MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

WATER QUALITY ASSESSMENT
SUMMERLAND TROUT HATCHERY

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SUMMARY

The water supply for the Summerland Trout Hatchery has been deteriorating in terms of increased nitrate levels for the past several years. The water supply to the hatchery is an artesian ground water supply, known as Shaughnessy Springs.

Nitrate nitrogen levels in Shaughnessy Springs have increased from 0.8 mg/L in 1951 to about 7.0 mg/L in 1985. These levels are well below a proposed working water quality criterion of 40 mg/L to protect freshwater aquatic life.

Nitrogen enters groundwater from anthropogenic activities within the recharge area of the spring. The recharge area to Shaughnessy Springs has seen increased residential activities, with a population increase of over 100% since 1951. The groundwater at Shaughnessy Springs is less than thirty years old, based upon a 1984 analysis for tritium.

The contribution of agriculture to nitrogen entering the groundwater diminished between 1970 and 1980 in comparison to that from septic tanks. Nitrogen from septic tanks enters the groundwater on a year-round basis compared to nitrogen loading from agriculture, which would be more sporadic.

Increasing nitrogen values after 1974 presumably reflect the increasing population in the recharge area, first seen in 1961. As well, there seems to be about a thirteen-year lag time between population and nitrate increases.

An alert level of 13 mg/L nitrate nitrogen is proposed for Shaughnessy Springs since existing concentrations are well below the working water quality criterion. This alert level is meant to indicate a nitrate concentration at which appropriate measures should be taken to stop increasing nitrate levels, or to determine conclusively if a real concern exists for

the water supply. Present nitrate levels are about one-half the proposed alert level. The alert level probably will not be reached for at least twenty years, given past and projected trends in nitrate levels and population.

A concern existed that other contaminants, such as pesticides, might also be present in the water. Analyses conducted in November 1985 could not detect pesticides in Shaughnessy Springs, while a toxicity test using Daphnia magna showed 0% toxicity at 100% concentration for 48 hours. All other characteristics in the water supply were at low levels, and would be of no concern.

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1. INTRODUCTION

Summerland is located 18 kilometres northwest from Penticton. The water supply for the Summerland Trout Hatchery apparently has been deteriorating over the past several years. In late 1985, the Resource Quality Section of the Water Management Branch was asked to carry out a water quality assessment of the problem by the Planning and Assessment Branch.

The water supply to the hatchery is an artesian groundwater supply, known as Shaughnessy Springs. Nitrate values in the water supply apparently have increased over the last decade. A concern was expressed about whether other contaminants, such as pesticides, might also be entering the ground water supply. The area near Summerland has seen intense agricultural pressure (orchards) and increased residential development, with subsequent use of septic tanks and disposal to ground. If the source of the increasing nitrate values could be identified, the concern related to other contaminants might be addressed.

The suspected recharge area for Shaughnessy Springs is shown in Figure 1. It includes Eneas and Prairie Creeks. The water quality of Prairie Creek will be addressed in a separate report[9]. The population in the recharge area is projected to increase from 3 745 in 1976 to 5 280 in 1996.

2. WATER QUALITY CRITERIA FOR NITRATE IN HATCHERY WATER

In order to protect freshwater aquatic life in British Columbia, Nordin and Pommen[1] tentatively have recommended that nitrate nitrogen should not exceed 40 mg/L. However, due to the confined nature of the hatchery environment and the extreme sensitivity of different fish species at early life stages to different contaminants, a lower nitrate value may be needed for fish hatcheries. The Department of Fisheries and Oceans did not propose a criterion for nitrate at fish hatcheries since nitrate levels normally "found in freshwater are of no harm to fish"[5].

Westin[2] did extensive tests to address the problem of acceptable nitrate levels in hatchery water. Some of Westin's[2] more important findings were:

1. Nitrate is statistically ($p=0.05$) more active in saltwater at 15 parts per thousand than in freshwater. After a 96-hour exposure period, the factors for toxicity between fresh and salt water were from 1.24 to 1.38 for chinook salmon and 1.14 to 1.41 for rainbow trout.

2. The maximum allowable nitrate concentration should be 370 ppm NO_3 (83.5 mg-N/L) to protect chinook salmon and 250 ppm NO_3 (56.14 mg-N/L) to protect rainbow trout. These criteria were based on several extraordinary factors: (a) 7-day tests, as opposed to 96-hour toxicity tests; (b) a mortality rate of 10% as opposed to the more common 50% level; and (c) concentrations found for the salt-water situation, as opposed to freshwater. To convert the salt-water limits to comparable freshwater limits, the activity ratios for each species (from point 1 above) can be used. Using a conservative approach wherein the lowest ratio is applied, comparable freshwater limits become 103.5 mg-N/L (83.5 mg/L x 1.24) to protect chinook salmon and 64.3 mg-N/L (56.4 mg/L x 1.14) to protect rainbow trout.

3. Standard 96-hour LC_{50} tests showed that maximum non-toxic concentrations in freshwater were 5800 ppm NO_3 (1300 mg-N/L) for chinook and 6000 ppm NO_3 (1345 mg-N/L) for rainbow trout.

4. An application factor of 0.01 was used to calculate appropriate maxima. This factor is low compared to more commonly used factors of 0.05 to 0.10.

Westin[2] reasoned that a 10% mortality rate in a hatchery is acceptable, therefore an LC_{10} should be used. However, with the other large safety factors which Westin used to calculate a maximum allowable concentration, such a conservative approach is difficult to justify. Thus the values for 96-hour LC_{50} tests in freshwater, described in 3 above, are more appropriate departure points from which to calculate allowable concentrations.

It is also considered appropriate that an application factor of 0.05 should be applied to define average conditions, while a factor of 0.10 should be applied to determine maximum acceptable conditions. Using these factors and the lower 96-hour LC_{50} value of 1300 mg-N/L, the average acceptable nitrate nitrogen value is calculated to be 65 mg/L and the maximum acceptable level, 130 mg/L.

Since the criterion for nitrate proposed by Nordin and Pommen[1] for a non-hatchery situation is lower than the one developed here, it should also be deemed as appropriate for hatcheries. Thus, the maximum nitrate concentration should not exceed 40 mg-N/L.

However, an "alert" level likely also should be proposed for this particular hatchery since nitrate values are well below these criteria. When nitrate levels consistently reach the "alert" level, appropriate measures should be taken to correct the situation or to determine conclusively if a real concern exists for the water supply. This level is derived using the 96-hour LC_{50} of 1 345 mg-N/L and the application factor of 0.01, favoured by Westin. The alert level for nitrate is calculated to be 13 mg-N/L.

3. WATER QUALITY ASSESSMENT

An assessment of water quality requires an examination of point and non-point sources in the recharge area, as well as an assessment of the water quality of Eneas Creek, located to the north of Shaughnessy Springs.

3.1 WASTE DISCHARGES

Only those operations in the recharge area which use soil disposal systems or which discharge effluents to creeks in the recharge area are discussed. As well, non-point sources discussed are those in the recharge area.

3.1.1 COMMERCIAL SOURCES

A cannery (PE 3471) located beside the hatchery, and the Summerland Hatchery itself (PE 1585), discharge wastewater directly to Okanagan Lake. These effluents are not discussed further.

Four other facilities discharge wastewater in the recharge area, all to the ground. These are the Summerland Hospital (PE 169), Summerland Peach Orchard Park (PE 3471), Parkdale Home (PE 5125), and Ye Olde Inn (PE 5649). An apartment/mobile home complex (PE 6489) has been proposed since the early 1980's, but is not yet built. A refuse site (PR 2501) is located near the western boundary of the recharge area.

The Summerland Hospital (PE 169) recently began using a rotating biological contactor (RBC) and sand filters to provide treatment prior to disposal to a tile field. Data in Table 1 relate to treatment which was provided to the wastewater before use of the RBC and sand filters. Ammonia nitrogen levels were measured at about 20 mg/L. These nitrogen levels potentially can be oxidized to nitrate, which subsequently can enter the groundwater.

Summerland Peach Orchard Park (PE 3471) is a 100-unit tent and trailer park. Two sets of washrooms use two separate septic tanks and tile disposal fields. The permit allows the discharge of 45.4 m^3/d from one septic tank and 22.7 m^3/d from the second septic tank. The data in Table 2 indicate that no forms of nitrogen have been tested in the effluent from either system.

Parkdale Home (PE 5125) is an intermediate and personal care home which now uses a septic tank and tile field to dispose of laundry wastewater and a secondary package treatment plant and tile field to dispose of other domestic-type wastewater. The data in Table 3 relate to wastewater quality prior to the wastewater being separated, and when all wastewater was treated solely in the package treatment plant. No data exist on levels of nitrogen discharged from either system.

Ye Olde Inn (PE 5649) is an 18-room hotel with a restaurant, lounge and tavern. Wastewater is treated in a septic tank followed by pressurized sand and anthracite filters, with ultimate disposal by pressure injection into two deep wells. The data in Table 4 indicate an ammonia nitrogen level of 28.6 mg/L for one sample. This ammonia can be oxidized to nitrate.

The Corporation of the District of Summerland operates a refuse site to the west from Summerland. Permit PR 2051 allows for the disposal on a maximum daily average basis of 46 m^3/d of municipal-type solid waste. Nitrogen levels expected in the leachate from this site could vary from 10 to 500 mg/L, depending upon the age of the refuse and the quantity of water which percolates through the wastes.

The average precipitation which could affect the amount of leachate is shown below.

Mean Monthly Precipitation (mm) at Summerland(11)

Jan	32.3	May	26.2	Sept	19.5
Feb	17.6	June	29	Oct	15.9
Mar	15.1	July	19.9	Nov	21.8
Apr	18.7	Aug	28.5	Dec	32

Since most months have less than about 25 mm of precipitation, it is likely that very little leachate from the refuse site would enter the groundwater. However, any leachate which did reach the groundwater could contain elevated nitrate concentrations, although these flows would receive considerable dilution between the western edge of the recharge area and Shaughnessy Springs.

Thus, commercial sources of wastewater could be adding from 20 to 30 mg/L of nitrate nitrogen to the groundwater from disposal fields, and 10 to 500 mg/L nitrogen from the refuse site.

3.1.2 RESIDENTIAL AND NON-POINT SOURCES

Major non-point sources of nitrate in the recharge area are fertilizer, irrigation water and livestock wastes. Residential sources of nitrate would originate in tile disposal fields associated with private dwellings.

The Ministry of Agriculture and Food recommends the use of the following quantities of fertilizer: 80 kg-N/ha for apples, 170 kg-N/ha for cherries, and 200 kg-N/ha for peaches(13). The average usage was estimated to be 100-110 kg-N/ha, although it was felt that the actual application rate would likely be even less(13). It might generally be expected that one- quarter to one-third of the fertilizer would be applied in the autumn, with the remainder in the spring(13). Actual quantities of fertilizer applied would depend upon a leaf analysis, shoot growth, and the grower's experience(13).

The application of irrigation water would occur from late May to late September, according to need. A "scheduling system" is in use in the Summerland area, which accounts for evaporation, rainfall, and soil type. This information is broadcast on the radio, so that individual growers can regulate the application of irrigation water. This probably results in very little leachate being generated(13). On gravelly soils, it is estimated that irrigation would take place every 8 to 12 days(13).

If fertilizer were applied in the autumn, the potential exists for more of it to reach the groundwater than if it were applied in the spring, since plant uptake is less. Using an application rate of one-third of 110 kg-N/ha, assuming the fertilizer was on the land from November through February, that it was uniformly available to all precipitation which fell in those months (see Section 3.1.1), and that all nitrate enters the groundwater, the calculated maximum nitrate nitrogen concentration would be 35.3 mg/L. If only one-quarter of an application rate of 110 kg N/ha were applied, the calculated concentration would be 24.1 mg/L. Both these values are of the same magnitude as for point sources. In reality, the majority of the orchards in the recharge area are apple orchards. At an application rate of one-third of 80 kg-N/ha, the maximum resulting concentration would be 25.7 mg/L.

Nutrient loadings to Okanagan Lake from non-point sources via ground and surface water were estimated for the Okanagan Basin study[3]. Estimated nitrate loadings from these non-point sources to Okanagan lake are presented below.

	Estimated Annual Loads (kg/year)			
	Total Nitrogen		Total Phosphorus	
	1970	1980	1970	1980
Irrigation	329	391	13	5
Livestock	142	-	1	-
Fertilizer	8 164	6 306	76	21
Sub-total: Agriculture[1]	8 635	6 697	90	26
Septic Tanks[2]	5 681	5 795	824	841
Total	14 316	12 492	914	867

[1] From Table A-8, reference 3, for area 5D1 (Eneas and Prairie Creeks)

[2] From Table A-9, reference 3, for area 5D1 (Eneas and Prairie Creeks)

These calculated loadings indicate that the relative contribution of agriculture has diminished from 1970 to 1980 in comparison to that from septic tanks. As well, the total nutrient load has decreased in the same period. It was also the general feeling of the Ministry of Agriculture and Food representative in Summerland, that the number of hectares devoted to agricultural production had diminished[13].

However, the validity of the magnitude of these estimates is not known. A recent report[4] speculated that the actual nutrient load from non-point sources could be as much as five times greater than estimated for the Okanagan Basin study. The rationale for this speculation was that the 1980 calculated loads were simple extrapolations of the 1970 data base, which contained errors.

Regardless, the basic conclusion that the importance of agricultural non-point sources is decreasing while that of septic tanks is increasing, is still likely valid.

3.2 AMBIENT WATER QUALITY

3.2.1 SHAUGHNESSY SPRINGS

3.2.1.1 General Water Chemistry

A summary of data collected at the intake to the fish hatchery is in Table 5. The water is well buffered to acidic inputs, with a median pH of 8.0 and mean alkalinity of about 240 mg/L. The water would be classified as being hard, with an average hardness value of 265 mg/L. This high hardness would reduce the potential for acute toxicity from any metals which may be present.

Metals have been analyzed infrequently. All were below varying detection limits, depending upon the metal, except for the following. An aluminum value of 0.1 mg/L is equal to the criterion of 0.1 mg/L for federal fish hatcheries[5]. The barium concentration of 0.05 mg/L, and that of boron of 0.07 mg/L, were well below criteria for marine waters (the only available criteria), of 0.5 to 1.0 mg/L and 5.0 mg/L, respectively[6]. Molybdenum at 0.03 mg/L, was well below the recently proposed criteria of 1 to 2 mg/L to protect aquatic life in British Columbia[7].

Dissolved oxygen levels were naturally high ($\geq$8.0 mg/L). These can be altered, as required, in the hatchery. However, these high levels ensure that any ammonia which is discharged from point or non-point sources will be converted to nitrate, which is considerably less toxic than ammonia.

All phosphorus values were less than 0.05 mg/L. The mean dissolved orthophosphorus was 0.010 mg/L, the mean total dissolved phosphorus was 0.012 mg/L, and the mean total phosphorus was 0.016 mg/L. The short water retention time in hatchery troughs, and the fact that many of the troughs are inside the hatchery building, would result in no concern related to subsequent algal blooms.

Dissolved solids ranged from about 355 to 380 mg/L. The mean suspended solids value was 3 mg/L, a level which would ensure excellent protection to aquatic life. Turbidity was low, less than 1 NTU.

Concentrations of chlorides and sulphates "found in freshwater are of no harm to fish"[5]. "Salmonids can tolerate high concentrations (50 to 500 mg/L) of sodium and potassium ions"[5], concentrations which are not approached at the Summerland Trout Hatchery.

Temperature values ranged from 6° to 14°C. Temperature is controlled at the hatchery so that the timing of a hatch can be controlled.

Most of the nitrogen in the Shaughnessy Springs water is in the form of nitrate. All nitrite nitrogen values have been <0.005 mg/L. Ammonia nitrogen has been as high as 0.02 mg/L, however the mean value was 0.008 mg/L. For the range of ammonia, temperature and pH values measured at the hatchery, all un-ionized ammonia (toxic fraction) nitrogen values were calculated to be ≤0.001 mg/L, well below the criterion of 0.007 mg/L[8].

Nitrate (or nitrate/nitrite) nitrogen values ranged from 4.2 to 6.7 mg/L. These values are well below the criterion of 40 mg/L cited in Section 1.1, and still at least about one-half the "alert" level.

A sample collected in November 1985 was analyzed for several of the aforementioned characteristics, plus organo-chlorine pesticides, organophosphorus pesticides and solvent soluble herbicides. No pesticides or herbicides were detectable in the sample. In addition, a LT_{50} using Daphnia magna was conducted. There was 0% mortality at 100% concentration after 48 hours.

These results reveal that although nitrogen values in Shaughnessy Springs are continuing to rise, there apparently is no cause for alarm in terms of toxicity or the presence of pesticides or herbicides.

3.2.1.2 Trends in Nitrate Concentrations

Trends were not apparent for any water quality characteristic in Shaughnessy Springs, except for nitrate.

Total nitrogen values determined for Shaughnessy Springs have been plotted as Figure 2 for the period 1974 to 1985, and by five-year increments in Figure 2a. An assessment of the data set (n=53) indicated that, in the springs, nearly 97% of the total nitrogen was in the form of nitrate nitrogen. It has thus been assumed that total nitrogen in the spring water is all in the form of nitrate nitrogen.

Values of nitrate have risen from about 4.4 mg/L in 1974 to about 7.0 mg/L by the end of 1984. This is an increase of 0.24 mg/L per year (2.6 mg/L/11 years). An assumption that such a straightline relationship exists for the period of record is apparent in Figures 2 and 2a.

To determine if this apparent trend has changed through time, historical records for nitrate for both the hatchery and the water supply were searched. One value of 0.82 mg-N/L was recorded in November 1951 for the hatchery water. The intervening 22 years (1952-1973) has seen an increase, assuming a straight line relationship, of 0.16 mg/L per year ((4.4-0.8)÷22). Of interest was a nitrate value of 3.8 mg/L, recorded in May 1970[14]. The predicted value for November 1970, using the straight line relationship, would have been 3.86 mg/L. Increases in the last decade have been 50% more than those in the preceding two decades. However, the exact time that the greater increases in nitrate nitrogen occurred (0.24 mg/L per year compared to 0.16 mg/L per year) has not been determined.

A larger continuous data base existed for nitrate in the effluent from the hatchery (1969 to 1984) than in the spring water (1974-1984). The effluent values were plotted in Figures 3 and 3a. If the period of record of 1974 to 1984 is used as a reference point for the data in Figure 3, an increasing trend of nitrate for the effluent is apparent, similar to that for the Shaughnessy Spring water. However, prior to 1974, nitrate values in the effluent, although fluctuating greatly, remained relatively constant at approximately 4.25 mg/L.

This implies that there have been at least two significant increases in nitrate to the groundwater since 1951. One occurred sometime before 1974, and was only reflected in increasing values in Shaughnessy Springs after that time. A second occurred probably sometime after 1951 but before 1969 (the first year of data for the effluent). The second increase was reflected itself in an increase in nitrate in the Springs sometime in the same period.

It is likely that all increases evident were due to land use changes in the recharge area within recent time. "The presence of significant levels of tritium in water arises due to the thermonuclear testing carried out primarily in the northern hemisphere between the years 1953 and 1962. ... Groundwater recharged prior to 1953 is relatively low in tritium but post 1953 waters can contain several hundreds or thousands of tritium units"(15). A sample of Shaughnessy Springs water collected in October 1984 indicated that a large portion of the water originally entered the groundwater zone sometime after 1953 (15).

Trends of increasing nitrate values may therefore be related to an increasing population base in the recharge area. The population in the Summerland area and the recharge area has increased, and is projected to increase, as follows(16):

Year	Population Summerland Region	Populated Recharge Area
1951	3 807	2 120*
1961	4 692	2 613*
1971	6 074	3 383*
1976	6 724	3 745**
1981	7 473	4 138**
1985	8 190	4 510**
1991	8 900	4 890**
1996	9 650	5 280**

* Estimated by the Author, based upon proportional increases in population in Summerland Region.

** Estimated by Planning and Assessment Branch from Summerland Region population, with rates of population growth applied.

The increases in nitrogen between 1951 and 1974 and 1974 and 1985 are shown in Figure 4, in comparison to projected populations in the catchment area during the same period. Between 1961 and 1974, the slopes of both variables in Figure 4 are virtually the same. Between 1974 and 1985, the slope of the population graph decreases slightly, while that of the nitrogen values in Shaughnessy Springs increases. Population is estimated to increase at this more gradual rate between 1985 and 1995.

If increased nitrogen values in Shaughnessy Springs arose from residential development alone, the information in Figure 4 could lead to the following possibilities:

1. Increasing nitrogen values after 1974 reflect the increased population first seen in the recharge area in 1961. This would mean that there is a thirteen-year lag time between population and groundwater impacts.

2. The population in the catchment area increased at about the same rate for twenty years, from 1961 to 1981. If the finding from point 1 (above) is correct, nitrogen values can be expected to increase at the current rate until 1994. Thereafter, values could increase again for another five years (corresponding to 1976-1981 population increase) before increases would become less pronounced.

It also is possible that due to dilution of wastewater entering the groundwater by other low-nitrate sources, a plateau would be reached above which the nitrogen values would not increase. This plateau would not exceed the concentration of total nitrogen in septic tank effluents. However, this can only occur if the recharge to the catchment area comes solely from septic tank discharges.

Thus, the alert level of 13 mg/L (Section 2.0) should not be reached for a significant time period, probably in the order of twenty years. This assumes that past increases in nitrogen in Shaughnessy Springs are due in the most part to the increased population in the recharge area.

3.2.2 ENEAS CREEK

The water quality of Eneas Creek has been sampled at two sites since 1974, Site 0500326, above Summerland and Site 0500324, at the creek mouth (Figure 1). These data are summarized in Table 6.

Eneas Creek is highly buffered to acidic discharges, with a mean alkalinity of over 200 mg/L at both sites and a median pH of 8.3. Clark and Peppin revealed a trend of decreasing pH values, measured in the field, at the mouth[10]. Mean total hardness values were over 200 mg/L, which would help to prevent acute toxicity to aquatic life from metals. Most metal values were low and below criteria for the protection of aquatic life.

Total phosphorus values ranged from 0.011 to 0.133 mg/L at Site 0500326, upstream from Summerland. Values at Site 0500324 at the mouth were about the same. Suspended solids were generally low, although some high maximum values did occur, presumably associated with runoff and/or freshet. Turbidity values were all less than 5 NTU at Site 0500326, with the maximum value at Site 0500324 at the mouth increasing to 8.3 NTU. These data imply that runoff is the most likely source of solids.

This is further implied by data for fecal coliforms. The median value increased from 50 MPN/100 mL at Site 0500326 to 130 MPN/100 mL at Site 0500324. The conclusion related to runoff being an important source of contaminants in the creek has important implications when nitrate and total nitrogen values are examined at the two sites.

The percentage of nitrate (or nitrate/nitrite) nitrogen to total nitrogen increases from 62.1% (standard deviation:17.6) at Site 0500326 to 87.4% (standard deviation: 5.7) at Site 0500324, at the mouth. This implies that large quantities of nitrate are entering Eneas Creek from surface and groundwater sources. Since nitrate and total nitrogen values at Site 0500324 are always higher than at Site 0500326 (Figure 5), and since the data were collected at times when surface runoff was and was not occurring, it is likely that groundwater is recharging Eneas Creek and increasing nitrate levels.

The data in Figure 5 tend to confirm this conclusion. The data for nitrate at Sites 0500326 and 0500324 show little or no increase in concentration over the period of record (Figure 5a). If the first and last data points for Site 0500324 at the mouth are joined, one can infer that nitrate nitrogen values have slowly increased at this site. This implied increase is only 1 mg/L in a period of eight years, about one-half that seen for nitrate in Shaughnessy Springs or the hatchery effluent. It implies that possibly one of two of the following processes is happening:

1. The groundwater which recharges Eneas Creek has a lower nitrate concentration than that groundwater which feeds Shaughnessy Springs, or

2. A large quantity of low nitrate water, possibly such as surface runoff, enters Eneas Creek downstream from Site 0500326, thereby diluting the effect of the groundwater.

In reality, probably both of these processes are taking place, to some degree.

4. DISCUSSION

Nitrogen is not sorbed or taken up by soils. Therefore all nitrogen which enters the soil mantle potentially can enter groundwater, unless it is taken up by plants.

The change of land use in the recharge area from agricultural to residential is extremely important when looking at nitrate entering groundwater. Applied fertilizers, or wastes from livestock, can either enter the soil mantle or be washed off the soil surface as runoff, eventually entering lakes or streams. If the nitrogen from these sources enters the soil mantle, it potentially can be taken up by plants with a root zone in the upper soil horizon. Precipitation or irrigation waters are required to transmit the nitrogen into the soil.

A different situation applies to disposal of wastewater by septic tank and tile fields. In this situation, a constant water supply provides nitrogen on a fairly constant basis, year round. By design, the field provides for downward movement of the wastewater, towards the groundwater. In fact, the Ministry of Health regulations (577/75) require 0.23 m of gravel in the bottom of the trench (and 0.33 m to 0.58 m of cover material). The depth of burial of the field is within the root zone of grass, the usual plant cover for a field. Therefore some of the applied wastewater and its nitrogen components could be lost to the grass cover through such action as capillary rise. However, a certain portion would be lost on a year-round basis, with the amount increasing in the winter months when requirements of the plant cover are reduced.

It has been shown in earlier sections that except for the refuse site, commercial sources contribute from 20 to 30 mg/L nitrate to the soil systems. A similar range is applicable to non-point septic tank sources, as documented below.

A study of several rural Wisconsin families revealed the following ammonia and nitrate levels in wastewater generated from their homes[12]:

Source	Percentage Contribution to Waste (1) %	(2) Adjusted %	Concentration (mg/L) (3) NH_3-N	(4) NO_3-N	(5) NO_3+NH_3-N	(6) Septic Tank
Toilet	21.5	22.9	111	2	113	25.9
Garbage Disposal	12.7	13.1	0.9	0.0	0.9	0.1
Dishes	11.4	12.2	10.5	0.6	11.1	1.4
Laundry	24.7	26.3	1.1	1	2.1	0.6
Bath/Shower	23.5	25.1	2	0.4	2.4	0.6
Total	93.8	99.6				28.6

Notes: (1) Values in Column (2) are calculated by multiplying values in column (1) by 100/93.8

(2) Values in Column (5) are calculated by adding values in columns (3) and (4)

(3) Values in Column (6) are calculated by multiplying column (2) by column (5), and dividing by 100.

These data indicate that septic tanks contribute approximately 30 mg/L of nitrate nitrogen to the groundwater, assuming all the ammonia is oxidized to nitrate. Thus, there are approximately equal contributions of nitrate to the groundwater from commercial sources and residential sources.

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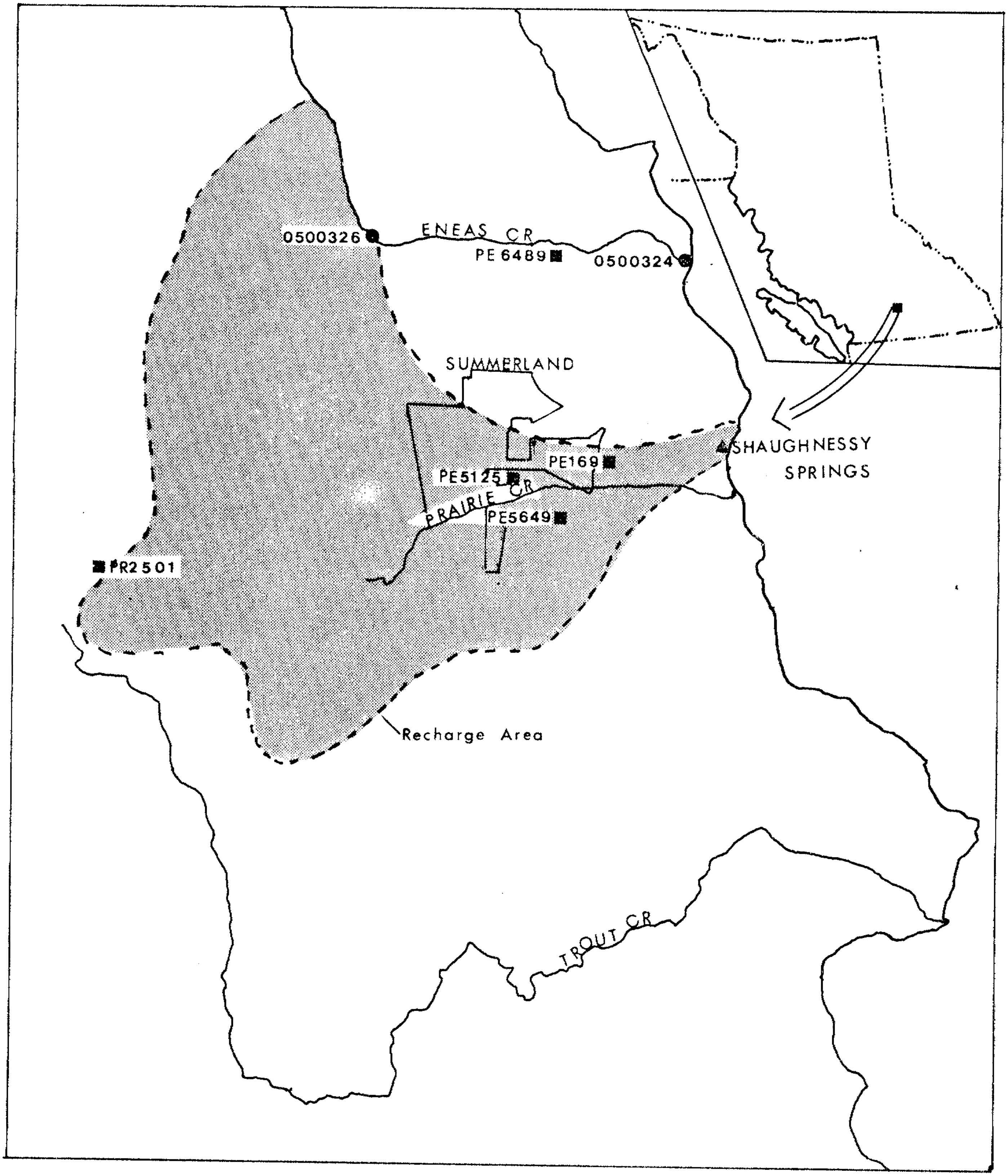

FIGURE 1 LOCATION MAP

FIGURE 2
TOTAL NITROGEN IN SHAUGHNESSY SPRINGS

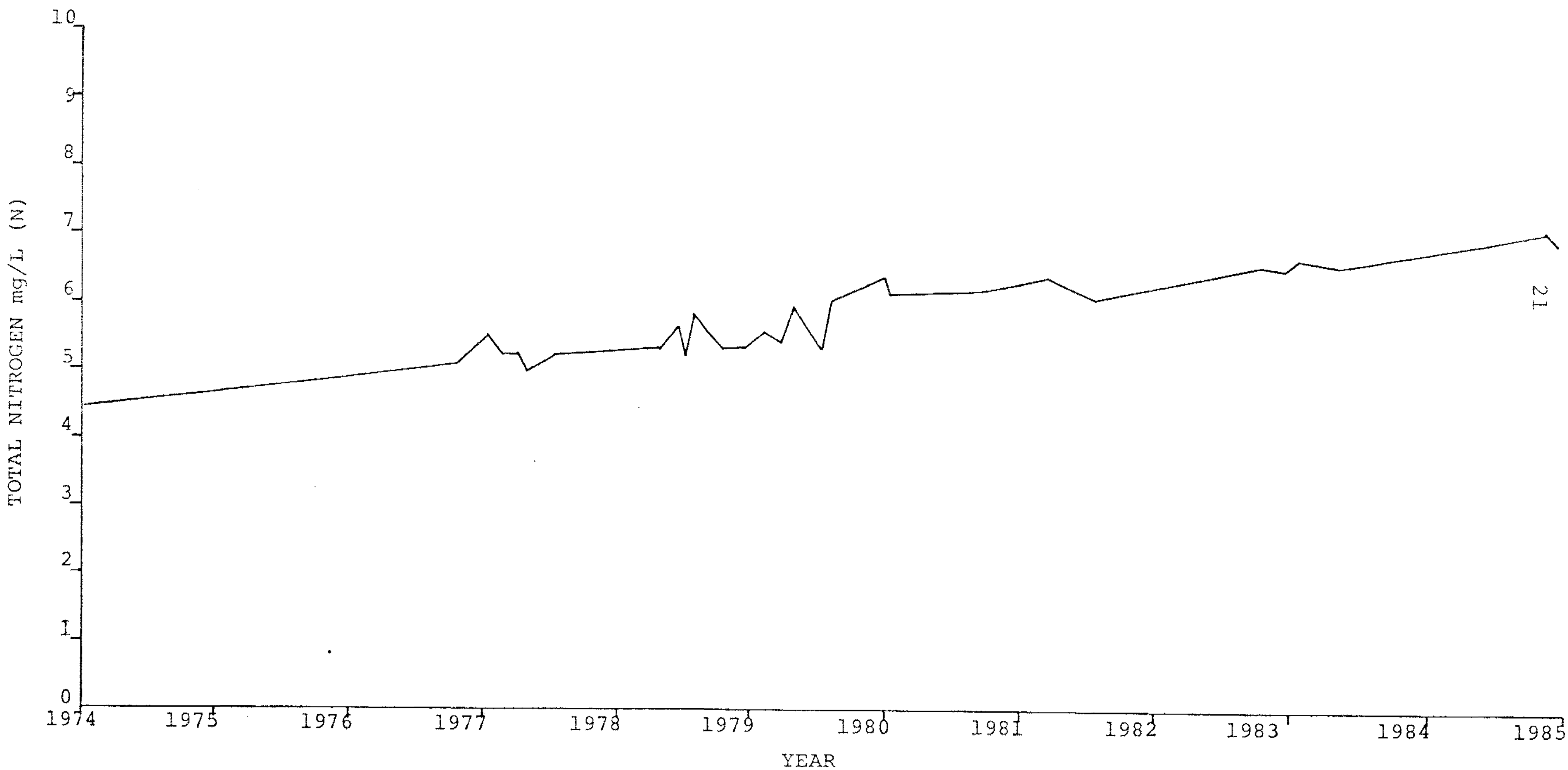

FIGURE 2(A)
NITRATEIN SHAUGHNESSY SPRINGS
BY FIVE-YEAR INCREMENTS

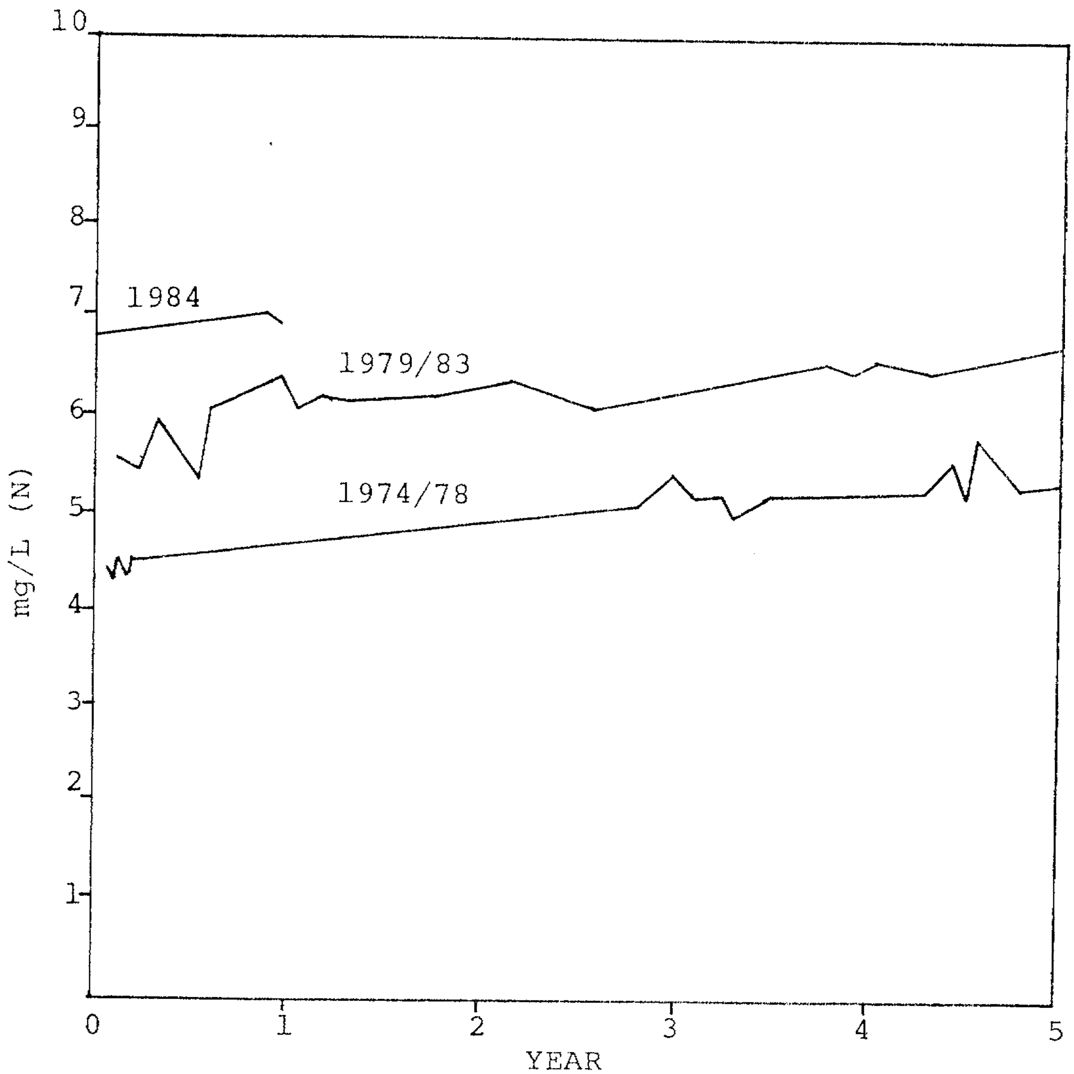

FIGURE 3
NITRATE IN EFFLUENT FROM
SUMMERLAND HATCHERY

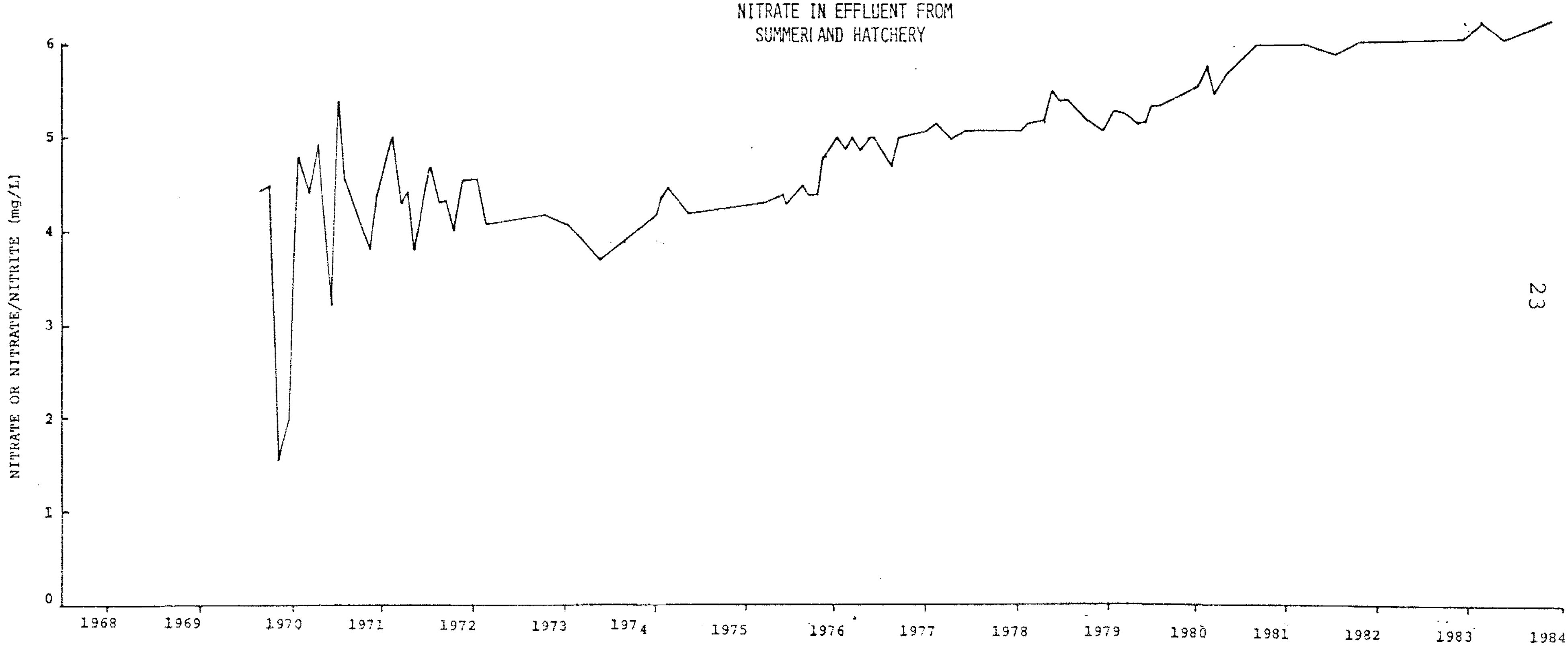

FIGURE 3 (A)
NITRATE IN EFFLUENT FROM SUMMERLAND TROUT HATCHERY
BY FIVE-YEAR INCREMENTS

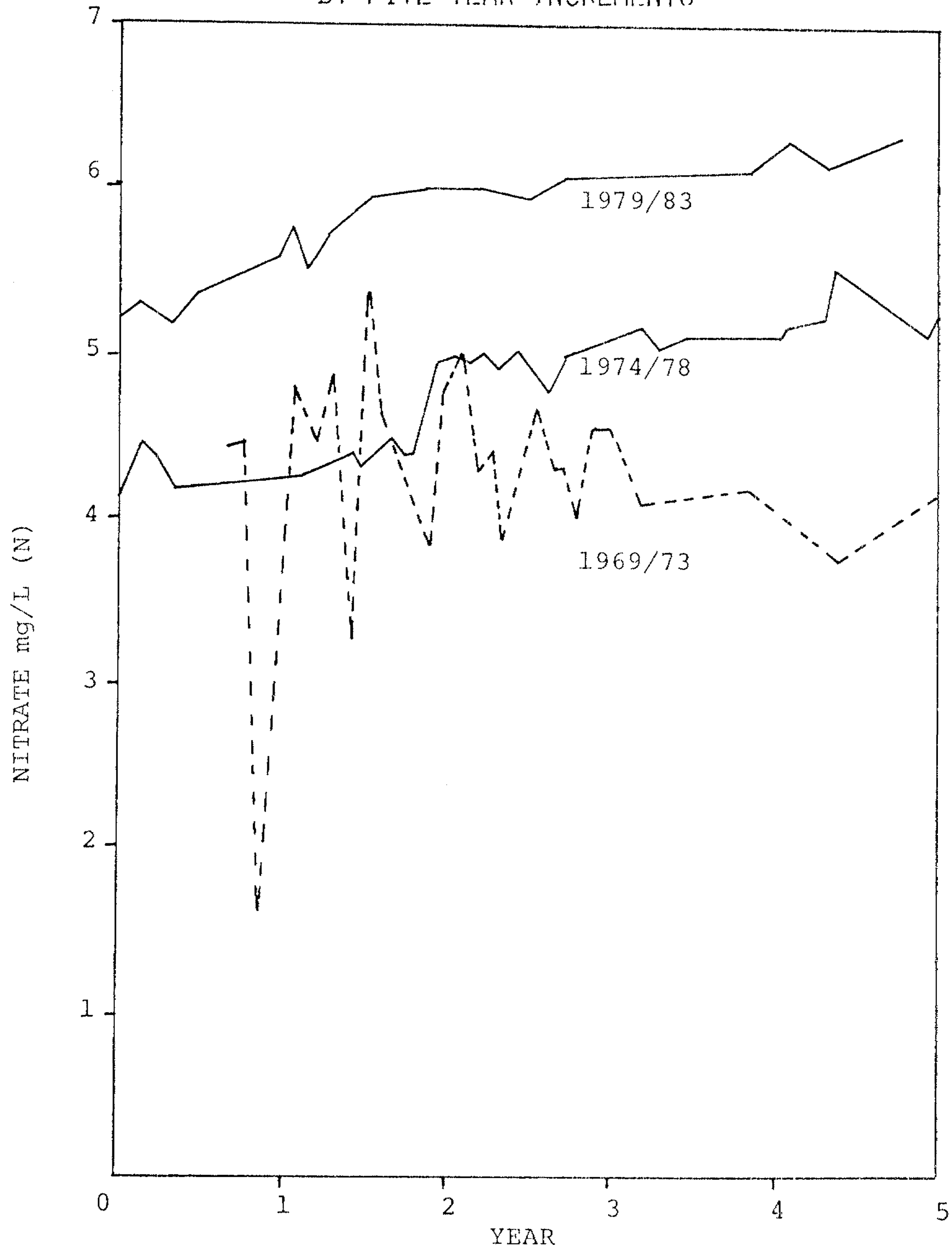

FIGURE 4

INCREASING NITROGEN IN SHAUGHNESSY SPRINGS
AND IN POPULATION IN CATCHMENT AREA , WITH TIME

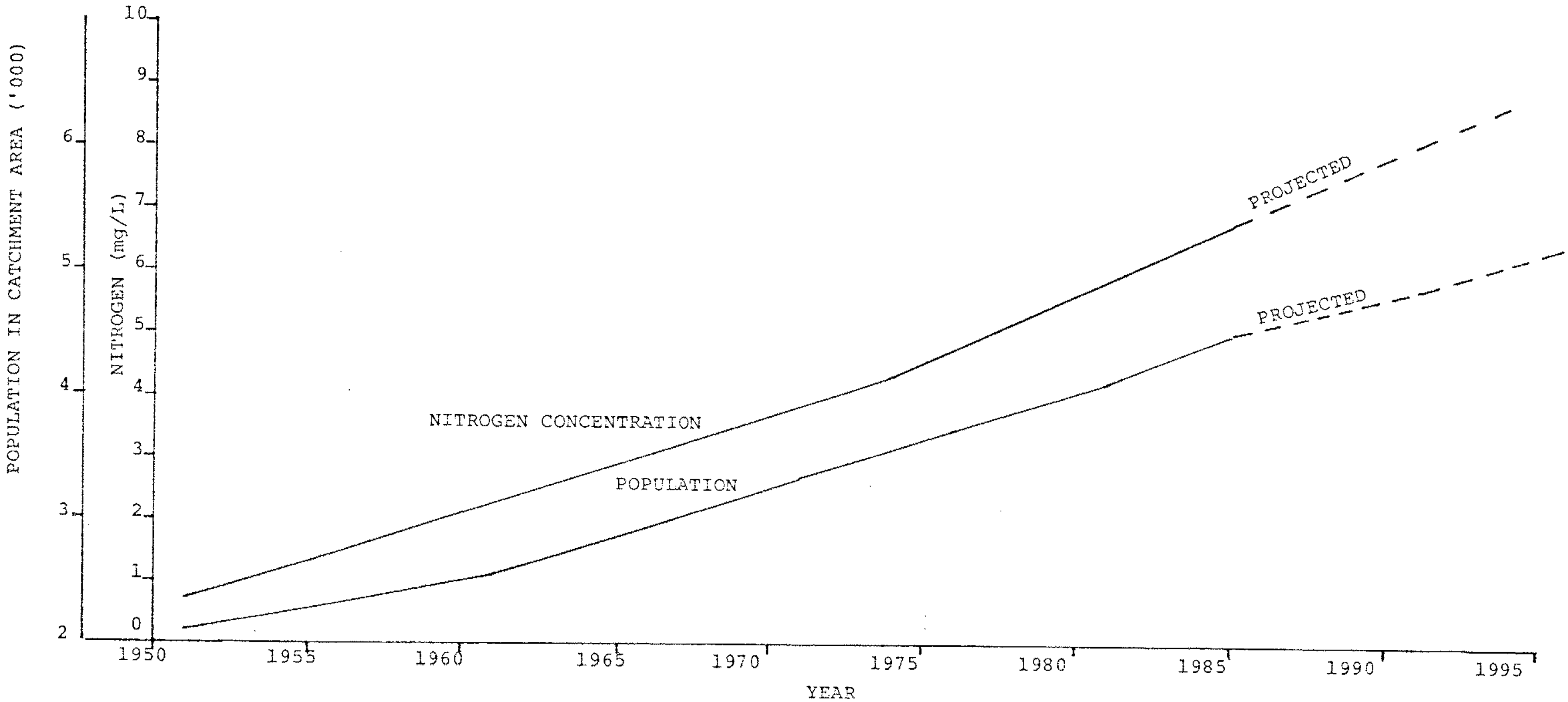

FIGURE 5
NITROGEN IN ENEAS CREEK

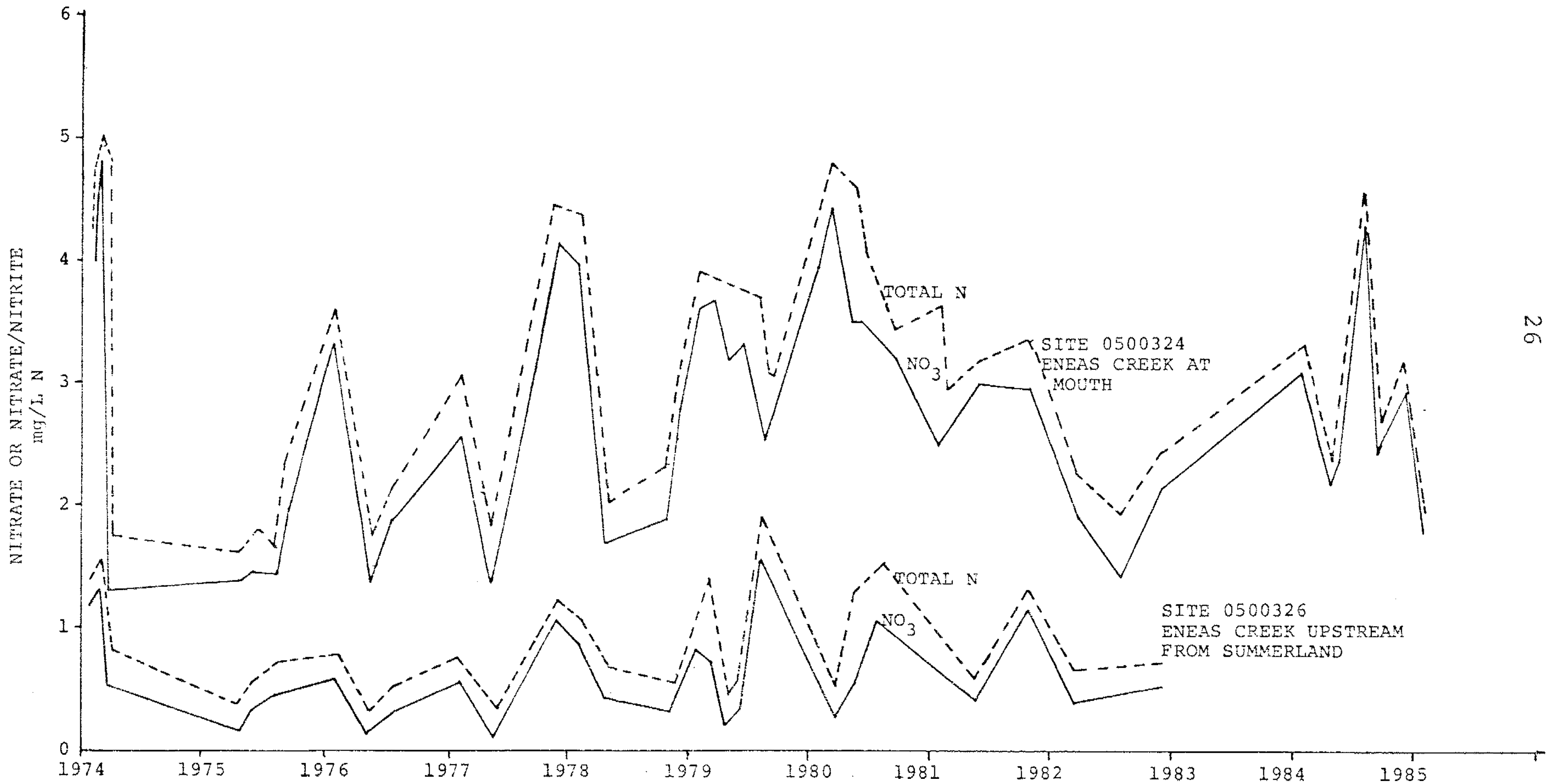

FIGURE 5 (A)

NITRATE IN ENEAS CREEK
BY FIVE-YEAR INCREMENTS

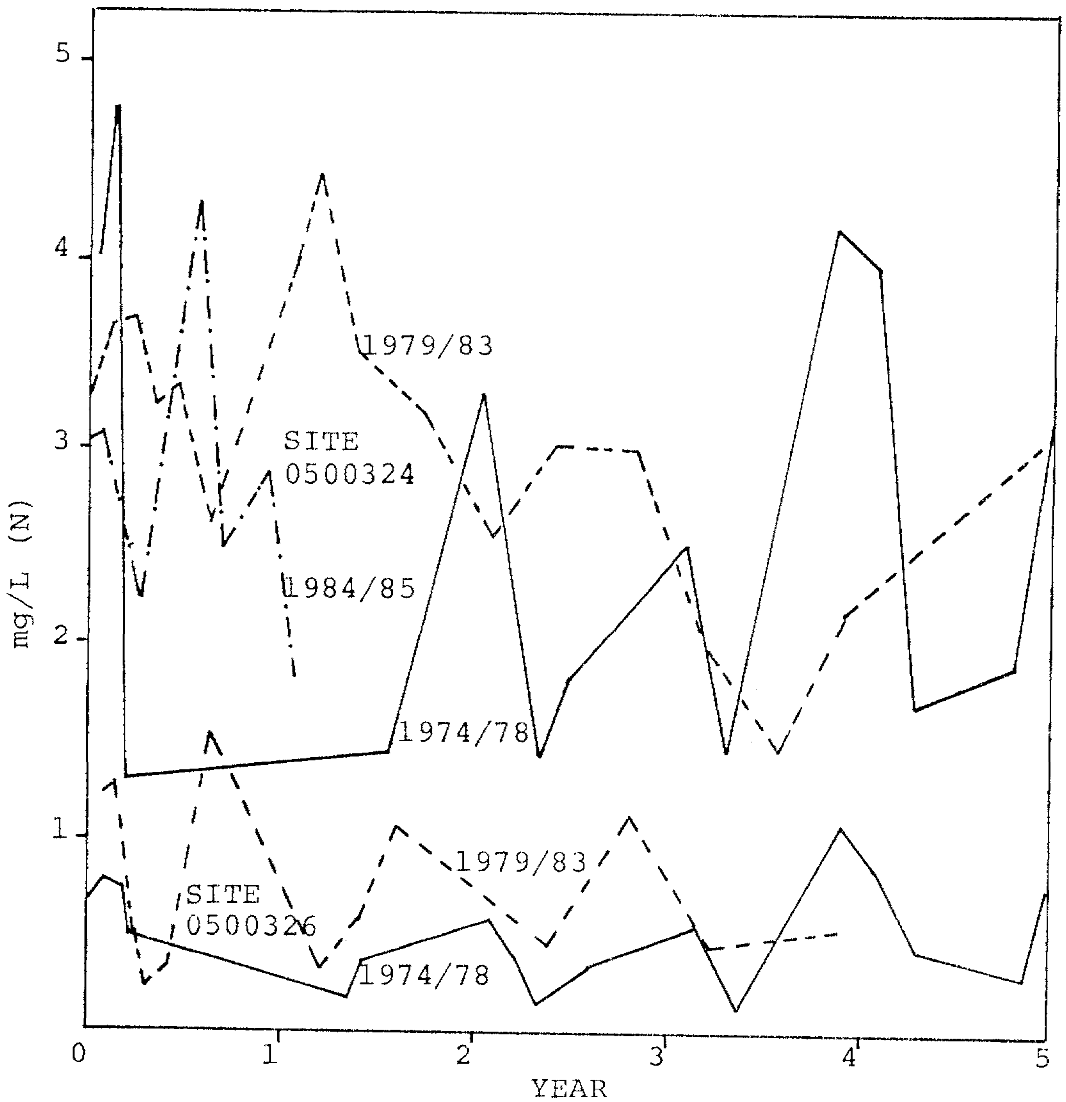

Table 1
Effluent Data Summary
Summerland Hospital (PE 169)

Characteristic	Number	Values*		
		Maximum	Minimum	Mean
Arsenic	1	0.013	-	-
Coliforms- fecal	21	>24 000 000	>2 400	>240 000+
Nitrogen - ammonia	2	21.2	20	-
- nitrate	2	0.05	0.04	-
- nitrite	2	0.01	<0.005	-
Oil and Grease	1	22.3	-	-
Oxygen - BOD_5	40	338	54	-
- dissolved	22	7.2	0.5	2.0
pH	28	7.8	6.7	7.2+
Phosphorus - total dissolved	1	13	-	-
- total	1	13.9	-	-
Solids - suspended	41	179	16	56
- total	41	588	296	438
Temperature	35	31	12	22.5
Turbidity	2	68	27	-

+ Median Value
* Values are as mg/L except:
  (1) Coliforms as MPN/100 mL
  (2) pH
  (3) Temperature as °C
  (4) Turbidity as NTU

Data Source: B.C. Ministry of Environment Computerized Data Storage and Retrieval System

Table 2
Effluent Data Summary
Corporation of the District of Summerland
Summerland Peach Orchard Park
(PE 3471)

Characteristic	July 15, 1982	
	Septic Tank 1	Septic Tank 2
BOD_5 (mg/L)	155	354
pH	8.2	8.2
Solids - suspended (mg/L)	83	250
- total (mg/L)	402	772
Specific Conductivity (μS/cm)	1050	1700

Data Source: B.C. Ministry of Environment Computerized Data Storage and Retrieval System.

Table 3
Effluent Data Summary
Parkdale Home (PE 5125)

Characteristic	Number	Values*		
		Maximum	Minimum	Mean
Coliforms - total	1	>2400	-	-
Oxygen - BOD_5	18	140	<10	33.2
- dissolved	12	5.8	1.0	3.3
pH	22	7.7	7.1	7.4+
Solids - dissolved	3	270	178	229
- suspended	22	232	9	53
- total	13	388	210	308
Temperature	14	28	15	22

+ Median Value
* Values are as mg/L except:
  (1) Coliforms as MPN/100 mL
  (2) pH
  (3) Temperature as °C

Data Source: B.C. Ministry of Environment Computerized Data Storage and Retrieval System

Table 4
Effluent Data Summary
Ye Olde Inn (PE 5649)

Characteristic	Number	Values*		
		Maximum	Minimum	Mean
Chlorine Residual	5	3	0	0.6
Nitrogen - ammonia	1	28.6	-	-
- nitrate	1	<0.02	-	-
- nitrite	1	0.01	-	-
Oxygen - BOD_5	9	330	170	219
- dissolved	7	11.2	4.6	6.8
pH	8	6.8	2.8	4.95+
Phosphorus - ortho dissolved	1	<0.003	-	-
- total	1	1.1	-	-
Solids - suspended	8	98	3	38
- total	5	1010	584	777
Temperature	8	25	13	19

+ Median Value
* Values are as mg/L except:
  (1) pH
  (2) Temperature as °C

Data Source: B.C. Ministry of Environment Computerized Data Storage and Retrieval System

Table 5
Ambient Water Quality Data Summary
Site 0500323
Shaughnessy Springs

Characteristic	Number	Values*		
		Maximum	Minimum	Mean
Alkalinity	19	249	217	239
Arsenic	2	<0.25	<0.005	-
Carbon - organic	17	10	<1	2
- inorganic	3	65	64	64.7
Chloride	14	7	5.1	6.2
Coliforms - fecal	42	79	<2	<2+
- total	42	130	<2	12+
Colour - true	5	5	<5	5
Hardness - calcium	13	89.5	77	83.5
- magnesium	7	15.6	13	14.8
- total	6	273	254	265
Metals (dissolved)				
- aluminum	1	0.1	-	-
- barium	1	0.05	-	-
- boron	1	0.07	-	-
- cobalt	1	<0.1	-	-
- cadmium	3	<0.01	<0.0005	0.0006+
- chromium	2	<0.01	<0.005	-
- copper	3	<0.01	0.001	0.003+
- iron	2	<0.1	<0.01	-
- lead	3	<0.1	<0.001	<0.001+
- manganese	2	<0.02	<0.01	-
- mercury	2	<0.00005	<0.00005	-
- molybdenum	1	0.03	-	-
- nickel	2	<0.05	<0.01	-
- vanadium	1	<0.01	-	-
- zinc	1	<0.01	-	-
Nitrogen - ammonia	24	0.02	<0.005	0.008
- nitrate/nitrite	40	6.7	4.3	5.5
- nitrate	19	5	4.2	4.6
- nitrite	29	<0.005	<0.005	<0.005
- organic	30	0.34	0.02	0.15
- total	57	6.76	4.34	5.38
Oxygen - BOD_5	19	<10	<10	<10
- dissolved	42	12.8	8.0	9.8
pH	59	8.3	7.6	8.0+
Phosphorus - ortho dissolved	20	0.018	0.008	0.010
- total dissolved	11	0.014	0.007	0.012
- total	55	0.049	0.011	0.016
Potassium	7	3.8	3.7	3.7
Sodium	13	21	17.8	19.5
Solids - dissolved	2	386	380	383
- suspended	55	34	<1	3
- total	53	414	356	385

Table 5 Continued

Characteristic	Number	Values*		
		Maximum	Minimum	Mean
Specific Conductivity	62	628	540	590
Sulphate	19	58.9	47.2	53.2
Temperature	50	14	6	11
Turbidity	7	0.5	0.2	0.3

+ Median Value
* All values are as mg/L except:
1. Coliforms as MPN/100 mL
2. Colour
3. pH
4. Specific Conductivity as µS/cm
5. Temperature as °C
6 Turbidity as NTU

Data Source: B.C. Ministry of Environment Computerized Data Storage and Retrieval System.

1975 - Oct' 83

TABLE 6
AMBIENT WATER QUALITY DATA SUMMARY

Characteristic	Eneas Creek at Mouth Site 0500324				Eneas Creek above Summerland Site 0500326			
	Number	Values*			Number	Values*		
		Maximum	Minimum	Mean		Maximum	Minimum	Mean
Alkalinity	24	260	136	224	20	297	79.5	215.5
Carbon: - organic	21	10	<1	3.8	18	10	<1	5
Chloride	28	4.3	2.1	3.4	23	4.7	1.2	2.8
Coliforms - fecal	17	>24 000	46	130+	10	>2400	<2	50+
Colour TAC	14	15	<5	7.5	13	40	<5	11.9
Hardness - calcium	21	91.3	45.3	74	16	80	23.5	60.5
- magnesium	21	18.6	8.6	13.7	16	23.3	4.8	13.3
- total	20	297	149	241	16	289	78.4	205.8
METALS: - aluminum (d)	1	0.02	-	-	-	-	-	-
- arsenic (d)	1	<0.25	-	-	-	-	-	-
- barium	1	0.06	-	-	-	-	-	-
- boron (d)	1	0.04	-	-	-	-	-	-
- Cadmium (d)	13	<0.0005	<0.0005	<0.0005	10	<0.0005	<0.0005	<0.0005
- Cadmium (t)	3	0.0015	<0.0005	<0.0005+	1	<0.0005	-	-
- Chromium (d)	3	<0.005	<0.005	<0.005	3	<0.005	<0.005	<0.005
- Copper (d)	12	<0.01	<0.001	<0.001+	9	0.007	<0.001	0.002
- Copper (t)	2	0.002	0.001	0.0015	1	0.002	-	-
- iron (d)	11	0.2	<0.01	0.10	8	0.1	0.01	0.09
- iron (t)	3	0.3	0.2	0.23	1	0.1	-	-
- lead (d)	10	0.002	<0.001	<0.001+	8	0.004	<0.001	0.002
- lead (t)	2	<0.001	<0.001	<0.001	1	<0.001	-	-
- manganese (d)	10	0.02	<0.01	0.018	9	0.02	<0.01	0.02
- mercury (t)	10	0.00015	<0.00005	<0.00005+	9	0.00019	<0.00005	<0.00005
- molybdenum (d)	2	0.02	<0.01	-	1	0.0053	-	-
- molybdenum (t)	3	0.02	0.008	0.01	1	0.01	-	-
- nickel (d)	7	<0.01	<0.01	<0.01	7	0.01	<0.01	<0.01
- zinc (d)	8	0.006	<0.005	<0.005+	9	<0.005	<0.005	<0.005
- zinc (t)	2	0.009	<0.005	-	1	<0.005	-	-
Nitrogen: - ammonia	23	0.02	<0.005	0.011	17	0.059	<0.005	0.018
- nitrate	21	4.5	1.44	2.92	14	1.53	0.11	0.64
- nitrite	30	0.006	<0.005	<0.005	23	0.01	<0.005	<0.005
- Kjeldahl	32	0.64	0.18	0.37	25	0.72	0.19	0.30
Oxygen - BOD_5	5	<10	<10	<10	3	<10	<10	<10
- dissolved	26	14.4	7	10.9	22	16	8.2	11.8
pH	38	8.5	8.1	8.3+	31	8.7	8	8.3+
Phosphorus-ortho dissolved	15	0.018	0.003	0.012	-	-	-	-
-total dissolved	15	0.026	0.01	0.016	9	0.102	0.008	0.030
-total	37	0.125	0.017	0.037	31	0.133	0.011	0.034
Solids: - dissolved	11	396	300	361	4	368	300	336
- suspended	24	89	2	19	20	58	1	7
- total	23	434	232	355	20	370	126	291

TABLE 6
AMBIENT WATER QUALITY DATA SUMMARY

Characteristic	Eneas Creek at Mouth Site 0500324				Eneas Creek above Summerland Site 0500326			
	Number	Values*			Number	Values*		
		Maximum	Minimum	Mean		Maximum	Minimum	Mean
Specific Conductivity	41	619	329	526	33	575	180	458
Temperature	37	16.5	3	9.4	32	18	0.5	7.5
Turbidity	12	8.3	1.8	3.4	8	3.9	0.8	2.6
Uranium (d)	1	0.015	-	-	1	0.018	-	-

+ Median Value
* Values are as mg/L except:
  (1) Coliforms as MPN/100 mL
  (2) Colour TAC
  (3) pH
  (4) Specific Conductivity as µS/cm
  (5) Temperature as °C
  (6) Turbidity as NTU