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REPORT ON SURFACE AND GROUNDWATER QUALITY OF THE NUT BROOK SUB-BASIN, KELLIGREWS RIVER

DEPARTMENT OF ENVIRONMENT
Water Resources Division

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EXECUTIVE SUMMARY

A study was conducted to determine the water quality of the Nut Brook drainage basin of the Kelligrews River. This basin has a number of sources of possible water quality degradation. Results of this study indicate both surface water and groundwater quality deterioration in the Nut Brook sub-basin of the Kelligrews River system. Water quality deterioration is most obvious in the Nut Brook valley adjacent to the CBS landfill site and down gradient from salt storage sheds and a rendering plant. Water quality improves downstream of this area, but still exhibits characteristics of a highly impacted system. Results demonstrate that that elevated concentrations of sodium chloride in surface water and groundwater are sourced from the salt storage sheds, while elevated nutrients concentrations are sourced from the landfill and rendering plant. Results also indicate that the landfill and the Department of Works, Services and Transportation depot are the source of elevated metals concentrations in Nut Brook surface waters. High coliform bacterial levels are also observed near the landfill and sewage treatment station.

1.0 INTRODUCTION

In recent years the Kelligrews River has been the subject of public attention and concern due to a perceived pollution potential from industrial activities located in the Nut Brook sub-watershed. These activities consist of a municipal waste site, a salt storage depot, a rendering plant, a derelict vehicle storage site, and a sewage dewatering centrifuge facility. Besides detracting from the Kelligrews River aesthetic value, water quality deterioration in the river could pose a health risk for people in the area utilizing groundwater as a water supply source, as well as for people who use the river for recreational activities, such as swimming, bathing, and fishing. The Conception Bay South Municipal Park, located near the mouth of the Kelligrews River, has been in operation for about 12 years. The Kelligrews River widens at one point to form a swimming pool in the municipal park.

The potential hazards to public health as a result of the conflicting uses of the river have come to light over the past several years. Several articles expressing concern about contaminated surface and well waters, and health risks associated with the use of the swimming pool have appeared in local and provincial newspapers. In response to concerns expressed by the residents of Conception Bay South, the Water Resources Management Division of the Department of Environment and Lands carried out a limited surface water and groundwater sampling program in the fall of 1993. The study was intended to provide a preliminary characterization of the location, extent, and severity of water quality degradation in the Kelligrews basin.

1.1 Previous Work

A number of previous reports have been prepared for the area by both academic and government agencies. A study conducted by the Department of Environment and Lands from 1978 to 1981 found elevated level of various chemical parameters in surface waters in the vicinity of the landfill. Lake sediment sampling done by the Department of Mines and Energy showed anomalous concentrations of uranium and some other metals. However anomalous concentrations of uranium could not be found in either soils samples (Sherwin in Drover 1993) or in the underlying bedrock. Houle (1985 in Drover 1993) suggested groundwater may be responsible for the mobilization and deposition of uranium in the bottom sediments. MacLeod (1992 in Drover 1993) took bottom core sediments from Nut Brook Pond and proposed a mechanism whereby groundwater entering the pond was the transport vehicle for elevated uranium concentrations in core samples. A 1992 study of the Kelligrews River municipal park swimming pool by the Department of Environment and Lands concluded that no Canadian Council of Ministers of the Environment water quality guidelines for recreational water use were exceeded. Griffin (1988 in Drover 1993) compared the geochemistry of the Kelligrews and lower Gullies River drainage systems and concluded that stream water chemistry in the Kelligrews River drainage basin was being altered as a result of anthropogenic inputs. Drover (1993) collected surface water samples from the Nut Brook drainage area and sediment samples from Nut Brook Pond. He concluded that:

- The local geochemical environment of the Nut Brook drainage basin had been significantly altered by anthropogenic sources, particularly in the lower part of the drainage area.

- High concentrations of sodium and chloride in the surface waters of the basin are the result of salt-laden groundwaters, sourced in the region of the salt storage sheds.
- Peak uranium concentrations are the result of precipitating uranium from groundwater.

1.2 Objectives

The objectives of this study were:

- To assess the impact of industrial development on the Kelligrews River.
- To identify water quality problems.
- To delineate chemical and bacterial contaminant sources.

1.3 Basin Description

The Kelligrews River is located in Conception Bay South on the Avalon Peninsula. It flows in a northwesterly direction entering Conception Bay at Kelligrews Point. The river originates in Sandy Pond, a small pond located just east of Black Mountain. The major tributary, Nut Brook, flows into Kelligrews River about one kilometre downstream of Sandy Pond. Nut Brook originates in an area of bogs and small ponds just southeast of the Trans Canada Highway, approximately 2 kilometres west of the Foxtrap Road interchange.

The Kelligrews River basin, and in particular the Nut Brook sub-basin, has been the site of considerable development over the years. Development began in this sub-basin in the 1950's with construction of the Trans Canada Highway which runs through the brook's headwaters. Light industry in the Nut Brook basin consists of a Works, Services, and Transportation depot for equipment maintenance and road salt storage, a municipal landfill and incinerator, a sewage handling facility, and a rendering plant. All of these developments are concentrated in a small area just north of the Trans Canada Highway.

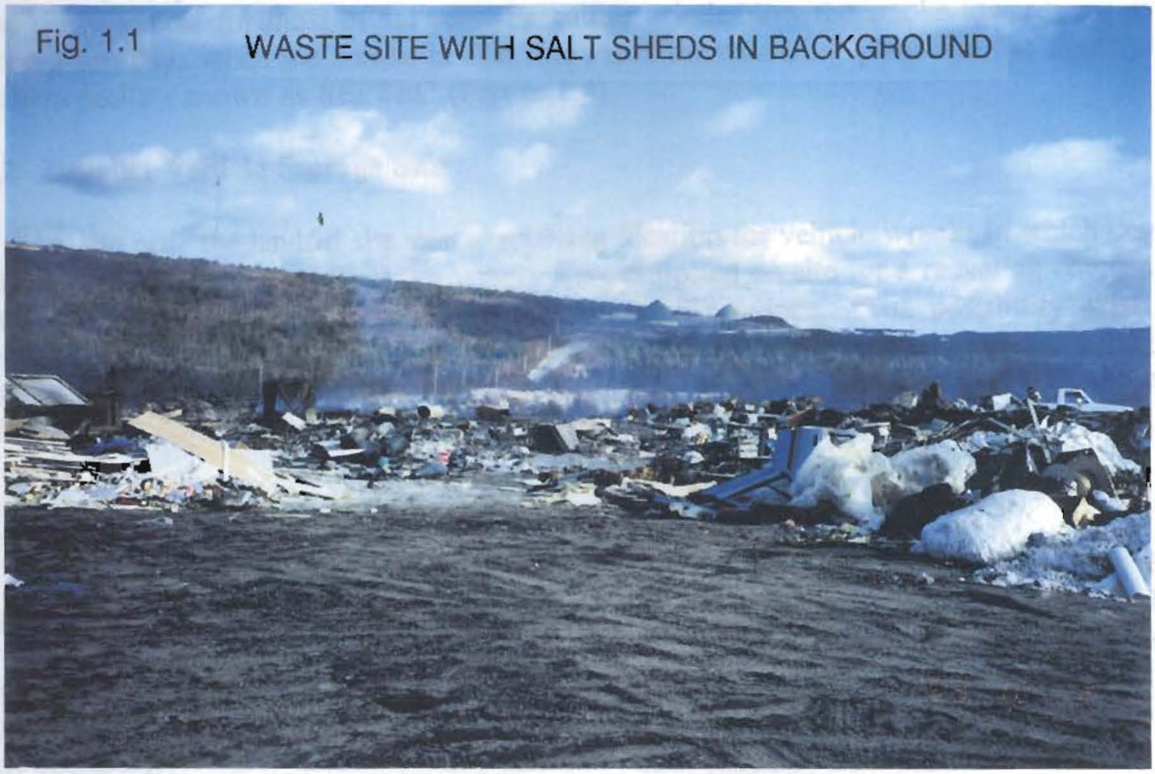
1.4 Potential Sources of Pollution

There are a number of possible sources of pollution within the Nut Brook sub-basin. They are discussed in the following sections.

1.4.1 Conception Bay South Landfill

A municipal landfill (Figures 1.1 and 1.2) has been in operation since 1973. This landfill receives garbage from the Conception Bay South(CBS) area. Garbage is placed, compacted and buried at the site. The landfill is not lined. Since the waste site has been in operation for over twenty years, a groundwater contaminant plume probably exists down gradient of the site. Practically all waste sites in Newfoundland are unlined which allows rainwater percolating down through the compacted and buried waste to dissolve waste constituents and reach the water table. Groundwater movement then transports this solute solution, called leachate, down gradient to form a leachate plume. Waste sites are usually located either near the coast so that any contaminants emanating from the them enters the ocean and are diluted, or are located sufficiently far away from water bodies and developed areas to allow for the natural decay of contaminants into the environment with time.

Figure 1.1 and 1.2



A teepee incinerator (Figure 1.3) also exists on the site for burning garbage. The landfill itself is frequently smouldering from fires. Because of this, smoke from the teepee and the waste site is visible for most of the year. Prevailing winds blow the smoke towards the TCH, but there are days when the smoke is blown towards the rendering plant and the septic water treatment facility known as SEPTEC (Figure 1.4).

1.4.2 Derelict Vehicle Storage Site

A site near the landfill site was a receiving location for vehicle wrecks in which derelict vehicles were stored until sufficient numbers were collected on site for a recycling company to come and crush the vehicles for shipment out of the province. The possibility exists for lubricants and coolants to leak out of these derelict vehicles while stored there and during the crushing operation. Since early 1993, vehicle wrecks have been stock piled within the main landfill site.

1.4.3 Rothsay Rendering Plant

Situated in the valley bottom next to Nut Brook Pond, the Rothsay Rendering Plant (Figures 1.5 and 1.6) was constructed in 1974. The plant accepts biological wastes from abattoirs, henneries, and dead animals such as horses and cows for disposal by rendering down this matter to produce meat meal. Effluent from this plant is piped to an aerobic bacteria aerator, and then into a marsh that drains into Nut Brook Pond(personal communication with plant operator).

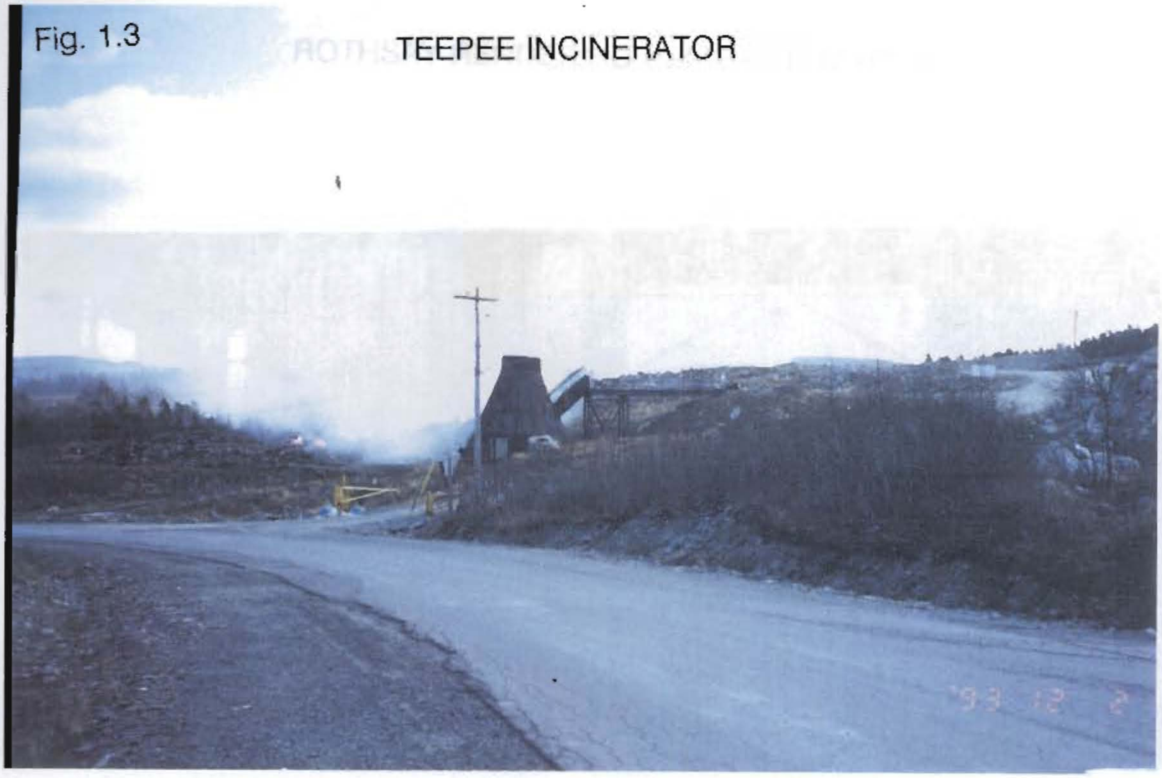
1.4.4 Salt Storage Sheds

A Department of Works, Services, and Transportation (WST) highways depot is situated within the basin near Penny's Hill. Two salt storage sheds (Figures 1.7 and 1.8) are used to store road salt used for ice control on highways. These sheds were constructed about four and twelve years ago respectively. Any road salt not used at the end of the winter is taken outside and mixed with sand. This mixture is left outside throughout the year(personal communication with Burne Walsh, WST - Foxtrap Depot). Runoff from the storage shed environs is directed to a road drainage ditch grading towards Nut Brook and the Rothsay plant at the bottom of the hill.

1.4.5 Septic Waste Centrifuge

A septic waste treatment facility called SEPTEC (Figure 1.9) is situated within the basin. It separates water and solids of septic tank wastes. The separated liquid is trucked to St. John's and pumped into the sewer system at Beck's Cove where it enters the harbour. The solids are stored on site for selling as a plant nutrient(communication with plant operator). To date, there are more solids produced than sold, resulting in mounds of the solids stored on site (Figure 1.10). This material is not covered, therefore the possibility exists for runoff from this pile eventually reaching Nut Brook. The runoff would contain nitrates leached from the piles. The treatment facility was constructed about 1991.

Figure 1.3
Figure 1.4



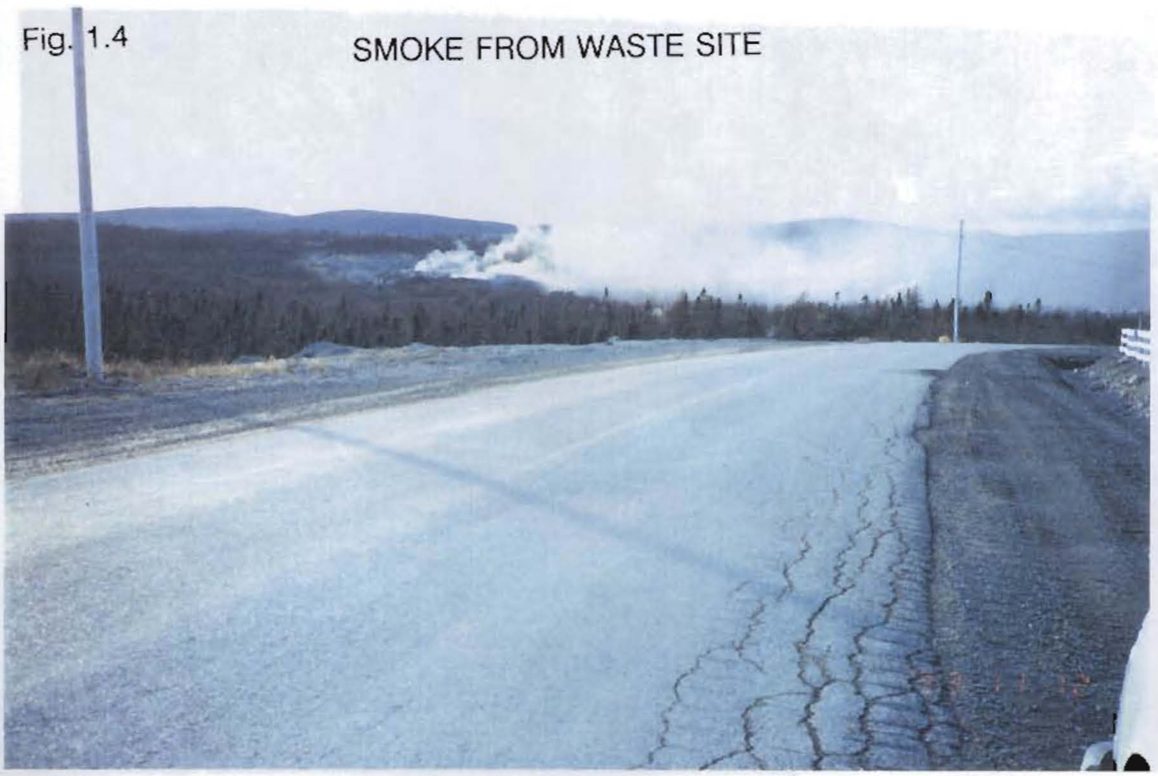


Figure 1.5
Figure 1.6

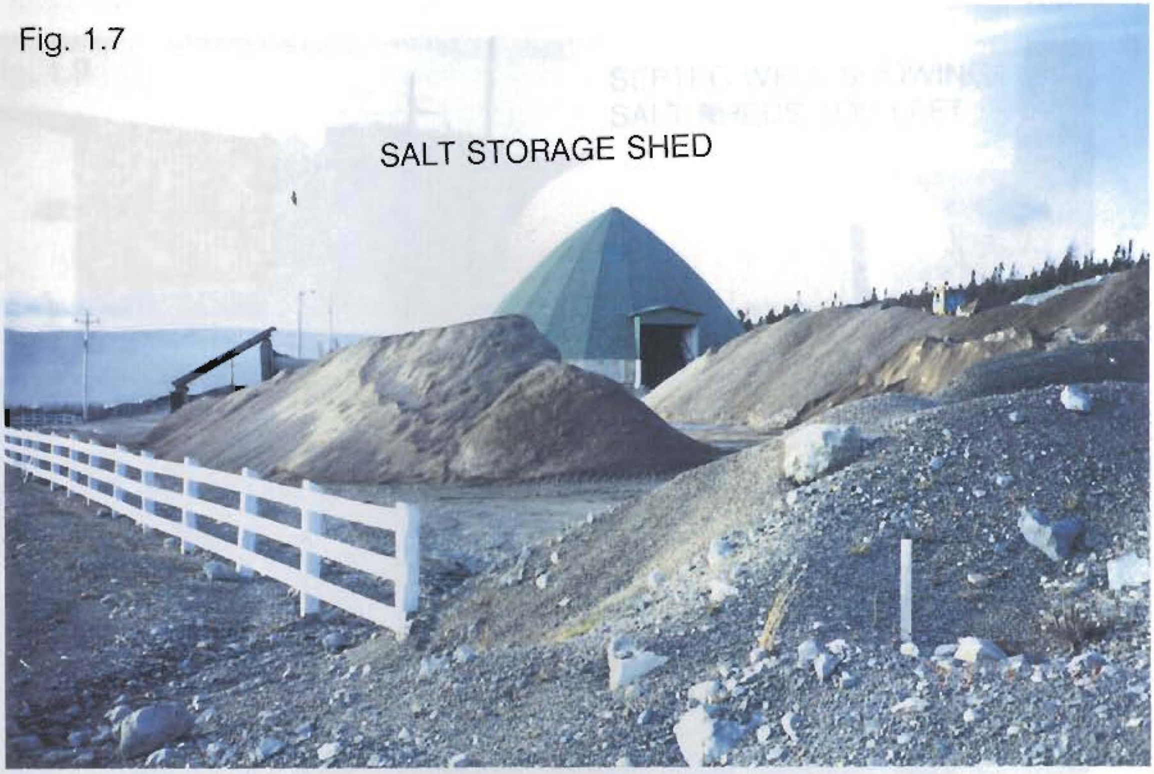
Fig. 1.5 ROTHSAY RENDERING PLANT FROM REAR

Fig. 1.6

ROTHSAY AERATOR NEXT TO NUT BROOK POND

Figure 1.7
Figure 1.8

Fig. 1.7



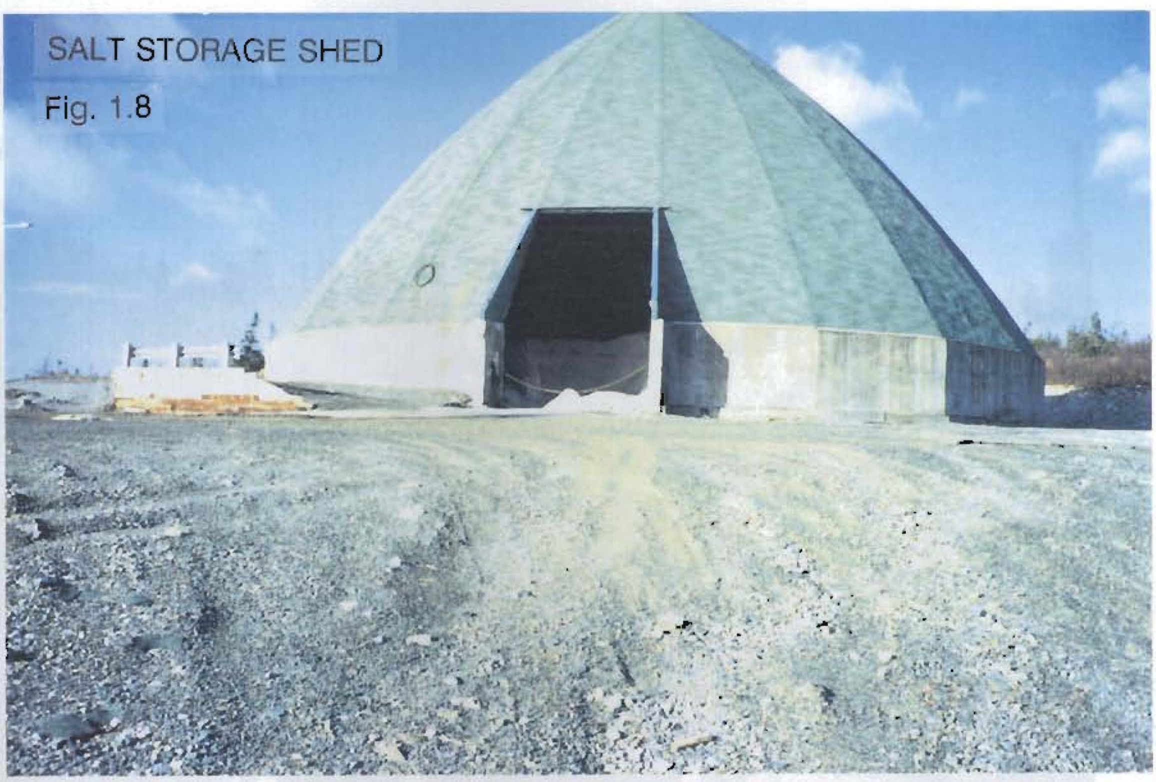
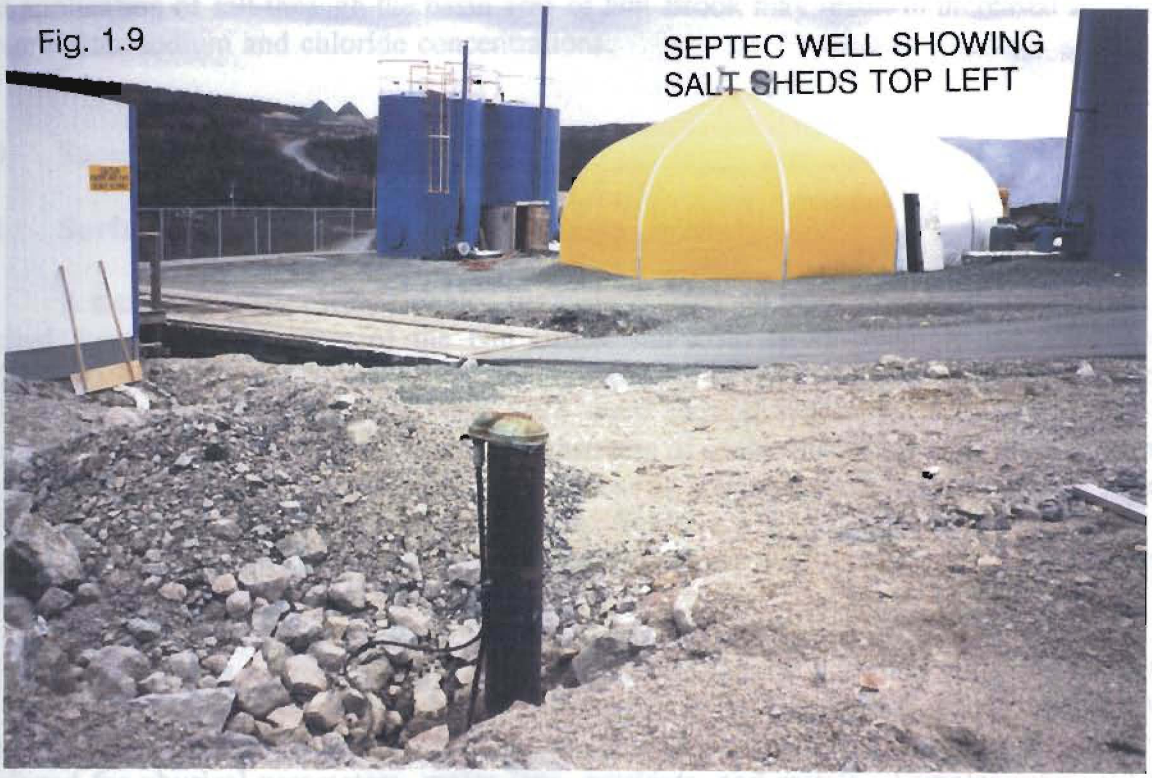


Fig. 1.8

Figure 1.9
Figure 1.10



SEPTEC SOLIDS PILE

Fig. 1.10

1.4.6 Road Salt Application - TCH Highway

Road salt is applied to control icing conditions on the TCH in winter and early spring. The application of salt through the basin area of Nut Brook may result in increased surface and groundwater sodium and chloride concentrations.

2.0 Sampling Sites and Procedure

2.1 Surface Waters

A total of five sites were sampled for surface water on September 8, 1993. Stations were located from the headwaters of the Nut Brook sub-basin downstream to the mouth of the Kelligrews River. Station SW1 was located upstream of development and provided background information; stations SW2, SW3, and SW4 were located within the Nut Brook sub-basin developed area; station SW5 was located downstream of of the Nut Brook sub-basin at the mouth of the Kelligrews River, and allowed an assessment of how well the Kelligrews River basin was able to assimilate inputs from the sub-basin. Table 2.1 lists the sampling stations, their descriptions, and potential impact sources. Figure 2.1 shows their location. Sites generally match those of Drover (1993).

Two samples were collected from each site. One sample was analyzed at the Department of Mines and Energy laboratory in St. John's, while the other was analyzed at the Water Analysis Laboratories in Mount Pearl. Samples submitted to the Water Analysis Laboratory were analyzed for physical parameters, major ions, nutrients, and metals. Samples submitted to the Department of Mines and Energy laboratory were analyzed for major ions and metals. Bacteriological parameters were analyzed at the Department of Health laboratory in St. John's.

Table 2.1 Kelligrews River Surface Water Sampling Sites, September 1993

Station	Description	Potential Impact Sources
SW1	Nut Brook 50 m upstream TCH	None
SW2	Nut Brook @ Incinerator Road	Salt Storage Sheds
SW3	Nut Brook @ CBS Landfill	Salt domes+landfill+SEPTEC+car wrecks (not rendering plant)
SW4	Nut Brook @ Nut Brook Pond Outlet	All of SW3 sources+rendering plant
SW5	Kelligrews River @ Red Bridge Road	All of SW4 sources+dilution by other sub-basins

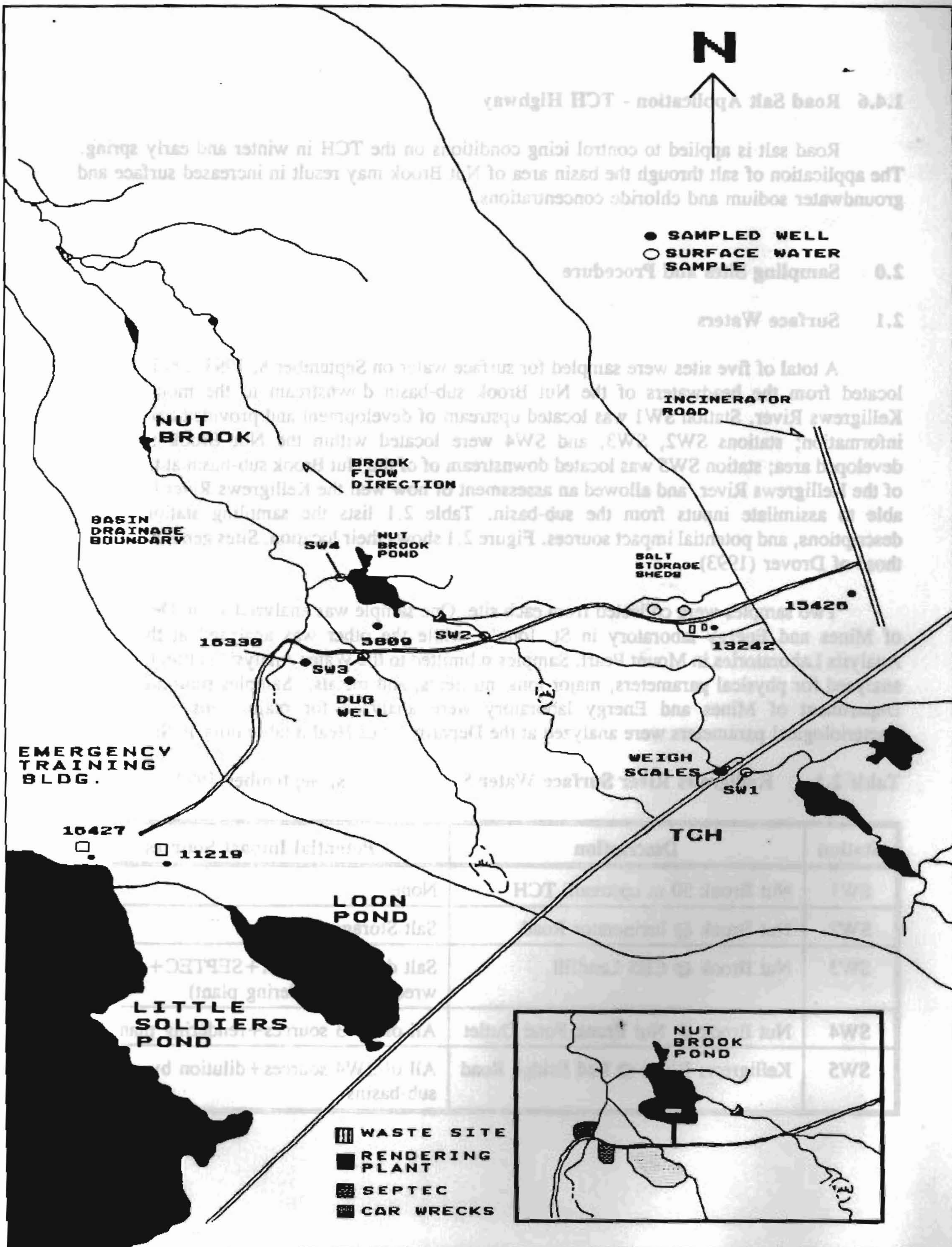


Figure 2.1 Surface and Well Sampling Sites

2.2 Groundwater

This study did not entail the drilling of any monitoring wells. Therefore, existing wells within and adjacent to the Nut Brook drainage basin were located and sampled to provide an indication of groundwater quality. This was accomplished by first searching a database maintained by Water Resources Division of all drilled wells in the Province. This information is sent to this department by licenced water well drilling companies as required under the *Well Drilling Act*. A list of drilled wells is shown in Table 2.2. Next a reconnaissance survey of all establishments was done to obtain information on where they obtain their potable water and what effluent, if any, emanates from each establishment. This survey was also done as a check of the drilled well data obtained and to locate any dug wells within the drainage basin. A total of nine wells were sampled.

Sampling was done in September 1993 of all dug and drilled wells in and near the drainage basin that could be influenced by anthropogenic actions within the basin. The surface water sampling program was carried out at the same time. Figure 2.1 shows their location. Water sampling consisted of drawing tap water from each establishment after letting the water run for 5 minutes. This purging of the well was done to obtain a representative sample of groundwater from the formation and not of water that was stagnant in the well bore or pressure tank for any length of time. Samples were collected in clean, inert one-litre water sampling bottles, two per site. Each sample was placed in a cooler, and delivered to the Water Analysis Laboratories the same day. The second set of samples was taken to the Department of Mines and Energy for analysis by their ICP Ultrasonic Nebulization analyzer. No groundwater springs were observed to be sampled.

3.0 RESULTS AND DISCUSSION

3.1 Physical Parameters

Physical water parameters are quite valuable in establishing the quality of a water system. Specific conductivity is a measure of dissolved salts. High conductivities reflect high levels of dissolved solids. The pH of a water is a measure of acidity, and can affect nutrient availability, trace element toxicity, and biological species composition. Dissolved oxygen is important for survival of fish. Color is a measure of organic material, while turbidity is a measure of suspended solids.

Table 2.2 Nut Brook Basin Area Drilled Wells

ADDRESS	WELLOWNER (last name first)	WELL #	DATE (D/M/Y)	WELL DEPTH (M)	FINAL STATUS	YIELD L/MIN	KIND OF WATER	LITHOLOGY
Incinerator Road	Dept. Works, Services & Transportation	13242	03/03/88	69.0	AB	11.0	FR	obdn 008 rock 069
Incinerator Road	EMO Building	11219	01/10/84	86.9	WS	73.0	FR	sand 017 grvl rock 073
Incinerator Road	Dept. Works, Services & Transportation	15426	28/11/90	147.9	WS	1.0	FR	brwn sand/grvl 007 brwn grnt 148
Incinerator Road	Rothsay Rendering Plant	5809	00/03/75	15.2	AB	54.6		
Incinerator Road	SEPTEC	16330	16/04/92	18.3	WS	90.1	FR	whit/red grnt 007 red grnt 018
Foxtrap Access Road	Petten Jeff	14729	11/10/89	105.2	WS	9.0	FR	red obdn 028 brwn grnt 105
Incinerator Road	Fire Survival Center	16427	25/08/92	30.5	WS	22.0	FR	brwn sand obdn 007 grey slte 031
Middle Bight Road	Hayes Jim	16112	04/10/91	109.7	WS	81.8	FR	brwn grvl/sand 024 grey/red shle 110
TCH	Weigh Scales, Dept. WST*							

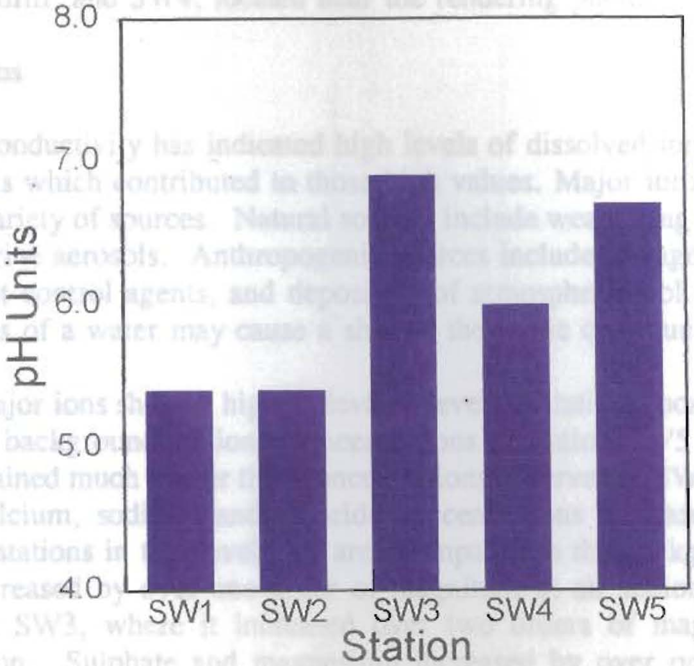
AB - abandoned; WS - water supply; FR - fresh; obdn - overburden; grvl - gravel; grnt - granite; slte - slate; shle - shale

* Information unavailable on weigh scales well

Parameter mg/L	SW1	SW2	SW3	SW4	SW5
Cadmium	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Chromium	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
	0.003	0.001	0.001	0.001	0.001
Copper	< 0.005	< 0.005	< 0.005	< 0.005	0.020
	0.002	0.008	0.005	0.004	0.003
Iron	0.47	0.78	0.72	0.57	0.13
Mercury	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Manganese	< 0.005	0.130	0.610	0.110	< 0.005
	0.016	0.109	0.605	0.170	0.035
Nickel	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
	< 0.002	< 0.002	0.004	0.003	0.002
Lead	0.002	0.005	0.001	0.007	0.005
Zinc	< 0.005	0.020	0.010	0.010	< 0.005
	0.0025	0.0097	0.0066	0.0110	0.0032
Cobalt					
	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum					
	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Yttrium					
	< 0.0005	0.0020	0.0008	0.0016	< 0.0005
Total Coliform (no/100 ml)	60	< 20	5600	120	20
Fecal Coliform (no/100 ml)	< 10	< 10	3700	90	< 10

The general trend in pH values was to increase in the developed area, but unlike specific conductivity, pH did not tend to show a substantial decrease with distance downstream (Figure 3.2). Two of the stations in the developed zone showed an increase over the background value of 5.4 pH units: station SW3, where a pH of 6.9 was observed (over 10x more alkaline than background) and SW4 with a pH of 6.0. The increases at SW3 and SW4 suggest that inputs from the landfill and rendering plant should be considered as major sources of pH increases.

Figure 3.2. pH values for Kelligrews River stations (September 1993). Stations below the landfill area have elevated pH compared to headwaters.



Guidelines for the protection of freshwater aquatic life state that pH should not vary beyond the range of 6.5 - 9.0 pH units (CCME, 1987). Stations SW1 and SW2 violated this guideline, but the low pH values at these stations (Table 3.1) are probably due to organic acids associated with the boggy headwaters.

The International Joint Commission (1977 in McNeely et al., 1979) recommended that discharges should not alter ambient pH by more than 0.5 pH units. Field pH at station SW3 increased 1.5 pH units over ambient pH (5.4). pH at stations SW4 and SW5 increased 0.6 and 1.3 pH units, respectively.

Dissolved oxygen decreased from 7.46 mg/L at the background station to 5.71 mg/L at station SW3, and to 6.30 mg/L at station SW4. Low dissolved oxygen values were localized, however, as demonstrated by the high value (10.21 mg/L) observed at station SW5. Both SW3 and SW4 probably receive large inputs of organic wastes - SW3 from the landfill and possibly sewage handling facility, and SW4 from the rendering plant. Processes such as decomposition of organic wastes can deplete oxygen levels to near zero values. Guidelines for the protection of freshwater aquatic life state that the lower limit for dissolved oxygen for cold-water fish should not fall below 6.5 mg/L (CCME,1987). Stations SW3 and SW4 are both less than this limit (Table 3.1).It is likely that salmonids (e.g. trout) are unable to survive in most oxygen depleted areas. As well, the toxicity of elements such as lead, zinc, copper, and ammonia is enhanced by low dissolved oxygen.

Turbidity and total suspended solids remained relatively low at all stations. Color values were relatively high at all stations, except SW5. The highest color values were observed at SW3, located at the landfill, and SW4, located near the rendering plant.

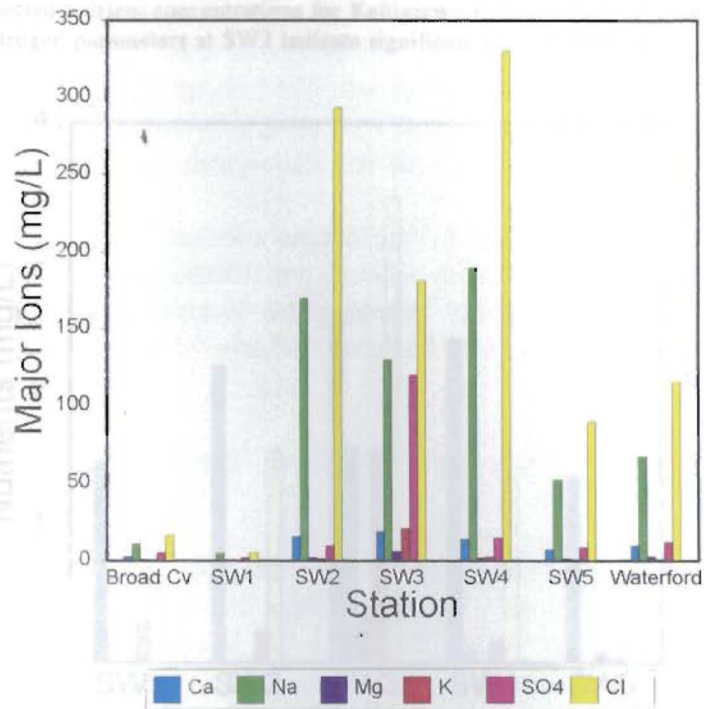
3.2 Major Ions

Specific conductivity has indicated high levels of dissolved ions. This section examines the individual ions which contributed to those high values. Major ions are contributed to water systems from a variety of sources. Natural sources include weathering of soils and bedrock, and deposition of marine aerosols. Anthropogenic sources include sewage, industrial effluents, de-icing salts or dust control agents, and deposition of atmospheric pollutants. Changes in major ion concentrations of a water may cause a shift in the biotic community.

Major ions showed highly elevated levels at stations located in the developed area compared to the background station. Concentrations at station SW5 decreased as a result of dilution, but remained much higher than concentrations observed at SW1, the background station (Figure 3.3). Calcium, sodium, and chloride concentrations increased by over one order of magnitude at all stations in the developed area compared to the background station. Potassium concentration increased by over one order of magnitude at all stations in the developed area, except at station SW3, where it increased over two orders of magnitude compared to the background station. Sulphate and magnesium increased by over one order of magnitude at station SW3 compared to the background station. These increases and resulting high concentrations are not typical of natural waters. All elements, except sodium and chloride, reached peak concentrations at station SW3 (Table 3.1), the station located at the landfill, suggesting that the landfill may be the primary source for most of the increases observed in the major ion concentrations. Sodium and chloride peaked at stations SW2 and SW4, the two stations located closest to the salt storage sheds, suggesting that salt laden surface and subsurface waters were the primary source for the high sodium and chloride concentrations observed in the basin.

Hardness, which is a function of calcium and magnesium in solution, and total dissolved solids, also followed this pattern of increase in the developed area followed by decrease downstream.

Figure 3.3. Major ion concentrations from Kelligrews River stations (September 1993) and mean September major ion concentrations for Canada-Newfoundland monitoring stations on Broad Cove and Waterford Rivers (1987-1991). As with specific conductivity, only the headwater station (SW1) is similar to natural rivers.



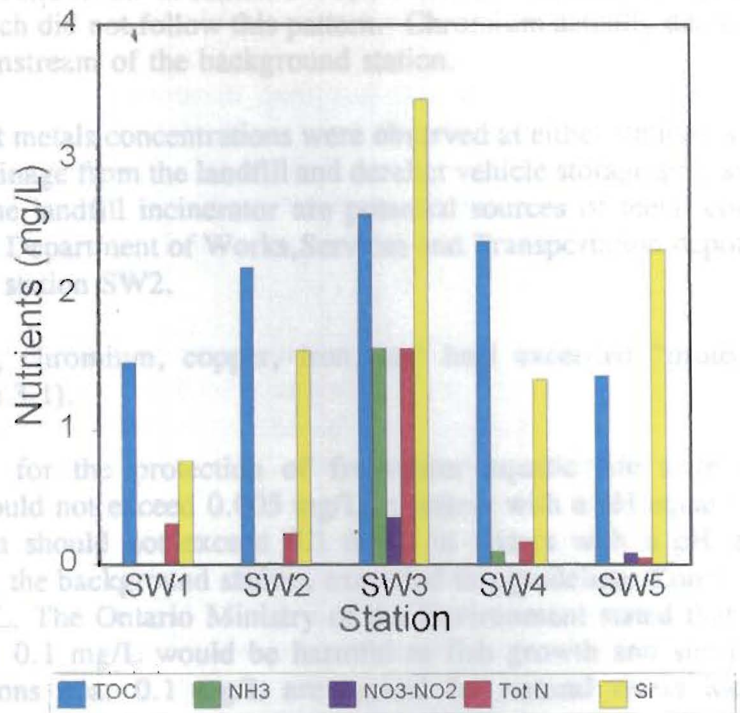
Alkalinity is a measure of a water's ability to neutralize acid. Alkalinity or bicarbonate concentration showed a sharp increase at station SW3, indicating a large input of alkaline material from the landfill.

3.3 Nutrients

Decomposing organic matter is a primary source of nutrients. Nutrient enrichment and eutrophication can result in changes to aquatic populations. Nutrient rich conditions can result in prolific growths of aquatic vegetation. Decomposition of this vegetation can lead to excessive utilization of dissolved oxygen, which in turn can affect fish and benthic organism diversity and density.

Most nutrients exhibited elevated concentrations at stations located in the developed zone, compared to the background station. Phosphorus remained at or below detection limit at all stations. Elevated concentrations were particularly evident at SW3, where the highest concentrations for all detectable nutrients were observed (Figure 3.4). The greatest increases observed at SW3 were ammonia which increased from less than 0.02 mg/L at the background station to 1.60 mg/l at SW3 (aproximately two orders of magnitude), and nitrate-nitrite which increased from less than 0.004 mg/L at SW1 to 0.350 mg/L at SW3 (again, almost two orders of magnitude).These increases at SW3 indicate large inputs of nutrient rich organic waste such as sewage and animal or vegetable waste. The most obvious sources of this waste are the landfill and SEPTEC facility. Elevated levels of these same two nutrients at SW4 (Table 3.1) may be the result of effluent from the rendering plant.

Figure 3.4. Selected nutrient concentrations for Kelligrews River stations (September 1993). High values for all nitrogen parameters at SW3 indicate significant organic loading to surface water.



The concentrations of all nutrients at station SW5, except nitrate-nitrite, and silicon were comparable to background concentrations.

Guidelines for the protection of aquatic life state that nitrite concentration should not exceed 0.06 mg/L. A numerical limit is not recommended for nitrate. The analytical methodology reports only the total of nitrate plus nitrite. Stations SW3 and SW5 had values in excess of 0.06 mg/L nitrate-nitrite and are considered to have exceeded the nitrite guideline (Table 3.1).

3.4 Metals

Concerns over metals relate to their toxicity and bioavailability, particularly for uncomplexed ions, the potential for bioaccumulation, and hazards to human health (CCME, 1987). Uncomplexed forms are usually more readily available to aquatic organisms than are complexed forms. Speciation and bioavailability of trace metals in water are controlled by various physical and chemical interactions. These interactions are affected by many factors such as pH, temperature, hardness, type and concentration of metal ions, and dissolved organic carbon, etc.

Aluminum, chromium, copper, iron, manganese, nickel, lead, zinc and ytterbium were the only metals consistently detectable.

Nearly all detectable metals increased from about 2 to 4 times their background concentrations in the developed area (Table 3.1). Manganese, however, exhibited much higher increases in the developed area - over two orders of magnitude at station SW3. Values generally declined to background levels at station SW5, the farthest downstream station. Chromium was the only metal which did not follow this pattern. Chromium actually decreased in concentration at all stations downstream of the background station.

The highest metals concentrations were observed at either stations SW2 or SW3. Surface and subsurface drainage from the landfill and derelict vehicle storage site, as well as atmospheric deposition from the landfill incinerator are potential sources of metal contamination at SW3. Drainage from the Department of Works,Services and Transportation depot may account for the elevated metals at station SW2.

Aluminum, chromium, copper, iron, and lead exceeded "protection of aquatic life guidelines" (Table 3.1).

Guidelines for the protection of freshwater aquatic life state that total aluminum concentrations should not exceed 0.005 mg/L in waters with a pH equal to or below 6.5. The total concentration should not exceed 0.1 mg/L in waters with a pH greater than 6.5. All stations, including the background station, exceeded this guideline. Concentrations ranged from 0.14 to 0.46 mg/L. The Ontario Ministry of the Environment stated that concentrations equal to or greater than 0.1 mg/L would be harmful to fish growth and survival (CCME,1987). Mean concentrations near 0.1 mg/L are typical for natural rivers located on the Avalon Peninsula.

Iron concentrations ranged from 0.13 to 0.78 mg/L. Iron precipitates may produce adverse effects on fish and other aquatic organisms, so a maximum concentration of 0.3 mg/L has been established for protection of the aquatic environment (CCME, 1987). All stations, except station SW5, exceeded this guideline. Sewage and landfill leachate are anthropogenic sources of iron (CCME,1987). Iron concentrations in natural waters on the Avalon Peninsula are generally below 0.3 mg/L.

Lead is a toxic material which is bioaccumulated by aquatic organisms. It forms a coagulative film on the mucous membrane of fish and this leads to eventual suffocation (McNeely et al., 1979). Guidelines for protection of freshwater aquatic life range from 0.001 to 0.007 mg/L, depending on hardness (CCME,1987). All stations, except station SW3, exceeded this guideline based on hardness values obtained at the stations. The highest concentration observed was 0.007 mg/L. Average lead concentrations for natural rivers in the area are generally around 0.0003 mg/L. The toxicity of lead decreases with increasing alkalinity. Since several stations on the Kelligrews River system have low alkalinities, any lead present might have high toxicity. Sources of lead include precipitation, fallout of lead dust, and industrial and municipal wastewater discharges.

Guidelines for the protection of aquatic life for copper range from 0.002 to 0.004 mg/L depending on hardness. The results from the Department of Mines and Energy indicated that all stations, except station SW1, exceeded this guideline based on hardness values measured at the stations. The highest value observed was 0.008 mg/L. Results from the Water Analysis Laboratory showed that only station SW5, with a value of 0.020 mg/L exceeded this guideline. Mean concentrations near 0.001 mg/L are typical of natural rivers in the area.

Guidelines for the protection of the aquatic community, including zooplankton and phytoplankton, state that the concentration of chromium should not exceed 0.002 mg/L. Results from the Water Analysis Laboratory were all less than detection limit. Results from the Department of Mines and Energy showed that only the background station exceeded this guideline, but all other stations measured a value of 0.001 mg/L. Chromium concentrations for natural rivers in the area are generally at or below detection limits.

3.5 Bacteria

Indicator organisms, rather than specific pathogenic organisms, are utilized to determine bacteriological water quality. One of the most commonly used indicator organisms are fecal coliform bacteria, associated with the feces of warm-blooded animals. Waters contaminated with fecal material may contain other pathogenic organisms.

Guidelines for recreational water quality state that fecal coliforms should not exceed 200 per 100 ml (Health and Welfare Canada,1992). A fecal bacteria count of 3700 per 100 ml was observed at station SW3. The landfill and SEPTEC were likely sources of this potentially dangerous indicator. The fecal count at SW4 was elevated (90 per 100 ml), but below the guideline, showing no major problem near the rendering plant on this sampling date.

3.6 Well Sampling Results

Table 3.2 shows the results of the well sampling program conducted on September 8, 1993. The results were compared with the Canadian Water Quality Guidelines, maximum acceptable concentrations(MAC) values, where a guideline value existed for a specific parameter. Those values which exceeded the MAC concentrations are flagged by a grey background in the table. Elevated values, values that exceed designated background concentrations are important indicators of natural or man made processes occurring locally in the subsurface regime. Elevated concentrations are shown underlined. Background values were calculated from sampled wells up gradient of anthropogenic sources in the basin. Since no wells are situated up-gradient of the TCH, a source of deicing salt, sodium and chloride backgrounds were not calculated.

Since sampling was done on existing wells, the groundwater sampling results of this report may not represent the true picture of groundwater quality for the area under study. Surface water sampling can be accomplished at any point of choosing, but interpreting groundwater sampling results, using existing well locations, considerably reduces the accuracy of any plume delineation.

Table 3.2 Well Water Sample Results

Parameter mg/L	Weigh Scales	Rothsay #5809	Incin. Site Dug Well	Well #16330 SEPTEC	Well #16427 Fire Sh.	Well #15426 WST	Well #11219 EMO Bldg	Well #14729 J Petten	Well #16112 J Hayes	Dale Phillips Dug Well
Alkalinity (as $CaCO_3$)	66.8	159	25.6	8.15	69.0	45.1	79.2	72.3	94.1	28.4
Apparent Colour TCU	4	8	57	7	<3	4	<3	<3	22	4
Hardness (as $CaCO_3$)	74.4	233	31.3	34.5	61.1	116	65.2	75.6	17.4	32.5
Kjeldahl nitrogen N	0.03	1.2	0.02	0.09	0.04	0.06	0.03	0.05	0.04	0.03
Nitrate (+nitrite) N	0.028	0.012	0.38	0.41	0.121	0.060	0.089	1.2	2.2	0.30
pH units	7.47	7.72	6.36	5.92	8.07	7.83	8.03	8.31	8.80	6.55
Total Phosphorus PO_4	<0.02	0.21	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02
Specific Conductance	203	1390	139.5	370	144.3	419	158.2	193.2	236	137.5
Turbidity NTU	2.13	2.26	17.6	1.78	1.06	0.72	0.50	1.49	7.50	5.31
Calcium	25	75	10	10	22	44	22	26	5.6	8.4
	26.66	80.98		11.43	23.52	52.73	23.82	25.66	7.03	10.63
Magnesium	2.90	11	1.53	2.32	1.50	1.60	2.50	2.60	0.84	2.80
	2.771	11.964		2.097	1.463	2.069	2.348	2.432	0.864	2.527

Parameter mg/L	Weigh Scales	Rothsay #5809	Incin. Site Dug Well	Well #16330 SEPTEC	Well #16427 Fire Sh.	Well #15426 WST	Well #11219 EMO Bldg	Well #14729 J Petten	Well #16112 J Hayes	Dale Phillips Dug Well
Manganese	<0.005	2.92	0.61	0.52	<0.005	<0.005	<0.005	<0.05	<0.005	0.01
	0.007	2.688		0.419	0.008	0.019	0.003	0.020	0.006	0.017
Iron	0.02	0.07	0.41	0.02	<0.01	0.02	<0.01	0.02	0.02	0.05
Copper	0.03	<0.005	0.67	0.04	0.07	0.02	0.28	<0.005	<0.005	0.08
	0.033	0.010		0.029	0.063	0.041	0.209	0.011	0.008	0.162
Zinc	0.02	0.08	0.15	0.02	0.04	0.74	0.23	0.01	<0.005	0.02
	0.0084	0.103		0.0257	0.036	0.7482	0.2732	0.0057	0.0059	0.0122
Cadmium	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Lead	<0.001	0.007	0.005	0.005	0.001	0.003	<0.001	<0.001	<0.001	<0.001
Chloride	28	261	9.6	109	7.5	33	5.2	8.9	12.5	22
Sodium	11	220	11	66	7.7	33	6.9	13	49	12
	10.51	181.67		58.13	5.52	31.94	6.23	12.98	47.64	12.40
Potassium	0.39	23	1.14	0.86	0.52	0.25	0.66	0.65	1.34	0.65
	0.3	22.9		0.8	0.5	0.3	0.6	0.6	1.3	0.6
Aluminum	0.11	<0.05	<0.05	0.22	<0.05	<0.05	<0.05	<0.05	0.57	<0.05
Chromium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	0.003	0.002		0.002	0.003	0.001	0.001	0.002	<0.001	0.002
Nickel	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Parameter mg/L	Weigh Scales	Rothsay #5809	Incin. Site Dug Well	Well #16330 SEPTEC	Well #16427 Fire Sh.	Well #15426 WST	Well #11219 EMO Bldg	Well #14729 J Petten	Well #16112 J Hayes	Dale Phillips Dug Well
	<0.002	<0.002		<0.002	<0.002	0.002	<0.002	<0.002	<0.002	0.003
Ammonia	<0.02	1.2	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride	0.09	0.22	0.06	0.09	0.13	0.69	0.11	0.60	0.13	0.10
Sulphate	4.0	210	21	5.8	2.1	120	2.1	16	8.0	3.4
	4.4	180.0		6.2	2.4	126.9	2.2	15.0	9.1	3.5
Total Dissolved Solids	135	1180	93	247	96	279	105	129	157	92
Total Suspended Solids	<4	<4	4	<4	<4	<4	<4	<4	<4	6
Total Organic Carbon	1.3	2.5		1.2	1.3	1.3	1.0	1.2	1.1	1.1
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Molybdenum (ppb)	<1	1		1	1	18	1	20	2	1
Silicon	5.73	4.87		4.03	6.01	4.24	6.18	4.42	5.33	8.04
Cobalt (ppb)	<1	<1		<1	<1	<1	<1	<1	<1	<1

Parameter mg/L	Weigh Scales	Rothsay #5809	Incin. Site Dug Well	Well #16330 SEPTEC	Well #16427 Fire St.	Well #15426 WST	Well #11219 EMO Bldg	Well #14729 J Petten	Well #16112 J Hayes	Dale Phillips Dug Well
Yttrium (ppb)	0.6	0.9		5.1	1.6	<0.5	<0.5	<0.5	<0.5	<0.5

All parameters have units of milligrams/litre (mg/L) unless otherwise stated. Second row results per parameter and results from Dept. of Mines and Energy (M&E), I.C.P. Ultrasonic Nebulization. Shaded area indicates parameter exceeds *Canadian Drinking Water Quality Guidelines* maximum acceptable concentration (MAC). Underline indicates an elevation concentration value.

Wells that are closest and down gradient of suspected sources of contamination usually show the highest concentrations related to the source of contamination. The only wells sampled that provide an indication of groundwater contamination within the valley and down gradient of the possible contamination sources are the Rothsay Plant and SEPTIC wells. The dug well on the waste site is up gradient of the site and does not penetrate bedrock. One would suspect theRothsay rendering plant well as the most susceptible to contamination. The well is located at the bottom of a hill at the crest of which are situated two salt storage sheds operated by the Dept. of Works, Services, and Transportation. The well is also in close proximity to the Conception Bay South waste disposal site.

3.6.1 Rothsay Rendering Plant Well

The well water exceeds Canadian Drinking Water Guidelines in 3 parameters - chloride(261 mg/L), manganese(2.9 mg/L), and total dissolved solids(118 mg/L). Elevated concentrations for magnesium, calcium, potassium, ammonia, and sulphate were also noted which indicate possible contamination from their own effluent and possibly the landfill site. High values of ammonia(1.2 mg/L - 50 times background), potassium(23 mg/L - 20 times background), and total phosphorus(0.21 mg/L - 10 times background) can be the result of animal waste decay and their by products. Whether some of these values are due to any waste site leachate cannot be determined given the location of the existing wells. The high Na and Cl concentrations at SW2 indicate that the high Na and Cl concentrations in the Rothsay well are not solely due to the rendering plant, but are to a large part the result of runoff from the salt storage sheds. It appears that the deeper groundwaters in the valley have been charged with salt from the salt storage sheds at the top of the hill. This is reinforced by the elevated NaCl values downstream where some groundwater is discharging to Nut Brook and possibly the Kelligrews River.

3.6.2 SEPTEC Well

This drilled well also seems to be affected by salt in the valley groundwater system. Elevated Na(66 mg/L) and Cl(109 mg/L) concentrations further suggest contamination of the bedrock aquifer. Also manganese(0.52 mg/L) and pH(5.92) exceeds MAC limits for drinking water. As can be seen from Figure 1.9, the land grading around this well is not sloped properly away from the casing, but has a depression surrounded by coarse aggregate. This allows surface water or any spilled contaminant to pond around the casing, eventually running down the side of the casing into the groundwater regime.

3.6.3 Waste Site Dug Well

This well is likely less than 5m deep. Chemical and physical parameters exceed MAC for drinking water for iron, pH, manganese and turbidity. The well is situated immediately up-gradient of the waste site fill area. The well appears to be located in reworked ground as seen in Figure 3.5. The high concentrations could be naturally occurring as this well obtains its water from shallow subsurface waters above the bedrock.

Fig. 3.5

3.6.4 Works, Services and Transportation Well

A picture of the presently used well is shown in Figure 3.6. This well is located on the dirt road to the weigh scales and has satisfactory water quality. An earlier well near the depot was abandoned due to road salt contamination from the salt storage sheds.

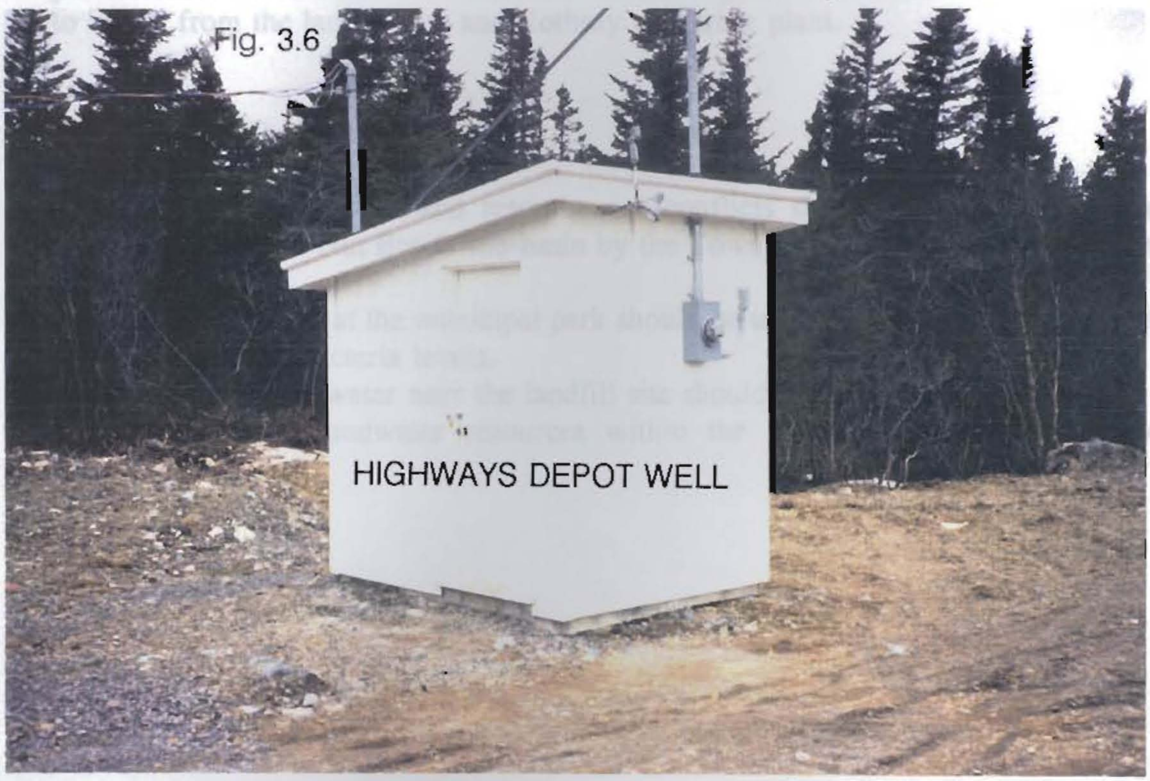


Fig. 3.6

4.0 CONCLUSIONS

The present study confirms that:

1. Alterations in physical, chemical and bacteriological properties of the Nut Brook sub-basin and Kelligrews River basin result from the industrial activity concentrated in the Nut Brook sub-basin.
2. High concentrations of sodium chloride in both surface and groundwaters exist in the Nut Brook sub-basin. The source of this increase appears to be the two salt storage sheds situated near the top of Pennys Hill.
3. High concentrations of calcium, magnesium, potassium, and sulphate and are also observed in Nut Brook sub-basin surface and groundwaters. Peak concentrations at SW3 indicate the landfill as the major contributor of these ions.
4. Concentrations of all major ions at SW5 were greater than background concentrations, indicating that the Kelligrews River system was still significantly affected by the inputs from the Nut Brook sub-basin.
5. High nutrient concentrations in both surface waters and groundwaters of the Nut Brook sub-basin probably result from organic inputs from the landfill and Rothsay rendering plant.
6. Elevated metal concentrations in Nut Brook surface waters appear to originate from the landfill site.
7. High concentrations of fecal coliform organisms at site SW3 probably result from sewage inputs from the landfill and SEPTEC sites.
8. Low dissolved oxygen concentrations in the Nut Brook sub-basin are likely caused by breakdown of organic material from the landfill, SEPTEC site, and Rothsay rendering plant.
9. pH increases in the Nut Brook sub-basin and Kelligrews River basin seem to be related to inputs from the landfill site and Rothsay rendering plant.

5.0 RECOMMENDATIONS

1. Water quality degradation and resource use conflicts should be considered in future development of the Nut Brook sub-basin by the Town of Conception Bay South and the City of St. John's.
2. CBS swimming pool at the municipal park should be tested regularly during the summer for fecal coliform bacteria levels.
3. human contact with water near the landfill site should be minimized.
4. Further use of groundwater resources within the Nut Brook sub-basin should be discouraged.

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