site XE03198-01 (22nd and Renfrew Street). This outfall discharges directly to Still Creek at the center of Renfrew Park. Renfrew Park has high public usage and is located near a school and daycare center.

Sources of bacteria from urban runoff may include animal droppings, cross connections with sanitary sewers, illegal sanitary hookups to storm drains and illegal dumping (e.g., from recreational vehicles).

Storm sewers which had consistently high coliform levels were visibly contaminated with a thicker growth of slime and algae on the bottom of the discharge pipe and surrounding area. The water itself was usually a milky colour and often contained food waste such as vegetables and pasta products. The size of food particles was typical of those easily flushed down the drain of kitchen sinks. Tissue paper often was evident in the discharge water or in the area surrounding the outfalls.

Note: Krahn and Walker used different subjective criteria in categorizing sites for the two different surveys discussed in Sections 2 and 3 of this report. These sections have not been standardized because other authors had already quoted the various results.

4. PESTICIDE SURVEY

4.1 Method

Pesticides in the form of insecticides, fungicides, herbicides and rodenticides may enter storm water systems from various sources. Pesticides are commonly used in agricultural, industrial and residential areas. Certain industries use products which resemble pesticides in their environmental effects. For example polychlorinated biphenyls (PCB's) are commonly used in the electrical industry and for various other commercial uses.

Since a wide variety of non-point sources exist in the study area, and since pesticide analyses are costly, only 10 samples were collected from representative storm drains. Replicate samples were collected at three sites to ascertain sampling precision. Included in the survey was a ditch along No. 1 Road North, Richmond, adjacent to a potato field being sprayed prior to harvest and a ditch near the former location of Later Chemical, earlier identified as a site-specific source of toxic chemicals (Cain, Clark and Zorkin, 1980).

4.2 Results and Discussion

Site locations, dates of sample collection and analytical results are tabulated in Table 4.1. The fact that, excluding two samples, all results were below the detection limit is not conclusive, since samples were not collected until autumn, past the time of peak pesticide use. High levels were observed for certain pesticides collected adjacent to the former location of Later Chemical. It is recommended that monitoring be continued at this site. Negative results were obtained near the recently sprayed potato field.

5. ACIDITY/ALKALINITY SURVEY

5.1 Method

On April 5, 1978, the pH data presented in Table 5.1 were recorded for the Fraser River between the training wall and the south shore of the Fraser opposite New Westminster[3]. These values, ranging from 5.8 to 6.0, were below the acceptable range of pH (6.5-8.5[5]) and much lower than the average values (7.5-7.6[6]) usually observed for this portion of the river.

To determine the quantity of acid required to change the pH of a large volume of river water, samples were randomly taken at points upstream from the training wall and in both arms of the river downstream. The samples were then titrated using standardized sulphuric acid solutions to measure the buffering capacity of the river against strong acid.

Although ammonia toxicity in the Fraser River was negligible, there is concern that ammonia toxicity could increase with the introduction of a large amount of base.

$$NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O \qquad (1)$$

Equation (1) shows that an excess of hydroxide ion could shift the equilibrium from the non-toxic ammonium ion to the toxic undissociated form of ammonia. Titrations using standardized base (NaOH) were performed to determine the buffering capacity of samples of Fraser River water and storm water to basic discharges.

5.2 Results and Discussion

The source of an acidic discharge, such as mentioned in Section 5.1, should be determined. Several of the storm water ditches in this area were known to have low pH but it was not known if they were sufficiently acidic or of a great enough volume to cause such a change in the pH of the river. These ditches were examined both for buffering capacity as well as for their effect on the Fraser River.

Although ammonia toxicity in the Fraser River was negligible, there is concern that ammonia toxicity could increase with the introduction of a large amount of base.

The results of the various titrations are tabulated and graphed in Appendix 5, Tables 5.2 to 5.10, and Figures 8 to 15.

Available data indicated that storm water discharged near Pattullo Bridge on the south shore was generally acidic. Storm water ranged from 5.9 to 6.4, whereas river pH was slightly basic, ranging from 7.1 to 8.0. Ditch water appeared dark brown/black in color. Both dark colour and low pH are believed to have resulted from contaminants leached from numerous hog fuel landfills in this area. Storm water discharged from a storage yard for pre-fabricated concrete (located one half kilometre upstream from Site No. XE03148-03 along Nelson Road on Lulu Island) was found to be alkaline, ranging from 9.5 to 12.4.

Figure 15 shows that the Fraser River water is buffered reasonably well against acid until it reaches approximately pH 5.8. However, below pH 5.8 a minimal addition of strong acid will cause a drop to pH 4.0 or less. For comparison, theoretical titration curves for distilled water are presented in Figure 16.

Since there were no known acidic discharges within the training wall area, storm water discharges were at first suspected of being the source of the low pH observed on April 5, 1978. Titration of the river water with ditch water however, required approximately 25% ditch water by volume to lower the pH to 6.4 (see Figure 12) using the most acidic storm water found (from 133rd Street and 116th Avenue, Surrey). Several other titrations indicated that a 30 to 50% dilution was required to lower the Fraser by one pH unit (see Table 5.9). It therefore seems unlikely that typical storm water discharges in this vicinity could have lowered the pH of this reach of the Fraser River to 5.9.

Krahn has estimated that a discharge of 24 cubic metres of pure H_2SO_4 would have been required to lower the pH of the water contained within the training wall and south shore to pH 5.9. This estimate may well be conservative since water volume was assumed to be stationary because the duration of low pH was unknown. The source of such a volume of acid has not been determined and warrants further investigation. (Lesser amounts of weak acid may have caused similar effects).

In order to determine the buffering capacity of Fraser River water against a basic solution, several titrations using basic control solutions were made. The titration of Fraser River water with NaOH showed an immediate change with minimal aliquots of base (see Figures 13 or 15); thus the pH of the Fraser River seems as sensitive to the addition of a strong base as is distilled water. Similarly, titration of Fraser water with basic storm water collected from Site No. XE03148-03 showed that great dilution was required before the mixed samples reach pH levels acceptable for aquatic life (Table 5.10). When compared to chemically pure water, the Fraser River was buffered approximately 100 times better against acid but only 1.2 times better against base (see Table 5.11).

It must be emphasized that these results were based on a small number of titrations, but have been confirmed by additional unpublished data collected by the Ministry of Environment in 1979.

Note: The Lower Mainland Region of the Waste Management Branch investigated the possibility that the low pH values in the Fraser might have resulted from dumping of battery acid at nearby auto-wreckers. They found that batteries currently are taken away without acid being drained (Gough, 1980); also weekly monitoring showed the pH to remain above 6.4 (Moore and Gough, 1980) in nearby drainage ditches.

6. TIDAL INFLUENCE ON DRY WEATHER STORM WATER FLOW

6.1 Method

The flow patterns of approximately 70% of the storm sewer discharges in the study area were found to be influenced by tidal reversal of river flow. Therefore a project was initiated to characterize changes in contaminant levels that change with tide and also to determine a procedure for monitoring a discharge under tidal influence.

Following consultations between the WMB, WIB and EPS, it was decided that for this preliminary study one typical site would be examined. The site selected (XE03104-01) is located on the centerline at the south end of Carrington Street in south Vancouver. The discharge is from a concrete pipe approximately one metre in diameter equipped with a tide gate enclosed in a locked wire cage. Upstream from the cage was a combination open ditch and covered pipe (Figure 17).

The equipment used included two Sirco automatic samplers (Model Number MK-VS7-7), a Hydrolab Surveyor (Model 6D In-Situ Water Quality Analyzer with a Mark VII Recorder), and a YSI conductivity meter (Model Number 33 with manual temperature compensation). Water velocity was measured with a Mead Instruments Model H-302 open stream velocity probe.

The Sirco samplers were set to collect 500 mL samples every fifteen minutes over a six hour period. These samples were combined into one composite. The experiment was carried out over one day, August 3, 1978.

Manual grab samples were collected every half hour beginning with the observed high tide at 0430 (0400 from tide tables[7] Pacific Standard Time) and ending at 1000 (low tide) August 3, 1978. Samples were collected at different locations for low and high tide, as indicated in Figure 17. The sampling and sample preservation was done according to standard procedures[4]. All analyses were performed by British Columbia's Environmental Laboratory.

6.2 Results and Discussion

6.2.1 Flow

Flow was estimated by manual measurement of depth, cross-sectional area and water velocity. The results are recorded in Table 6.1 and Figure 18. Time and tidal depth are shown in Figure 19 for reference. Starting at high tide at 0430, virtually no flow occurred until the level of river water dropped below the top of the flood gate, (Figure 19). This event occurred 2½ hours after the observed high tide, (0700 P.S.T.), and peak flow was reached 40 minutes thereafter. At 0830, four hours after high tide, flow decreased to a steady rate of 1/2 to 1/3 the peak flow. Visual observation continued for one hour after low tide and no change in flow was noted. Samples collected or measurements taken during the first 2½ hours of the study were of river water, for the following hour samples were mixed river and storm water, and thereafter storm water only.

6.2.2 Specific Conductance

Replicate conductivity measurements were made at the air/water interface and the water/sediment interface at the outfall. The data are presented in Table 6.1 and Figures 20 and 21.

Conductivity of river water measured at the bottom of the pool was between 1 300 and 1 900 μ siemens/cm. A slow drop occurred with ebbing tide until the tide gate opened, after which time there was a steady decrease in conductivity. Within four hours after high tide, surface and bottom measurements had both stabilized within a range of 400 to 600 μ siemens/cm. When surface and bottom measurements were similar, it was assumed that the discharge water was 100% storm water.

6.2.3 Temperature

Measurements made of the discharge while the tide gate remained closed, remained constant at 20°C. When the gate opened, the temperature decreased to 17.5°C and then began to rise, perhaps due to solar warming (Table 6.2 and Figure 22).

6.2.4 Dissolved Oxygen (DO)

Data are presented in Table 6.2 and Figure 22. The pattern for dissolved oxygen was similar to that observed for temperature. Prior to the tide gate opening, oxygen concentration in the river water was in the 7.8-7.9 mg/L range, but following the gate opening, the DO concentration in the mixed river and storm water dropped to 1.9-2.0 mg/L. After 0900 hours, dissolved oxygen levels began to rise.

6.2.5 pH

Storm water was observed to have slightly lower pH than the river water (Table 6.2 and Figure 23).

6.2.6 Nitrogen

Separate analyses were performed for NO_2^-, NO_3^-, $NO_2^- + NO_3^-$, Kjeldahl nitrogen and total nitrogen. All five concentrations showed an increase with a rise in storm water flow (Tables 6.2 and 6.3, Figures 24 and 25).

NO_3^- concentrations prior to the opening of the tide gate were at non-detectable levels, but after the tide gate opened showed measurable levels. Concentrations of NO_3^- and NO_2^- both peaked with maximum storm water discharge, then fell to lesser concentrations. The mean $NO_2^- + NO_3^-$ nitrogen concentration was 0.18 mg/L, but more than half of the analyses for total nitrogen were in excess of 1.0 mg/L suggesting that Kjeldahl nitrogen was the main form of nitrogen being discharged to the Fraser River and estuary at this location and time. Figures 24 and 25 indicate that sampling a partial tide cycle at ½ hour intervals is not sufficient for accurate determination of changes in nitrogen levels in a day.

6.2.7 Total Phosphate Phosphorus (Unfiltered)

Concentrations of 0.02 to 0.07 mg/L were observed during the period from high tide until the tide gate opened. Once the gate had opened, values of 0.20 to 0.50 mg/L were observed (an order of magnitude increase). As indicated in Table 6.3 and Figure 26 these relatively high levels continued beyond the study period.

6.2.8 Total Inorganic Carbon (TIC) and Total Organic Carbon (TOC)

Total inorganic carbon and total organic carbon both showed increases in concentration peaking just after maximum flow and decreasing slightly thereafter (Table 6.4 and Figure 27).

6.2.9 Colour

During low tide (tide gate open), both TAC colour and true colour were observed to increase by approximately an order of magnitude, true colour changing from less than 5 relative units to a range of 40-60 R.U., and TAC from 6-13 up to 46-79 R.U. (Table 6.4 and Figure 28). The river water and the ditch water between the river and the closed tide gate were observed to be a light pale green colour, extending up the ditch (Figure 17) for a short distance beyond the tide gate. There the colour became dark brown. As the tide gate opened the plume of river water was observed to retract back into the pipe as the rising head of water in the ditch forced water out. A dark brown stain then appeared at the outfall. This line of delineation has been observed in other ditches, such as those in the Ladner and Delta regions along the Fraser River, and has been a quick visual method of checking the progress of a tidal flush. Parameters such as colour and specific conductance suggested that river water seeps through the closed gate.

6.2.10 Phenolics, Oil and Grease

Phenolic concentrations did not rise above the detection limit of 0.002 mg/L at any time during the study. Since the catchment area serviced by the drain was residential/agricultural, phenolics were not expected to be found in any significant concentration.

Oil and grease levels fluctuated during the survey (Table 6.4 and Figure 29) with a peak occurring as the flood gate opened. A source of oil and grease to the river may have been a boat dock and refueling station upstream from the sampling site.

6.2.11 Non-Filterable Residue

As low tide occurred and the tide gate opened, a drop in the concentration of suspended matter was observed, followed by an increase (Table 6.5 and Figure 30).

The high non-filterable residue (NFR) concentration in river water at 0440 hours was similar to that observed for nitrogen, phosphate and total organic carbon.

6.2.12 Total Metals

Copper, zinc, iron, manganese, arsenic and chromium demonstrated peak concentrations shortly after maximum flow (Table 6.5 and Figures 31 to 34).

Copper, zinc, iron, manganese, mercury, nickel, arsenic, chromium and lead were generally at or slightly above their respective MDC's, with the exception of arsenic and copper which had consistently greater concentrations after the initial flow. The peak of the metal concentrations and subsequent decline may have been a result of settling out of sediment after the initial turbulence. Iron and copper both showed a small rise in concentration at 0600 hours, similar to that observed for phosphorus, total organic carbon, and oil and grease.

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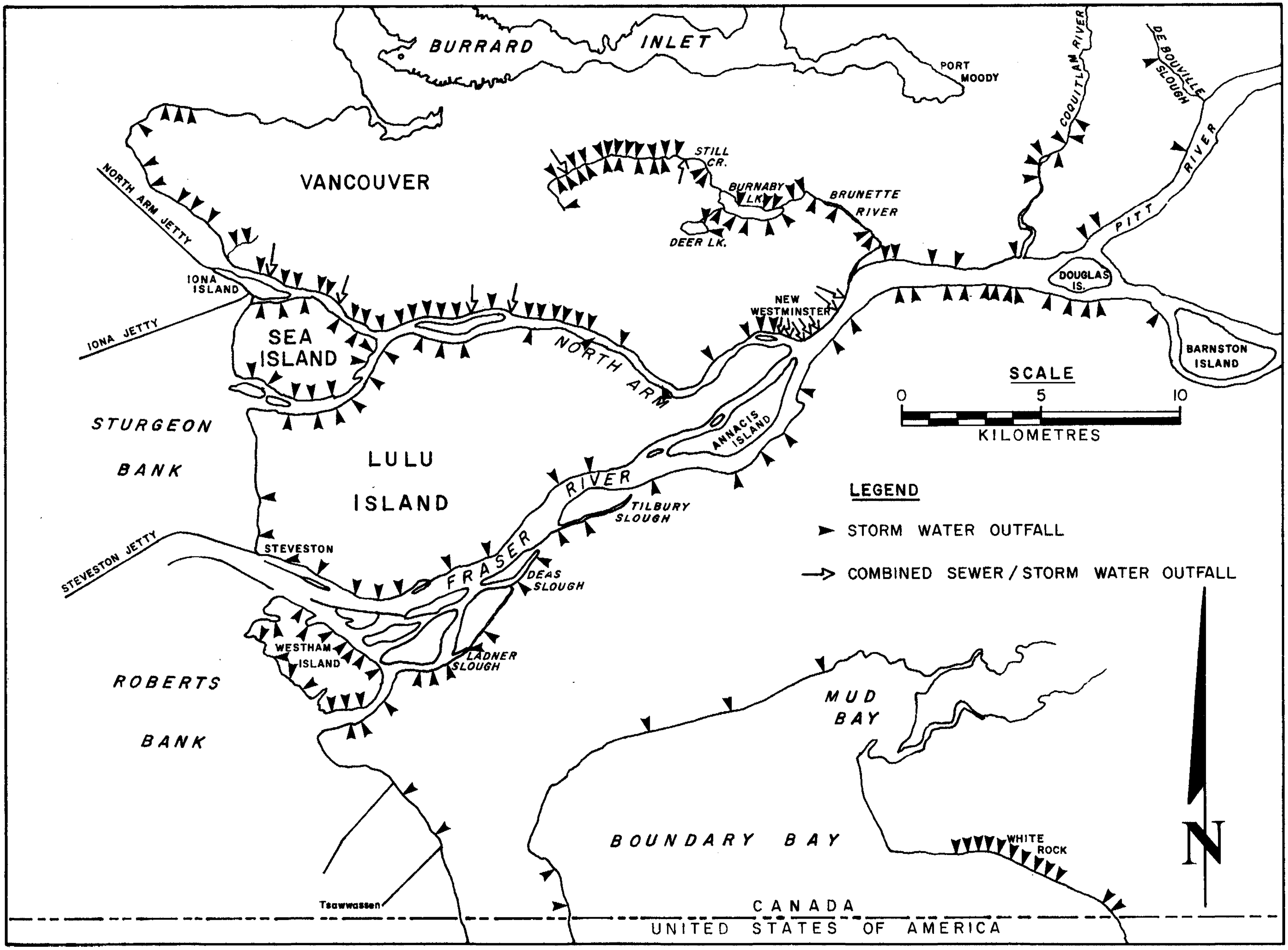
FIGURE I

LOCATION OF STORM SEWER OUTFALLS



APPENDIX 1

Instrument Design for Wet Weather Storm Water Monitoring

The experience gained in the 1978 monitoring program may be applied to future studies of storm water discharges to the Fraser River estuary, in both wet and dry weather. Even with a fully automated sampling system set up over a particular site, it is difficult to obtain a good sample profile. Manual sampling of storm water includes monitoring the progress of an oncoming storm, travelling to the sample site and then sampling the effluent at the proper intervals. Parameters such as dissolved oxygen, conductivity, pH, temperature, salinity, flow velocity, flow volume and general observations of effluent and receiving water conditions must be recorded. For a successful sampling sequence at least two technicians should be present, and communications, transportation and workload must be well planned.

To catch a storm flush successfully, a simple, portable, automated system is required. The factors involved in developing an automated system include:

a) Selection of the sample site. Equipment must be protected from vandalism, and this requires location in a patrolled area or housing in unbreakable containers. The site should also be accessible for servicing.

b) Proximity of an electrical power source. Dependency on storage batteries is reduced if power mains can be used.

c) Sensing the storm water flow. The automated system must have a reliable method of sensing the change in flow levels of water in the pipe, so that sampling will start at the first indication of the storm flush.

d) Collection of the correct sample size. The sample size must be large enough for the test requirements of the analytical laboratory. Instrumentation has been designed and tested for sampling the initial period of wet weather storm water. This system includes three, unmodified, battery operated Sirco samplers, a water level detecting probe, a Manning dipper flow meter and flume or weir. A sketch of this set-up is presented in Figure 2.

The level detecting probe was designed and constructed by Mr. K. Hui. It consists of a PVC plastic ring with two threaded electrodes positioned in the ring directly across from each other. The adjustable gap between the two probes acts as a circuit break and is activated when the rising level of water completes the circuit. The probe is connected through one terminal of a 12 volt battery and then to a four post relay (See Figure 3).

The sampling system is very flexible, since the fully charged battery can be connected to the sampling equipment and left on-site for an indefinite period of time before a storm event. Once the storm occurs, the rising water level will close the probe circuit, energizing the relay. The relay switch then connects all equipment such as samplers, temperature and flow recorders to the battery. The battery life and hence the total sampling time period depends on the amount of equipment used and the sampling periods at which the samplers are set. The length of the total sampling period can be increased simply by connecting two or more automobile storage batteries in parallel circuits. The time of circuit activation may be determined by subtracting the elapsed time recorded by the dipper from the time when the system is serviced by technicians.

A proposed schedule for monitoring wet weather storm water is given in Table 1.1. The sampling for the initial tests should be at the shortest interval setting of the Sirco samplers (3.75 minutes). At this setting, sampling will continue over the first 90 minutes of the storm. Every four consecutive samples may be combined to form 15 minute composites in order to have an adequate volume of sample for analysis. The sampling period will not necessarily include the peak flow recorded for the storm since this could occur at any time during the storm event but will include the initial washoff of pollutants. The seven 15 minute composite samples should provide an indication of concentration levels reached during the first part of a storm and may indicate whether a first flush occurs.

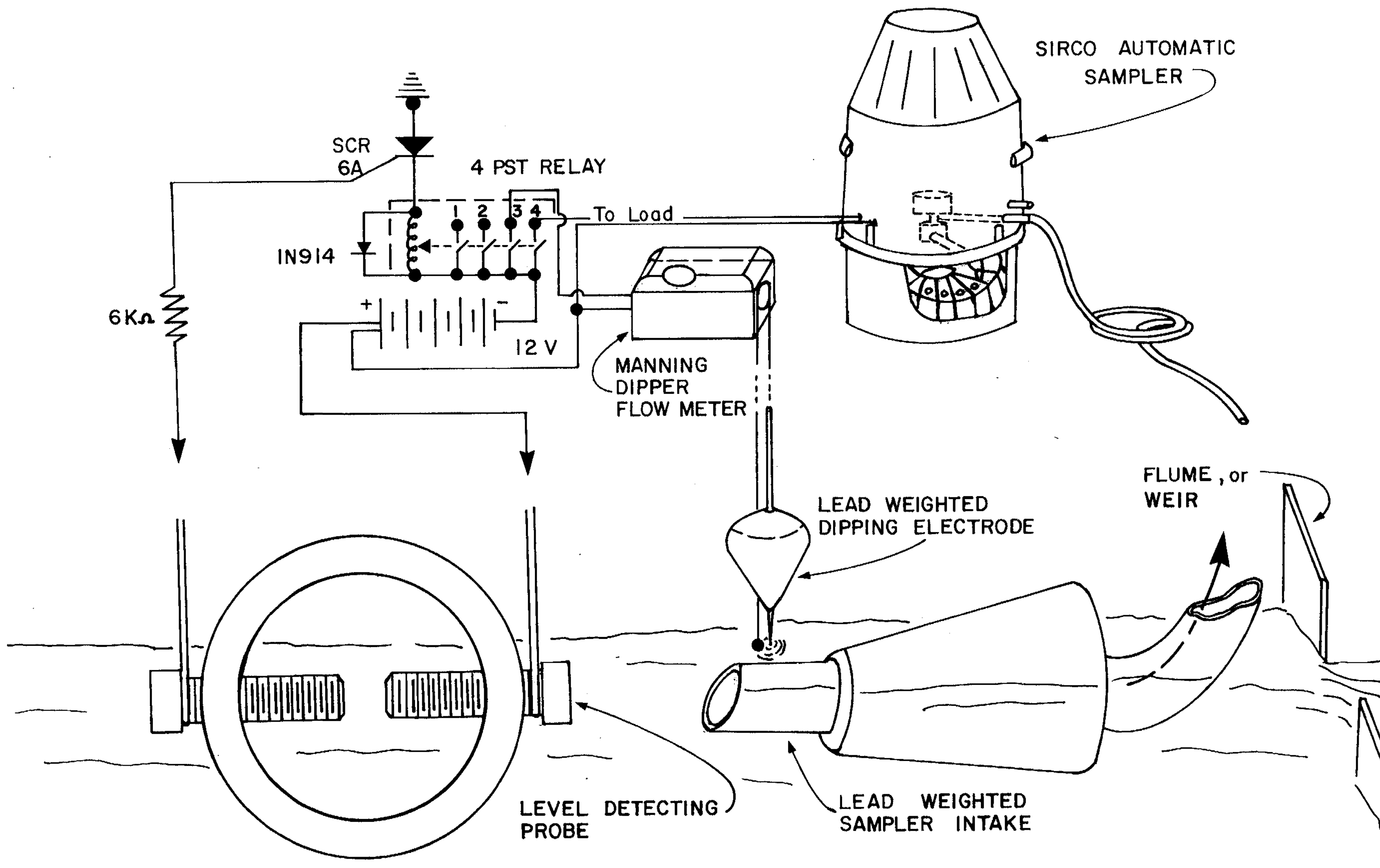


FIGURE 2. MOISTURE SENSITIVE SWITCH (MSS) AND STORM WATER SAMPLING SYSTEM

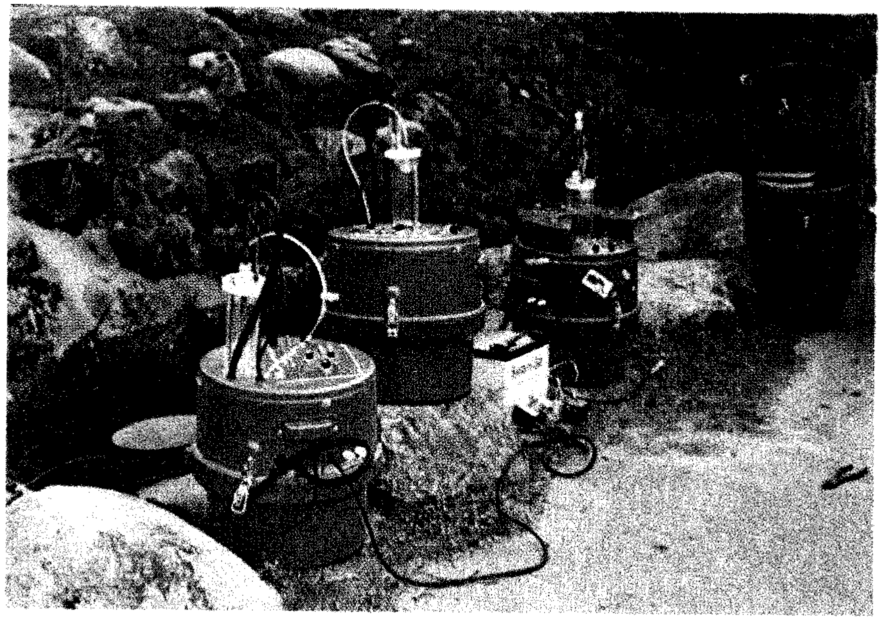


FIGURE 3

Sirco Samplers and Power Supply

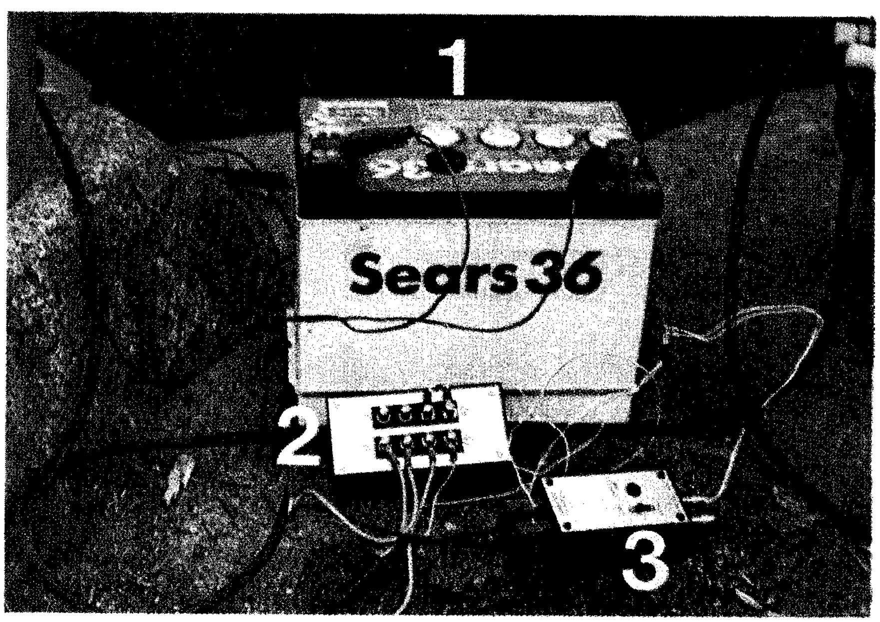


FIGURE 4

Power Supply (1), Circuit Box (2), and Moisture Sensitive Switch (3).

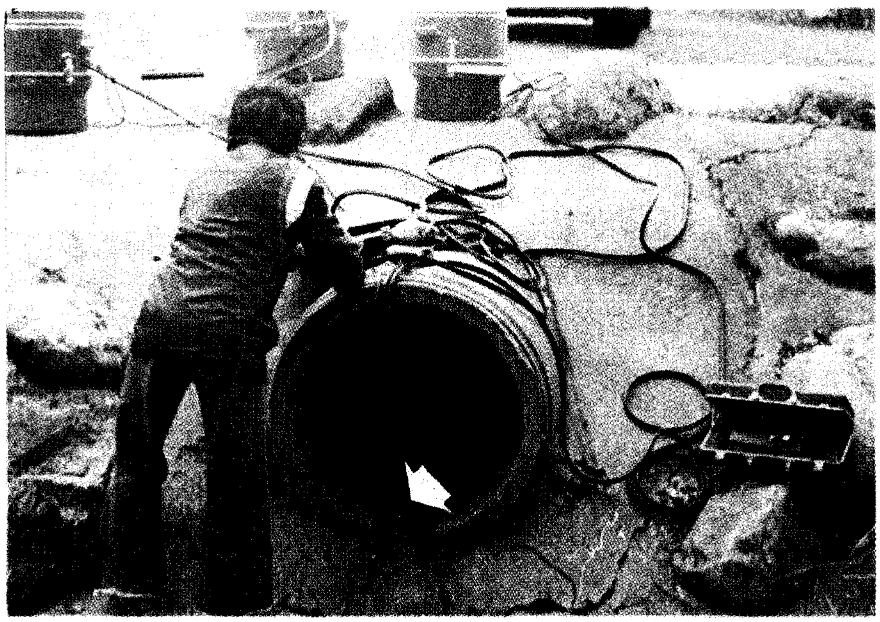


FIGURE 5

Installation of sampling hoses, measuring equipment and level detecting probe (see arrow).

TABLE 1.1

A PROPOSED SCHEDULE FOR WET WEATHER STORM WATER SAMPLING

Time (Minutes)	Composite Number	Metals	General	Phenols	Oil and Grease
00.00	1	1	1	Must be manual single grabs due to bottle and preservation type.	
03.75	↓				
07.50	↓				
11.25	↓				
15.00	2	2	2	2	2
18.75	↓				
22.50	↓				
24.25	↓				
30.00	3	3	3	3	3
33.75	↓				
37.50	↓				
41.25	↓				
45.00	4	4	4	4	4
47.75	↓				
51.50	↓				
54.25	↓				
60.00	5	5	5	5	5
63.75	↓				
67.50	↓				
71.25	↓				
75.00	6	6	6	6	6
78.75	↓				
82.50	↓				
84.25	↓				
90.00	7	7	7	7	7

APPENDIX 2

Data Tables for the
Metal and Nutrient Survey

TABLE 2.1
METAL AND NUTRIENT SURVEY DATA

Site	Description	Date	Aluminum	Ammonia	Arsenic	Carbon (Inorganic)	Carbon (Organic)	Chromium	Color (T.A.C.)	Conductivity (umhos/cm)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Nitrate	Nitrite	Nitrogen (Kjeldahl)	Nitrogen (Organic)	Nitrogen (Total)	Non. Filt. Res.	Oil and Grease	pH (Units)	Phenol	Phosphorus (T)	Total Res. 105	Zinc
RESIDENTIAL																												
XE03107-01	Yew Street	78-09-09	0.23	0.087	<0.005	12	5	<0.005	11	445	0.006	0.8	0.002	-	0.10	<0.01	0.08	<0.005	0.47	0.38	0.55	11	2.7	7.1	<0.002	0.076	-	0.120
		78-10-02	2.70	0.605	0.006	21	17	0.011	51	269	0.030	6.0	0.003	0.61	0.05	<0.01	-	-	3.00	2.40	3.09	250	2.5	7.0	<0.002	0.910	442	0.005
XE03126-01	Fraserview Golf Course at 57 Street	78-08-09	0.20	0.200	0.007	7	10	<0.005	21	121	0.030	0.4	0.066	0.02	<0.05	<0.01	1.78	0.082	2.00	1.80	3.86	5	<1.0	7.0	<0.002	0.294	-	0.070
		78-10-02	0.09	1.730	<0.005	9	5	<0.005	14	135	0.010	0.2	0.004	0.02	<0.05	<0.01	-	-	4.00	2.27	6.00	6	1.4	7.3	<0.002	0.523	102	0.007
XE03127-01	Fraserview Golf Course at Rupert Street	78-08-09	0.06	0.022	<0.005	13	3	<0.005	6	162	0.013	0.2	0.005	0.03	<0.05	<0.01	2.55	<0.005	0.50	0.48	3.05	1	<1.0	6.9	<0.002	0.039	-	0.013
		78-10-02	0.03	0.045	<0.005	21	1	<0.005	8	205	0.011	0.2	0.010	0.05	<0.05	<0.01	-	-	0.26	0.22	1.72	2	<1.0	8.0	<0.002	0.030	148	0.009
XE03161-01	Francis Road West	78-08-22	0.03	-	<0.005	144	8	0.007	42	10 600	0.010	2.2	0.007	0.46	<0.05	<0.01	-	-	2.00	-	2.00	18	2.7	8.2	-	0.312	7 398	<0.005
		78-10-12	0.06	-	<0.005	87	14	0.008	63	7 550	0.006	3.4	0.010	0.54	<0.05	<0.01	-	-	2.00	-	2.21	22	2.7	7.6	<0.002	0.354	4 836	0.024
XE03197-01	Still Creek at Renfrew Park	78-09-06	-	-	-	10	4	-	9	143	0.006	-	0.012	-	0.05	-	-	-	-	-	-	6	<1.0	7.0	<0.002	-	-	0.016
XE03198-01	Still Creek at Renfrew/22nd	78-08-09	0.18	0.128	<0.005	14	5	<0.005	10	163	0.008	0.9	0.006	0.13	<0.05	<0.01	2.15	0.053	0.75	0.62	2.95	8	<1.0	7.2	<0.002	0.084	-	0.007
		78-09-06	0.24	-	<0.005	-	-	<0.005	-	-	-	0.6		0.08	-	<0.01	-	-	0.78	-	3.78	-	-	-	-	0.051	116	-
XE03224-01	Buckingham Street	78-08-10	1.30	0.880	0.007	9	25	<0.005	-	116	0.020	3.6	0.125	0.21	0.06	<0.01	-	0.043	2.00	1.12	-	44	<1.0	-	0.009	0.242	-	-
		78-09-06	0.33	-	<0.005	10	4	0.010	15	123	0.004	0.8	0.013	0.11	0.06	<0.01	-	-	0.26	-	0.79	7	1.1	7.4	<0.002	0.036	90	0.007
XE03231-01	Hume Park at North Road	78-08-10	0.12	-	<0.005	17	15	<0.005	-	175	0.009	1.1	0.031	0.18	<0.05	<0.01	-	0.008	1.00	0.98	-	7	12.3	-	0.002	0.052	-	-
		78-09-08	0.29	-	<0.005	11	7	<0.005	43	142	0.006	1.2	0.008	<0.02	<0.05	<0.01	-	-	0.55	-	0.91	-	1.8	7.4	0.002	0.031	118	0.007
XE03273-01	Point Grey Golf Course	78-08-09	0.50	0.020	<0.005	11	4	<0.005	6	3 970	0.006	0.7	<0.001	0.05	<0.05	<0.01	0.03	<0.005	0.20	0.18	-	14	9.4	7.7	<0.002	0.032	-	<0.005
		78-10-02	0.13	0.120	<0.005	22	7	0.013	26	6 790	0.005	0.9	0.002	-	<0.05	<0.01	-	-	0.41	0.29	0.45	13	1.9	7.5	<0.002	0.063	4 344	<0.005
	MEAN		0.41	0.384	0.005	26	8	0.007	23	1 944	0.011	1.5	0.019	0.18	0.05	<0.01	1.32	0.029	1.26	0.90	2.41	28	2.8	7.4	0.003	0.196	1 955	0.021
	MEDIAN		0.19	0.124	<0.005	13	6	<0.005	15	169	0.009	0.9	0.008	0.10	<0.05	<0.01	1.78	0.008	0.70	0.62	2.21	8	1.6	7.4	<0.002	0.070	148	0.007
LANDFILL																												
XE03143-01	Landfill Creek at Fraser Mills/ Crown Zellerbach	78-08-10	0.60	0.397	0.008	30	11	<0.005	85	272	0.020	12.0	0.023	0.96	<0.05	<0.01	0.07	0.018	1.00	0.60	1.09	21	5.6	6.9	0.013	0.127	-	0.060
		78-09-21	0.15	-	<0.005	26	11	<0.005	74	222	0.004	2.3	0.007	0.35	<0.05	<0.01	-	-	0.61	-	1.04	15	3.2	7.0	0.004	0.076	176	0.019
	MEAN		0.38	0.397	0.007	28	11	<0.005	80	247	0.012	7.2	0.015	0.66	<0.05	<0.01	0.07	0.018	0.81	0.60	1.07	18	4.4	7.0	0.009	0.102	176	0.040
	MEDIAN		0.38	0.397	0.007	28	11	<0.005	80	247	0.012	7.2	0.015	0.66	<0.05	<0.01	0.07	0.018	0.81	0.60	1.07	18	4.4	7.0	0.009	0.102	176	0.040
INDUSTRIAL																												
XE03113-01	West Coast Cellufibre/Manitoba Street	78-08-10	-	0.013	0.012	17	15	-	2	127	0.009	-	0.003	-	<0.05	-	<0.02	<0.005	0.68	0.67	0.68	12	2.0	6.7	0.013	0.149	-	0.070
		78-10-02	0.13	<0.005	<0.005	18	11	<0.005	47	160	0.006	1.5	<0.001	0.19	<0.05	<0.01	-	-	0.40	0.40	0.42	18	2.6	6.8	0.007	0.070	116	0.019
XE03114-01	Fraser Mills/Crown Zellerbach	78-08-10	0.02	0.526	0.009	37	13	<0.005	93	266	0.003	5.0	0.003	0.39	<0.05	<0.01	0.16	0.014	1.00	0.47	1.17	12	6.4	6.9	0.028	0.096	-	0.050
		78-09-21	0.50	-	0.005	36	15	0.008	143	296	0.006	12.5	0.012	0.50	<0.05	<0.01	-	-	1.00	-	1.19	21	4.6	7.0	0.026	0.104	232	0.110
XE03168-01	No. 4 Road North	78-08-22	0.10	-	<0.005	31	16	0.005	152	613	0.003	33.0	0.004	0.45	<0.05	<0.01	-	-	2.00	-	2.00	45	2.7	7.2	<0.002	0.321	464	0.005
		78-10-12	0.80	-	<0.005	40	11	0.008	195	690	0.008	17.0	0.008	0.73	<0.05	<0.01	-	-	3.00	-	3.32	49	9.5	6.8	<0.002	0.419	500	0.017
XE03216-01	Lozelles Creek at Warren Loat Park	78-08-10	0.70	1.28	0.005	3	48	0.005	159	77	0.05	0.9	0.200	0.15	0.06	<0.01	0.87	0.040	4.00	2.72	4.91	22	8.2	6.6	0.015	0.187	-	0.140
		78-09-06	0.09	-	<0.005	<1	6	<0.005	11	28	0.01	0.2	0.018	0.02	0.07	<0.01	-	-	0.35	-	0.53	5	<1.0	6.7	0.002	0.032	30	0.130
XE03227-01	Caribou Road	78-08-10	0.03	0.027	0.006	22	13	<0.005	68	177	0.004	1.3	0.005	0.38	<0.05	<0.01	0.02	<0.005	1.00	0.97	1.02	5	2.3	7.0	0.003	0.057	-	0.006
		78-09-08	1.30	-	<0.005	17	14	<0.005	70	216	0.006	3.2	0.005	0.34	<0.05	<0.01	-	-	0.63	-	0.77	-	2.2	6.9	0.002	0.033	194	0.011
	MEAN		0.41	0.370	0.006	22	16	0.006	94	265	0.0105	8.3	0.026	0.35	0.05	<0.01	0.27	0.016	1.41	1.05	1.60	21	4.2	6.9	0.010	0.147	256	0.056
	MEDIAN		0.70	0.027	0.005	20	14	0.005	82	197	0.006	3.2	0.005	0.38	<0.05	<0.01	0.09	0.010	1.00	0.67	1.10	18	2.7	6.8	0.005	0.100	213	0.064

TABLE 2.1 (continued)
METAL AND NUTRIENT SURVEY DATA

Site	Description	Date	Aluminum	Ammonia	Arsenic	Carbon (Inorganic)	Carbon (Organic)	Chromium	Color (T.A.C.)	Conductivity (µmhos/cm)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Nitrate	Nitrite	Nitrogen (Kjeldahl)	Nitrogen (Organic)	Nitrogen (Total)	Non. Filt. Res.	Oil and Grease	pH (Units)	Phenol	Phosphorus (T)	Total Res. 105	Zinc
COMMERCIAL																												
XE03158-01	No. 1 Road South	78-08-22	0.70	-	< 0.005	28	11	0.005	10	4 480	0.050	1.5	0.004	0.09	< 0.05	< 0.01	-	-	3.00	-	3.00	24	2.3	7.7	< 0.002	0.395	2 666.	0.300
		78-10-12	0.20	-	0.006	72	12	0.006	36	3 820	0.015	3.2	0.014	0.20	< 0.05	< 0.01	-	-	3.00	-	3.19	28	2.8	7.6	0.002	0.939	2 206	0.480
XE03185-01	Elliot Street, Delta	78-08-22	0.50	-	< 0.005	12	2	< 0.005	7	477	0.005	1.5	0.004	< 0.02	< 0.05	< 0.01	-	-	0.21	-	0.25	25	< 0.1	7.4	< 0.002	0.049	300	0.010
		78-09-27	0.90	-	< 0.005	28	9	0.007	44	1 600	0.005	3.0	0.005	0.27	< 0.05	0.01	-	-	1.00	-	1.05	37	2.7	7.5	< 0.002	0.171	976	0.011
XE03203-01	Still Creek at Skeena	78-08-09	0.24	0.595	< 0.005	8	4	< 0.005	13	88	0.020	0.8	0.021	0.05	< C.05	< 0.01	0.64	0.036	2.00	1.41	2.68	3	< 1.0	7.0	< 0.002	0.140	-	0.007
		78-09-08	0.70	-	< 0.005	9	10	0.006	-	102	0.040	1.5	0.074	0.06	< 0.05	< 0.01	-	-	2.00	-	3.00	-	4.1	7.1	0.002	0.790	126	0.033
XE03205-01	Still Creek at Gilmore	78-08-09	0.02	0.152	< 0.005	22	8	< 0.005	37	160	0.004	2.1	0.005	0.66	< 0.05	< 0.01	0.24	0.007	0.55	0.40	0.08	4	1.9	6.9	0.002	0.025	-	< 0.005
		78-09-08	0.04	-	< 0.005	21	13	< 0.005	69	175	0.002	1.9	0.003	0.39	< 0.05	< 0.01	-	-	0.61	-	1.15	-	1.6	7.0	0.005	0.039	134	0.005
XE03206-01	Still Creek at 401	78-08-09	0.80	-	< 0.010	-	39	0.008	418	718	0.030	50.0	0.030	2.68	< 0.05	< 0.01	0.04	0.010	3.00	-	-	156	7.8	6.3	0.004	0.231	-	0.050
		78-09-06	1.20	-	< 0.005	22	33	0.006	224	205	0.018	8.0	0.110	0.70	< 0.05	< 0.01	-	-	2.00	-	2.16	21	11.4	6.2	0.012	0.066	218	0.190
XE03207-01	Still Creek at Willingdon	78-08-09	0.50	0.107	< 0.005	34	12	< 0.005	82	233	0.030	2.9	0.047	0.42	< 0.05	< 0.01	0.61	0.014	0.90	0.79	1.52	15	2.7	6.8	0.026	0.265	-	0.090
		78-09-08	2.10	-	0.036	39	37	0.070	109	606	0.320	2.3	4.800	0.30	< 0.05	< 0.01	-	-	2.00	-	3.15	-	5.1	9.7	0.031	1.040	506	1.500
XE03208-01	Willingdon	78-08-09	2.80	-	< 0.005	150	205	0.008	2 200	1 100	0.020	25.0	0.023	4.85	< 0.05	< 0.01	< 0.02	0.012	6.00	-	6.00	165	16.8	6.3	-	0.614	-	0.080
		78-09-06	1.90	-	< 0.005	25	21	0.007	237	228	0.007	3.3	0.013	0.48	< 0.05	< 0.01	-	-	0.69	-	0.87	26	6.6	6.3	0.112	0.079	216	0.006
XE03236-01	Kingsway Avenue	78-08-10	0.07	0.041	< 0.005	12	1	< 0.005	2	192	0.007	0.2	0.010	0.03	< 0.05	< 0.01	1.16	< 0.005	0.12	0.08	2.28	< 1	< 1.0	6.6	< 0.002	0.006	-	0.050
		78-09-21	0.08	-	< 0.005	11	1	< 0.005	< 1	227	0.006	0.2	0.011	0.07	< 0.05	< 0.01	-	-	0.09	-	1.68	3	1.0	6.7	< 0.002	0.006	170	0.140
	MEAN		0.80	0.224	0.007	33	26	0.010	234	901	0.036	6.7	0.323	0.70	< 0.05	< 0.01	0.45	0.014	1.70	0.67	2.14	39	4.3	7.1	0.014	0.303	752	0.185
	MEDIAN		0.60	0.130	< 0.005	22	12	0.006	44	231	0.017	2.2	0.014	0.29	< 0.05	< 0.01	0.43	0.011	1.50	0.60	2.16	24	2.7	7.0	0.002	0.156	259	0.050
AGRICULTURAL																												
XE03147-01	Colony Farm Creek	78-08-10	0.16	8.7	< 0.005	37	38	< 0.005	112	229	0.010	7.0	0.005	-	< 0.05	< 0.01	< 0.02	< 0.005	13.00	4.3	13.00	42	-	6.7	0.100	1.850	-	0.009
		78-09-21	0.02	-	< 0.005	30	4	< 0.005	59	172	0.004	9.5	< 0.001	0.55	< 0.05	< 0.01	-	-	1.00	-	1.02	30	1.6	6.9	< 0.002	0.278	146	< 0.005
XE03148-01	Nelson Road (Industrial Influence)	78-08-22	1.90	-	< 0.005	44	15	0.009	187	822	0.010	4.9	0.002	0.58	< 0.05	0.01	-	-	10.00	-	10.00	72	2.6	7.5	-	0.232	608	< 0.005
		78-10-12	1.10	-	0.006	108	46	0.016	319	918	0.009	16.5	0.004	1.16	< 0.05	< 0.01	-	-	12.00	-	12.05	58	5.3	7.3	0.052	0.347	642	0.040
XE03152-01	George Massey Tunnel	78-08-22	1.30	-	< 0.005	21	8	0.005	44	505	0.003	6.0	0.002	0.41	< 0.05	< 0.01	-	-	0.43	-	0.48	46	2.5	7.5	< 0.002	0.149	364	< 0.005
		78-10-12	1.10	-	0.006	34	23	0.007	223	500	0.010	12.5	0.010	0.81	< 0.05	< 0.01	-	-	2.00	-	2.07	36	3.3	6.9	0.005	0.314	376	0.008
XE03154-01	Finn Road	78-08-22	2.00	-	< 0.005	9	5	0.007	14	97	0.003	3.2	0.004	0.06	< 0.05	< 0.01	-	-	0.29	-	0.33	64	2.1	7.7	0.005	0.106	130	< 0.005
		78-10-12	0.06	-	< 0.005	32	13	< 0.005	96	1 020	0.006	7.5	0.004	0.61	< 0.05	< 0.01	-	-	1.00	-	1.10	30	5.7	7.1	< 0.002	0.133	646	< 0.005
XE03183-01	Crescent Slough	78-08-28	0.09	-	0.005	31	10	< 0.005	26	626	0.001	1.5	< 0.001	0.10	< 0.05	< 0.01	-	-	-	-	4.17	16	3.3	7.6	< 0.002	0.095	374	< 0.005
		78-09-27	0.50	-	0.016	134	40	0.010	203	1 550	0.007	6.0	0.003	0.52	< 0.05	0.02	-	-	0.41	-	41.37	34	5.2	7.9	-	0.362	802	0.021
XE03190-01	Morris Road	78-08-28	1.30	-	< 0.005	16	2	0.009	7	2 120	0.008	5.5	0.004	0.12	< 0.06	0.02	-	-	0.30	-	0.32	61	1.2	7.8	< 0.002	0.086	1 406	0.008
		78-09-27	1.00	-	< 0.005	55	7	0.015	27	11 000	0.020	5.0	0.002	-	< 0.05	< 0.01	-	-	0.30	-	0.30	76	4.5	7.7	0.008	0.462	7 132	< 0.005
XE03192-01	CB Main Road South	78-08-28	-	-	0.007	35	22	0.018	33	14 500	-	2.2	0.003	0.40	-	0.01	-	-	4.00	-	4.00	80	-	7.7	< 0.002	0.359	9 766	0.012
		78-09-27	2.20	-	0.005	33	14	0.008	26	7 400	0.007	2.3	0.003	-	< 0.05	0.01	-	-	3.00	-	3.00	79	4.3	7.6	0.002	0.307	4 632	0.015
XE03193-01	Tsawwassen Indian Reserve	78-08-28	0.05	-	< 0.005	28	5	0.006	9	38 100	0.040	0.7	< 0.001	0.10	< 0.05	< 0.01	-	-	0.43	-	0.43	10	1.5	8.0	< 0.002	0.113	27	< 0.005
		78-09-27	0.15	-	< 0.005	30	5	< 0.005	16	20 600	0.004	0.7	0.002	-	< 0.05	< 0.01	-	-	0.57	-	0.64	14	4.1	7.9	< 0.002	0.065	15	< 0.005
XE03194-01	Trim Road	78-08-28	0.10	-	0.006	20	11	< 0.005	36	407	0.002	2.4	< 0.001	0.80	< 0.05	< 0.01	-	-	0.65	-	0.65	14	2.0	7.5	< 0.002	0.097	250	0.005
		78-09-27	0.80	-	0.008	44	17	0.009	44	508	0.005	1.8	0.002	-	< 0.05	< 0.01	-	-	2.00	-	2.00	23	-	7.7	0.012	0.150	322	0.007
	MEAN		0.71	8.7	0.006	41	16	0.008	82	5 621	0.009	5.3	0.003	0.49	< 0.05	< 0.01	< 0.02	< 0.005	3.02	4.3	5.39	44	3.3	7.5	0.013	0.306	1 626	0.009
	MEDIAN		0.50	8.7	< 0.005	33	12	0.007	40	870	0.007	5.0	0.003	0.52	< 0.05	< 0.01	< 0.02	< 0.005	1.00	4.3	1.55	39	3.3	7.6	< 0.002	0.191	376	0.005

TABLE 2.2

PREPARATION METHOD CODES[4] FOR METAL AND NUTRIENT SURVEY DATA

Site	Description	Date	Aluminum 267	Ammonia 108	Arsenic 251	Carbon (Inorganic) 124	Carbon (Organic) 103	Chromium 255	Color (TAC) 024	Conductivity (µmhos/cm) 011	Copper 256	Iron 257	Lead 258	Manganese 260	Mercury 261	Nickel 263	Nitrate 110	Nitrite 111	Nitrogen (Kjeldahl) 113	Nitrogen (Organic) 112	Nitrogen (Total) 114	Non. Filt. Res. 008	Oil and Grease 003	pH (Units) 004	Phenol 117	Phosphorus (T) 119	Total Res. 007	Zinc 753
RESIDENTIAL																												
XE03107-01	Yew Street	78-08-09	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	-	3503	0206	0001	1701	0101	0003	0001	0101	0703	0101	0401	0103	-	0207
		78-10-02	0205	1703	0101	0102	0102	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0102	0003	0001	0103	0703	0101	0401	0103	0101	0207
XE03126-01	Fraserview Golf Course at 57 Street	78-08-09	0207	1703	0101	0101	0101	0210	1701	0101	0204	0204	0207	0203	3503	0206	0001	1701	0102	0003	0001	0101	0702	0101	0401	0103	-	0204
		78-10-02	0206	1703	0101	0102	0102	0207	1701	0101	0201	0204	0208	0201	3503	0207	-	-	0102	0003	0001	0101	0702	0101	0401	0103	0101	0208
XE03127-01	Fraserview Golf Course at Rupert Street	78-08-09	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	0001	1701	0101	0003	0001	0101	0702	0101	0401	0103	-	0207
		78-10-02	0206	1703	0101	0102	0102	0207	1701	0101	0207	0204	0208	0201	3503	0207	-	-	0101	0003	0001	0101	0703	0101	0401	0103	0101	0208
XE03161-01	Francis Road West	78-08-22	0207	-	0103	0101	0101	0210	1701	0101	0204	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	-	0103	0101	0207
		78-10-12	0207	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03197-01	Still Creek at Renfrew Park	78-09-06	-	-	-	0101	0101	-	1701	0101	0207	-	0208	-	3503	-	-	-	-	-	-	0101	0702	0101	0401	-	-	0208
XE03198-01	Still Creek at Renfrew/22nd	78-08-09	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	0001	1701	0101	0003	0001	0101	0702	0101	0401	0103	-	0207
		78-09-06	0206	-	0103	-	-	0207	-	-	-	0204	-	0201	-	0207	-	-	0101	-	0001	-	-	-	-	0103	0101	-
XE03224-01	Buckingham Street	78-08-10	0205	-	0103	0101	0101	0210	-	0101	0204	0204	0207	0203	3503	0206	-	1701	0102	0003	-	0101	0703	-	0401	0103	-	-
		78-09-06	0207	-	0103	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	0101	0702	0101	0401	0103	0101	0207
XE03231-01	Hume Park at North Road	78-08-10	0207	-	0103	0101	0101	0210	-	0101	0206	0204	0207	0203	3503	0206	-	-	0102	0003	-	0101	0703	-	0401	0103	-	-
		78-09-08	0207	-	0103	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	-	0703	0101	0401	0103	0101	0207
XE03273-01	Point Grey Golf Course	78-08-09	0205	0101	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3502	0206	0001	1701	0101	0003	-	0101	0703	0101	0401	0103	-	0207
		78-10-02	0207	0101	0101	0101	0102	0210	1701	0101	0206	0204	0207	-	3502	0206	-	-	0101	0003	0001	0101	0703	0101	0401	0103	0101	0207
LANDFILL																												
XE03143-01	Landfill Creek at Fraser Mills/Crown Zellerbach	78-08-10	0205	1703	0101	0102	0102	0210	1701	0101	0204	0204	0207	0203	3503	0206	0001	1701	0102	0003	0001	0101	0703	0101	0401	0103	-	0204
		78-09-21	0207	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	0101	0703	0101	0401	0103	0101	0207
INDUSTRIAL																												
XE03113-01	West Coast Cellufibre/Manitoba Street	78-08-09	-	1703	0101	0101	0101	-	1701	0101	0206	-	0207	-	3503	-	0001	1701	0101	0003	0001	0101	0703	0101	0401	0103	-	0204
		78-10-02	0206	1703	0101	0102	0102	0207	1701	0101	0207	0204	0208	0201	3503	0207	-	-	0101	0003	0001	0101	0703	0101	0401	0103	0101	0208
XE03144-01	Fraser Mills/Crown Zellerbach	78-08-10	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	0001	1701	0102	0003	0001	0101	0703	0101	0401	0103	-	0204
		78-09-21	0205	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0204
XE03168-01	No. 4 Road North	78-08-22	0207	-	0103	0101	0101	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
		78-10-12	0205	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03216-01	Lozelles Creek at Warren Loat Park	78-08-10	0205	1703	0101	0102	0102	0210	1701	0101	0204	0204	0204	0203	3503	0206	0001	1701	0102	0003	0001	0101	0703	0101	0401	0103	-	0204
		78-09-06	0206	-	0103	0101	0101	0207	1701	0101	0207	0204	0208	0201	3503	0207	-	-	0101	-	0001	0101	0702	0101	0401	0103	0101	0201
XE03227-01	Caribou Road	78-08-10	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	0001	1701	0102	0003	0001	0101	0703	0101	0401	0103	-	0207
		78-09-08	0205	-	0103	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	-	0703	0101	0401	0103	0101	0207

TABLE 2.2 (continued)

PREPARATION METHOD CODES[4] FOR METAL AND NUTRIENT SURVEY DATA

Site	Description	Date	Aluminum 267	Ammonia 108	Arsenic 251	Carbon (Inorganic) 124	Carbon (Organic) 103	Chromium 255	Color (TAC) 024	Conductivity (µmhos/cm) 011	Copper 256	Iron 257	Lead 258	Manganese 260	Mercury 261	Nickel 263	Nitrate 110	Nitrite 111	Nitrogen (Kjeldahl) 113	Nitrogen (Organic) 112	Nitrogen (Total) 114	Non. Filt. Res. 008	Oil and Grease 003	pH (Units) 004	Phenol 117	Phosphorus (T) 119	Total Res. 007	Zinc 753
COMMERCIAL																												
XE03158-01	No. 1 Road South	78-08-22	0205	-	0103	0101	0101	0210	1701	0101	0204	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0204
		78-10-12	0207	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0204
XE03185-01	Elliot Street, Delta	78-08-28	0205	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	0101	0702	0101	0401	0103	0101	0207
		78-09-27	0205	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03203-01	Still Creek at Skeena	78-08-09	0207	1703	0103	0101	0101	0210	1701	0101	0204	0204	0207	0203	3502	0206	0001	1701	0102	0003	0001	0101	0702	0101	0401	0103	-	0207
		78-09-08	0205	-	0103	0101	0101	0210	-	0101	0204	0204	0207	0203	3503	0206	-	-	0102	-	0001	-	0703	0101	0401	0103	0101	0207
XE03205-01	Still Creek at Gilmore	78-08-09	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3502	0206	0001	1701	0101	0003	0001	0101	0702	0101	0401	0103	-	0207
		78-09-08	0206	-	0103	0101	0101	0207	1701	0101	0207	0204	0208	0201	3502	0207	-	-	0101	-	0001	-	0702	0101	0401	0103	0101	0208
XE03206-01	Still Creek at 401	78-08-09	0205	-	0103	-	0102	0210	1701	0101	0204	0204	0207	0203	3502	0206	0001	1701	0102	-	-	0103	0703	0101	0401	0103	-	0204
		78-09-26	0205	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0103	0703	0101	0401	0103	0101	0207
XE03207-01	Still Creek at Willingdon	78-08-09	0205	1703	0101	0101	0101	0210	1701	0101	0204	0204	0207	0203	3502	0206	0001	1701	0101	0003	0001	0101	0703	0101	0401	0103	-	0204
		78-09-08	0205	-	0103	0102	0102	0210	1701	0101	0204	0204	0204	0203	3502	0206	-	-	0102	-	0001	-	0703	0101	0401	0103	0101	0204
XE03208-01	Willingdon	78-08-09	0205	-	0103	0102	0102	0210	1701	0101	0204	0204	0207	0203	3502	0206	0001	1701	0102	-	0001	0103	0703	0101	-	0103	-	0204
		78-09-06	0205	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0101	-	0001	0103	0703	0101	0401	0103	0101	0207
XE03236-01	Kingsway Avenue	78-08-10	0207	1703	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	0001	1701	0101	0003	0001	0101	0702	0101	0401	0103	-	0204
		78-09-21	0206	-	0101	0101	0101	0207	1701	0101	0207	0204	0208	0201	3503	0207	-	-	0101	-	0001	0101	0702	0101	0401	0103	0101	0201
AGRICULTURAL																												
XE03147-01	Colony Farm Creek	78-09-10	0207	1703	0103	0102	0102	0210	1701	0101	0206	0204	0207	-	3503	0206	0001	1701	0102	0003	0001	0101	-	0101	0401	0103	-	0207
		78-09-21	0207	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03148-01	Nelson Road (Industrial Influence)	78-08-22	0205	-	0103	0101	0101	0210	1701	0101	0204	0204	0207	0203	3502	0206	-	-	0102	-	0001	0103	0703	0101	-	0103	0101	0207
		78-10-12	0205	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0102	-	0001	0103	0703	0101	0401	0103	0101	0204
XE03152-01	George Massey Tunnel	78-08-22	0205	-	0103	0101	0101	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0101	-	0001	0101	0703	0101	0401	0103	0101	0207
		78-10-12	0205	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0102	-	0001	0103	0703	0101	0401	0103	0101	0207
XE03154-01	Finn Road	78-08-22	0205	-	0103	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	0101	0703	0101	0401	0103	0101	0207
		78-10-12	0207	-	0103	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03183-01	Crescent Slough	78-08-28	0206	-	0101	0101	0101	0207	1701	0101	0207	0204	0208	0201	3503	0207	-	-	-	-	0001	0101	0703	0101	0401	0103	0101	0208
		78-09-27	0205	-	0101	0102	0102	0210	1701	0101	0206	0204	0207	0203	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03190-01	Morris Road	78-08-28	0205	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	0203	3503	0206	-	-	0101	-	0001	0101	0703	0101	0401	0103	0101	0207
		78-09-27	0205	-	0101	0101	0101	0210	1701	0101	0204	0204	0207	-	3502	0206	-	-	0101	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03192-01	CB Main Road South	78-08-28	-	-	0101	0101	0101	0210	1701	0101	-	0204	0207	0203	-	0206	-	-	0102	-	0001	0101	-	0101	0401	0103	0101	0207
		78-09-27	0205	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	-	3502	0206	-	-	0102	-	0001	0101	0703	0101	0401	0103	0101	0207
XE03193-01	Tsawwassen Indian Reserve	78-08-28	0206	-	0101	0101	0101	0207	1701	0101	0201	0204	0207	0201	3502	0207	-	-	0101	-	0001	0101	0703	0101	0401	0103	0102	0207
		78-09-27	0206	-	0101	0102	0102	0207	1701	0101	0207	0204	0207	-	3502	0207	-	-	0101	-	0001	0101	0703	0101	0401	0103	0102	0208
XE03194-01	Trim Road	78-08-28	0206	-	0101	0101	0101	0207	1701	0101	0207	0204	0208	0201	3503	0207	-	-	0101	-	0001	0101	0703	0101	0401	0103	0101	0208
		78-09-27	0207	-	0101	0101	0101	0210	1701	0101	0206	0204	0207	-	3502	0206	-	-	0102	-	0001	0101	-	0101	0401	0103	0101	0207

TABLE 2.3

SUMMARY OF MEAN (MEDIAN) VALUES OF METALS
AND NUTRIENTS IN RESIDENTIAL, LANDFILL, INDUSTRIAL
COMMERCIAL AND AGRICULTURAL AREAS

Parameter	Residential	Landfill	Industrial	Commercial	Agricultural	Overall Mean
Aluminum	0.406 (0.19)	0.375 (0.375)	0.408 (0.7)	0.797 (0.6)	0.706 (0.5)	0.538
Ammonia	0.384 (0.124)	0.397 (0.397)	0.370 (0.027)	0.224 (0.130)	8.7 (8.7)	2.02
Arsenic	0.005 (<0.005)	0.007 (0.007)	0.006 (0.005)	0.007 (<0.005)	0.006 (<0.005)	0.006
Carbon (Inorganic)	26.10 (12.5)	28 (28)	22.2 (20)	32.9 (22)	41.2 (32.5)	30.1
Carbon (Organic)	8.38 (6)	11 (11)	16.2 (13.5)	26.1 (11.5)	15.8 (12)	15.5
Chromium	0.007 (<0.005)	0.005 (<0.005)	0.006 (<0.005)	0.010 (0.006)	0.008 (0.007)	0.007
Color (TAC)	23.2 (14.5)	79.5 (79.5)	94 (81.5)	234 (44)	82.3 (40)	102
Conductivity	1 940 (169)	247 (247)	265 (197)	901 (231)	5 620 (970)	949
Copper	0.011 (0.009)	0.012 (0.012)	0.011 (0.006)	0.036 (0.017)	0.009 (0.007)	0.016
Iron	1.45 (0.85)	7.15 (7.5)	8.29 (3.2)	6.71 (2.2)	5.29 (4.95)	5.78
Lead	0.019 (0.003)	0.015 (0.015)	0.026 (0.005)	0.323 (0.014)	0.003 (0.003)	0.077
Manganese	0.18 (0.095)	0.655 (0.655)	0.35 (0.38)	0.704 (0.285)	0.478 (0.52)	0.47
Mercury	0.054 (<0.05)	<0.05 (<0.05)	0.053 (<0.05)	<0.05 (<0.05)	<0.05 (<0.05)	<0.05
Nickel	<0.01 (<0.01)	<0.01 (<0.01)	<0.01 (<0.01)	<0.01 (<0.01)	<0.01 (<0.01)	<0.01
Nitrate	1.32 (1.78)	0.07 (0.07)	0.268 (0.09)	0.452 (0.425)	<0.02 (<0.02)	0.426
Nitrite	0.029 (0.008)	0.018 (0.018)	0.016 (0.010)	0.014 (0.011)	<0.005 (<0.005)	0.016
Nitrogen (Kjeldahl)	1.26 (0.765)	0.805 (0.805)	1.41 (1)	1.70 (1.5)	3.02 (1)	1.64
" (Organic)	0.976 (0.62)	0.6 (0.6)	1.05 (0.67)	0.67 (0.595)	4.3 (4.3)	1.52
" (Total)	2.41 (2.21)	1.07 (1.07)	1.60 (1.10)	2.14 (2.16)	5.39 (1.55)	2.52
Non Filt. Res.	27.6 (8)	18 (18)	21 (18)	39.1 (24)	43.6 (39)	29.90
Oil and Grease	2.78 (1.6)	4.4 (4.4)	4.15 (2.65)	4.31 (2.7)	3.28 (3.3)	3.78
pH	7.38 (7.35)	6.95 (6.95)	6.86 (6.85)	7.07 (6.95)	7.5 (7.6)	7.15
Phenol	0.003 (<0.002)	0.009 (0.009)	0.01 (0.005)	0.014 (0.002)	0.013 (<0.002)	0.01
Phosphorus (T)	0.196 (0.070)	0.102 (0.102)	147 (0.1)	0.303 (0.156)	0.306 (0.191)	0.21
Total Res. (105C)	1 950 (148)	176 (176)	256 (213)	752 (259)	1 630 (376)	953
Zinc	0.021 (0.007)	0.040 (0.040)	0.056 (0.065)	0.185 (0.05)	0.009 (0.005)	0.062

(Values in mg/L; Mercury in μg/L).

TABLE 2.4

MEAN OVERALL DRY WEATHER
STORM SEWER DISCHARGE

Storm Sewer Type	Number	Mean Flow (m^3/s)	Total Discharge (m^3/day)
Non-Tidal Sewers	86	0.015	112 000
Tidal Sewers	54	0.015	35 000
Tidal Ditches	40	0.121	209 000
Total	180	0.039	356 000

TABLE 2.5

APPROXIMATE DISTRIBUTION OF DRY WEATHER STORM WATER
VOLUMES TO THE FRASER RIVER AND ESTUARY

Region	Approximate Volume (m^3/day)	Percent of Total (%)
North Arm	108 000	30%
South Arm	117 000	33%
Main Stem	88 000	25%
Boundary Bay, Roberts Bank and Sturgeon Bank	43 000	12%
Total	356 000	100%

TABLE 2.6

ESTIMATED POLLUTANT CONCENTRATIONS IN DRY WEATHER STORM SEWER OUTFALLS DURING JULY, AUGUST, SEPTEMBER AND OCTOBER 1978

Parameter	Mean Dry-Weather Storm Sewer Concentration at Mean Flow		Loading in kg/Day
Aluminum	0.538	mg/L	192
Arsenic	<0.006	"	<2.1
Carbon (Inorganic)	30.10	"	10 706
Carbon (Organic)	15.50	"	5 518
Chromium	0.007	"	<2.5
Coliform (Fecal)	1 060 x 10	MPN/100 mL	*2.6×10^{12}
Copper	0.016	mg/L	5.7
Copper (Total)	0.016	"	5.7
Iron (Total)	5.78	"	2 058
Lead (Total)	0.077	"	27.4
Manganese (Total)	0.47	"	167
Mercury	<0.05	µg/L	<0.1
Nickel (Total)	<0.01	mg/L	<3.6
Oil and Grease	3.78	"	1 350
Nitrogen (Kjeldahl)	1.64	"	584
Nitrogen (NH_3^-)	2.02	"	719
Nitrogen (NO_2^-)	0.016	"	5.7
Nitrogen (NO_2^- + NO_3^-)	0.442	"	157
Nitrogen (NO_3^-)	0.426	"	152
Nitrogen (Organic)	1.52	"	541
Nitrogen (Total)	2.52	"	897
Non Filterable Res.	29.90	"	10 600
pH	7.51	"	
Phenolics	0.01	"	3.6
Phosphate	0.01	"	3.6
Phosphorus (Total)	0.21	"	75
Total Residue	953	"	339 000
Zinc (Total)	0.061	"	22

* Coliforms are in organisms/day.

APPENDIX 3

Graphs and Data Tables for the Coliform Survey

FIGURE 6

SUMMARY OF DRY WEATHER FECAL COLIFORM DATA FOR SOME TYPICAL RESIDENTIAL, AGRICULTURAL, INDUSTRIAL, LANDFILL, AND COMMERCIAL STORM SEWERS IN THE FRASER RIVER ESTUARY

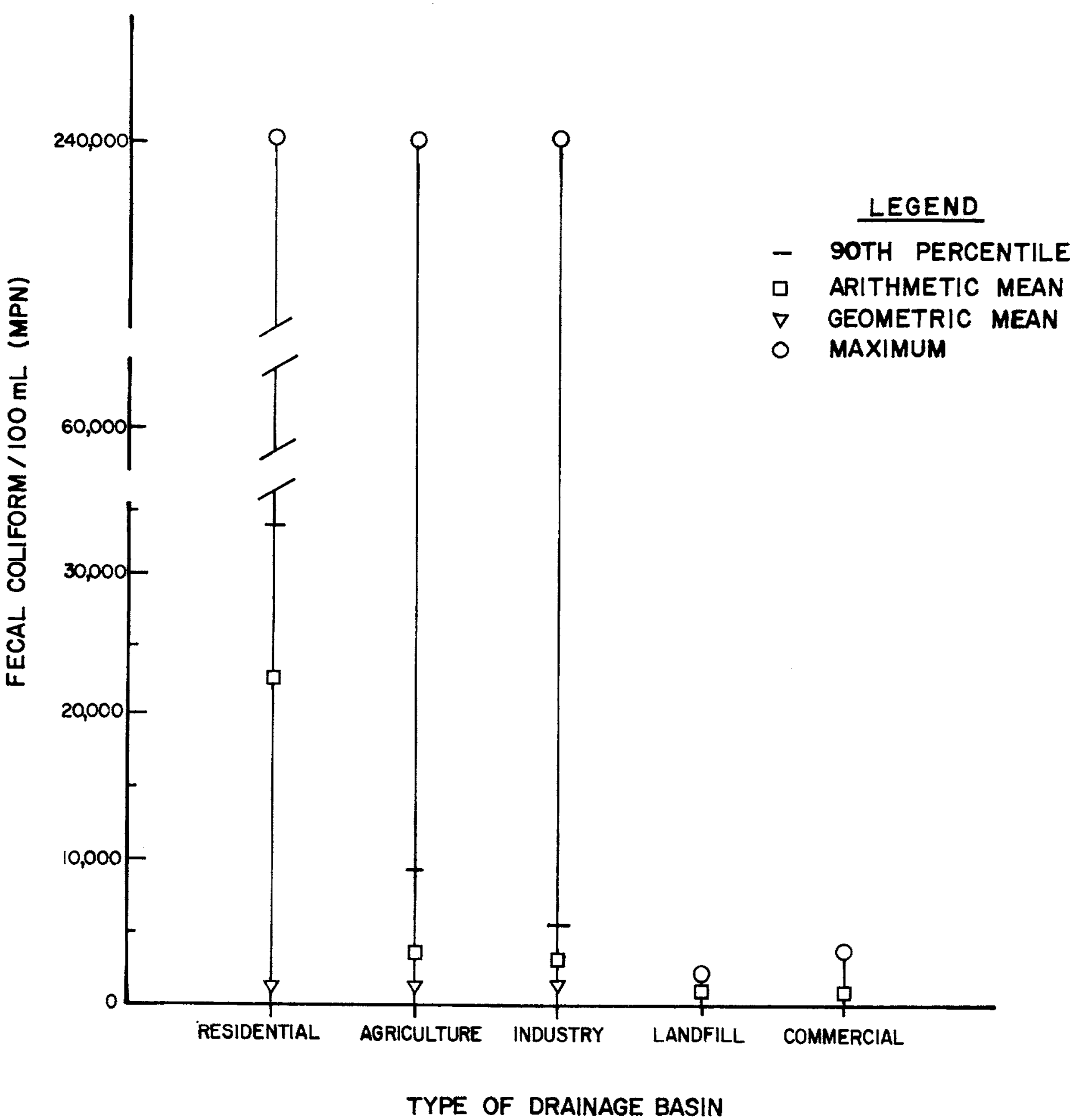


FIGURE 7

Children playing near stormwater discharge.

TABLE 3.1

FECAL COLIFORM DATA FOR RESIDENTIAL SITES

(MPN/100 mL)

Site	Name	Date	Value
XE03126-01	Vivian/57th Discharge A	78-09-05	>24 000
		78-09-20	>240 000
		78-10-03	79 000
		78-10-04	33 000
XE03126-02	Vivian/57th Discharge B	78-09-05	700
		78-09-20	7 900
		78-10-03	11 000
		78-10-04	>240 000
XE03159-01	Steveston Highway West	-	790
		-	<20
XE03160-01	Williams Road Discharge	78-09-11	3 500
		78-09-18	230
		78-09-25	490
XE03161-01	Francis Rd. Storm Discharge	78-09-11	1 100
		78-09-18	1 100
		78-09-25	230
XE03164-01	No. 2 Road North Discharge	78-09-11	5 400
		78-09-18	1 700
XE03198-01	Renfrew Park Discharge	-	92 000
		-	>24 000
		-	13 000
		-	900
XE03207-01	Willingdon St. Discharge B	79-09-05	490
		78-09-20	170
		78-10-03	50
XE03224-01	Buckingham Street Discharge	78-09-12	130
		78-09-19	490
		78-09-19	490
		78-10-04	<20
		78-10-04	110
XE03225-01	Deer Lake/Southeast Drain	78-09-12	80
		78-09-19	<20
		-	110
XE03231-01	Hume Park North Bank	78-09-12	230
		78-09-19	80
XE03237-01	Hawthorne Street Discharge	78-09-12	<20
		78-09-18	<20
XE03273-01	Point Grey Golf Course-01	78-10-03	230

TABLE 3.2

FECAL COLIFORM DATA FOR AGRICULTURAL SITES

(MPN/100 mL)

Site	Name	Date	Value
XE03104-01	Carrington Street Discharge	78-09-05	1 700
		78-09-20	1 100
XE03107-01	Yew Street Storm Discharge	78-09-05	9 200
		78-09-20	1 300
XE03147-01	Colony Farm Ditch	78-09-12	9 200
		78-20-04	>24 000
		-	490
XE03152-01	George Massey Tunnel	78-09-11	2 400
		78-09-18	3 500
XE03154-01	Finn Road Ditch	78-09-18	170
XE03162-01	No. 1 Road North Richmond-01	78-09-11	230
		78-09-18	270
		79-09-25	330
XE03180-01	68th Street River Road Delta	78-09-07	1 300
		78-09-14	3 500
		78-09-25	2 400
XE03183-01	Crescent Slough Discharge	78-09-07	5 400
		78-09-14	>24 000
XE03190-01	Morris Road Storm Discharge	78-09-07	3 500
		78-09-14	3 500
XE03192-01	C.B. Main Road South	78-09-07	60
		78-09-14	<20
XE03193-01	Indian Reserve Drainage	78-09-07	790
		78-09-14	170
		78-09-25	60
XE03194-01	Trim Road Discharge Westham	78-09-07	790
		78-09-14	130

TABLE 3.3

FECAL COLIFORM DATA FOR INDUSTRIAL SITES

(MPN/100 mL)

Site	Name	Date	Value
XE03122-01	Kerr Street Storm Discharge	78-09-05	790
		78-09-20	490
XE03144-01	Fraser Mills Discharge	78-09-12	250
		78-09-17	2 200
XE03158-01	No. 1 Road South Ditch, Richmond	78-09-11	1 700
		78-09-18	3 500
		78-09-25	1 300
XE03163-01	McCallan Road Discharge, Richmond	78-09-11	110
		78-09-18	50
XE03168-01	No. 4 Road North Discharge	78-09-11	9 200
		78-09-18	3 500
XE03169-01	Shell Road North Discharge	78-07-18	5 400
		78-09-11	790
XE03170-01	No. 5 Road Discharge, Richmond	78-09-11	2 400
		78-09-18	790
		78-09-25	5 400
XE03201-01	Grandview Highway, Number 4	78-09-18	790
XE03203-01	Skeena Street Storm Discharge A	78-09-05	>24 000
		78-09-20	7 000
		78-10-03	4 900
		78-10-04	11 000
XE03207-01	Willingdon Street Discharge B	78-09-05	490
		78-09-20	170
		78-10-03	50
XE03213-01	Holdom Street Discharge	78-09-20	330
		78-10-03	220
		78-10-04	220
XE03216-01	Warren Loat Park Discharge	78-09-05	490
		78-09-20	40
		78-10-03	80
XE03220-01	South Burnaby Lake	78-07-21	490

TABLE 3.4

FECAL COLIFORM DATA FOR LANDFILL SITES

(MPN/100 mL)

Site	Name	Date	Value
XE03143-01	King Edward Street Discharge	78-09-12	1 110
		78-09-19	40
XE03148-01	Nelson Road Ditch	78-09-11	1 300
		78-09-18	330
		78-09-25	330

TABLE 3.5

FECAL COLIFORM DATA FOR COMMERCIAL SITES

(MPN/100 mL)

Site	Name	Date	Value
XE03185-01	Elliot Street Discharge, Delta	78-09-07	2 400
		78-09-14	3 500
	-	-	3 800
	-	-	2 400
XE03236-01	Kingsway Street Discharge	78-09-12	170
		78-09-19	<20
		78-10-04	20

TABLE 3.6

STATISTICAL BREAKDOWN OF FECAL COLIFORM DATA

(MPN/100 mL)

Drainage Basin Type	Maximum	Arithmetic Mean	Geometric Mean	90th Percentile	10th Percentile
Residential	>240 000	20 600	880	33 000	20
Agricultural	>24 000	3 686	1 007	9 200	60
Industrial	>24 000	843	841	5 400	80
Landfill	1 300	622	363	1 110	40
Commercial	3 800	1 759	472	3 500	20

APPENDIX 4

Data Tables for the
Pesticide Survey

TABLE 4.1

PESTICIDE ANALYSES RESULTS FROM STORM DRAINS

Date Sampled	Site Description	Aroclor 1242 mg/L	Aroclor 1254 mg/L	Arclor 1260 mg/L	DDD mg/L
	Minimum Detection Limit	0.0004	0.0004	0.0004	0.0004
10/19/78	No. 2 Road North, Richmond	<0.0004	<0.0004	<0.0004	<0.0004
10/19/78	Landfill Site, Braid Street	"	"	"	"
10/19/78	No. 1 Road North, Richmond	"	"	"	"
10/19/78	Landfill Site, Brunette River	"	"	"	"
10/19/78	Fraserview Golf Course	"	"	"	"
10/19/78	Fraserview Golf Course	"	"	"	"
10/19/78	Nelson Road Landfill, Richmond	"	"	"	"
10/19/78	Nelson Road Landfill, Richmond	"	"	"	"
11/10/78	Later Chemical, Sea Island	"	"	"	0.440
11/10/78	Later Chemical, Sea Island	"	"	"	0.380
Maximum Limit for the Protection of Freshwater and Aquatic Life.					0.025 µg/L

TABLE 4.1 (CONTINUED)

PESTICIDE ANALYSES RESULTS
FROM STORM DRAINS

DDE mg/L	DDT (P-P) mg/L	Chlordane mg/L	Methoxy-chlor mg/L	Lindane mg/L	Aldrin mg/L
0.0004	0.0004	0.0004	0.005	0.0004	0.0004
<0.0004	<0.0004	<0.0004	<0.005	<0.0004	<0.0004
"	"	"	"	"	"
"	"	"	"	"	"
"	"	"	"	"	"
"	"	"	"	"	"
"	"	"	"	"	"
"	"	"	"	"	"
"	"	"	"	"	"
0.080	0.060	3.60	0.280	0.350	"
0.140	0.050	3.20	0.340	0.390	"
1.5 µg/L	0.001 µg/L	0.004 µg/L	0.03 µg/L	0.004 µg/L	0.003 µg/L

TABLE 4.1 (CONTINUED)

PESTICIDE ANALYSES RESULTS
FROM STORM DRAINS

Penta Chloro Phenol	Tetra Chloro Phenol	Benzene Hexachlor mg/L	DDT O-P mg/L	Hepta-chlor mg/L	PCB 1242 mg/L	PCB 1254 mg/L	PCB 1260 mg/L
0.0001	0.0001	0.0004	0.0001	0.0001	0.0004	0.0004	0.0004
<0.0001	<0.0001	<0.0004	<0.0001	<0.0001	<0.0004	<0.0004	<0.0004
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"
<21 μg/L	—	0.028 μg/L	0.001 μg/L	0.008 μg/L	—	—	—

APPENDIX 5

Graphs and Data Tables for the Acidity/Alkalinity Survey

FIGURE 8

TITRATION OF 100 mL SAMPLES OF FRASER RIVER WATER AT ANNACIS I. (0920003), POPLAR I. AND BARNSTON I., WITH 0.052 N. H_2SO_4

1978-12-05

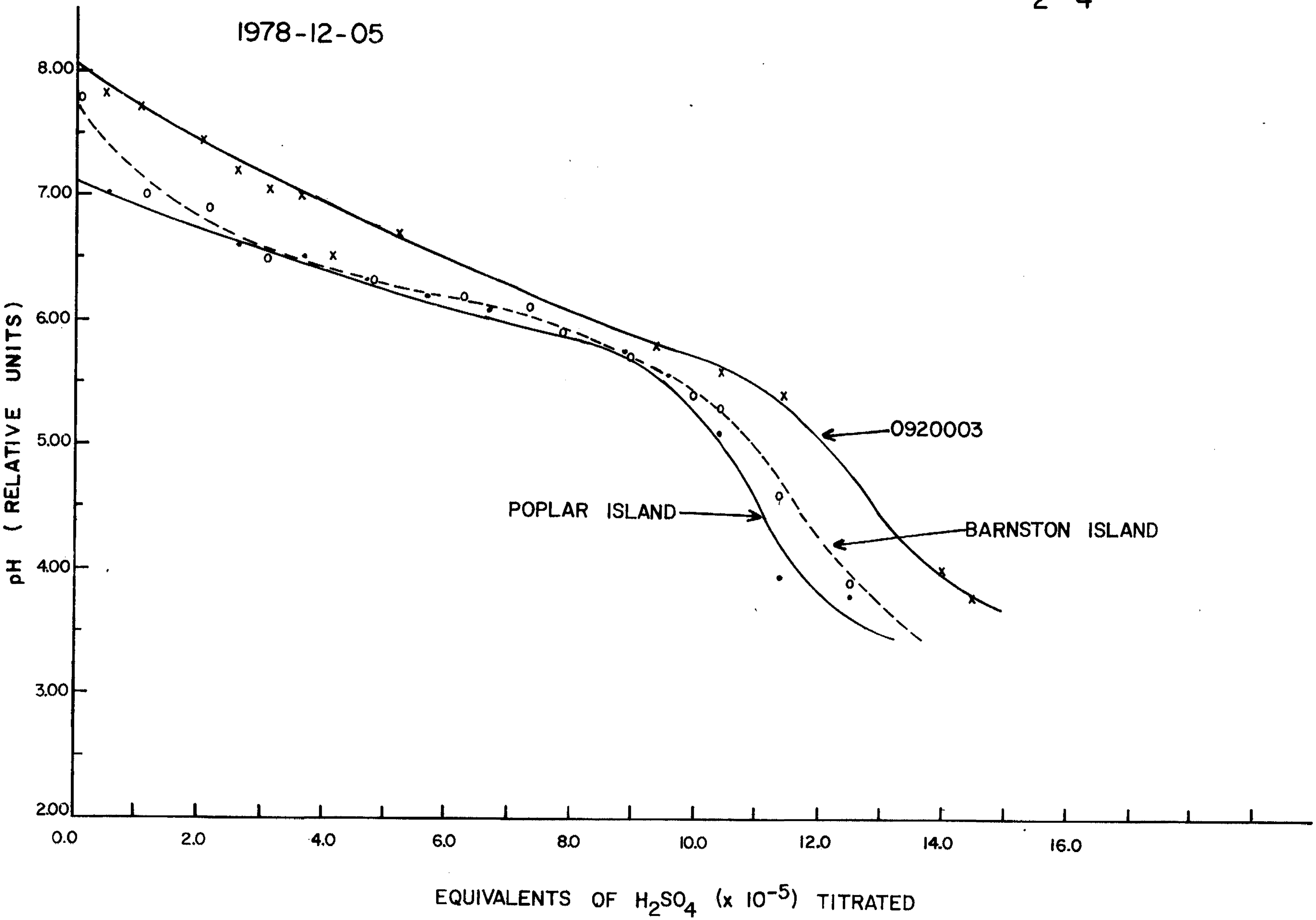


FIGURE 9

TITRATION OF 100 mL SAMPLES OF FRASER RIVER WATER AT PATTULLO BRIDGE, WITH 0.35 N H_2SO_4 1978-11-16

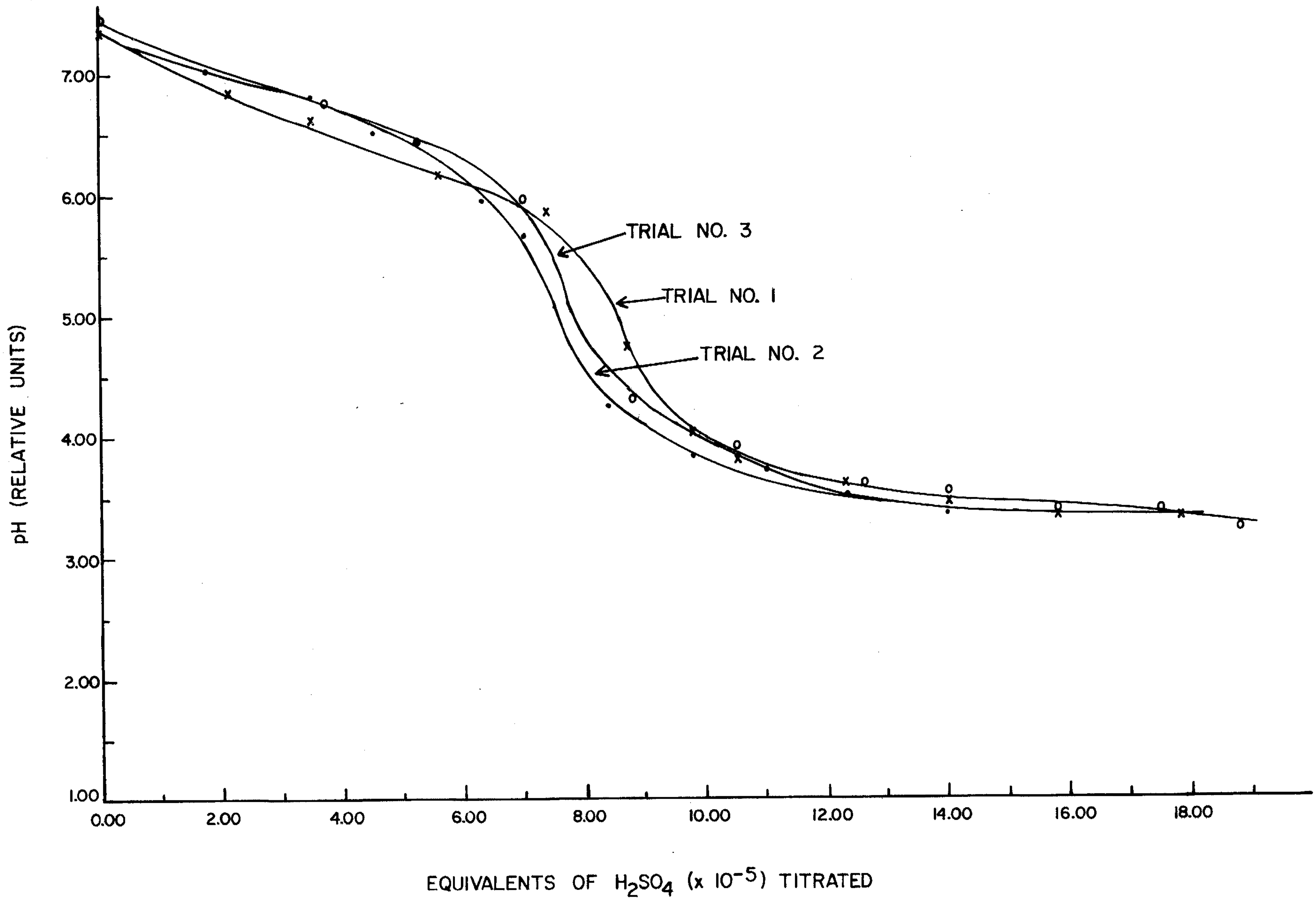


FIGURE 10

TITRATION OF 100 mL SAMPLES OF FRASER RIVER WATER AT OAK ST. BRIDGE SITES 0300118, 0300002 AND 0300119, WITH 0.22 N H_2SO_4

1978-11-28

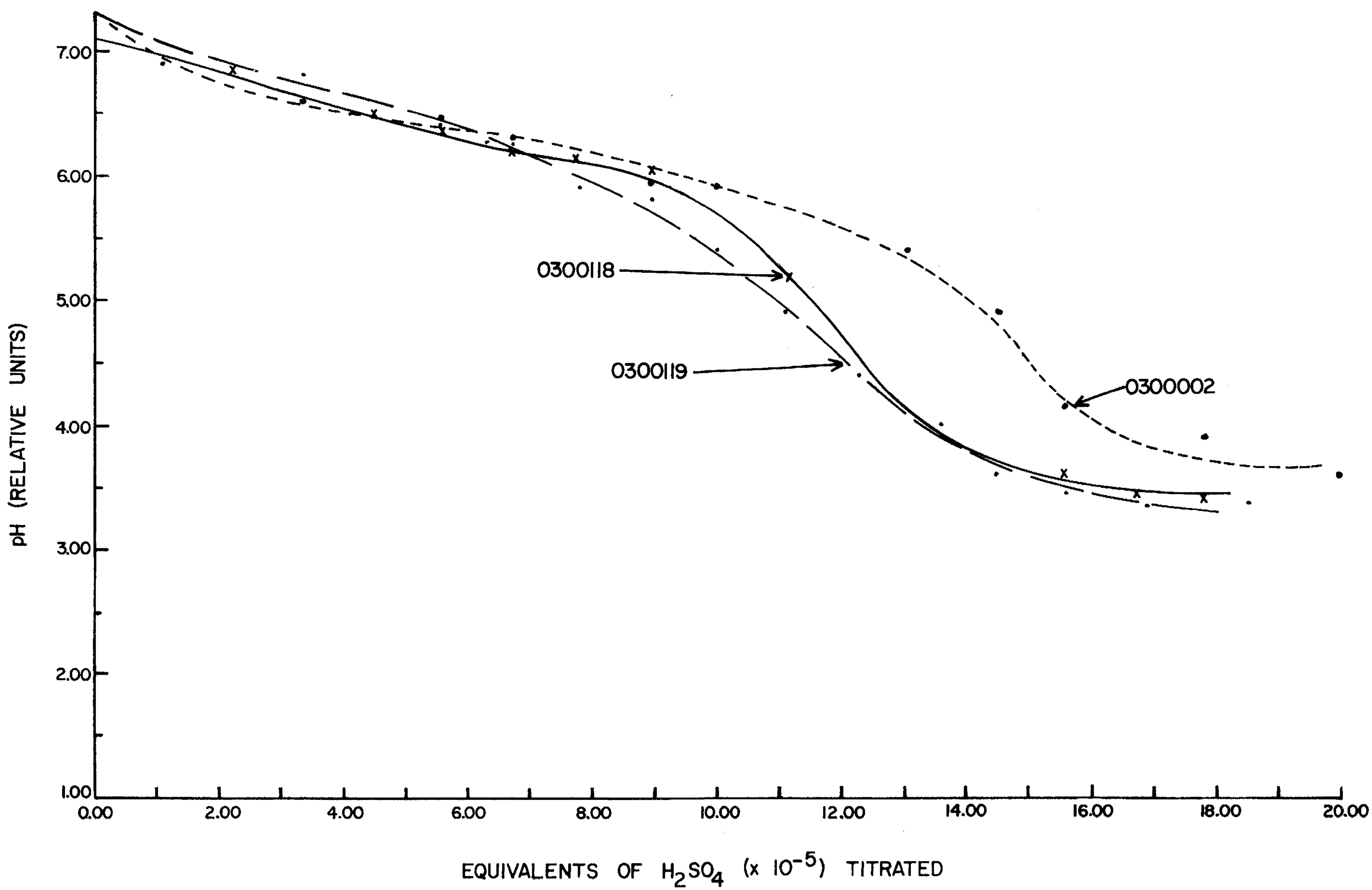


FIGURE 11

TITRATION OF 100 mL SAMPLES OF FRASER RIVER WATER AND STORM WATER RUNOFF WITH 0.162 N H_2SO_4

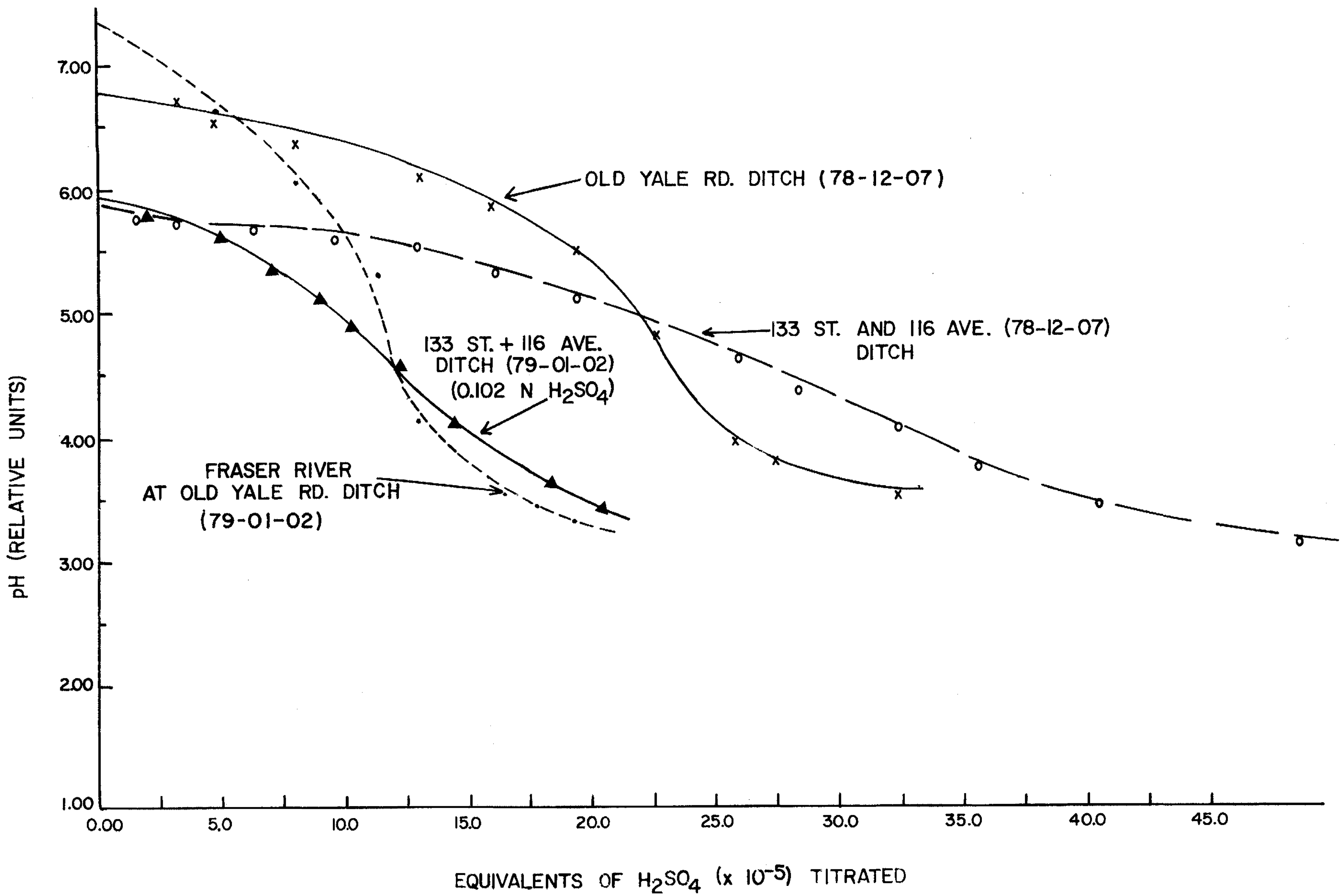


FIGURE 12

TITRATION OF FRASER RIVER WATER WITH STORM WATER RUNOFF

FROM 133 ST. AND 116 AVE., 126-A ST.

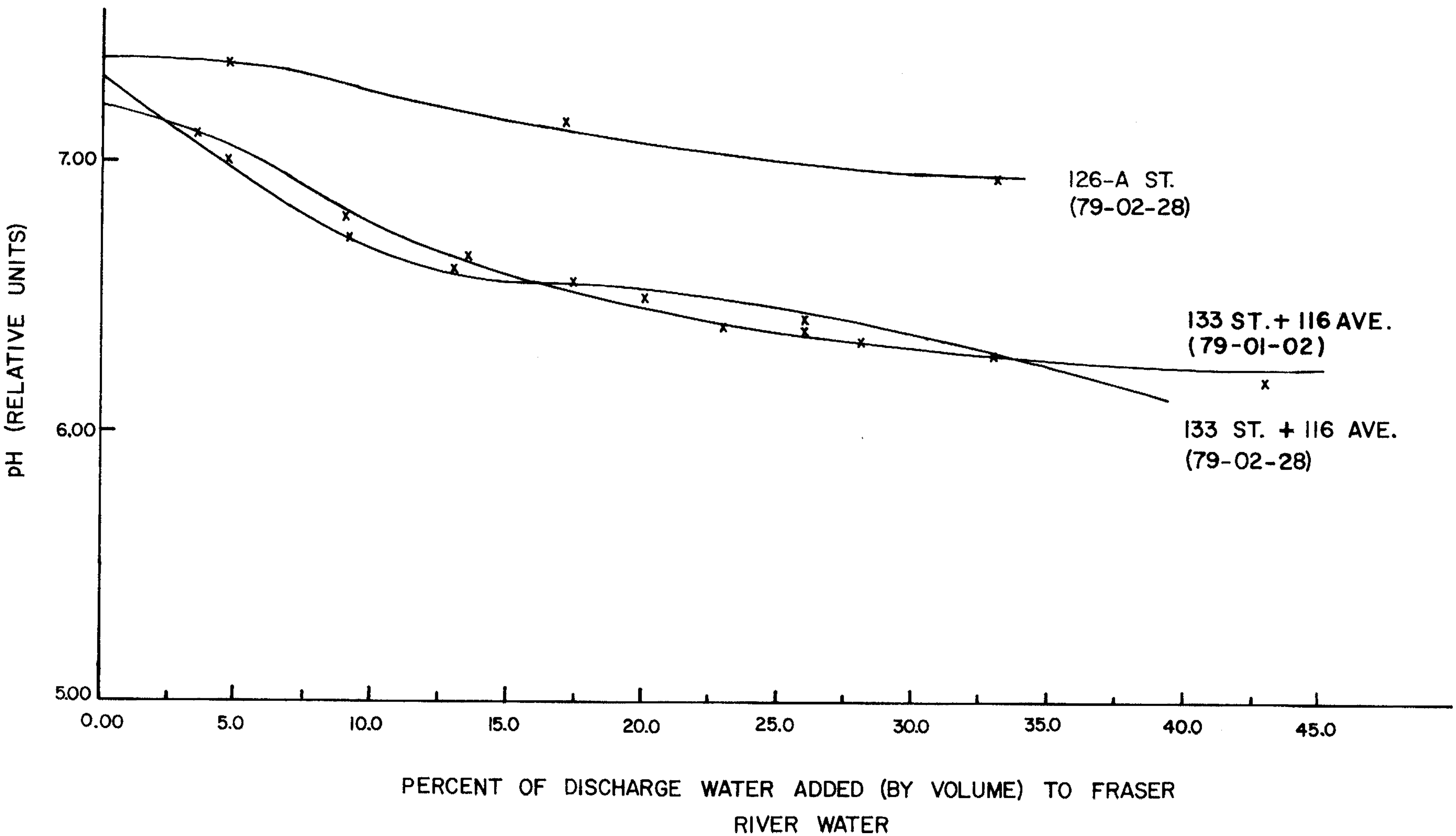


FIGURE 13

TITRATION OF 100 mLs OF FRASER RIVER WATER WITH NaOH

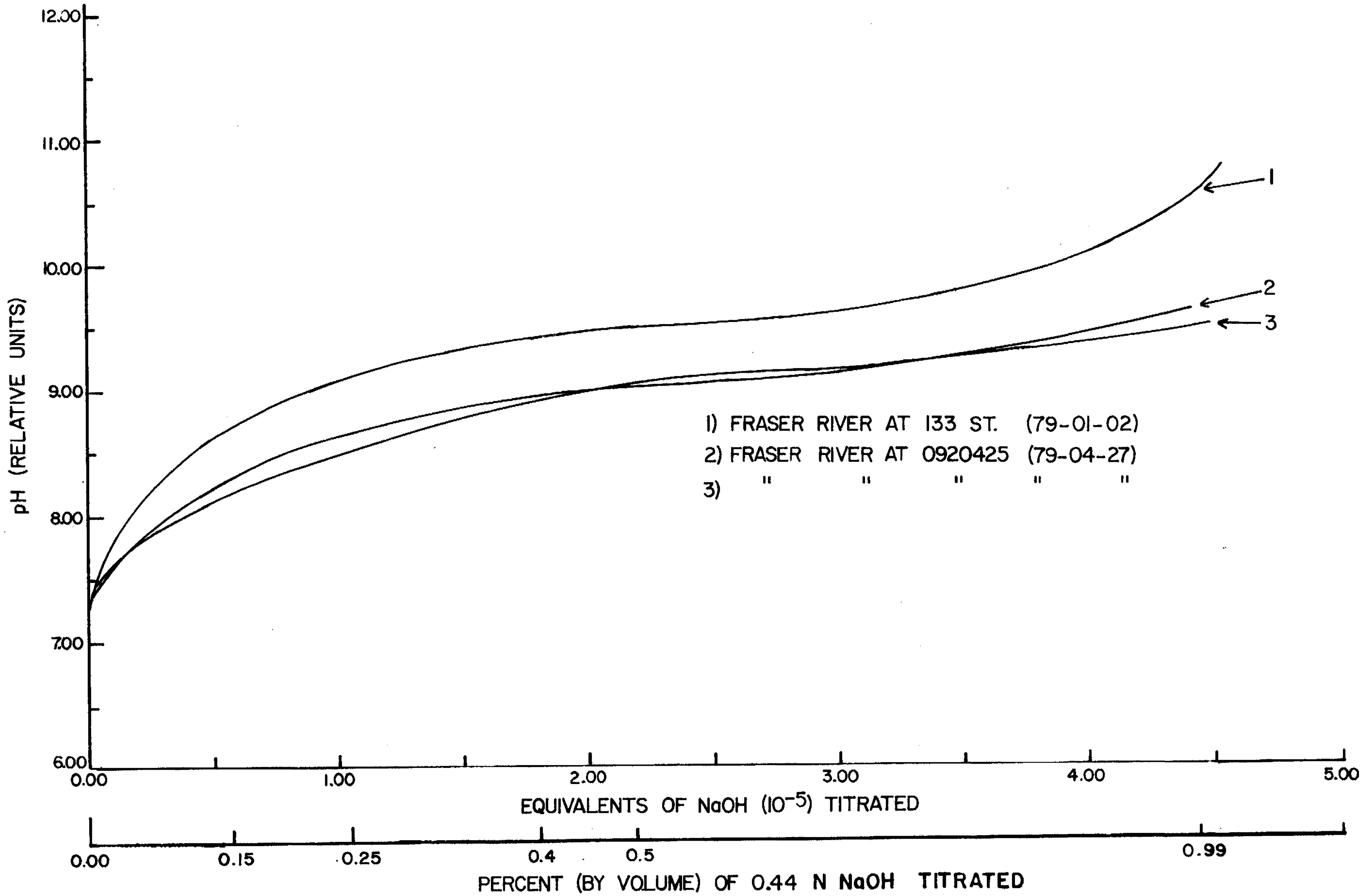


FIGURE 14

TITRATION OF 100 mLs OF FRASER RIVER WATER WITH STORM WATER (pH 12.4) FROM SITE NO. XE03148-03 1979-02-28, 79-04-18

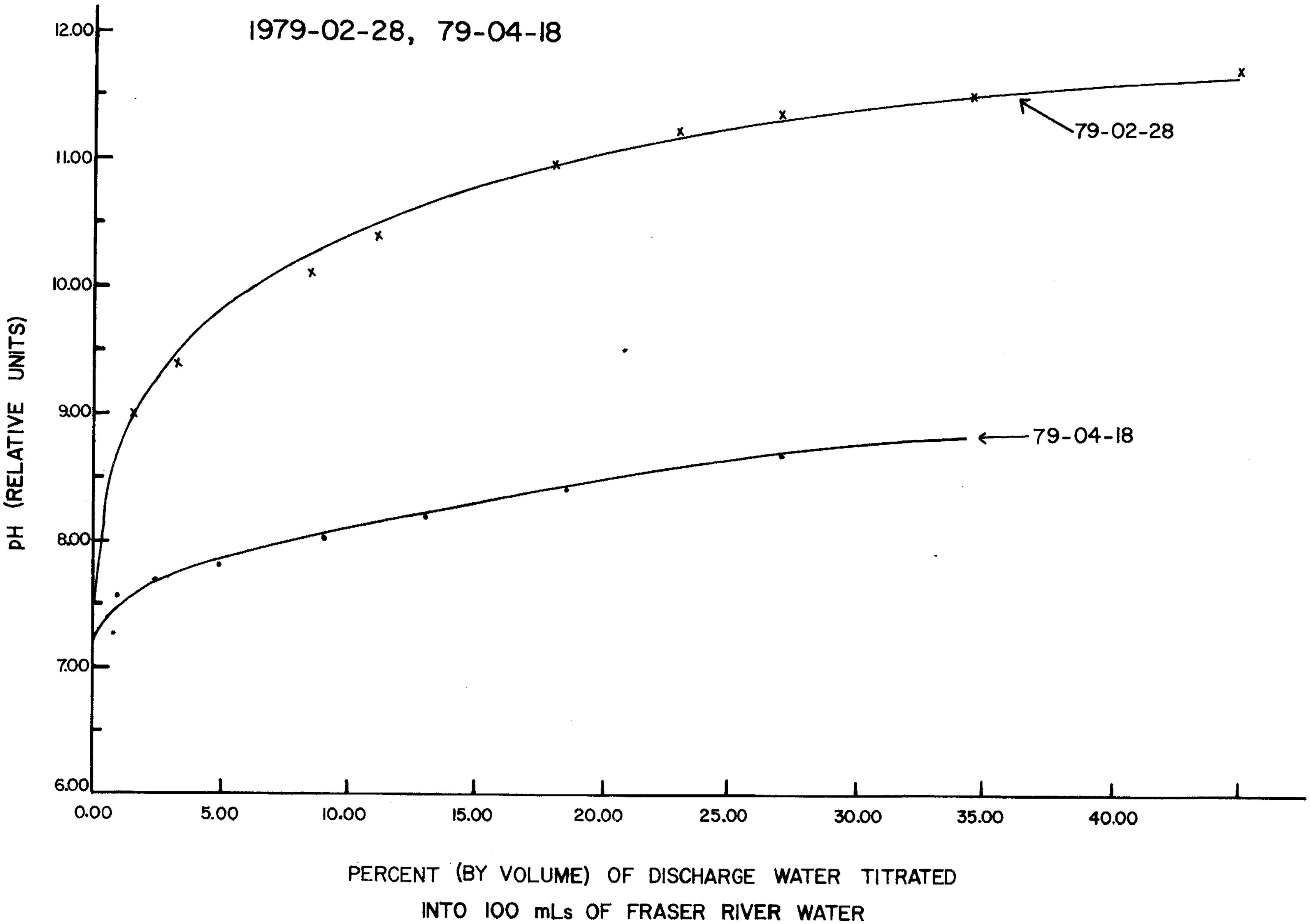


FIGURE 15

TITRATION OF 100 mL SAMPLES OF FRASER RIVER WATER AND DRAINAGE DITCH EFFLUENTS WITH STANDARDIZED H_2SO_4 AND NaOH

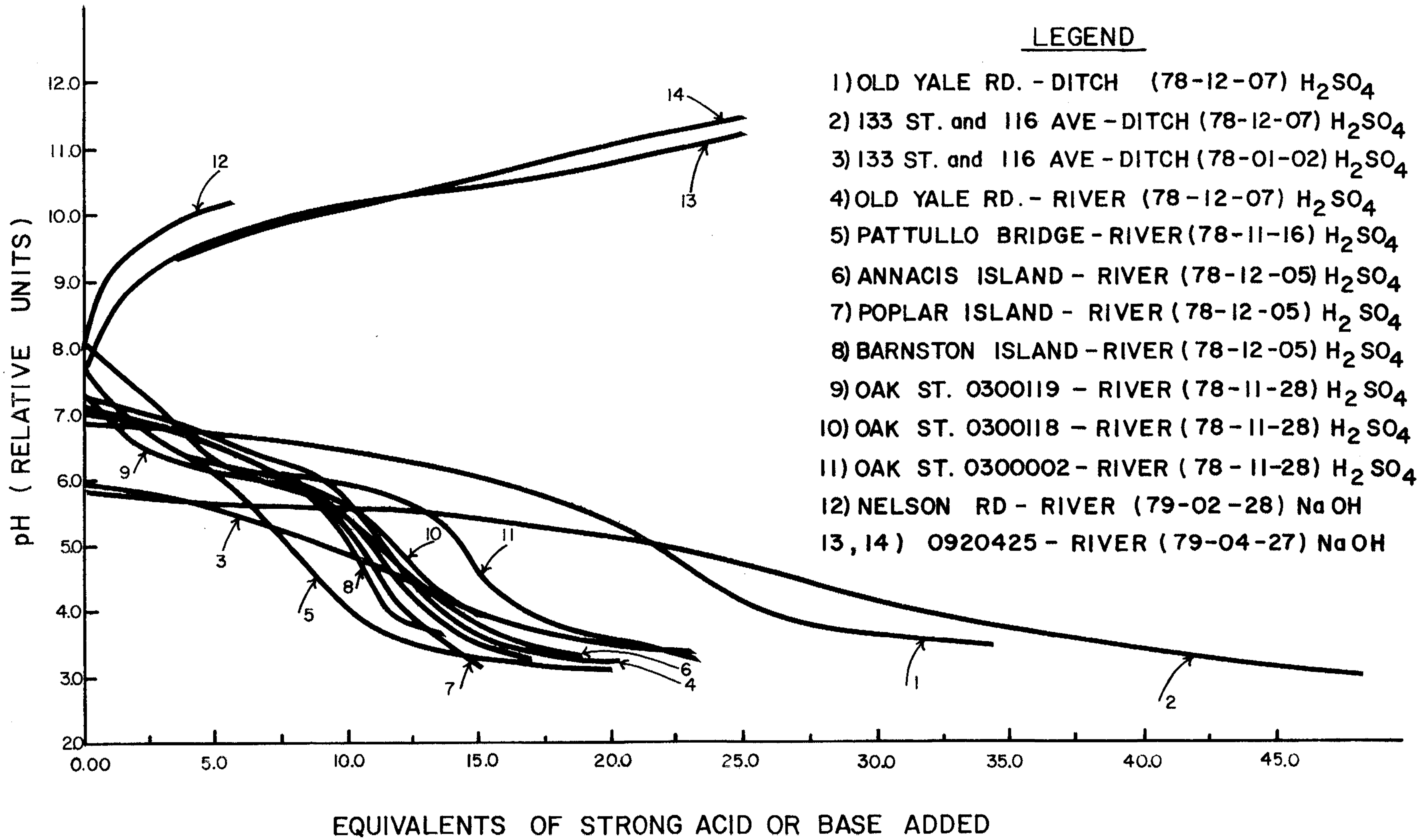


FIGURE 16

THEORETICAL GRAPH FOR THE TITRATION OF DISTILLED WATER WITH NaOH, NH_4OH, CH_3COOH, AND H_2SO_4

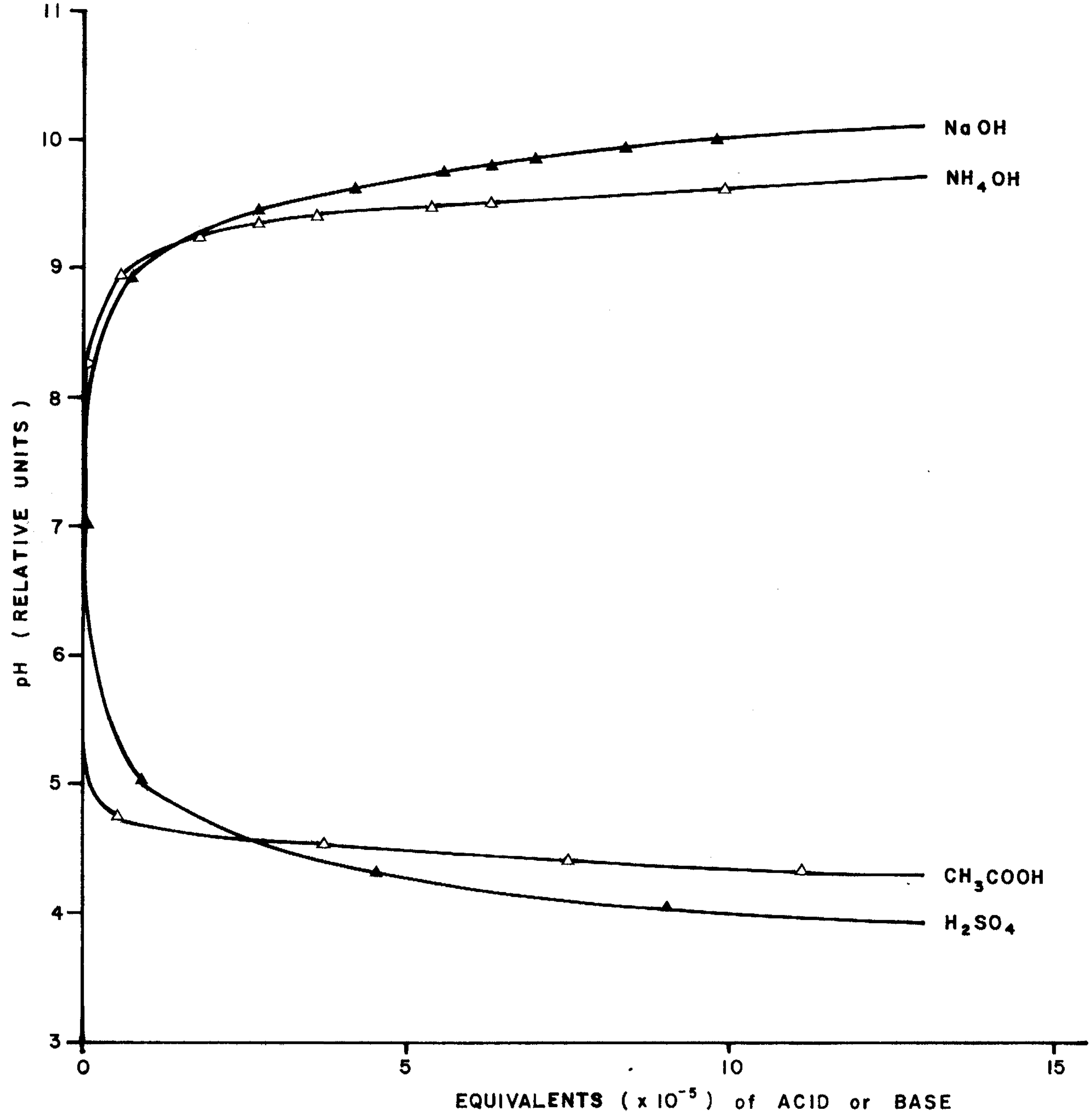


TABLE 5.1

FIELD MEASURED PARAMETERS* FOR FRASER SITE NO. 0920443

FRASER RIVER, INSIDE TRAINING WALL OPPOSITE NEW WESTMINSTER

1000 HRS. APRIL 5, 1978

Depth Meters	Temperature °C	pH	Dissolved Oxygen mg/L
0.00	5.6	5.8	12.8
1.00	5.6	5.88	13.0
2.00	5.6	5.90	13.0
3.00	5.6	5.92	13.0
4.00	5.6	5.98	13.1
5.00	5.6	6.00	13.1
6.00	5.6	6.00	13.0
6.00	5.5	6.00	13.0

* By M.J.R. Clark, Ph.D., using a Hydrolab Surveyor (Model 6D).

Additional data published elsewhere(3).

TABLE 5.2

TITRATION OF 100 ML SAMPLES OF FRASER RIVER WATER AT ANNACIS ISLAND (0920003), POPLAR ISLAND AND BARNSTON ISLAND WITH 0.052 N H_2SO_4

1978-12-05

0920003			* #2 D/S Poplar			* #3 D/S Barnston		
Vol. of H_2SO_4	pH	Equivs. of H_2SO_4	Vol. of H_2SO_4	pH	Equivs. of H_2SO_4	Vols. of H_2SO_4	pH	Equivs. of H_2SO_4
0.0	8.05	0.00	0.0	7.15	0.0	0.0	7.8	0.00
0.1	7.85	5.2×10^{-6}	0.1	7.00	5.20×10^{-6}	0.2	7.0	1.04×10^{-5}
0.2	7.70	1.04×10^{-5}	0.2	6.65	1.04×10^{-5}	0.4	6.9	2.08×10^{-5}
0.4	7.45	2.08×10^{-5}	0.3	6.55	1.56×10^{-5}	0.6	6.5	3.12×10^{-5}
0.5	7.20	2.60×10^{-5}	0.5	6.60	2.60×10^{-5}	0.9	6.3	4.68×10^{-5}
0.6	7.05	3.12×10^{-5}	0.7	6.50	3.64×10^{-5}	1.2	6.2	6.24×10^{-5}
0.7	7.00	3.64×10^{-5}	0.9	6.30	4.68×10^{-5}	1.4	6.1	7.28×10^{-5}
0.8	6.50	4.16×10^{-5}	1.1	6.20	5.72×10^{-5}	1.5	5.9	7.80×10^{-5}
0.9	6.75	4.68×10^{-5}	1.3	6.05	6.76×10^{-5}	1.7	5.7	8.85×10^{-5}
1.0	6.70	5.20×10^{-5}	1.5	5.90	7.81×10^{-5}	1.9	5.35	9.87×10^{-5}
1.8	5.80	9.36×10^{-5}	1.7	5.75	8.85×10^{-5}	2.0	5.30	1.04×10^{-4}
2.0	5.60	1.04×10^{-4}	1.8	5.55	9.37×10^{-5}	2.2	4.50	1.14×10^{-4}
2.2	5.40	1.14×10^{-4}	2.0	5.10	1.04×10^{-4}	2.4	3.90	1.25×10^{-4}
2.5	4.40	1.30×10^{-4}	2.2	3.95	1.14×10^{-4}			
2.7	4.00	1.40×10^{-4}	2.4	3.80	1.25×10^{-5}			
2.8	3.80	1.45×10^{-4}						

* D/S = Down Stream from

TABLE 5.3

TITRATION CURVE FOR FRASER RIVER WATER AT PATTULLO BRIDGE

NEW WESTMINSTER, 78-11-16

($0.35\ N\ H_2SO_4$)

mL of 0.35 N H_2SO_4	Equivs. of H_2SO_4	% H_2SO_4 By Volume	pH of River Water
TRIAL #1			
0.00	0.00	0.00	7.35
0.06	2.1×10^{-5}	0.06	6.85
0.10	3.5×10^{-5}	0.10	6.60
0.16	5.6×10^{-5}	0.16	6.15
0.21	2.35×10^{-5}	0.21	5.85
0.25	8.75×10^{-5}	0.25	4.70
0.28	9.80×10^{-5}	0.28	4.05
0.30	1.05×10^{-5}	0.30	3.80
0.35	1.23×10^{-4}	0.35	3.60
0.40	1.40×10^{-4}	0.40	3.45
0.45	1.58×10^{-4}	0.45	3.35
0.51	1.79×10^{-4}	0.39	3.25
TRIAL #2			
0.00	0.00	0.00	7.35
0.11	3.85×10^{-5}	0.11	6.70
0.15	5.25×10^{-5}	0.15	6.40
0.20	7.00×10^{-5}	0.20	5.95
0.25	8.75×10^{-5}	0.25	4.30
0.30	1.05×10^{-4}	0.30	3.90
0.36	1.26×10^{-4}	0.36	3.60
0.40	1.40×10^{-4}	0.40	3.55
0.45	1.58×10^{-4}	0.45	3.40
0.50	1.75×10^{-4}	0.50	3.35
0.55	1.93×10^{-4}	0.55	3.25
0.61	2.14×10^{-4}	0.61	3.15
TRIAL #3			
0.00	0.00	0.00	7.45
0.05	1.75×10^{-5}	0.05	7.05
0.10	3.50×10^{-5}	0.10	6.85
0.13	4.55×10^{-5}	0.13	6.50
0.15	5.25×10^{-5}	0.15	6.45
0.18	6.30×10^{-5}	0.18	5.95
0.20	7.00×10^{-5}	0.20	5.65
0.24	8.4×10^{-5}	0.24	4.25
0.28	9.8×10^{-5}	0.28	3.85
0.30	1.1×10^{-4}	0.30	3.70
0.35	1.23×10^{-4}	0.35	3.50
0.40	1.40×10^{-4}	0.40	3.35

TABLE 5.4

TITRATION OF FRASER RIVER WATER AT THE OAK STREET BRIDGE, SITE NOS. 0300119, 0300118 AND 0300002 WITH 0.22 N H_2SO_4

1978-11-28

0300119			0300118			0300002		
Vol. of H_2SO_4	pH	Equivs. of H_2SO_4	Vol. of H_2SO_4	pH	Equivs. of H_2SO_4	Vol. of H_2SO_4	pH	Equivs. of H_2SO_4
0.00	7.30	0.00	0.00	7.10	0.00	0.00	7.30	0.00
0.10	6.90	2.23×10^{-5}	0.10	6.85	2.23×10^{-5}	0.05	6.90	1.12×10^{-5}
0.15	6.80	3.35×10^{-5}	0.20	6.50	4.46×10^{-5}	0.15	6.60	3.35×10^{-5}
0.20	6.60	4.46×10^{-5}	0.25	6.45	5.58×10^{-5}	0.25	6.40	5.58×10^{-5}
0.25	6.45	5.56×10^{-5}	0.30	6.35	6.69×10^{-5}	0.30	6.30	6.69×10^{-5}
0.28	6.25	6.24×10^{-5}	0.35	6.25	7.80×10^{-5}	0.40	5.95	8.92×10^{-5}
0.30	6.25	6.69×10^{-5}	0.40	6.05	8.92×10^{-5}	0.45	5.90	1.00×10^{-4}
0.35	5.90	7.81×10^{-5}	0.50	5.20	1.12×10^{-4}	0.60	5.40	1.34×10^{-4}
0.40	5.80	8.92×10^{-5}	0.55	4.30	1.26×10^{-4}	0.65	4.90	1.45×10^{-4}
0.45	5.40	1.00×10^{-4}	0.60	3.95	1.34×10^{-4}	0.70	4.15	1.56×10^{-4}
0.50	4.90	1.12×10^{-4}	0.70	3.60	1.56×10^{-4}	0.80	3.90	1.78×10^{-4}
0.55	4.40	1.23×10^{-4}	0.75	3.45	1.67×10^{-4}	0.90	3.60	2.01×10^{-4}
0.60	4.00	1.34×10^{-4}	0.80	3.40	1.78×10^{-4}	0.95	3.50	2.12×10^{-4}
0.65	3.60	1.45×10^{-4}				1.00	3.30	2.23×10^{-4}
0.70	3.45	1.56×10^{-4}						
0.75	3.35	1.67×10^{-4}						

Acid = 0.22 N = 2.23×10^{-4} eq/mL

TABLE 5.5

TITRATION OF 100 ML SAMPLES FROM OLD YALE ROAD DITCH, 133rd ST. + 116 AVE., AND FRASER RIVER AT OLD YALE RD. WITH 0.162 N H_2SO_4

78-12-07 Old Yale Road		
Vol. of 0.162 N H_2SO_4	pH	Equivs. of H_2SO_4
0.00	6.86	0.00
0.20	6.75	3.24×10^{-5}
0.30	6.55	4.86×10^{-5}
0.50	6.38	8.10×10^{-5}
0.80	6.10	1.30×10^{-4}
1.00	5.87	1.62×10^{-4}
1.20	5.50	1.94×10^{-4}
1.40	4.80	2.27×10^{-4}
1.50	4.20	2.43×10^{-4}
1.60	3.95	2.59×10^{-4}
1.70	3.80	2.75×10^{-4}
2.00	3.50	3.24×10^{-4}

79-01-02 Fraser River at Old Yale Rd.		
Vol. of 0.162 N H_2SO_4	pH	Equivs. of H_2SO_4
0.00	7.30	0.00
0.30	6.57	4.86×10^{-5}
0.50	6.05	8.10×10^{-5}
0.70	5.30	1.13×10^{-4}
0.80	4.12	1.30×10^{-4}
0.90	3.85	1.46×10^{-4}
1.00	3.55	1.62×10^{-4}
1.10	3.40	1.78×10^{-4}
1.20	3.30	1.94×10^{-4}

78-12-07 133rd St. + 116 Ave.		
Vol. of 0.162 N H_2SO_4	pH	Equivs. of H_2SO_4
0.00	5.90	0.00
0.10	5.80	1.62×10^{-5}
0.20	5.75	3.24×10^{-5}
0.40	5.70	6.48×10^{-5}
0.60	5.60	9.72×10^{-5}
0.80	5.47	1.30×10^{-4}
1.00	5.30	1.62×10^{-4}
1.20	5.10	1.94×10^{-4}
1.60	4.65	2.59×10^{-4}
1.80	4.38	2.75×10^{-4}
2.00	4.05	3.24×10^{-4}
2.20	3.75	3.56×10^{-4}
2.50	3.40	4.05×10^{-4}
3.00	3.10	4.86×10^{-4}

79-01-02 133rd St. + 116 Ave.		
Vol. of 0.102 N H_2SO_4	pH	Equivs. of H_2SO_4
0.00	5.95	0.00
0.20	5.80	2.04×10^{-5}
0.50	5.60	5.09×10^{-5}
0.70	5.35	7.1×10^{-5}
0.90	5.10	9.1×10^{-5}
1.00	4.85	10.2×10^{-5}
1.20	4.55	12.2×10^{-5}
1.40	4.10	14.3×10^{-5}
1.80	3.60	18.3×10^{-5}
2.02	3.40	20.4×10^{-5}

TABLE 5.6

EQUIVALENTS OF H_2SO_4 REQUIRED TO LOWER
100 mL OF FRASER RIVER WATER
1 pH UNIT FROM IN-SITU VALUES

Sites for Fraser River Samples		Equivalents Required
1) New Westminster at Pattullo Bridge	(78-11-16)	5.35×10^{-5}
2) Surrey at Old Yale Road	(78-12-07)	7.20×10^{-5}
3) Poplar Island (0920488)	(78-12-05)	5.80×10^{-5}
4) Barnston Island (0920304)	(78-12-05)	2.40×10^{-5}
5) Annacis Island (0920003)	(78-12-05)	3.30×10^{-5}
6) Oak Street Bridge (0300118)	(78-11-28)	7.80×10^{-5}
7) Oak Street Bridge (0300002)	(78-11-28)	6.80×10^{-5}
8) Oak Street Bridge (0300119)	(78-11-28)	6.30×10^{-5}
Mean Value		5.65×10^{-5}
Sites For Ditch Water Samples		
1) Old Yale Road	(78-12-07)	17.2×10^{-5}
2) 133 Street and 116 Avenue	(78-12-07)	23.0×10^{-5}
3) 133 Street and 116 Avenue	(79-01-02)	10.3×10^{-5}

TABLE 5.7

TITRATION OF 100 MLS OF FRASER RIVER WATER
WITH 0.044 N NaOH, 1979-01-02

mL of 0.044 NaOH	Equivs. of NaOH	% NaOH By Volume	pH of River
0.00	0.00	0.00	7.25
0.15	0.66×10^{-5}	0.15	8.90
0.25	1.10×10^{-5}	0.25	9.10
0.40	1.76×10^{-5}	0.40	9.40
0.50	2.20×10^{-5}	0.50	9.30
1.00	4.4×10^{-5}	0.99	10.50

TABLE 5.8

TITRATION OF 100 MLS OF FRASER RIVER WATER AT 0920425
WITH 0.10 N NaOH, 1979-04-27

pH	mL of 0.1 N NaOH	Equivs. of NaOH	pH	mL of 0.1 N NaOH	Equivs. of NaOH
7.32	0.00	0.00	7.32	0.00	0.00
8.11	0.05	0.5×10^{-5}	8.25	0.05	0.05×10^{-5}
8.49	0.10	1.0×10^{-5}	9.07	0.25	2.5×10^{-5}
9.07	0.21	2.1×10^{-5}	9.45	0.40	4.0×10^{-5}
9.40	0.40	4.0×10^{-5}	9.69	0.55	5.5×10^{-5}
9.76	0.66	6.6×10^{-5}	9.90	0.75	7.5×10^{-5}
10.05	0.95	9.5×10^{-5}	10.12	1.00	10.0×10^{-5}
10.25	1.18	11.8×10^{-5}	10.55	1.51	15×10^{-5}
10.51	1.55	15.5×10^{-5}	10.85	2.01	20.1×10^{-5}
10.81	2.00	20.0×10^{-5}	11.20	3.00	30.0×10^{-5}
11.10	2.50	25×10^{-5}	11.46	5.04	50.4×10^{-5}
11.50	5.55	55.5×10^{-5}	11.85	10.00	100×10^{-5}
11.84	10.00	100×10^{-5}			

TABLE 5.9

TITRATION OF FRASER RIVER WATER WITH STORM WATER RUNOFF

FROM 133 ST. AND 116 AVE. AND FROM 126 A ST., SURREY (79-01-02, 79-02-28)

79-01-02			79-02-28			126 A St. (79-02-28)		
mL of 133 Rd. Water	Volume %	pH	mL of 133 Rd. Water	Volume %	pH	mL of 126 A St. Water	Volume %	pH
0.0	0.0	7.20	0.0	0.0	7.30	0.00	0.0	7.40
3.7	3.5	7.10	5.0	4.76	7.00	5.00	4.8	7.38
11.0	9.1	6.80	10.0	9.09	6.76	13.50	11.9	7.25
15.5	13.4	6.68	15.0	13.40	6.65	20.50	17.0	7.15
25.0	20.0	6.50	21.0	17.36	6.55	50.00	33.3	6.95
30.0	23.0	6.44	33.5	25.09	6.39			
35.0	25.9	6.38	50.0	33.33	6.29			
40.5	28.6	6.35						
50.0	33.3	6.30						
61.2	37.9	6.20						
75.0	43.0	6.20						

TABLE 5.10

TITRATION OF 100 ML OF FRASER RIVER WATER WITH STORM WATER

FROM SITE NO. XE03148-03 (79-02-28, 79-04-18)

79-02-28			79-04-18		
mL of XE03148-03 Titrated	% by Volume	pH of Fraser River Water	mL of XE03148-03 Titrated	% by Volume	pH of Fraser River Water
0.0	0.0	7.40	0.00	0.0	7.20
1.5	1.5	9.05	1.00	1.0	7.55
3.2	3.1	9.40	2.50	2.4	7.69
8.5	7.8	10.10	5.20	4.9	7.80
11.2	10.4	10.40	10.10	9.2	8.00
18.0	15.3	19.95	15.0	13.0	8.20
23.0	18.7	11.20	23.0	18.7	8.40
27.0	21.3	11.35	27.0	21.3	8.51
34.5	25.7	11.50	37.1	27.1	8.70
50.0	33.3	11.70	50.0	33.3	8.80

TABLE 5.11

COMPARISON OF THE EQUIVALENTS OF ACID REQUIRED TO CHANGE THE pH OF CHEMICALLY PURE H_2O VS. THE ACID REQUIRED TO CHANGE THE pH OF FRASER RIVER WATER

pH	Equivalents of Acid Required To Change Chemically Pure H_2O	Equivalents of Acid Required To Change Fraser River Water	Buffering Ratio of Fraser River / Pure H_2O
7.2	0.6×10^{-7}	-	
7.0	1.0×10^{-7}	0.9×10^{-5}	90
6.8	1.6×10^{-7}	2.4×10^{-5}	150
6.6	2.5×10^{-7}	3.6×10^{-5}	144
6.4	4.0×10^{-7}	5.0×10^{-5}	125
6.2	6.3×10^{-7}	6.6×10^{-5}	105
6.0	10.0×10^{-7}	8.8×10^{-5}	88
5.8	15.8×10^{-7}	9.6×10^{-5}	61
5.6	25.1×10^{-7}	10.2×10^{-5}	41
		Mean Ratio	100

pH	pOH -Log (OH^-)	Equivalents of Base Required To Change Chemically Pure H_2O *	Equivalents of Base Required To Change Fraser River Water	Buffering Ratio of Fraser River / Pure H_2O
7.00	7.00	-	-	-
7.20	6.80	1.6×10^{-7}	-	-
7.40	6.60	2.5×10^{-7}	2.0×10^{-7}	0.80
7.60	6.40	4.0×10^{-7}	5.0×10^{-7}	1.25
7.80	6.20	6.3×10^{-7}	8.0×10^{-7}	1.27
8.00	6.00	10.0×10^{-7}	16.0×10^{-7}	1.60
8.20	5.80	15.8×10^{-7}	24.0×10^{-7}	1.52
8.40	5.60	25.1×10^{-7}	35.0×10^{-7}	1.39
8.60	5.40	39.8×10^{-7}	47.0×10^{-7}	1.18
8.80	5.20	63.0×10^{-7}	65.0×10^{-7}	1.03
9.00	5.00	100.0×10^{-7}	88.0×10^{-7}	0.88
9.20	4.80	158×10^{-7}	120.0×10^{-7}	0.76
			Mean Ratio	1.17

Based on curve of Site No. 0300118 which best approximates the average of all the sites tested.

* Not considering dissolved CO_2.

APPENDIX 6

Figures and Data Tables for
Tidal Influence Study

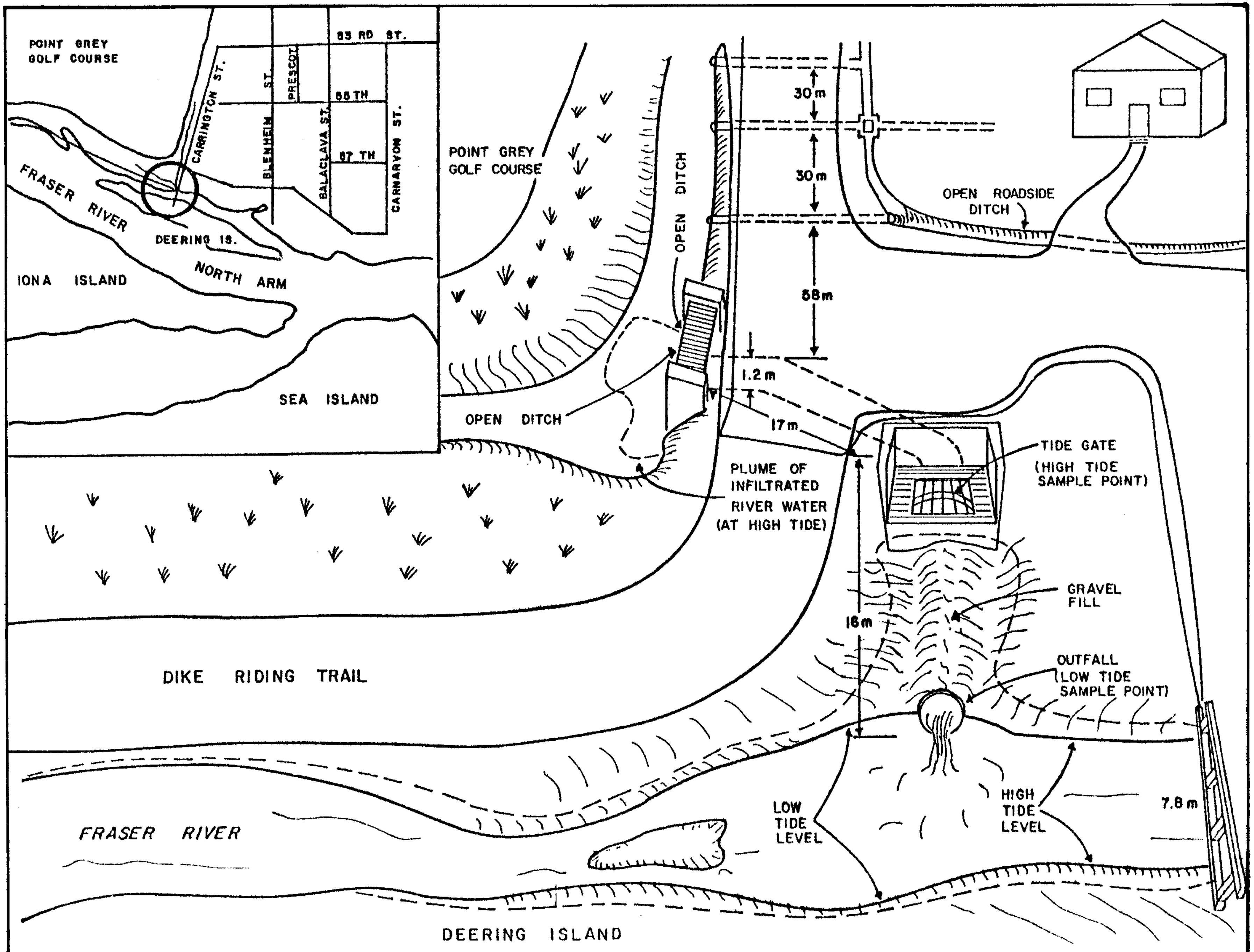


FIGURE 17 : CARRINGTON STREET OUTFALL

FIGURE 18

THE FLOW OF WATER FROM THE STORM PIPE

SITE NO. XE03104-01

1978-08-03

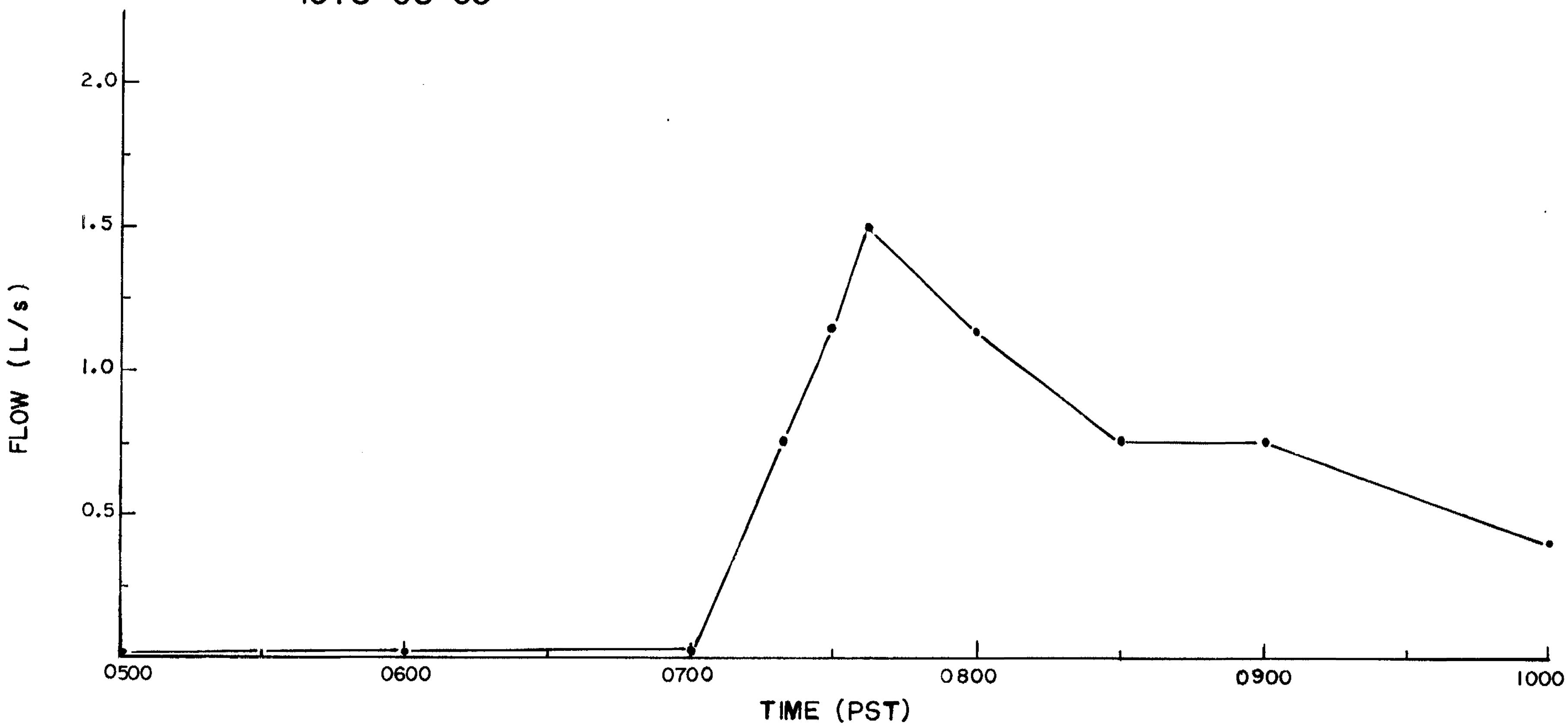


FIGURE 19

TIDAL CURVE AT POINT ATKINSON (CANADIAN TIDE AND CURRENT TABLES, 1978)
1978 - 08 - 03

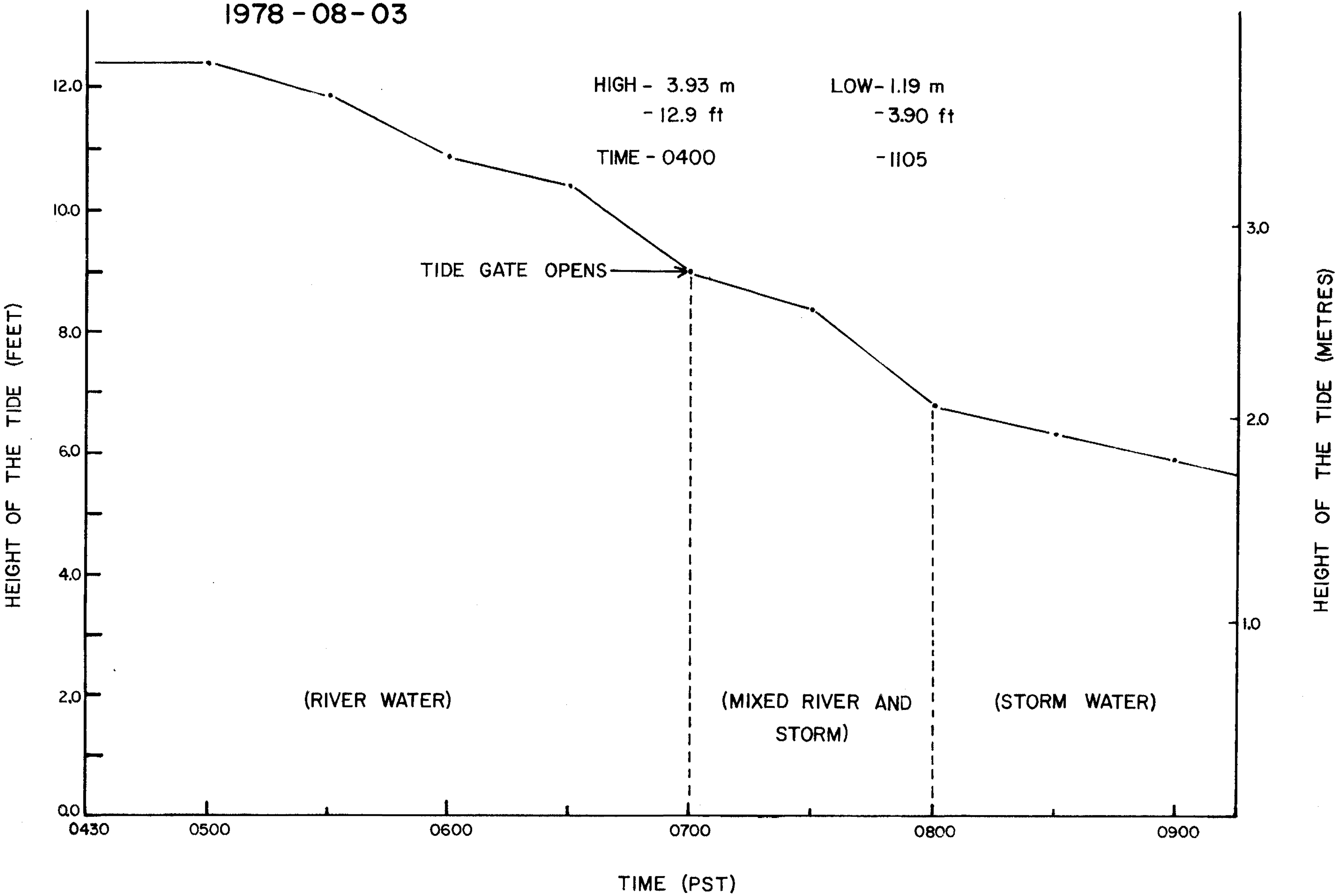


FIGURE 20

HYDROLAB MEASURED AND LABORATORY MEASURED SPECIFIC CONDUCTANCE OF DISCHARGE WATER AT SITE NO. XE03104-01

1978-08-03

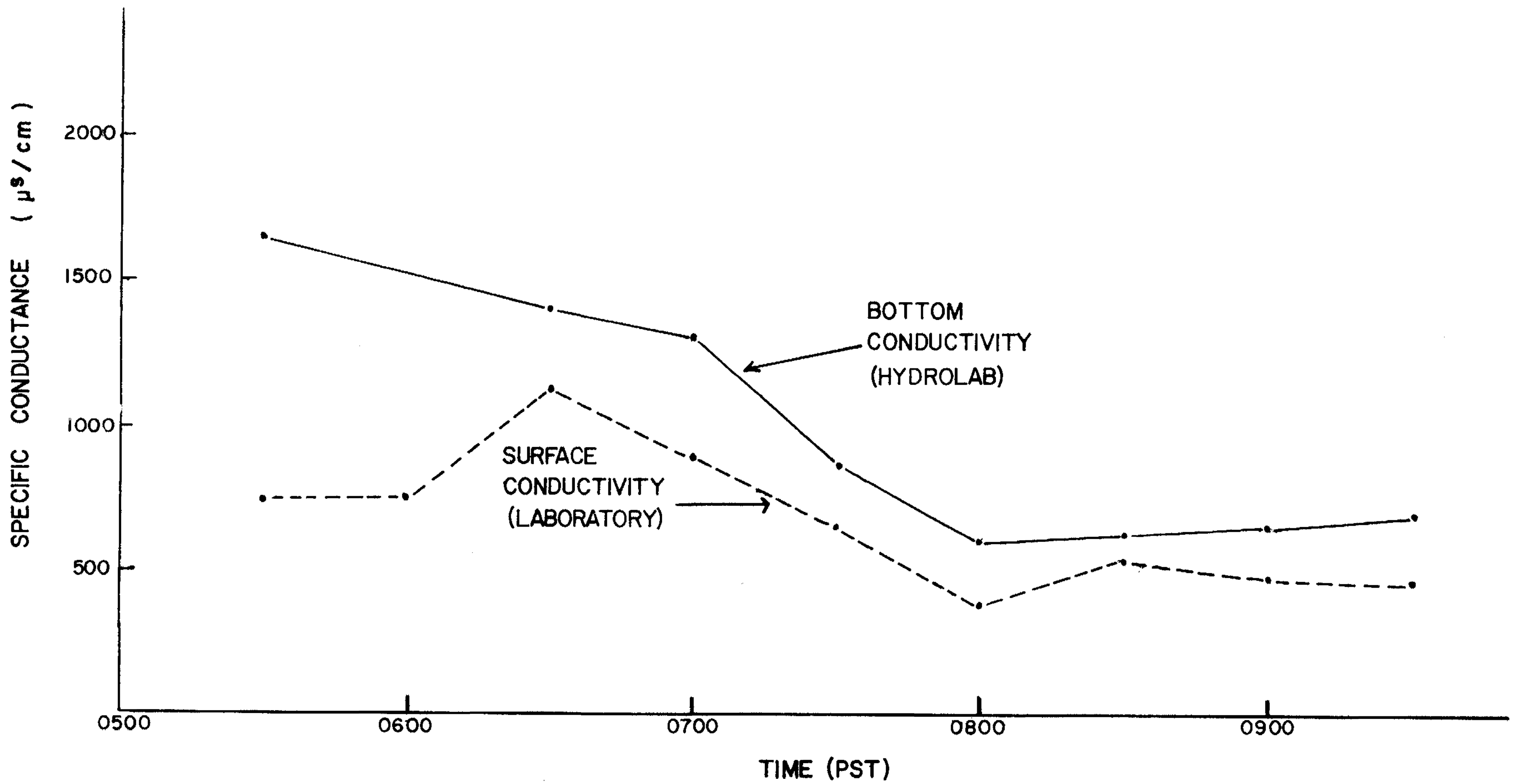


FIGURE 21

SPECIFIC CONDUCTANCE (YSI MODEL 33) OF THE SURFACE AND BOTTOM WATER AT SITE NO. XE03104-01

1978-08-03

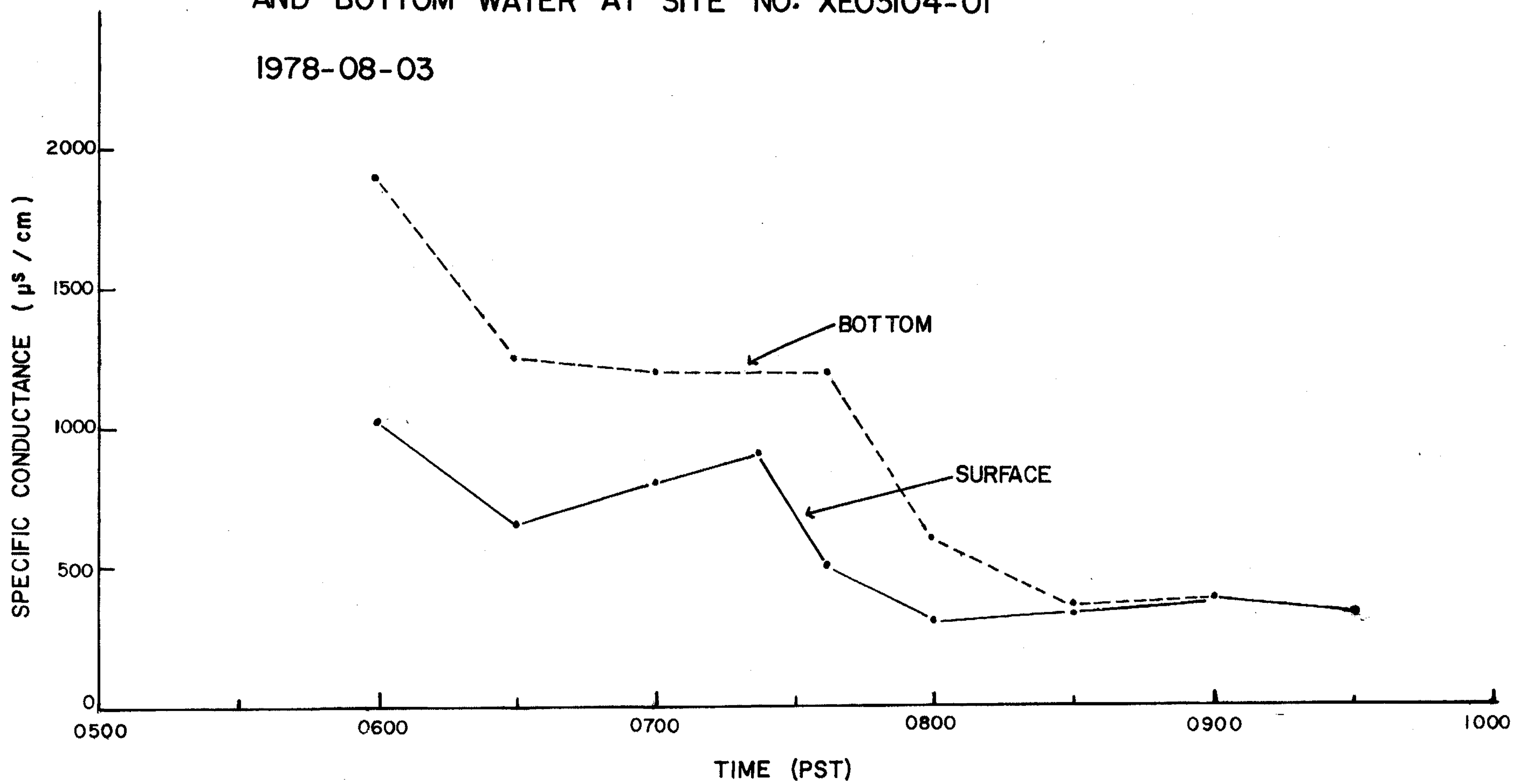


FIGURE 22

DISSOLVED OXYGEN AND TEMPERATURE OF DISCHARGE WATER

AT SITE NO. XE03104-01

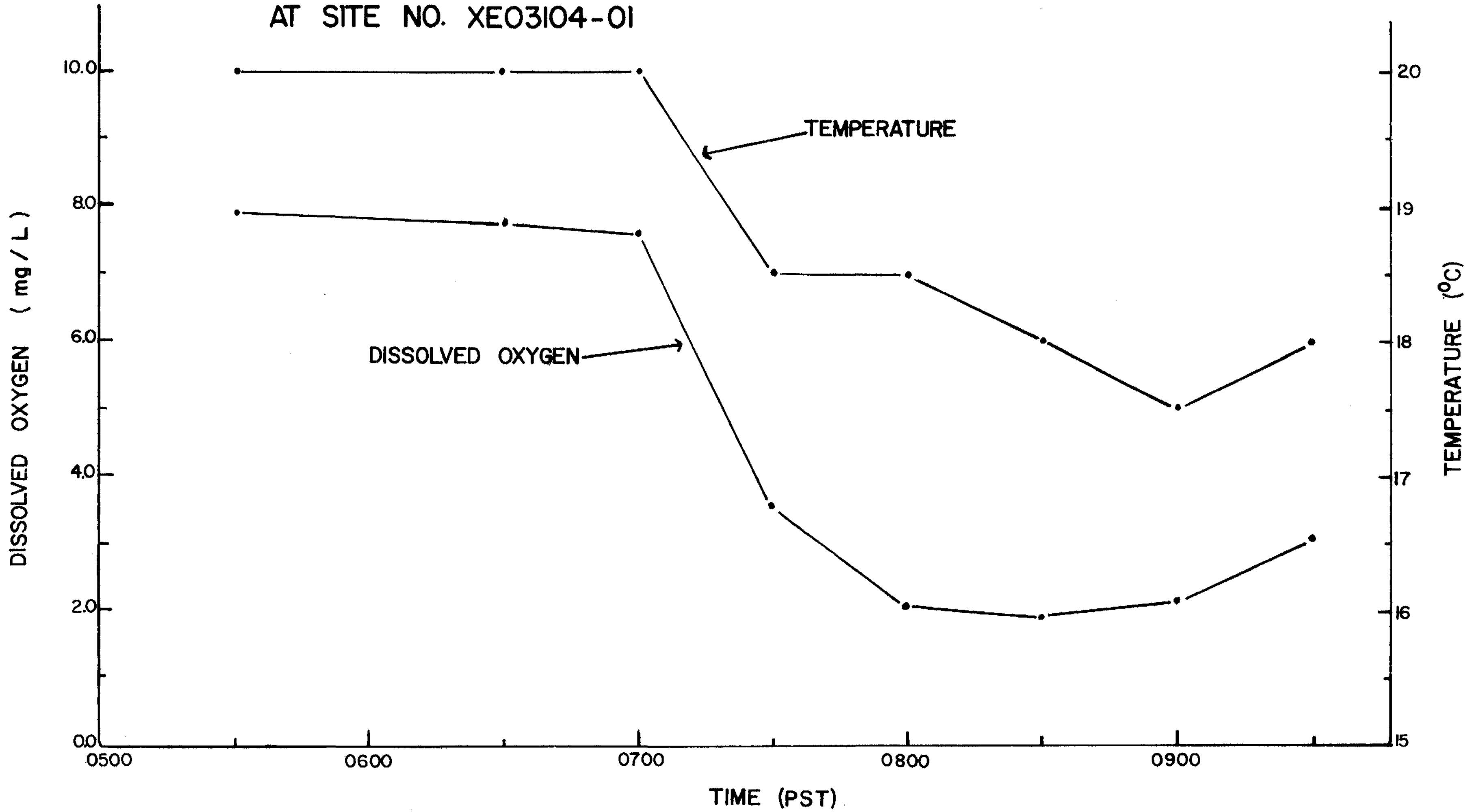
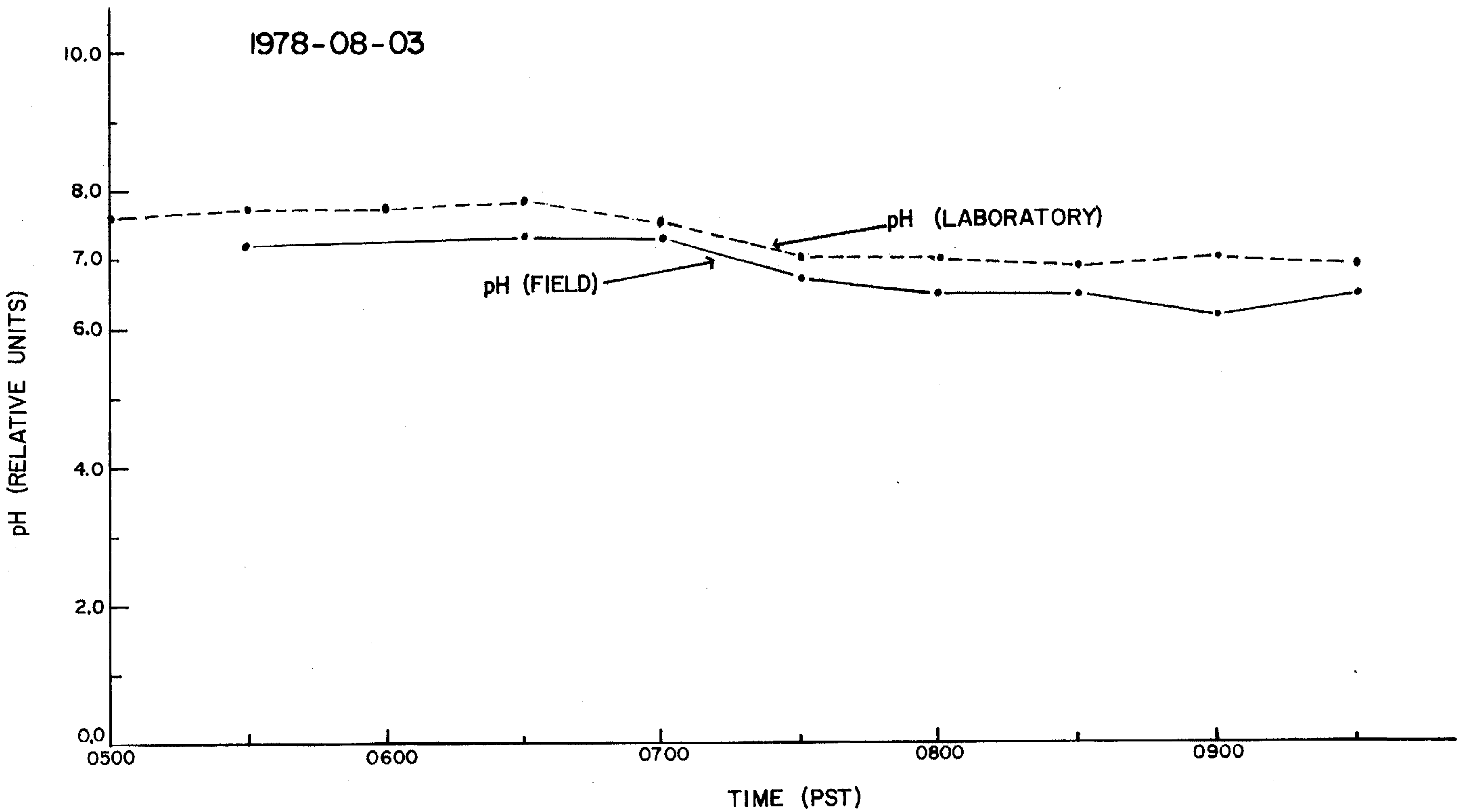


FIGURE 23

FIELD MEASURED AND LABORATORY MEASURED pH (REL UNITS) OF DISCHARGE WATER AT SITE NO. XE03104-01

1978-08-03



(NOTE THAT THE TWO MEASUREMENTS WERE FOR DIFFERENT DEPTHS).

FIGURE 24

NITRATE (NO_3^-), NITRITE (NO_2^-), AND NITRATE + NITRITE NITROGEN IN DISCHARGE WATER AT SITE NO. XE03104-01

1978-08-03

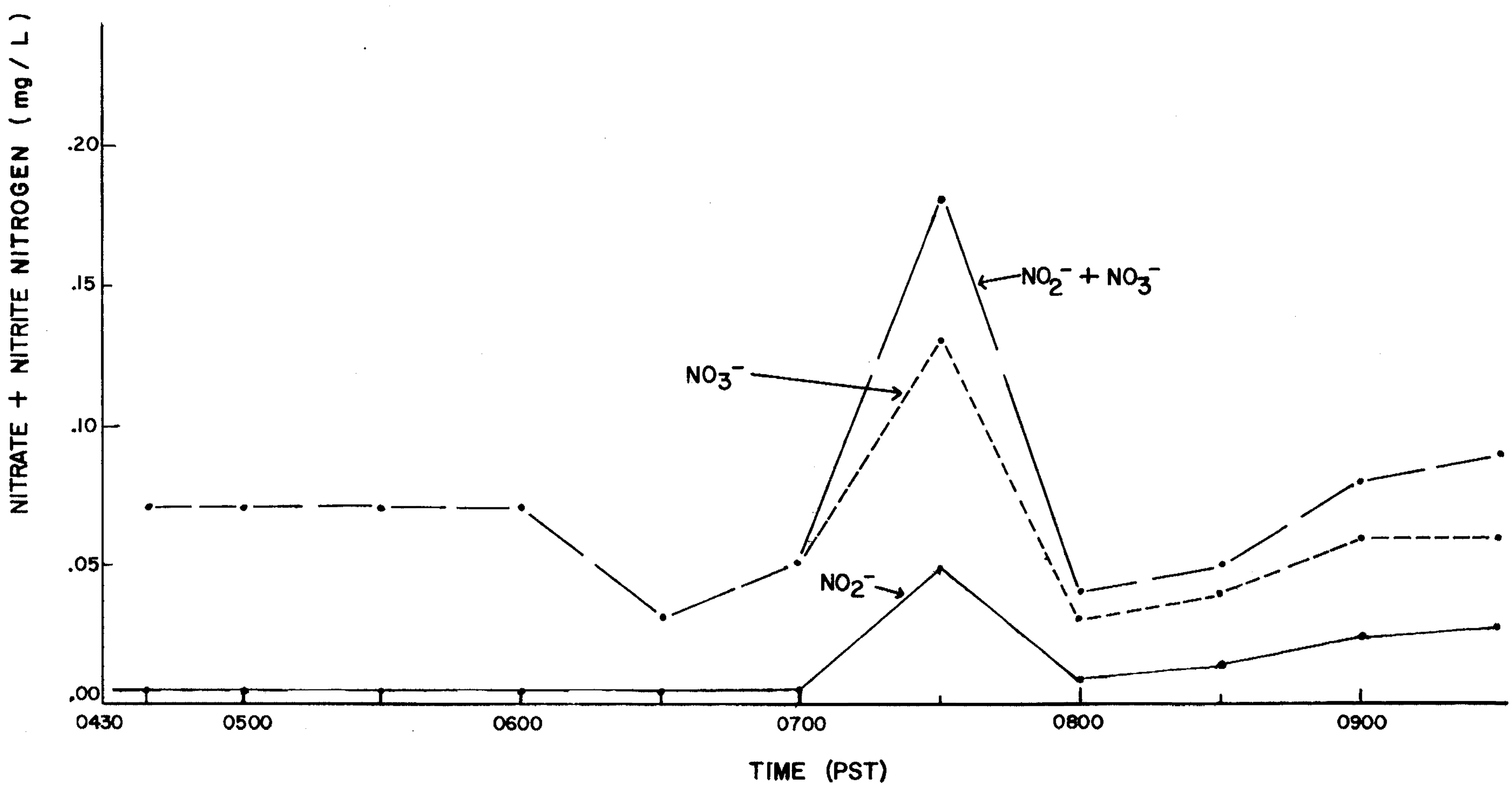


FIGURE 25

TOTAL AND KJELDAHL NITROGEN IN DISCHARGE WATER AT

SITE NO. XE03104-01

1978-08-03

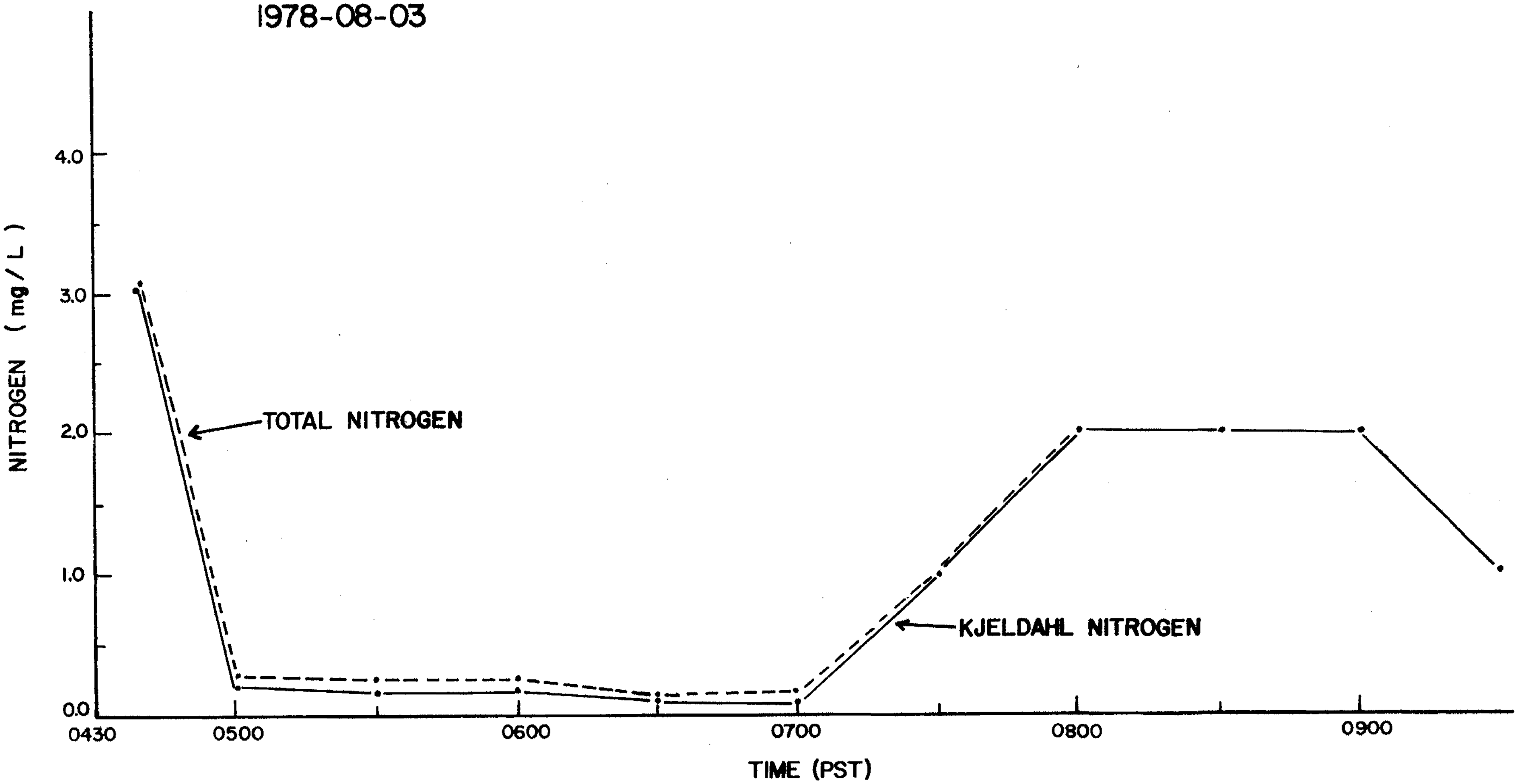
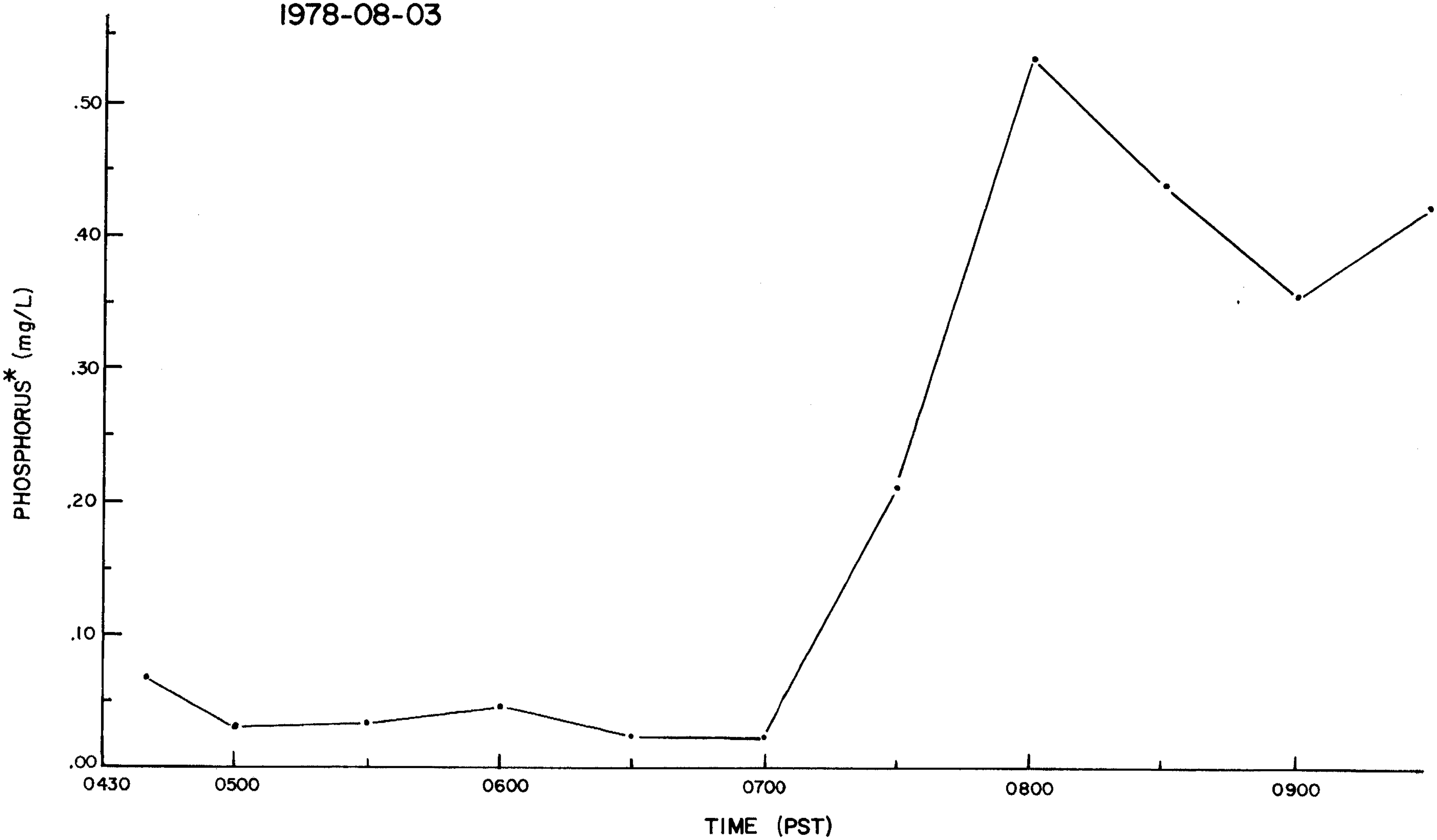


FIGURE 26

PHOSPHORUS* IN DISCHARGE WATER AT SITE NO. XE03104-01

1978-08-03



* TOTAL UNFILTERED PHOSPHATE AS P

FIGURE 27

TOTAL ORGANIC, AND TOTAL INORGANIC CARBON IN DISCHARGE WATER AT SITE NO. XE03104-01

1978-08-03

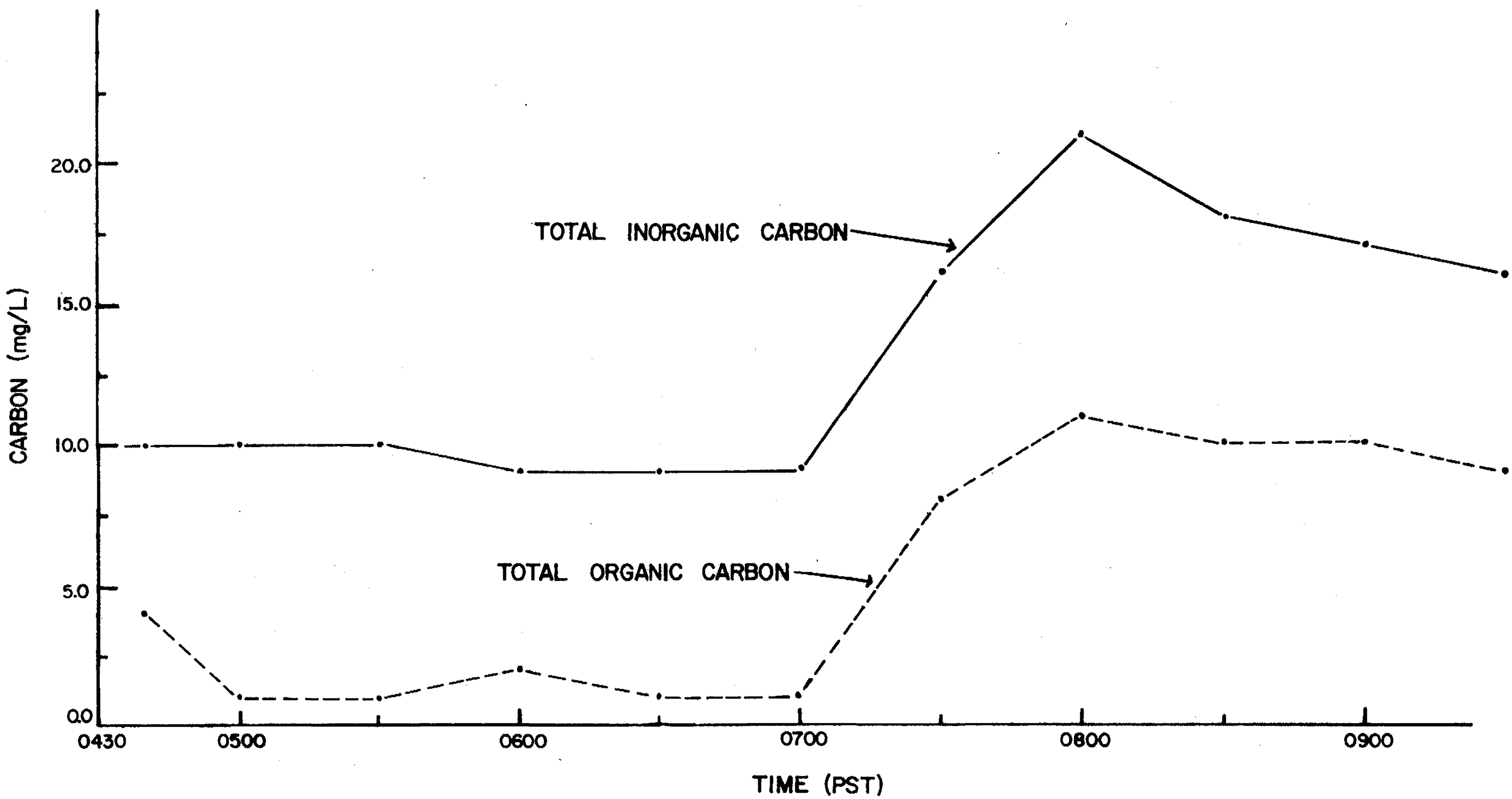


FIGURE 28

TRUE COLOUR AND T.A.C. - COLOUR OF RIVER OR STORM WATER

AT SITE NO. XE03104-01

1978-08-03

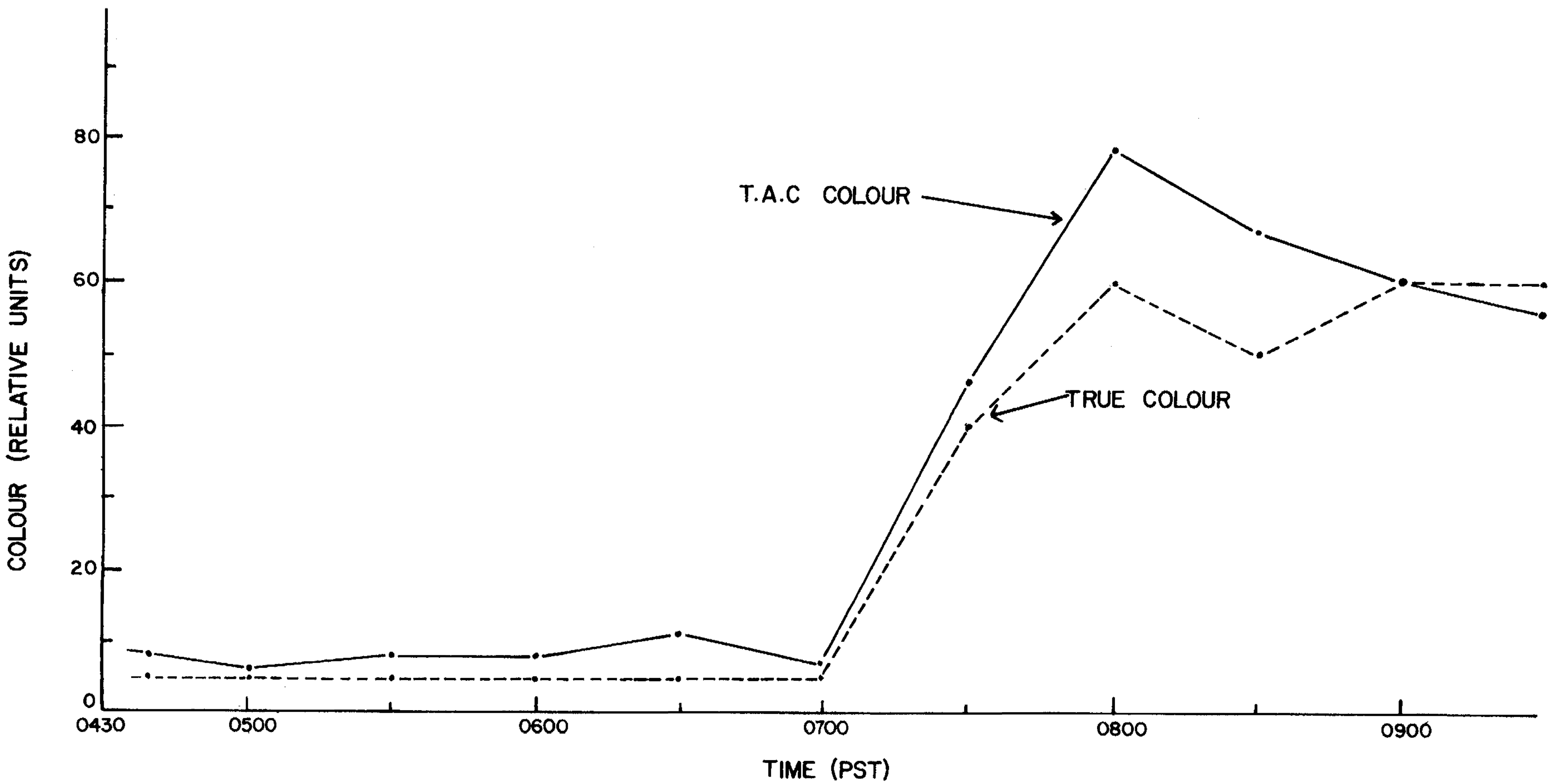


FIGURE 29

PHENOL, OIL AND GREASE IN DISCHARGE WATER AT

SITE NO. XE03104-01

1978-08-03

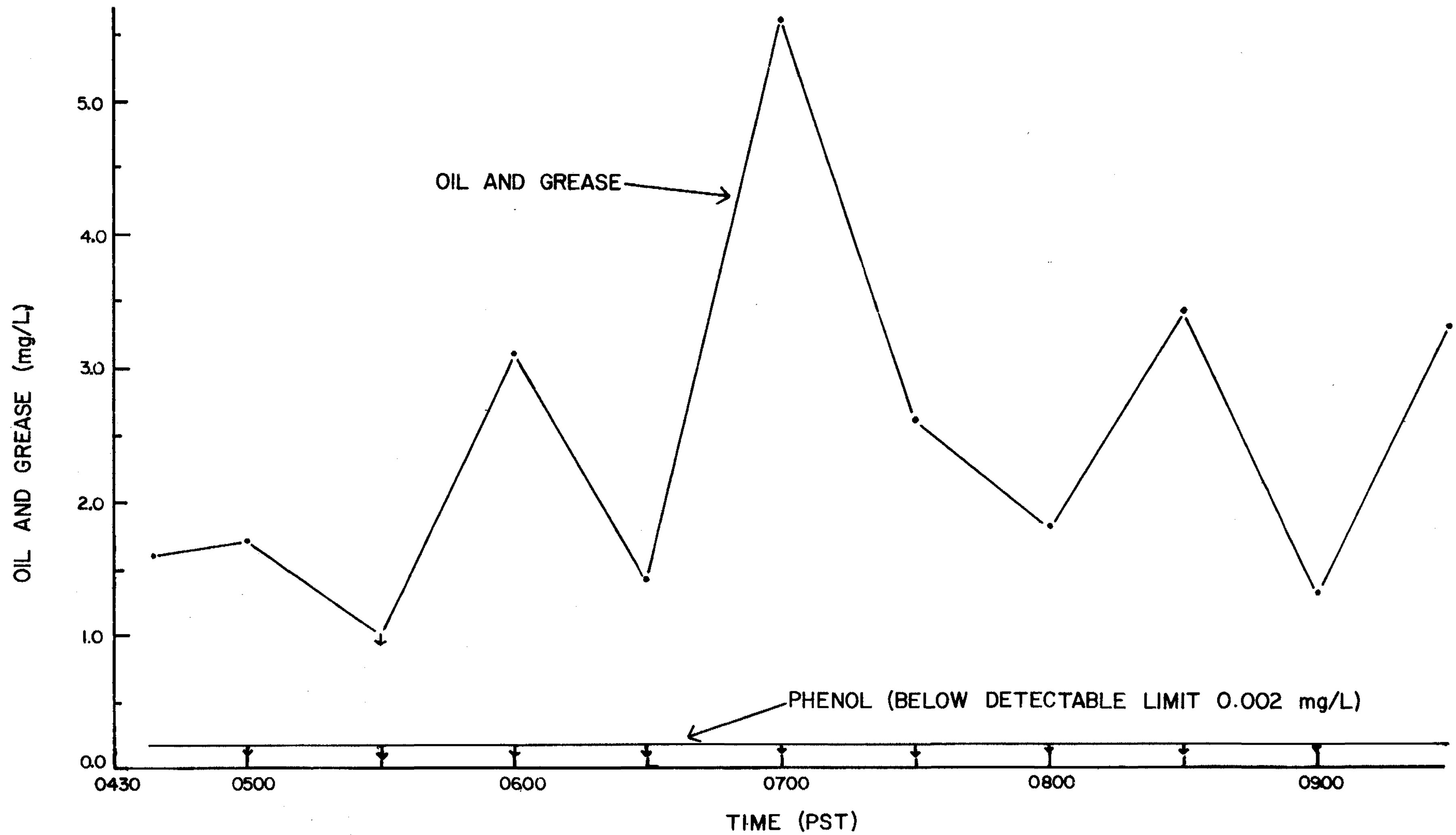


FIGURE 30

NONFILTERABLE RESIDUE (105°C) IN DISCHARGE WATER AT

SITE NO. XE03104-01

1978-08-03

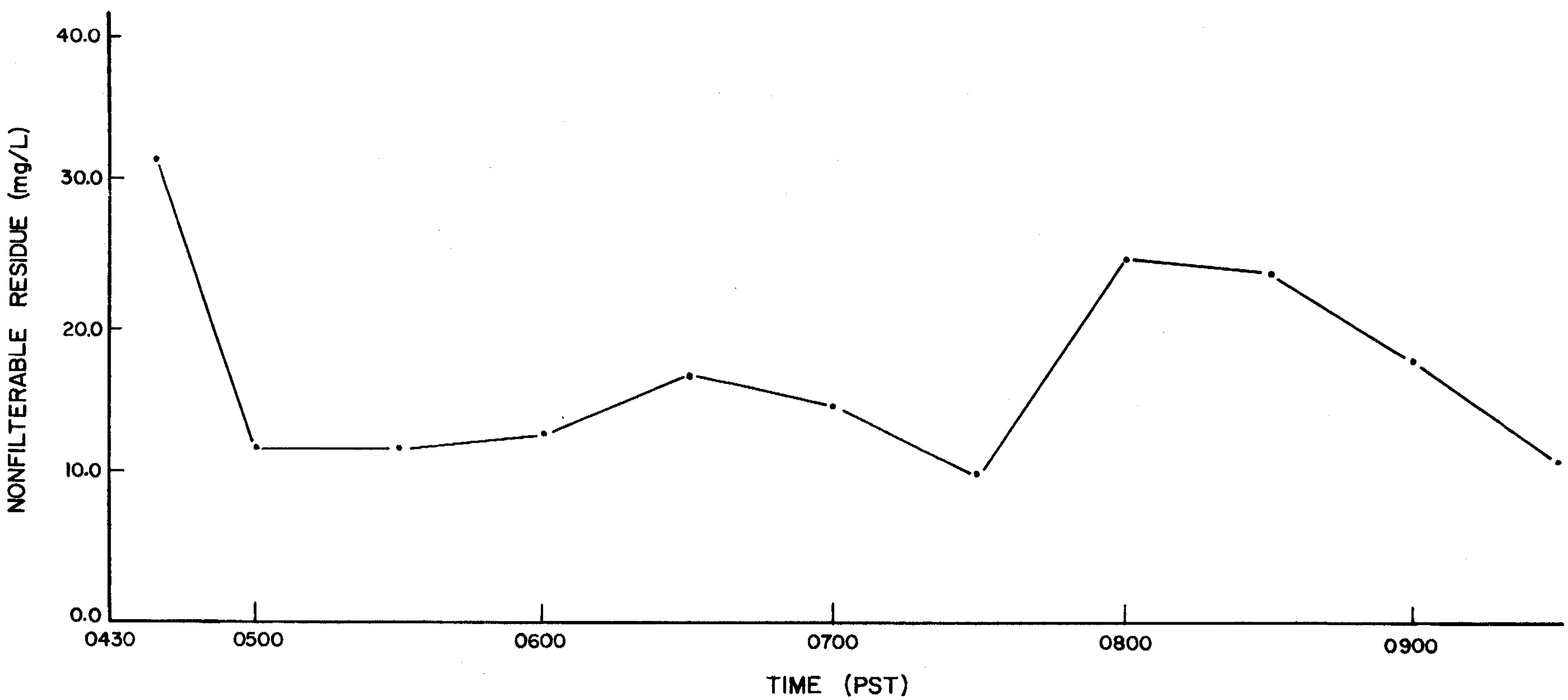
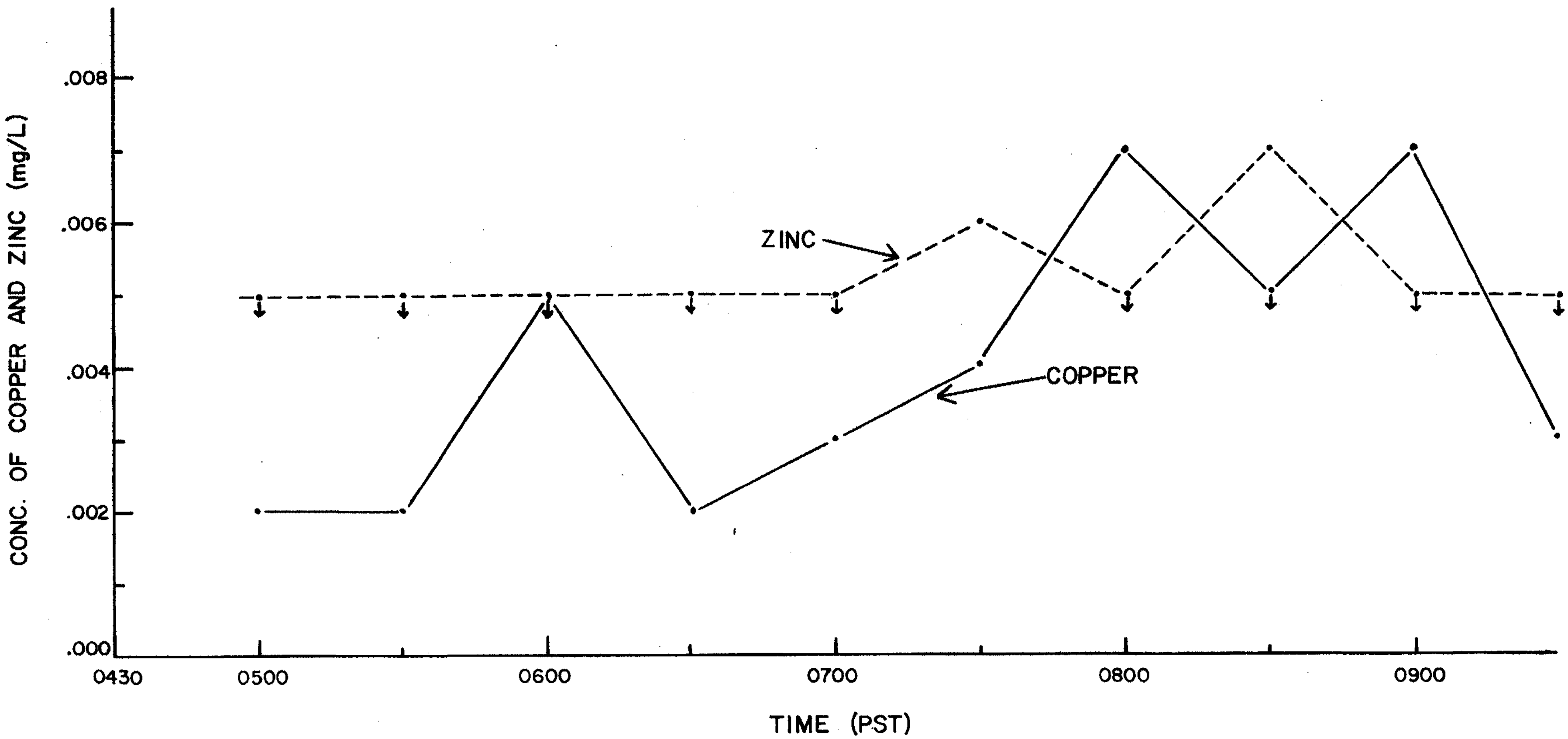


FIGURE 31

TOTAL COPPER AND TOTAL ZINC IN DISCHARGE WATER AT

SITE NO. XE03104-01

1978-08-03



NOTE: 0.005 mg / L = MINIMUM DETECTABLE CONCENTRATION FOR ZINC.

FIGURE 32

TOTAL IRON IN DISCHARGE WATER AT SITE NO. XE03104-01

1978-08-03

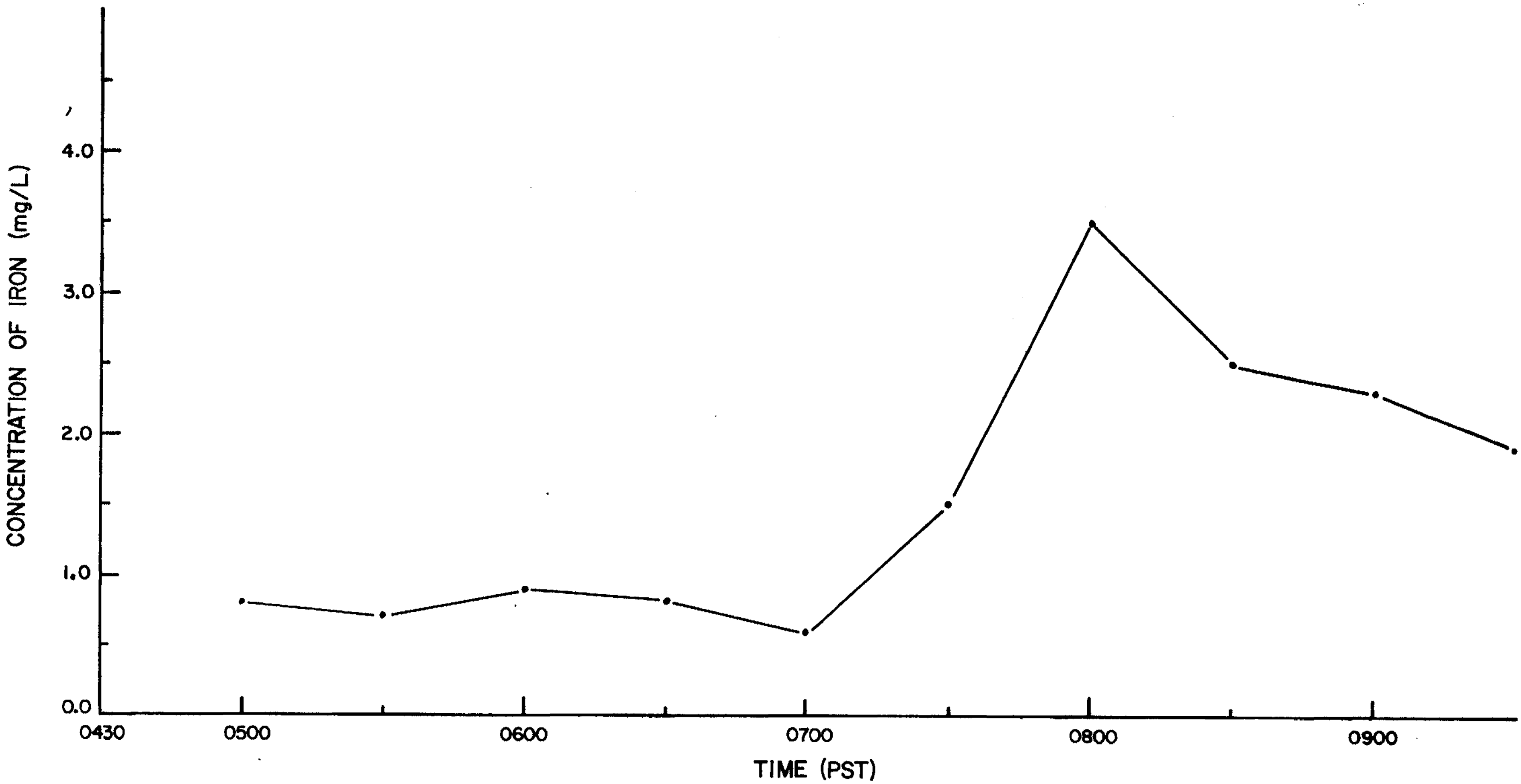
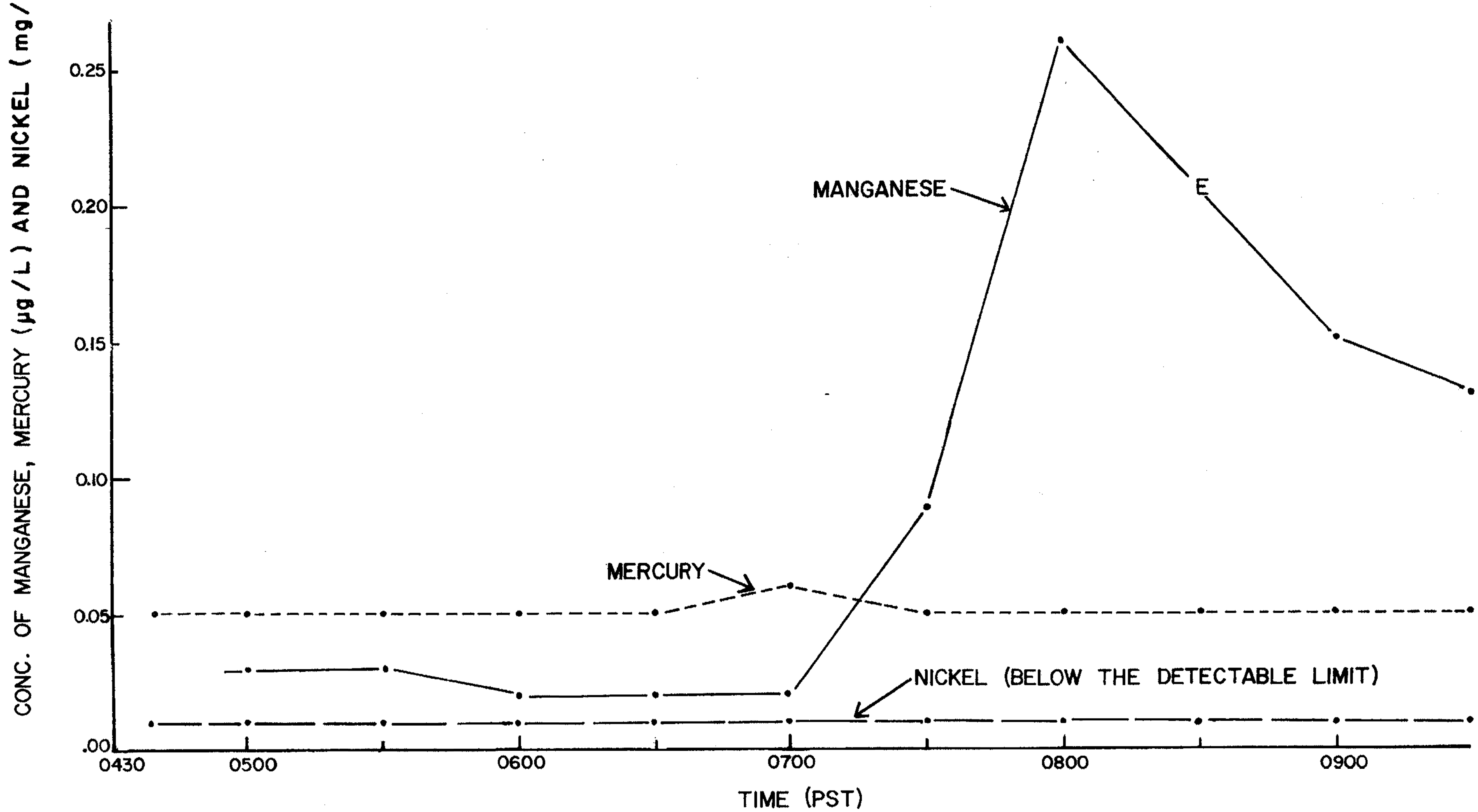


FIGURE 33

TOTAL MANGANESE, MERCURY AND NICKEL IN DISCHARGE WATER

AT SITE NO. XE03104-01

1978-08-03



NOTE : 0.05 µg/L = MINIMUM DETECTABLE CONCENTRATION FOR MERCURY

FIGURE 34

TOTAL ARSENIC, CHROMIUM AND LEAD IN DISCHARGE WATER

AT SITE NO. XE03104-01

1978-08-03

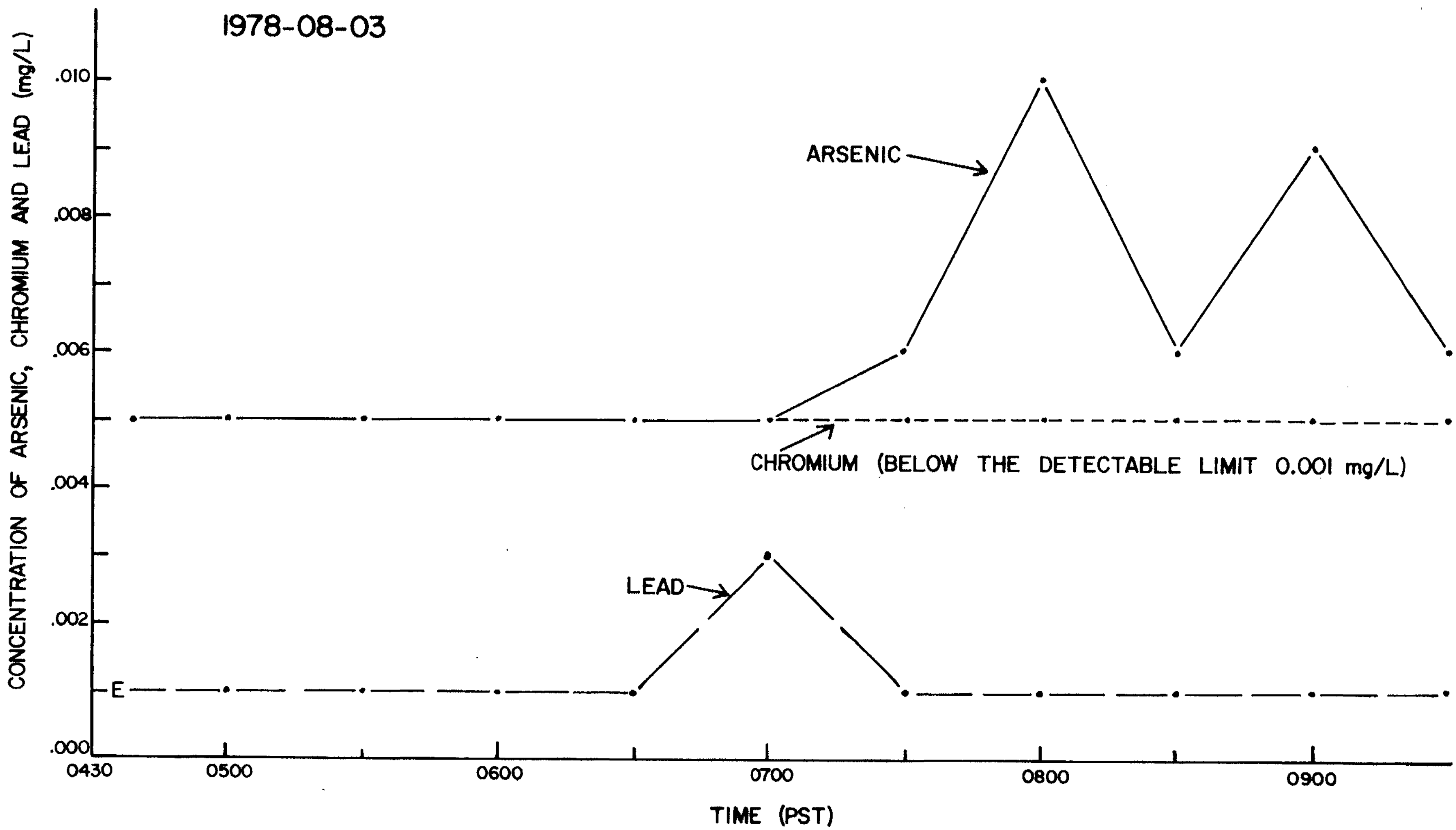


TABLE 6.1

TIDAL EFFECT DATA FOR A DRY WEATHER STORM SEWER DISCHARGE AT CARRINGTON ST., SOUTH VANCOUVER, SITE NO. XE03104-01

FLOW AND CONDUCTIVITY

Time P.S.T.	Flow L/Sec.	Specific Conductance (Hydrolab) µS/cm Bottom	Specific Conductance Laboratory µS/cm Surface	Specific Conductance (YSI) µS/cm Surface	Specific Conductance (YSI) µS/cm Bottom
0400	-	-	-	-	-
0440	-	-	702	-	-
0500	-	-	708	-	-
0530	-	-	712	-	-
0600	0.0	-	730	-	-
0630	-	1 650	1 120	-	-
0700	0.0	-	880	1 020	1 900
0730	1.0-1.5	1 400	640	650 800	1 250 1 200
0800	1.1	1 300	368	900	900
0830	1.0	850	520	500	1 200
0900	0.4	590	460	300	600
0930	-	605	450	320	350
1000	-	630	(a) 762	390	390
1030	0.4	675	-	340	340

(a) Composite Sample.

TABLE 6.2

TIDAL EFFECT DATA FOR A DRY WEATHER STORM SEWER DISCHARGE AT CARRINGTON ST., SOUTH VANCOUVER, SITE NO. XE03104 - 01

Time P.S.T.	Temperature YSI °C	Dissolved Oxygen (YSI) mg/L	pH (Laboratory)	pH (Hydrolab)	NO_3^- Laboratory mg/L
0400	-	-	-	-	-
0440	-	-	7.6	-	0.07
0500	-	-	7.6	-	0.07
0530	-	-	7.7	-	0.07
0600	-	-	7.7	-	0.07
0630	20.0	7.90	7.8	7.20	0.03
0700	-	-	7.5	-	0.05
0730	20.0	7.85	7.0	7.32	0.13
0800	20.0	7.60	7.0	7.32	0.03
0830	18.5	3.55	6.9	6.72	0.04
0900	18.5	2.05	7.0	6.52	0.06
0930	18.0	1.90	6.9	6.52	0.06
1000	17.5	2.15	(a) 7.2	6.20	(a) 0.07
1030	18.5	3.05		6.50	

(a) Composite Sample.

TABLE 6.3

TIDAL EFFECT DATA FOR A DRY WEATHER STORM SEWER DISCHARGE AT CARRINGTON ST., SOUTH VANCOUVER, SITE NO. XE 03104-01

NUTRIENTS

Time P.S.T.	NO_2^- mg/L	NO_2^- + NO_3^- mg/L	Nitrogen (Total) mg/L	Nitrogen (Kjeldahl) mg/L	Phosphorus mg/L
0400	-	-	-	-	-
0400	<0.005	0.07	3.07	3.00	0.068
0500	"	0.07	0.28	0.21	0.030
0530	"	0.07	0.24	0.17	0.031
0600	"	0.07	0.24	0.17	0.046
0630	"	0.03	0.13	0.10	0.023
0700	0.005	0.05	0.14	0.09	0.023
0730	0.048	0.18	1.00	1.00	0.214
0800	0.008	0.04	2.00	2.00	0.536
0830	0.013	0.05	2.00	2.00	0.440
0900	0.024	0.08	2.00	2.00	0.358
0930	0.026	0.09	1.00	1.00	0.425
1000	(a) 0.011	(a) 0.08	(a) 0.80	0.72	
1030					

(a) Composite Sample.

TABLE 6.4

TIDAL EFFECT DATA FOR A DRY WEATHER STORM SEWER
DISCHARGE AT CARRINGTON ST., SOUTH VANCOUVER,
SITE NO. XE03104-01
SOLIDS, COLOUR, CARBON, OIL AND GREASE AND PHENOL

Time P.S.T.	Total Inorganic Carbon mg/L	Total Organic Carbon mg/L	Colour True	Colour T.A.C.	Oil and Grease mg/L	Phenol mg/L	Non-Filt. Residue 105°C mg/L
0400	10.0	<1.0	-	-	<1.0	<0.002	-
0440	10.0	4.0	<5	8	1.6	"	32
0500	10.0	<1.0	<5	6	1.7	"	12
0530	10.0	<1.0	5	8	<1.0	"	12
0600	9.0	2.0	5	8	3.1	"	13
0630	9.0	<1.0	5	13	1.4	"	17
0700	9.0	<1.0	5	7	5.6	"	15
0730	16.0	8.0	40	46	2.6	"	10
0800	21.0	11.0	60	79	1.8	"	25
0830	18.0	10.0	50	67	3.4	"	24
0900	17.0	10.0	60	60	1.3	"	18
0930	16.0	9.0	60	56	3.3	"	11
1000			(a) 40	(a) 36			(a) 9

(a) Composite Sample.

TABLE 6.5

TIDAL EFFECT DATA FOR A DRY WEATHER STORM SEWER
DISCHARGE AT CARRINGTON ST., SOUTH VANCOUVER
SITE NO. XE03104-01

Time P.S.T.	Mercury μg/L	Nickel mg/L	Arsenic mg/L	Chromium mg/L	Lead mg/L	Zinc mg/L	Copper mg/L	Iron mg/L	Manganese mg/L
0400	<0.05	<0.01	-	<0.005	<0.001	<0.005	0.002	0.7	0.003
0440	"	-	<0.005	-	-	-	-	-	-
0500	"	<0.01	"	<0.005	<0.001	0.005	0.002	0.8	0.03
0530	"	"	"	"	"	"	0.002	0.7	0.03
0600	"	"	"	"	"	"	0.005	0.9	0.02
0630	"	"	"	"	"	"	0.002	0.8	0.02
0700	0.06	"	"	"	0.003	"	0.003	0.6	0.02
0730	<0.05	"	0.006	"	<0.001	0.006	0.004	1.5	0.09
0800	"	"	0.010	"	"	<0.005	0.007	3.5	0.26
0830	"	"	0.006	"	"	0.007	0.005	2.5	-
0900	"	"	0.009	"	"	<0.005	0.007	2.3	0.15
0930	"	"	0.006	"	<0.001	<0.005	0.003	1.9	0.13
1000	(a) "	(a) "	(a) 0.006	(a) "	<0.001	(a) 0.006	(a) 0.006	(a) 1.4	0.10
1030	-	-	-	-	-	-	-	-	-

(a) Composite Sample.

APPENDIX 7

A Study Comparing Surface to
Sub-Surface Metal Concentrations in Storm Water

In order to test the hypothesis that the surface film on the water contains higher metal concentrations than sub-surface water, samples were collected and analyzed from six storm sewer outfalls between June and August, 1979. The six sites were 133rd Street and 116 Avenue, Surrey (XE03274-01); No. 4 Road North, Richmond (XE03178-01); River Road and Westminster Highway (XE03174-01); Boundary Road (XE03275-01); Carrington Street, Vancouver (XE03104-01); and Gilbert Road North (XE03165-01). Sub-surface samples were collected by opening acid-washed bottles (supplied by Environmental Laboratory) well below the surface; surface films were collected repeatedly placing a glass plate flat on the water surface, and wiping with a plastic blade into bottles (glass and blade thoroughly cleaned with DI water and acetone). The samples were analyzed for the following metals: aluminum, cadmium, chromium, copper, iron, magnesium, manganese, molybdenum, nickel, lead and zinc.

The results (Table 7.1) indicated that metal concentrations in surface slicks were indeed higher than those in sub-surface samples. As a further check on the validity of the interpretation surface and sub-surface concentrations were compared by a paired t-Test (Ho: $\bar{x}_{surface} = \bar{x}_{subsurface}$). The null hypothesis was rejected in all cases where sufficient data were available to make the test (Table 7.2).

This indication of metal accumulation at the air/water interface is worth noting for several reasons: (i) technicians collecting water samples should be careful to avoid contaminating sub-surface water samples with surface films, and (ii) persons determining metal loadings to a receiving water should consider surface concentrations in their calculations. The impact of surface films on the aquatic environment requires further investigation.

TABLE 7.1

METAL ANALYSES

Site I.D.	Name	Date	Al	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Pb	Zn
XE03247-01	133rd & 116 Ave.												
	a. Subsurface	June 26, 1979	0.7	-	-	0.006	5.0	-	0.69	-	-	<0.001	0.052
	b. Surface		-	-	0.012	-	7.5	8.1	0.90	-	-	-	-
	a. Subsurface	July 11, 1979	-	-	-	0.008	4.4	-	0.54	-	-	0.011	0.052
	b.		1.5	-	0.006	0.03	4.9	5.6	0.72	0.011	-	-	0.10
	a. Subsurface	July 24, 1979	0.21	-	-	0.008	7.0	-	0.99	-	-	0.013	0.022
	b. Surface		-	-	-	0.02	8.0	-	1.05	-	-	0.042	0.027
	a. Subsurface	Aug. 7, 1979	5.02	-	-	0.02	12.9	-	1.14	-	-	0.07	0.12
	b. Surface		0.43	0.0009	0.02	0.04	12.3	-	1.13	-	0.02	0.07	0.25
	a. Subsurface	Aug. 21, 1979	0.37	-	-	0.01	10	-	1.37	-	-	0.021	0.04
	b. Surface		0.6	-	0.03	0.06	10	-	1.34	-	-	0.022	0.20
XE03168-01	No. 4 Rd. N, Richmond												
	a. Subsurface	June 26, 1979	-	-	-	0.023	18.	-	0.65	-	-	0.005	0.015
	b. Surface		2.7	-	0.053	0.10	120.	23.6	1.2	-	-	-	0.47
	a. Subsurface	July 24, 1979	0.08	-	-	0.007	13	-	0.74	-	-	0.009	-
	b. Surface		0.6	-	-	0.02	13	-	0.77	-	-	0.3	0.043
	a. Subsurface	Aug. 7, 1979	0.54	-	-	0.004	12.6	-	0.51	-	-	0.003	0.014
	b. Surface		7.14	0.0008	0.05	0.06	85.1	-	1.1	-	0.03	0.085	0.31
	a. Subsurface	Aug. 21, 1979	0.3	-	-	0.002	8.56	-	0.33	-	-	0.005	0.018
	b. Surface		3.5	-	0.04	0.05	42	-	0.6	-	-	0.1	0.31

TABLE 7.1 (CONTINUED)

METAL ANALYSES

Site I.D.	Name	Date	Al	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Pb	Zn
XE03174-01	River Rd. & Westminster Hwy.												
	a. Subsurface	June 26, 1979	0.8	-	-	0.033	1.3	-	0.05	-	0.01	<0.001	0.008
	b. Surface		23.8	-	0.42	0.08	50	14.5	1.55	-	-	-	0.29
	a. Subsurface	July 10, 1979	-	-	-	0.009	2.2	-	0.10	-	-	0.006	0.011
	b. Surface		10.5	-	0.028	0.12	20	7.7	0.96	-	-	0.2	0.20
	a. Subsurface	July 24, 1979	1.0	-	-	0.004	1.2	-	0.07	-	-	<0.001	0.008
	b. Surface		36.5	-	-	0.12	60	-	2.65	-	-	0.154	0.33
	a. Subsurface	Aug. 7, 1979	0.9	-	-	0.005	1.51	-	0.07	-	-	<0.001	0.011
	b. Surface		22.	0.0019	0.06	0.12	40	-	4.37	-	0.09	0.2	0.61
	a. Subsurface	Aug. 21, 1979	0.11	-	-	<0.001	0.32	-	0.02	-	-	<0.001	0.011
	b. Surface		9.3	-	0.07	0.07	34	-	0.58	-	-	0.019	0.37
XE03275-01	Boundary Road												
	a. Subsurface	July 24, 1979	1.7	-	-	0.06	6.5	-	0.96	-	-	0.015	0.02
	b. Surface		2.1	-	-	0.02	2.5	-	0.17	-	-	0.029	0.012
	a. Subsurface	Aug. 7, 1979	0.33	-	-	0.003	0.80	-	0.08	-	-	0.001	0.01
	b. Surface		0.55	0.0005	0.007	0.03	1.07	-	0.08	-	0.01	0.008	0.10
	a. Subsurface	Aug. 21, 1979	0.31	-	-	0.001	0.51	-	0.03	-	-	<0.001	0.011
	b. Surface		0.42	-	<0.005	0.004	0.84	-	0.06	-	-	0.003	0.08

TABLE 7.1 (CONTINUED)

METAL ANALYSES

Site I.D.	Name	Date	Al	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Pb	Zn
XE03104-01	Carrington St. Discharge												
	a. Subsurface	July 10, 1979	-	-	-	0.017	2.2	-	0.09	-	-	.005	0.015
	b. Surface		0.6	-	0.008	0.18	2.2	7.8	0.09	-	-	0.043	0.18
	a. Subsurface	July 24, 1979	1.0	-	-	0.01	2.5	-	0.05	-	<0.01	0.004	0.012
	b. Surface		11.1	-	-	0.06	17	-	0.23	-	0.04	0.083	0.007
	a. Subsurface	Aug. 8, 1979	0.47	-	-	0.006	0.7	-	0.04	-	0.01	<0.001	0.008
	b. Surface		7.12	<0.005	0.02	0.05	12.3	-	0.45	-	0.02	0.017	0.15
XE03165-01	Gilbert Rd. North												
	a. Subsurface	June 27, 1979	-	-	-	-	-	-	-	-	-	-	-
	b. Surface		1.1	-	0.010	0.031	11	21.8	0.37	-	-	-	0.12

TABLE 7.2

STATISTICAL COMPARISON OF SURFACE TO SUB-SURFACE METAL CONCENTRATIONS FOR SIX STORM SEWERS, JULY - AUGUST, 1979

Ho: $\bar{x}_{surface} = \bar{x}_{subsurface}$

Test Statistic: Two-tailed Paired t-Test (α=0.05)

Parameter	Calculated t	Table t (α=.05)	Conclusions
Aluminum	2.67	2.16	Surface ≠ sub-surface
Cadmium	ND	ND	No sub-surface data
Chromium	ND	ND	No sub-surface data
Copper	4.68	2.10	Surface ≠ sub-surface
Iron	3.26	2.09	Surface ≠ sub-surface
Magnesium	ND	ND	No sub-surface data
Manganese	2.31	2.09	Surface ≠ sub-surface
Molybdenum	ND	ND	Only 1 analysis
Nickel	ND	ND	Only 2 pairs
Lead	3.44	2.13	Surface ≠ sub-surface
Zinc	5.03	2.11	Surface ≠ sub-surface

ND = Not determined.

APPENDIX 8

The Use of Fraser River Water
For Irrigation in the Estuary Study Area

THE USE OF FRASER RIVER WATER FOR IRRIGATION IN THE ESTUARY STUDY AREA

1. INTRODUCTION

The agricultural land of the Fraser River Delta requires irrigation during the dry weather season, which for certain crops begins in the middle of March and continues through to October. The two main growing areas in the lower Fraser valley are eastern Lulu Island and southern Delta. Peat bogs on the north and south sides of the Westminster Highway between Highway 99 and No. 9 Road on Lulu Island, contain a variety of truck garden crops as well as the only major cranberry farms in the river delta. Westham Island and a triangular stretch of land in Delta between Ladner, Tsawwassen and Highway 99 make up the second major area. The crops there include forage, truck garden, berries and lawn turf.

2. THE LULU ISLAND REGION

Of all the crops grown on Lulu Island, the cranberry fields, occupying approximately 1 000 acres between No. 7 Road, No. 9 Road and the Westminster Highway, use the most water. Vegetables, fresh produce, berries, forage crops and green house operations use the remainder. Irrigation of the cranberry fields begins in mid March as a safeguard against frost. Soil temperature is continually monitored, and ditch water pumped onto the fields insulates the crop when the soil temperature, drops below $0^{o}C$. Frost prevention may continue into July and resume again in September until October. During dry weather, irrigation continues at a rate of 19 000 m^3/day (approximately 19 m^3/acre day) using water coming from No. 8 Road and Cambie Road ditches. With the permission of the Richmond Drainage Authority, the flood gates for these ditches are kept open to allow Fraser River water to flood in at high tide and maintain irrigated water lost to evaporation and increased demand by developing crops (Figures 35 to 39).

2.1 Harvesting the Cranberry Crops

Cranberries are harvested by one of two methods: dry or wet.

The dry method involves mechanical combs which rake the bushes, removing the berries and passing them onto a conveyor belt which then loads them into sacks. Sacks weighing approximately 800 pounds are loaded into wooden crates and removed via helicopter to transport trucks[9].

The wet method requires that fields be flooded by several inches of water, prior to harvesting, allowing the buoyant berries to float on the surface. There they are collected using wooden booms. An added feature of this method is that it aids in the control of the berry weevil population, a pest proven difficult to eradicate by chemical means[9].

Ditch water is also used for irrigation of other food and forage crops in the area, many of which are sold directly to the public from roadside stands.

2.2 Routing of Fraser River Water to the Lulu Island Agricultural Fields

River water is currently allowed to flood the north end of No. 8 Road and Cambie Road ditches, but the volume is insufficient to supply the future needs of fields located near the Westminster Highway[9]. To meet this demand, farmers have proposed that Nelson Road and No. 7 Road south ditches be extended to the north side of Westminster Highway. The cost of these extensions would be shared by the farmers and the Federal and Provincial governments.

Both Nelson Road and No. 7 Road South border the Richmond Landfill and the Nelson Road ditch receives leachate directly from that landfill. The Nelson Road ditch also receives storm water from a concrete fabrication plant and this water has pH levels of up to 12.6[2].

3. THE DELTA IRRIGATION SYSTEM

Areas lying south of Ladner between Highway 17 and Canoe Pass receive water from two major sources: the Cohilukthan and Mason Road Sloughs which intersect to form a ditch near the corner of 36th Avenue and Arthur Drive (Figure 35). This ditch continues south along Arthur Drive and then east along Parameter Road (34 B Avenue) crossing Highway 17 and extending to 72nd Street. There it parallels the road north to the entrance of the Boundary Bay Airport and dead ends.

Areas east of the Boundary Bay Airport are irrigated by ditch water running parallel to 88th, 92nd, 96th and 104th Street. These ditches are connected to Center Slough which parallels the Roberts Bank Railway and joins Big Slough. Big Slough discharges at the south end of 112th Street to Boundary Bay.

Both regions have problems maintaining a water supply of sufficient quality for irrigation. Ditches in the Mason-Cohilukthan Slough area do not drain well and water tends to become stagnant, rapidly degrading and becoming unsuitable for irrigation. Water from the two sloughs must be pumped to these ditches at the inconvenience and expense of the farmer(9).

3.1 Water Tables of the Southeast Delta Area

The water table southeast of the Boundary Bay Airport may be divided into three levels: upper fresh water, middle salt water and lower freshwater. At the start of the irrigation season, the upper fresh water layer is of good enough quality for use on food crops. Loss of water eventually occurs through evaporation and use. As the season progresses, fresh water pressure decreases allowing salt water to rise, increasing the salinity in the ditches. The maximum recommended level of specific conductance for purposes of irrigation is 2 000 μS/cm. Conductivity readings taken on June 12, 13 and July 4, 1979 ranged from 13 000 to 38 000 μS/cm in Center Slough. Salinity of ditch water was observed to increase steadily from Highway 99 to the dykes at Boundary Bay(9).

3.2 Method of Supplementing the Delta Irrigation Water Supply

With the permission of the Delta Municipal Drainage Commission, the flood gates to the Mason Road and Cohilukthan Sloughs are left open at peak demand periods to allow the Fraser River to flood the ditches at high tide. This additional water can supply most of the local needs but is insufficient for irrigation of the areas west of Highway 17 (Figure 35).

One of the two proposed methods of moving Fraser River water to the southeast Delta area is by connecting Crescent Slough with a ditch that would parallel Highway 99. The other is the extension of the 72nd Street ditch west along the north border of the Boundary Bay Airport to connect to Center Slough.

3.3 The Crescent Slough Connection

The water course from Crescent Slough to Center Slough passes along the border of Burns Bog. Leachate from the landfill and the natural peat could contaminate the higher quality river water. Farmers using the ditch water near Burns Bog do so only as a last resort, since the acidic nature of the water depresses soil pH. After a summer of irrigation with acidic water the application of buffering chemicals (lime) is necessary in the spring, adding to production costs. Modifications to the Tilbury Slough Dyke is currently underway, which should allow water in the immediate area to be used as a possible supply to Crescent Slough.

3.4 The Cohilukthan Slough Connection

To connect Cohilukthan Slough to Center Slough, a ditch running along the north side of the Boundary Bay Airport would be necessary. Water transported by this route would not be contaminated by seepage in the way that water in the proposed Crescent Slough ditch would be contaminated. Airport fields could also use water from the new ditch as a supplement to their present supply.

3.5 Water Volume Required

During low use periods, sloughs used to transport river water could operate under the gravity feed system currently being used. This involves locking tide gates in open positions during periods of high tide when the river is in reverse flow. At low tide, the gates would be closed to retain water already in the ditch. During high use periods, a pump with a maximum capacity of 0.71 m^3/sec (25 cfs) could be used to supplement gravity flow and satisfy the expected peak demand of 0.80 m^3/sec (28 cfs).

Combined gravity flow plus pump flow systems would satisfy agricultural needs along Center Slough, allowing overflow into Big Slough and discharge to Boundary Bay. This overflow would be intended to progressively reduce the salinity of Center Slough and the ditches along 88th, 92nd, 96th, 100th and 104th Street by flushing the salt water and maintaining the upper fresh water table.

This upper fresh water table would hopefully slow salt water seepage from Boundary Bay into the ditches.

4. RECOMMENDATIONS

Water in ditches and sloughs used for irrigation, should be monitored on a regular basis, especially during periods of heavy usage.

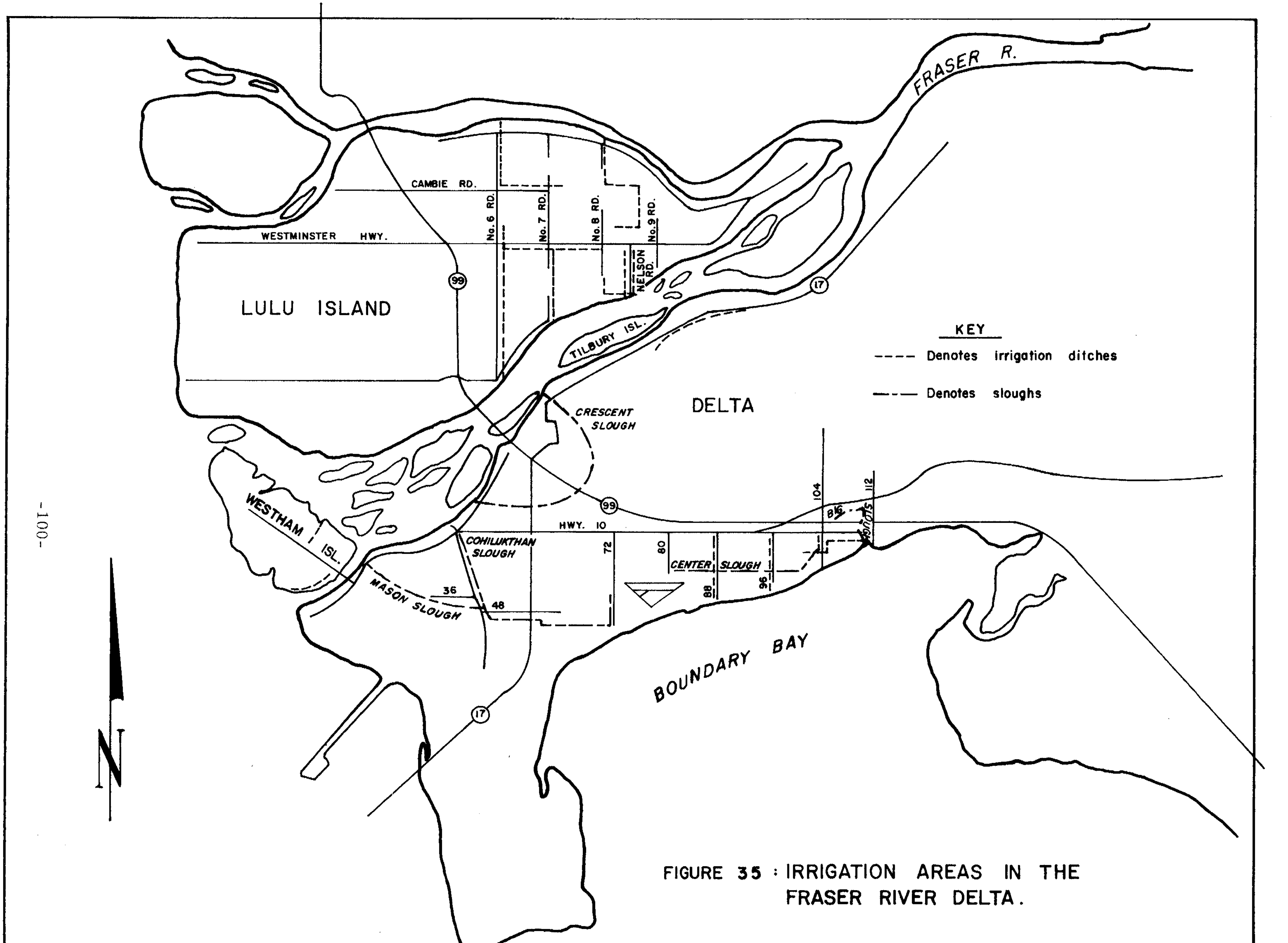


FIGURE 35 : IRRIGATION AREAS IN THE FRASER RIVER DELTA.

Figure 36

View of the Big Red Cranberry Farm

fields and access roads. Richmond.

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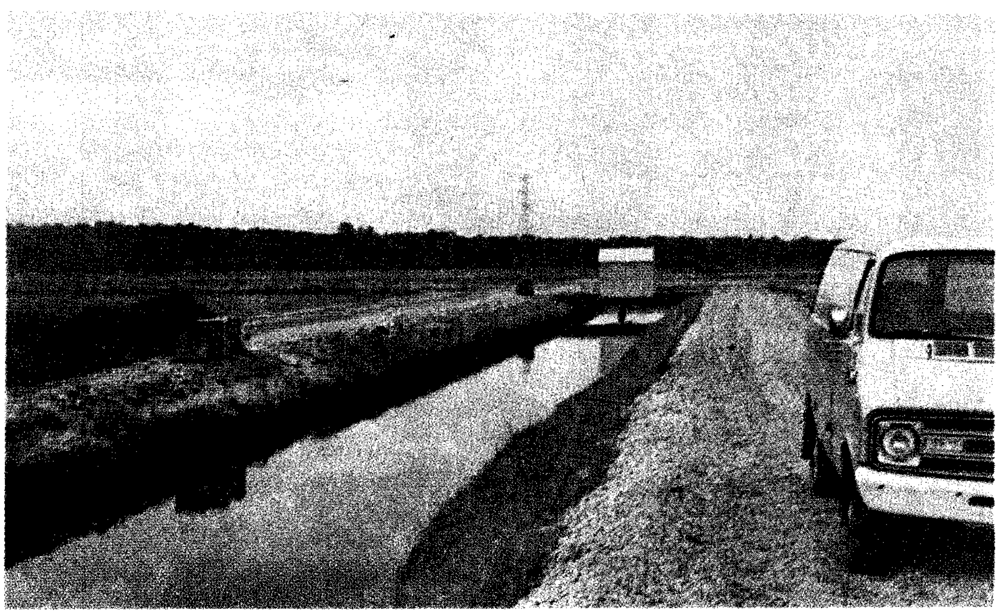

Figure 37

Fraser River water from No. 8 Road ditch and

irrigation pumphouse on Big Red Cranberry Farm, Lulu Island

Figure 38

Fraser River water from the Cambie Road ditch used for irrigation of newly planted cranberry fields

Figure 39

Ditch water (mixed with Fraser River water) being pumped onto crops in the Tilbury Slough area, Delta

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