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A REVIEW OF

GROUNDWATER CONDITIONS

ON

GALIANO ISLAND

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1. INTRODUCTION

1.1 Purpose of Study

This report is one of several written to examine the groundwater situation in the Gulf Islands. It pertains specifically to Galiano Island and its main objectives are as follows:

(i) To present a compilation of all previous information obtained to date on Galiano Island for presentation into a format for future referral.

(ii) To provide a general overview of the hydrology and hydrogeology of the Island with the primary objective to attempt an assessment of groundwater distribution, quantity and potential groundwater use.

(iii) To review and discuss water quality and delineate problem areas.

1.2 Methods of Investigation

1.2.1 Information Sources

In order to formulate this report the sources given below were utilized:

(i) Water well records and well location maps in the Groundwater Section files.

(ii) General information, previous groundwater related reports, results of previous field work, surficial and bedrock geology maps and aerial photography including water quality testing by the co-author, B. Mordaunt in specific areas.

1.2.2 Methods of Presentation

Methods employed to present the information within this report include the following:

(i) Examination and tabulation of pertinent information

contained on approximately 500 plotted water well records. Examination of an additional 50 water well records of wells completed up to December 1981 but not yet located and plotted.

(ii) Review of hydrographic data obtained from the Observation Well WR-258-80 near Sturdies Bay.

(iii) Presentation of various compiled data in map and tabulated form. Due to the length of Galiano Island it has been necessary to section the Island into two and sometimes three parts for presentation as shown in Figures 2 through Figure 9 of the report.

1.3 Previous Investigations

Although no comprehensive reports have been previously written concerning groundwater conditions on Galiano Island a considerable amount of field work has been conducted in the past by Groundwater Section staff members. Results of this previous field work constitute a major part of this report.

2. GEOGRAPHY

2.1 Location, Area, Topography and Drainage

Galiano Island is located midway in the outer chain of the Gulf Islands which lie off the southeast coast of Vancouver Island between Victoria and Nanaimo, B.C. (Figure 1). It is approximately 14,000 acres (5787 hectares) in size, approximately 16.5 miles in length (26.5 kilometers), can be reached by car ferry from both Vancouver Island and the Mainland and supports a permanent population of about 525 people (1976 Census). This number can triple due to the influx of visitors and part-time residents during the summer months.

As evident with the other Gulf Islands, the topography of Galiano Island trends northwest-southeast, reflecting bedrock structure and

stratigraphy. The relief is rounded and subdued, an indication of glacial action. The highest points are located from north to south; at Bodega Hill (approximately 800 feet or 244 metres), Quadra Hill (approximately 600 feet or 183 metres), Stockade Hill (approximately 144 feet or 44 metres), and Sutil and Galiano Mountains in the extreme southern portion (approximately 1000 feet or 305 metres).

Drainage areas on Galiano Island are shown in Figure 2 where 23 groundwater regions have been outlined, in general their boundaries representing the topographic divides or heights of land between natural drainage basins. These watersheds are considered synonymous with groundwater regions. These regional boundaries may be revised, however, when future hydrogeological studies reveal underlying zones of permeability which may alter the shape of certain groundwater regions. In the present study, groundwater regions were determined and named by Groundwater staff and adopted by the authors and form the basic geographic working units of this report.

2.2 Climate

The southerly Gulf Islands (Galiano, Mayne, Pender and Saturna) lie to leeward of the Vancouver Island ranges, and thus share a west coast summer dry climate wherein (a) maritime influence on temperature overshadows the effects of elevation, latitude and aspect (direction or exposure of slope), and (b) more than 90% of the precipitation falls as rain, over 75% during the winter months. Annual average precipitation is approximately 25 to 30 inches (635 to 762 mm) (including annual average snowfall of 12 to 15 inches (30.5 to 38.1 mm), the lowest in the Gulf Islands. Mean temperatures range from 2.8° to 3.3°C (37 to 37.94°F) in January and from 16.1°C to 17.2°C (60.98 to 62.96°F) in July, also the lowest in the Gulf Islands.

Sunshine exposure varies between 1900 and 2000 hours per annum, the highest in the Gulf Islands.

The low average annual precipitation together with a high number of sunshine hours are the principal meteorological influences causing almost annual extreme moisture deficits from May to early October throughout the Gulf Islands, especially in the southern portion. These drought effects are strongest (a) in wind swept locations, (b) on sunparched south, southeast and especially southwest slopes, and (c) on sites with shallow soils, for example, exposed coasts and rocky knolls (Chilton, 1975).

2.3 Geology

2.3.1 Bedrock Geology

The majority of geologic information in this report has been summarized from Henderson and Vigrass (1962), Carter (1977), Muller and Jeletsky (1970), and Foweraker (1974). As mentioned briefly in Section 2.1, the nature of the underlying structure and stratigraphy is strongly manifested in the topography of Galiano Island. As is evident in the other Gulf Islands, generally northwest-southeast trending elongated valleys, formed by glacial abrasion of less resistant shales or mudstones, alternate with more resistant ridges composed primarily of sandstones and conglomerates. Accordingly, along the coast, embayments and beaches indicate areas of greater erosion than the more resistant promontories.

2.3.1.1. Stratigraphy

Galiano Island and the other Gulf Islands lie within the Nanaimo Basin, a large depressional feature occupying the southern part of the Strait of Georgia. This feature forms the southern portions of an area covered by the Nanaimo Group, a term designating nine geologic sedimentary formations which were deposited in five successive series (Muller and Jeletsky, 1970) during the Late Cretaceous Period. These strata of alternating coarse and fine grained sedimentary rocks nonconformably overly older metamorphosed rocks with igneous instrusions and, in the Nanaimo Basin, extend south and southeast from Nanoose Bay through the Gulf Islands to Orcas Island, Washington. The sedimentary beds are tilted upwards away from the centre of the basin, and their eroded remnants are particularly evident on the western rim of the Basin as cuestas or asymmetrical ridges illustrated by the Sutil Mountain - Mt. Galiano highland and parallel ridges on Galiano Island. In the study area, four of the nine formations are evident and are listed below in order of increasing geological age:

FORMATION	PRINCIPAL LITHOLOGY
Gabriola	Sandstone
Spray	Shale
Geoffrey	Conglomerate
Northumberland	Shale

Figure 3 shows the areal distribution of each formation.

2.3.1.2 Structure

The strata on Galiano Island dip towards the northeast. The location of mapped faults and fractures on Galiano Island are presented in Figure 3. Many of the fractures trend approximately N. 20°E and consist of steeply dipping 80° to 90° normal faults, with movement of the southeast block down relative to northwest block. Three faults, depicted on the southeast end of Galiano, extend generally northwards from Georgeson Bay, near Mathews Point and just south of Scoones Point respectively and merge near the south end of Whaler Bay. Another mapped fault lies between Georgeson Bay and the Finlay Lake - Taylor Cove area. Three other faults cross the island at a southwest-northeast angle (a) near Cook Cove, (b) just south of Retreat and (c) south of Spotlight Cove.

According to Carter (1977), fracture zones on Galiano Island occur along the trend of faults projected towards Galiano Island from Saltspring and Vancouver Islands and probably represent the termination of those faults. Probably the same stress system produced both these faults and fracture zones.

2.3.2 Surficial Geology

As is the case with the other Gulf Islands, the latest glaciation affecting Galiano Island occurred when the main ice lobe of the last major, or Fraser Glaciation overrode the Gulf Islands as it moved southwards (Halstead, 1967). As the ice melted, it deposited various unconsolidated materials including a compact till composed of various sized particles ranging in

increasing diameter from clay to sand to gravel including boulders. Fluvial materials were deposited or transported by meltwater to either low areas in a marine environment or higher regions above marine influence. The melting glaciers resulted in (a) a corresponding rise in sea level, and (b) isostatic readjustment (upward in this case) of the ice-free land relative to sea level. The unconsolidated deposits overlying bedrock are generally thin, thus limiting groundwater potential, and the thicker sections are found in topographic troughs.

Detailed inventory of surficial geology on Galiano Island has been undertaken by the Terrestrial Studies Branch, Ministry of Environment, as part of an interdisciplinary environmental study of certain Gulf Islands. Colluvial deposits of varying thickness are generally found on the backslope or gently sloping side of bedrock cuestas. Most of the valley areas are characterized by either coarse colluvial material originating and transported from nearby rocky uplands (usually sandstone) or fine textured sediments deposited under former marine conditions. Coarser textured sands and gravels are also found. They represent old beach deposits and they vary from less than one metre to over four metres thick. Marine deposits are found as high as 275 feet above present sea level.

3. GROUNDWATER

3.1 Groundwater Occurrence

Throughout Galiano Island, the underlying bedrock consists primarily of alternating layers of resistant sandstone and softer shale (Figure 3). Sources of water are reportedly encountered (a) in fractures within, and (b) at the contact zones between these two rock types.

3.2 Groundwater Development

The number of drilled and dug wells and utilized springs in each groundwater region is shown in Figures 4 and 5 and in Table 1. Well drilling on Galiano Island appears to have accelerated in the mid-1960's (Table 2). Prior to this, wells were constructed more readily in the southern portion of the island, mainly around Sturdies Bay, Whaler Bay, Twiss Point and Cain Peninsula. The more recent development appears to be occurring in mid-Galiano; e.g., subdivisions in the Quadra Hill and Retreat Cove groundwater regions as shown in Figure 5, followed by South Galiano (Whaler Bay and Gulf Drive groundwater regions). Table 3 indicates the average rate of well development in each groundwater region carried out between 1977 and 1980 expressed as a percentage of the total number of recorded wells drilled on the island. Table 4 has been prepared to show average well depths and average well yields for each region. Areas where water quality concerns are significant are shown in Figures 6 and 7.

3.3 Groundwater Use

According to the methods of calculation presented in this section, a final table and diagram were constructed to indicate the ratio of utilization versus available stored groundwater per groundwater region (Figures 8 and 9 and Table 5). Figures exceeding 100 percent have been calculated for the South Galiano groundwater regions of Cain Peninsula, Gulf Drive, Sturdies Bay and Whaler Bay. Although these figures should be considered with reservation as they are based on a simplified model which could be amended when more groundwater data becomes available, they do identify areas where groundwater use may be exceeding natural storage capacity during minimum recharge periods. Other crucial areas are the groundwater regions of North Galiano (70%), Scoones Point (61%), Southwind Drive (55%) and Twiss Point (46%). With the exception of the North Galiano Region, the general trend on Galiano Island is that the percentage of demand

versus storage is highest in the older, more populated area in the south and decreases progressively northwards away from the settled portion.

As with all the Gulf Islands where summer residents swell the existing population, maximum withdrawals from available groundwater storage occurs during the minimum recharge period. Both the permanent and temporary elements of population continue to grow and that portion depending on well water places increasing pressure on the fixed amount of bedrock water storage supplies. In periods of drought, there can be expected a corresponding increase in both number and severity of groundwater problems.

Estimated potential recharge from precipitation is calculated on the basis of one inch of precipitation per year being available for recharge (Foweraker, 1974). Foweraker discovered that on Mayne Island his calculations of recharge exceeded by 2 1/2 times the estimated storage available for groundwater within the fractured bedrock media, he deduced that on an annual basis storage and permeability and not precipitation, appear to be the limiting factors controlling groundwater availability on the Gulf Islands, especially during the dry summer and autumn periods.

Recharge to the groundwater regime from septic field disposal systems has not been accounted for in the recharge calculations of this report for two reasons, (i) natural groundwater recharge generally occurs in the higher areas of the watersheds. (ii) since much of the residential development is concentrated in the coastal areas near the discharge end of the groundwater flow systems, groundwater recharge from septic fields is not considered to be a significant contribution regionally. Much of the septic effluent in

coastal areas might be expected to discharge through seepage into the sea or be lost through evaporation and transpiration.

In Table 5, the potential groundwater supplies in storage is calculated in acre-feet and converted to U.S. gallons. An estimate of groundwater usage is calculated based on the number of wells per region and utilizing a demand figure of 500 US gallons per day for each well for a period of 100 days of little or no recharge. The percentage of the estimated groundwater supplies in storage used is called the "percentage groundwater usage."

Unlike the Mayne Island study cited above, for Galiano Island there is little information regarding the thickness of the potable water-bearing zone between the water table and the underlying non-potable zone. Consequently, figures given in the available bedrock storage column of Table 5 are based on a model only where the potable water-bearing zone is assumed to be 200 feet thick. This gives a conservative figure for storage because many wells are deeper than 200 feet and supply good quality water. A storage coefficient of 1×10^{-4} is adopted in computing groundwater storage on Galiano Island. This figure has also been used in other reports concerning groundwater evaluation on several Gulf Islands where overburden over bedrock is generally thin (Foweraker, 1974, Hodge, 1978, and Chwojka, 1979). Based on this "model," the estimated available groundwater stored in the bedrock, employing Whaler Bay groundwater region as an example is as follows:

Estimated available bedrock storage =

= Area x thickness x storage coefficient

= Area (acres) x 200 x .0001

= 196 x .02

= 3.92 acre feet

= 3.92 x (No. of ft^2/acre x No. of USgal/ft^3)

= 3.92 x 43,560 x 7.48

= 3.92 x 325,828.8

= 1.28×10^6 U.S. gallons (Total Potable Groundwater in Storage)

The percentage groundwater usage versus groundwater in storage expressed as a percent is illustrated below:

$$= \frac{\text{(Groundwater usage)} \times 100}{\text{Volume in storage}}$$

$$= \frac{(1.6 \times 10^6 \text{ USgal}) \times 100}{1.28 \times 10^6 \text{ USgal}}$$

= 125.0% (based on a bedrock model with a 200 foot thick water-bearing zone and an "S" value of 0.0001)

An encapsuled version of the above explanation for Table 5 is presented as follows:

Example (Whaler Bay):

1.	Area of region	x Total thickness of rock to bottom of potable water-bearing zone	= Total volume of rock (acre-feet)	
	(196 acres)	x (assume 200 feet)	= (39,200 acre-feet)	
2.	Total volume of rock	x Storage coefficient	= Preliminary estimates of groundwater supplies in storage and available by pumping (acre-feet)	

(39,200 acre-feet) x (0.0001) = (3.92 acre-feet)

3. No. of wells x Daily use per well x Period of little or no recharge from precipitation = Groundwater usage in US gallons

(32 wells) x (500 USgal/day) x (100 days) = (1.6×10^6 USgal)

4. $\frac{\text{Estimated groundwater usage}}{\text{Total potable groundwater in storage}}$ in US gallons x 100 = Estimated groundwater usage versus groundwater in storage expressed as a percentage

$$\frac{1.6 \times 10^6 \times 100}{(\text{Volume in acre-feet}) \times (\text{No. of ft}^2) \times (\text{No. of USgal/ft}^3)}$$

$$\frac{1.6 \times 10^6 \times 100}{(3.92) \times (43{,}560) \times (7.48)}$$

$$\frac{1.6 \times 10^6 \times 100}{1.28 \times 10^6} = 125.0\%$$

A figure of over 100%, as above, indicates that present demand may be exceeding groundwater in storage and serious consideration should be given to curtailing or limiting future groundwater development in these particular regions. Demand-storage ratio figures should be considered with caution however, as they are based on only limited information. They do, however, serve to identify areas where existing and potential groundwater problems can occur. Problems that may arise are well field interference problems and salt water intrusion.

3.3.1 Groundwater Region Discussion

A discussion of the groundwater regions is given in the following sections. For convenience and ease of reference an arbitrary line has been chosen and shown in Figure 4 to divide

and distinguish between the more heavily developed southeastern and lesser developed northwestern extensions of Galiano Island. Sutil Mountain and Mathews Point regions have been excluded from the southeastern extension as limited development has occurred in these two regions. Consequently, those more heavily developed groundwater regions which comprise the southeastern extension are discussed in more detail than are those within the northwestern extension.

3.3.1.1 Northwestern Extension

The wells in this area are located chiefly along the southwestern coast. The entire groundwater region labelled Georgia Strait, falls within the area leased by MacMillan & Bloedel and has no groundwater development to date. The northwestern area is presently sparsely settled, but population and accompanying well drilling are increasing, especially in Trincomali Channel groundwater region and the subdivisions located near Retreat Cove (Retreat Cove and Greig Creek groundwater regions), in the Ganner Drive area (Quadra Hill groundwater region) and near Montague Harbour (Montague Harbour groundwater region) (Figure 4 and 5).

Most of these wells obtain water from sandstone or shaley sandstone (Gabriola Sandstone) and some from the Spray Shale formation (Figure 3). The majority of wells are less than 200 feet deep.

Average yields in this northwestern section of Galiano Island vary between 2.5 USgpm for 6 wells in the Payne Bay groundwater region and 18.0 USgpm for 8 wells in the Greig Creek groundwater region near Retreat Cove. Yields averaged 3.9 USgpm for 52 wells, 4.0 USgpm for 28 wells, 6.2 USgpm for 21 wells and 4.8 USgpm for 14 wells in the groundwater regions

of North Galiano, Trincomali Channel, Quadra Hill and Finlay Lake respectively (Table 4).

There is a fairly strong positive correlation between well development, chemical concentration problems and demand-storage percentages. Four groundwater regions exhibiting this relationship are North Galiano, Southwind Drive, Montague Harbour and Trincomali Channel in descending order of demand-storage percentages. In North Galiano region, all four elements chosen to indicate water quality (iron, specific conductance, chloride and hydrogen sulphide) have concentrations greater than the Recommended Standard. The three remaining groundwater regions have iron, specific conductance and hydrogen sulphide problems in varying degrees of concentration.

With regard to the utilization of groundwater in comparison to available groundwater stored in the bedrock, most of the regional figures for the northwestern section of Galiano Island are relatively low. Only in North Galiano (70%) and Southwind Drive (56%) groundwater regions does the demand-storage ratio exceed 50 percent. In those areas mentioned previously, which exhibit rapid well development, approximately one quarter of the available groundwater stored in bedrock is being used, i.e., Trincomali Channel, Retreat Cove - Greig Creek, Quadra Hill and Montague Harbour groundwater regions (Figure 8 and 9, Table 5).

3.3.1.2 Southeastern Extension

This area of Galiano Island is comprised of most of the regions southeast of the arbitrary dividing line shown in

Figure 4 (Sutil Mountain and Mathews Point regions have been exluded). As the majority of wells on the island are located within this area, each groundwater region will be discussed separately in descending order of demand-storage percentages.

These are as follows:

Groundwater Region	Demand-Storage Ratio
Cain Peninsula	563%
Gulf Drive	351%
Sturdies Bay	218%
Whaler Bay	125%
Scoones Point	61%
Twiss Point	46%
Georgeson Bay	29%

3.3.1.2.1 Cain Peninsula

Area - 24 acres (10 hectares)
No. of drilled wells in region - 16
No. of dug wells and utilized springs in region - 2

As evident with almost all other groundwater regions on Galiano Island the majority of population is concentrated along the coast. The rate of well development is relatively slow compared to growth experienced in some of the other regions; e.g., Whaler Bay and Gulf Drive (Table 3). Well depths range from 45 to 225 feet (14 to 69 metres) and average 159 feet).

The main water-bearing stratum is Gabriola sandstone with Spray Shale as a secondary source. A few drill logs show water originating at the contact zones between these two formations. Well yields vary between 0.1 and approximately 5.0 USgpm with an average of 1.9 USgpm (Table 4).

Water quality information indicates that this area has iron, chloride and hydrogen sulphide problems. The high chloride values (one well reporting 1950 mg/L chloride) show there is evidence of sea water intrusion (Figure 6).

This groundwater region has registered the highest demand-storage ratio on Galiano Island with 563 percent (Table 5). This, together with the associated water quality problems, would indicate a necessity for curtailing or severely limiting any future well development. Additional supplies of water could be obtained from the entrapment and storage of runoff from precipitation. This could be done by collecting rain water off roofs via gutters into covered barrels or underground/basement cisterns. Cisterns should be of water tight construction with a smooth inside surface. Covers must be able to keep out animals and dirt. After construction the cistern should be disinfected. The local Public Health Inspector can advise on the procedures to be followed.

3.3.1.2.2 Gulf Drive

Area - 87 acres (35 hectares)
Number of drilled wells in region - 35
Number of dug wells and utilized springs in region - 4

Well depths range between 30 and 250 feet while reported yields range between 20 gph to 25 gpm. The principal aquifer is sandstone described as "shaley", "blue or gray." The average well depth is 127 feet. The Gulf Drive region is situated on a peninsula where much of the fresh water recharge may be limited to the catchment area available on the peninsula. The majority of wells are located along the coast. Water quality has been tested in numerous wells within this region over the last few years by groundwater staff using a field hach kit and conductivity meter. Although some high chloride levels and hydrogen sulphide odours are evident in many wells, many wells located near the coast report good quality groundwater. As this area could be susceptible to sea water intrusion, quality of groundwater could change in time due to an increase in pumping in the area. A very high demand-storage ratio of 351 percent indicates that curtailing or severely limiting future well development is necessary. This figure represents the second highest demand-storage ratio of the 22 groundwater regions and is only exceeded by the Cain Peninsula region. Both this region and the Cain Peninsula region occupy a peninsula which may receive minimal recharge and consequently bedrock fracturing in the area could be overpumped resulting in a possible mining situation. Deterioration

of water quality particularly in the dry summer months could result.

3.3.1.2.3 Sturdies Bay

Area - 182 acres (74 hectares)
No. of drilled wells - 48
No. of dug wells and utilized springs in region - 4

Well depths range between 46 and 412 feet while reported well yields range from 1 gallon per hour to 60+ gallons per minute. The principal aquifer is described as "shaley" sandstone. Higher yielding wells report soft blue sandstone as the principal aquifer zone. This region is very popular and highly developed. Many wells located near the coast reported flowing artesian conditions at the time of construction. Water level information is, however, presently not known in this area. The majority of wells located within the region are likely rapidly recharged from precipitation falling on higher elevations to the east.

Due to high well density in this region, interference between wells may be a problem. For example, during pumping of observation well (WR-258-80) in 1980 located near the southeast corner of Winstanley and Shopland Roads, a water level decline in 2 wells downslope and to the north was immediately noted (approximately 500 feet to the north). This example is not believed to be an isolated case and well interference within some areas of Galiano Island could be a significant problem. Water quality testing within this region, however, suggests

there are few water quality problems. Only one well tested to date has shown evidence of salt water intrusion (905 mg/L). As evident in both Cain Peninsula and Gulf Drive regions, the Sturdies Bay region has a demand-storage ratio of over 100 percent (218%). The same cautions and restrictions outlined for Cain Peninsula and Gulf Drive regions would also apply to this region.

3.3.1.2.4 Whaler Bay

Area - 196 acres (79 hectares)
Number of drilled wells in region - 31
Number of dug wells and utilized springs in region - 3

Well depths range between 12 feet and 433 feet while reported yields range between 25 gph and 20 gpm. As is evident in the Sturdies Bay region, the principal aquifer is reported as "shaley" sandstone and "grey" sandstone. The majority of development within this region is within the Whaler Bay subdivision between Sturdies Bay Road and Whaler Bay. Most lots in this subdivision are approximately 1 acre in size. It is apparent that much of this subdivision is now serviced with community water supplied from a well located to the south of this subdivision about 3/4 mile inland from Sturdies Bay. Recharge to this well and the majority of wells located within this region likely occurs from higher elevations to the south. This region is one of four groundwater regions registering a demand-storage figure in excess of 100 percent (a figure of 125 percent has been calculated for this region). Development within this region has been considerable over the last few years. From Table 3 it can be seen that

since 1977 well development has increased by 28 percent. Once again, the same cautions and restrictions outlined for Cain Peninsula, Gulf Drive and Sturdies Bay regions would apply to this region.

3.3.1.2.5 Scoones Point

Area - 526 acres (213 hectares
No. of wells drilled in region - 34
No. of dug wells and utilized springs in region - 7

Well depths range between 10 and 350 feet while reported yields range between a few gallons per hour to 18 USgallons per minute. Most wells located within the boundaries of this region report yields around 1/2 gallon per minute. As apparent in most regions the principal aquifer zone is described as "shaley" sandstone. Wells report fractured sandstone as the principal aquifer zone. Conglomerate has also been mentioned as water-bearing in some areas. The majority of development within this region is centered around Burrell Point and Arbutus Point in the vicinity of Burrell Point Road and Bellhouse Road (Figure 4). Numerous complaints have been documented here where some of the shallower wells "dry up" in the summer. Some deeper drilled wells located near the coast have shown evidence of salt water contamination and in some cases have had to be abandoned. A demand-storage ratio of 61 percent does not indicate the necessity for severely restricting future well development at this time. This figure, however, coupled with the present water quality problems evident in some wells located near the coast, does suggest that caution should be exercised in locating and spacing of wells in the future. Table 3 indicates

that well development is occurring at quite a rapid rate with a figure of almost 15 percent recorded between 1977 and 1980.

3.3.1.2.6 Twiss Point

Area - 1,228 acres (497 hectares)
Number of drilled wells in region - 63
Number of dug wells and utilized springs in region - 11

Well depths range between 8 and 460 feet while reported well yields range between 15 gph to 30 gpm. The principal aquifer is described as "shaley" sandstone i.e., shale layering between sandstone. As is evident in most regions the majority of development is along the coast. Development inland is sparse (Figure 4). Most well records report moderate domestic yields up to 5 gpm. Some of the deeper wells located near the coast report salt water contamination problems. Well density along the coast has increased over the last few years and water level interference between wells may also pose a problem. The majority of higher yielding wells reporting up to 20 gpm are situated inland. A demand-storage figure of 46 percent suggests there is no immediate cause for concern. The majority of development within this large groundwater region is, however, concentrated near the coast. This demand-storage figure should therefore be considered with caution as the same coastal quality problems experienced in wells in other regions may eventually occur in this region.

3.3.1.2.7 Georgeson Bay

Area - 1565 acres (634 hectares)
Number of drilled wells in region - 39
Number of dug wells and utilized springs in region - 21

Well depths range from 16 feet and 377 feet while reported yields range between 2.5 gph to 12 gpm. The majority of wells, however, report yields less than 5 gpm. Most development is centered along the coast at Georgeson Bay and inland along the main road between higher terrain to the east and to the west (Mount Galiano). Well records indicate the principal aquifer material in wells located in the vicinity of Georgeson Bay is described as fractured conglomerate or shaley sandstone. The principal aquifer inland appears to be shaley sandstone. Present information available indicates groundwater inland is of good quality, soft and moderately mineralized. Recharge to wells located inland would likely be rapid originating from surrounding higher elevations. Although at present there is no evidence of salt water contamination around Georgeson Bay, well density in this area and location in relation to the ocean suggests the area has potential for water quality problems. A demand-storage figure of 29 percent suggests that groundwater usage is not exceeding normal recharge at this time.

3.4 Groundwater Chemistry

Water quality is affected by the concentration of dissolved minerals of which the most troublesome on Galiano Island is iron. High levels of chlorides, specific electrical conductance (a general

measure of total dissolved mineralization) and presence of hydrogen sulphide constitute more localized problems than iron, and all of these are most evident along coastal areas (Figure 6 and 7) especially where wells are clustered and/or constantly used to capacity. Certain recommended standards and objectives concerning drinking water quality have been set by the B.C. Ministry of Health (B.C. Ministry of Environment, 1979). Chloride and iron levels exceeding the recommended standard of 250 mg/L and 0.3 mg/L respectively, have been reported along coastal areas of the Scoones Point, Sturdies Bay, Gulf Drive, Whaler Bay, Twiss Point, Montague Harbour, Trincomali Channel and North Galiano Regions. Hydrogen sulphide odour has been detected in numerous wells, most noticeably along coastal areas, and may be associated with the fractured shale bedrock.

High concentrations of chloride in groundwater can result from (a) infiltration from surface sources including fertilizers, salts or sewerage, (b) tapping of groundwater that has been in the flow system long enough to evolve from predominantly bicarbonate to chloride water, (c) water extracted from marine deposited sediments, predominantly the Spray Formation, (Figure 3) containing residual salts and (d) sea water intrusion from overpumping areas near the coast (Moen, 1979). The recommended limit for chloride in drinking water is 250 mg/L.

Iron is one of the most common minerals found in the earth's crust. Natural water often contains dissolved and/or insoluble forms. It often occurs in association with shale formations, acid or neutral type water and areas where water may be corrosive, and may be associated with salt water intrusion. It is an aesthetic nuisance, especially in its insoluble form (ferric hydroxide) and can be considered a limitation when assessing available groundwater supply in the study area. The recommended limit for dissolved iron in drinking water is 0.3 mg/L.

Specific electrical conductance (or specific conductance) of water is a measure of its ability to conduct an electrical current, varying in direct proportion with the number of free ions or amount of dissolved material. A TDS (total dissolved solids) of 1000 mg/L corresponds with a specific electrical conductance of approximately 1600 umhos/cm (micromhos per centimeter). Specific conductance exhibits a general positive correlation with the length of time the water has been in the flow system, e.g., at greater depths and at discharge zones because concentration increases with distance of travel and time that the water is in the aquifer. The recommended limit for specific electrical conductance in drinking water is 1000.

Sulphurous water containing H_2S, produces a rotten egg smell in some Galiano Island wells. It may result from anaerobic decay of organic material and reduction of sulphates and is often associated with shales and clays.

In early August 1980, chemical tests were performed on some of the Galiano wells in order to update and supplement information in areas with high chemical concentration problems. The water was tested for temperature, pH, iron, chloride and hardness with a Hach chemistry testing kit and electrical specific conductivity using a Beckman conductivity meter. The most noticeable difference in these wells previously tested in August 1973 and again in August 1980 was a slight rise in iron concentration, especially in the southern, more populated area of the island.

3.5 Summary

Well density in the southeastern area of Galiano Island far exceeds that in the northwestern area. The majority of wells located within the northwestern area are located along the southwestern coast (Figures 4 and 5). Only in two regions within the northwestern area

does the demand-storage ratio exceed 50 percent. These are the North Galiano and Southwind Drive regions where figures of 70 and 56 percent have been calculated respectively. Development in these regions, as is common to all regions as Galiano Island, is concentrated mainly near the coast.

Four regions within the southeastern area have demand-storage ratios exceeding 100 percent. These are the Cain Peninsula, Gulf Drive, Sturdies Bay and Whaler Bay. The remaining regions have registered demand-storage ratios which indicate there is no immediate cause for concern. Water quality problems are, however, evident in numerous areas throughout the island. These problems include reports of high levels of iron, specific conductance, hydrogen sulphide and chloride. Sea water contamination is evident in some wells within Cain Peninsula, Gulf Drive, Scoones Point and Twiss Point. Further water quality testing may reveal additional problem areas and areas where the presence of good quality groundwater and unlikelihood of quality problems make these areas good candidates for possible future development.

3.6 Observation Well WR-258-80

At present there is one observation well on Galiano Island. This well is equipped with an automatic water level recorder and is located on the road right-of-way at the intersection of Winstanley and Shopland Roads. This well was drilled as part of the 1979-80 Observation Well Network expansion program. It is a 6-inch diameter bedrock well drilled to a depth of 300 feet. Water-bearing fractures were encountered at depths of 50, 150, 190, 195. The estimated theoretical well yield for short-term pumping has been determined as approximately 46 USgpm.

The purpose of the well is to monitor the long term water level fluctuations in an area where increasing development is occurring, to provide information on the amount of recharge to the aquifer and the effects of groundwater withdrawal upon the aquifer. Recorder charts obtained to date show evidence of pumping interference from neighbouring wells. This effect is particularly noticeable during the summer when demand is highest and water levels are approaching lowest levels for the year. Chemical analyses taken indicate the water is soft and moderately mineralized.

4. CONCLUSIONS AND RECOMMENDATIONS

1. Contact zones between shale and sandstone described generally as "shaley" sandstone, constitute the major water-bearing zones throughout most areas of Galiano Island. Fractured conglomerate constitutes the major water-bearing source around the Georgeson Bay area.

2. The average reported well yield and well depth based on approximately 500 plotted well records is 4.5 gpm and 154 feet. The deepest well on Galiano Island according to Groundwater Section files is 515 feet. The greatest reported well yield is 70 gpm.

3. Groundwater regions in the northwestern area of Galiano Island have generally low demand-storage ratios. Only in North Galiano and Southwind Drive regions does this ratio exceed 50 percent. Future well development is feasible away from the coast in these regions.

4. Groundwater regions that have registered demand-storage percentages in excess of 100 percent are the Cain Peninsula, Gulf Drive, Sturdies Bay and Whaler Bay regions. Serious consideration should be given to curtailing or limiting any future groundwater development in these regions. These regions are good candidates for the employment of water conservation measures such as collection of rain water off roofs via gutters into covered barrels or underground/basement cisterns. This practice would aid in supplementing meagre water supplies during dry periods of little or no recharge in these regions.

5. With present and ever increasing knowledge of areas where well construction is undesirable because of existing and potential water quality problems or well interference problems, it may be advisable to establish more community water supply wells. Community water supplies could service areas where, for example, salt water contamination is a problem. Well records have indicated that it is possible to construct moderate capacity wells (over 10 gpm) in many areas of Galiano Island.

6. It is recommended that an in-depth groundwater study be undertaken to document any water quality and well field interference problems within the four groundwater regions registering demand-storage ratios over 100 percent. This study could include a "door to door" survey involving collection of water samples for both field and complete laboratory analysis, documenting of specific complaints and problem areas, obtaining and contouring of water levels, determining the summer-permanent resident ratio and obtaining more accurate groundwater usage figures.

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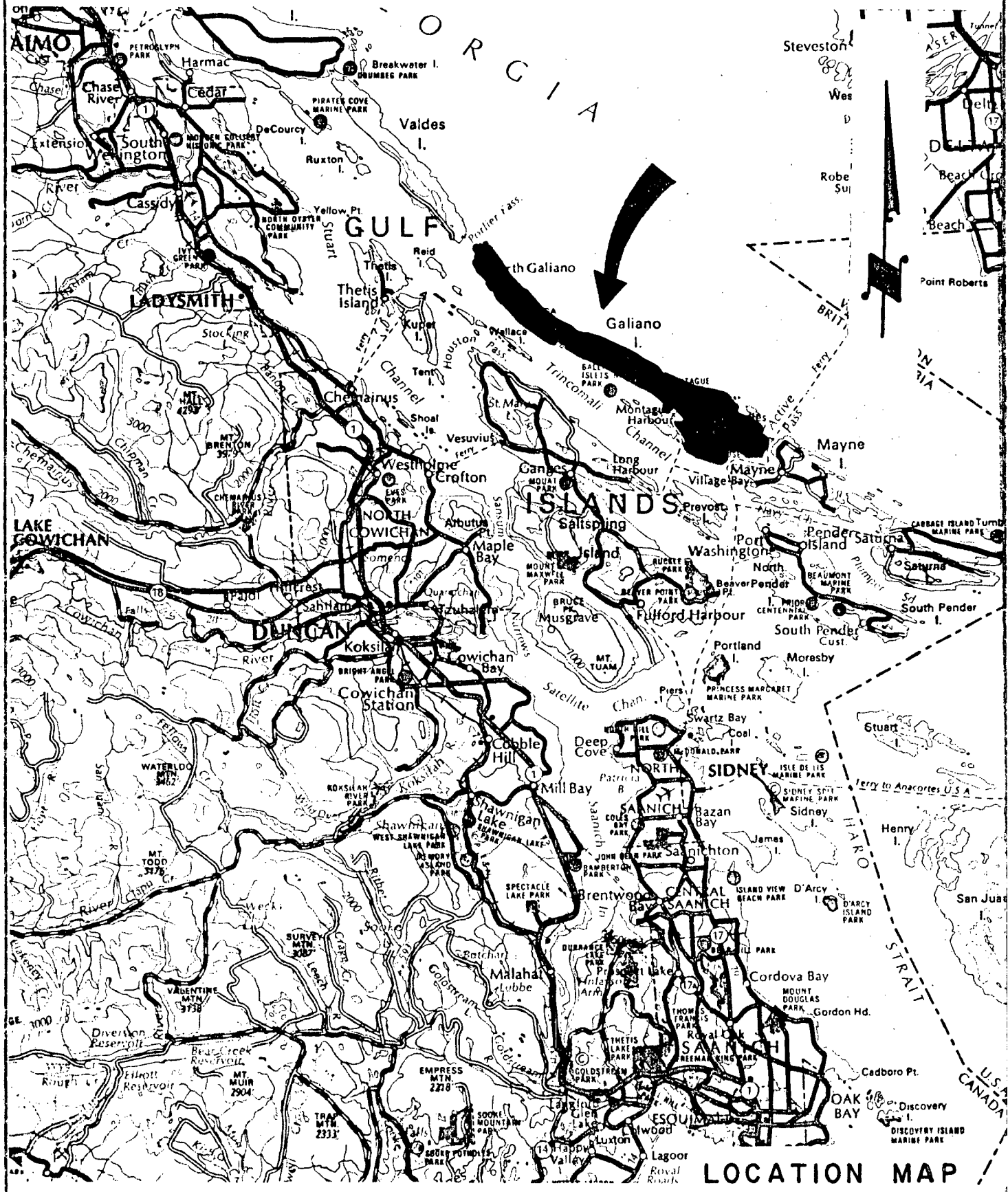
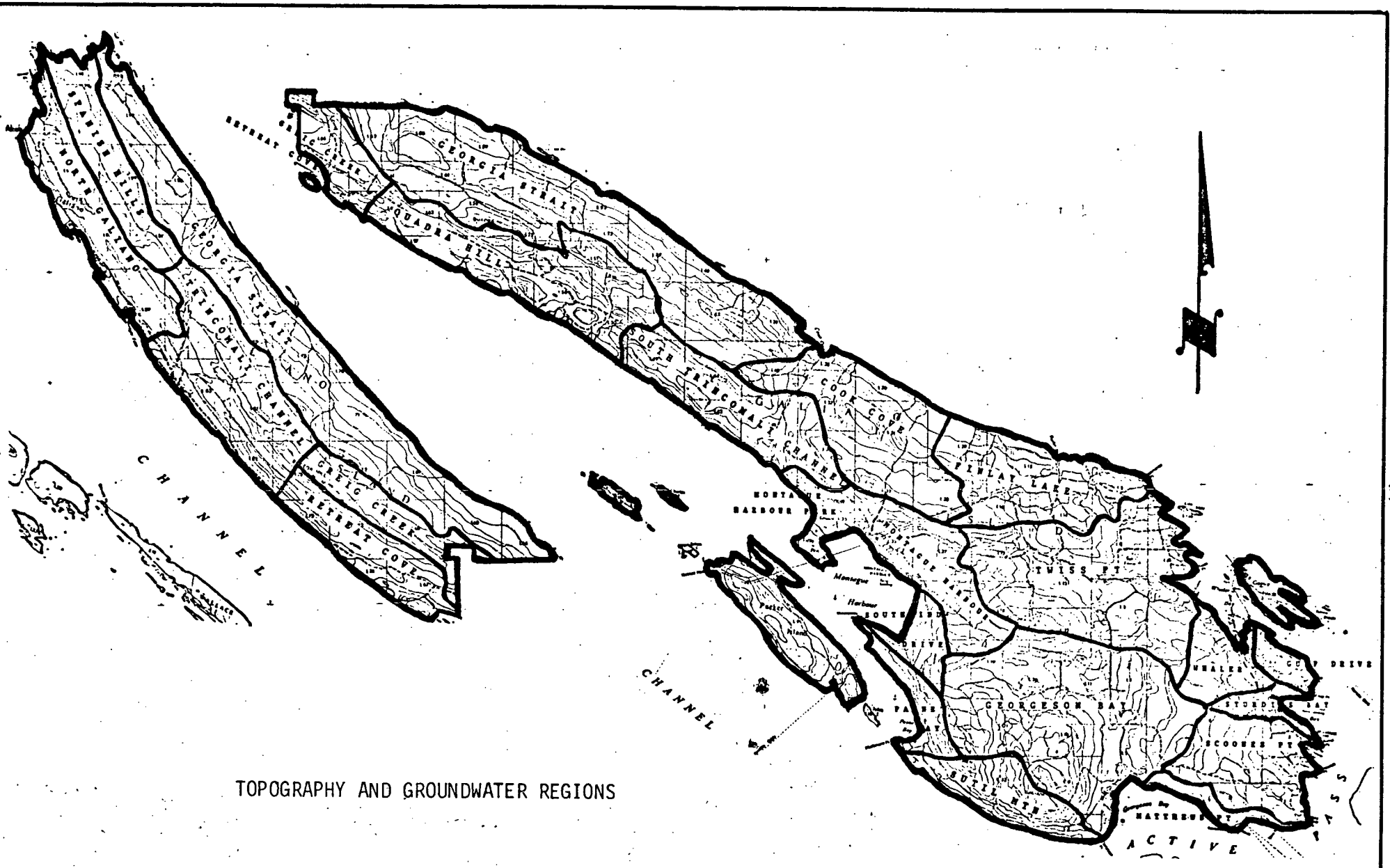


Province of British Columbia
Ministry of Environment
WATER MANAGEMENT BRANCH

A Review of Groundwater Conditions on Galiano Island

SCALE VER	N/A	DATE	DRAWN BY
HOR	1 inch = 6 miles	May 1983	
FILE No.	92 B 14		Figure 1



TOPOGRAPHY AND GROUNDWATER REGIONS

Province of British Columbia
Ministry of the Environment
ENVIRONMENTAL AND ENGINEERING SERVICE
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON

A Review of Groundwater Conditions on Galiano Island

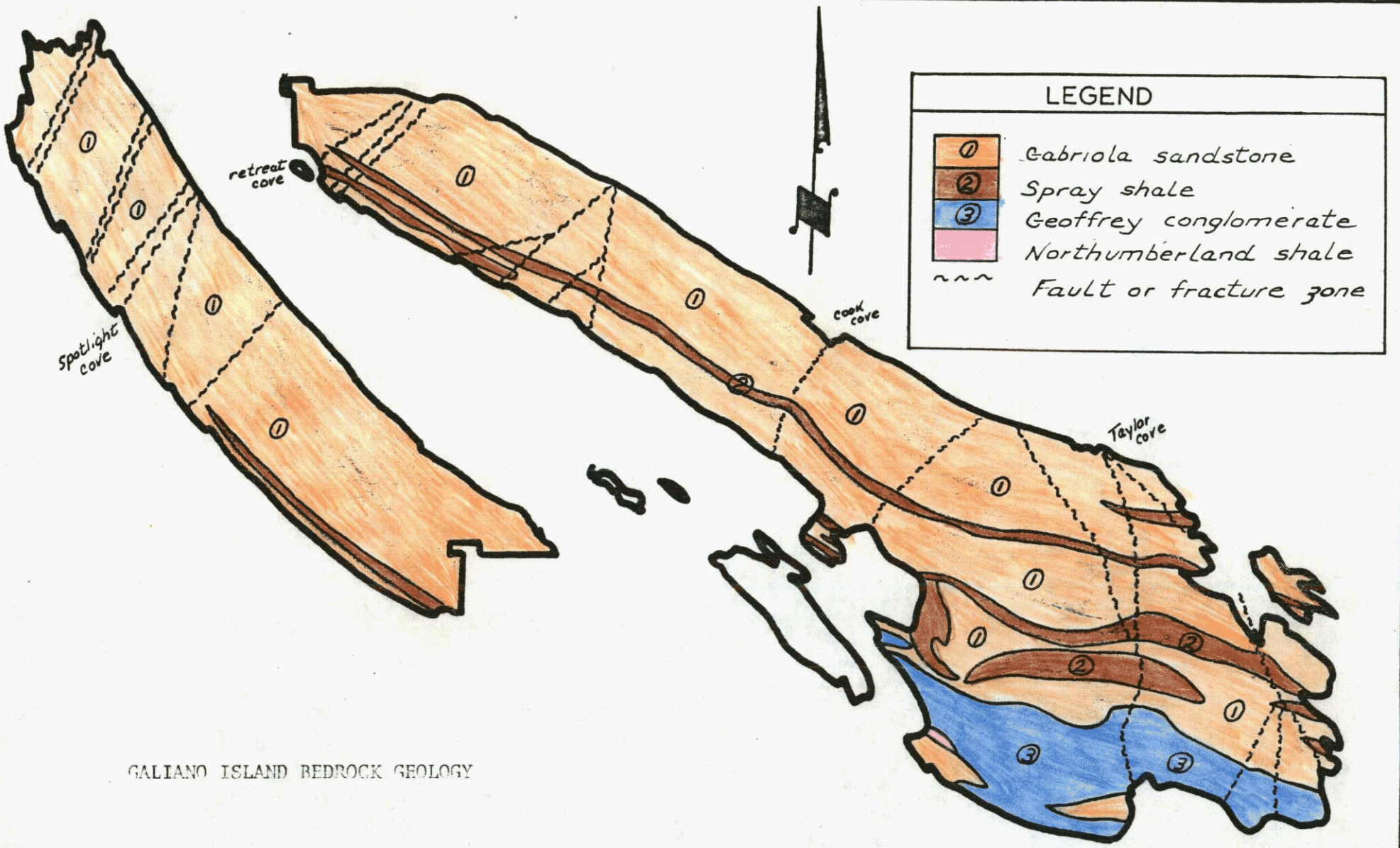
SCALE: VERT.
HOR.

DATE: May 1983

ENGINEER

FILE No. 92 B 14 DWG. No. Figure 2

bcil 6661 wrs



Note lithology after Henderson and Vigrass (1962).

Province of British Columbia
Ministry of Environment
INVENTORY AND ENGINEERING BRANCH

TO ACCOMPANY REPORT ON
A Review of Groundwater Conditions on Galiano Island

SCALE: VERT.
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DATE
May 1983

ENGINEER

FILE No. 92 B 14 DWG. No. Figure 3

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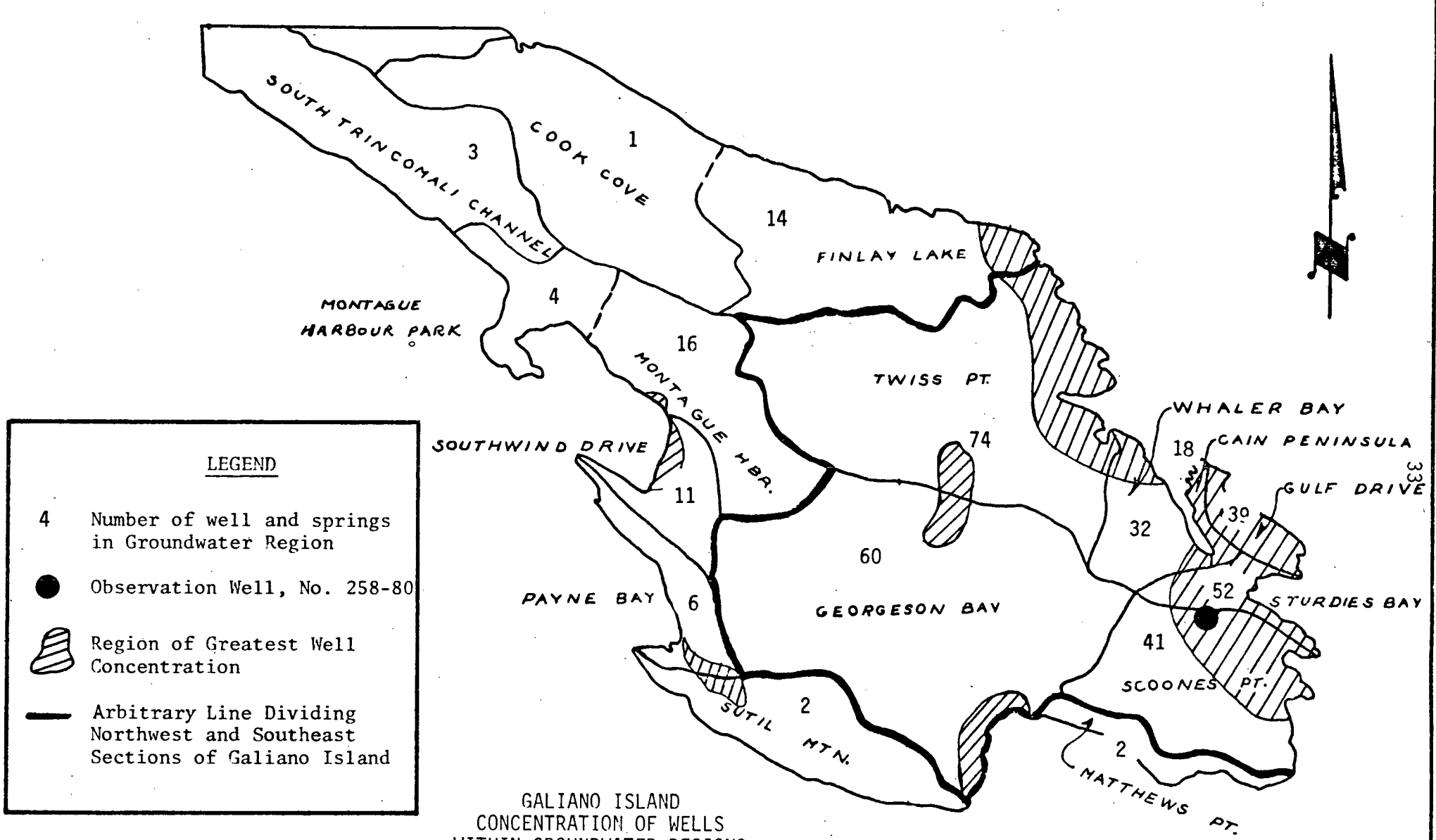
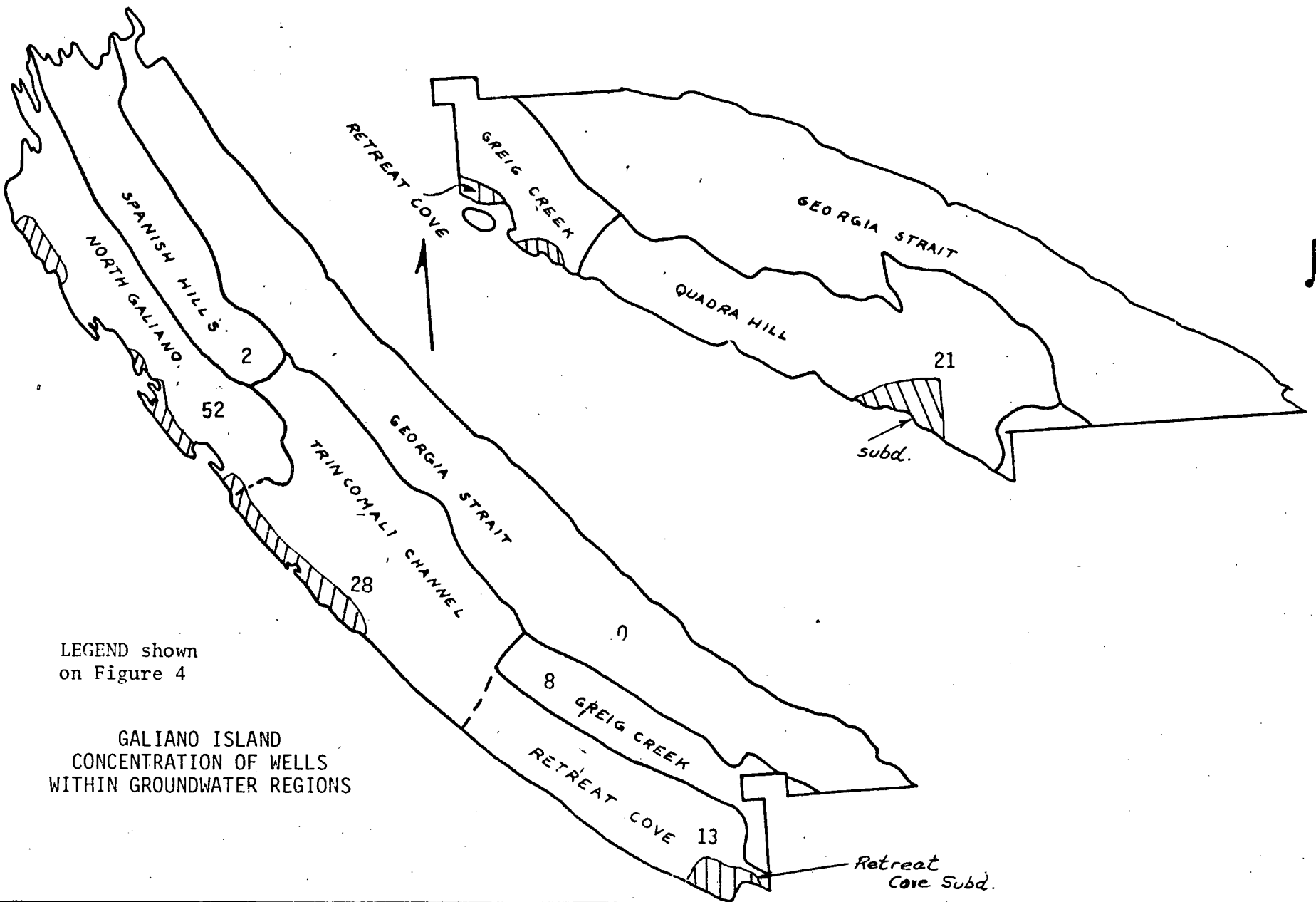


GALIANO ISLAND
CONCENTRATION OF WELLS
WITHIN GROUNDWATER REGIONS

BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT ENVIRONMENTAL AND ENGINEERING SERVICES WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON A Review of Groundwater Conditions on Galiano Island	SCALE: VERT. HOR. 1" = 4000' ENGINEER FILE No. 92 B 14 DWG. No. Figure 4
		DATE May 1983



LEGEND shown on Figure 4

GALIANO ISLAND
CONCENTRATION OF WELLS
WITHIN GROUNDWATER REGIONS

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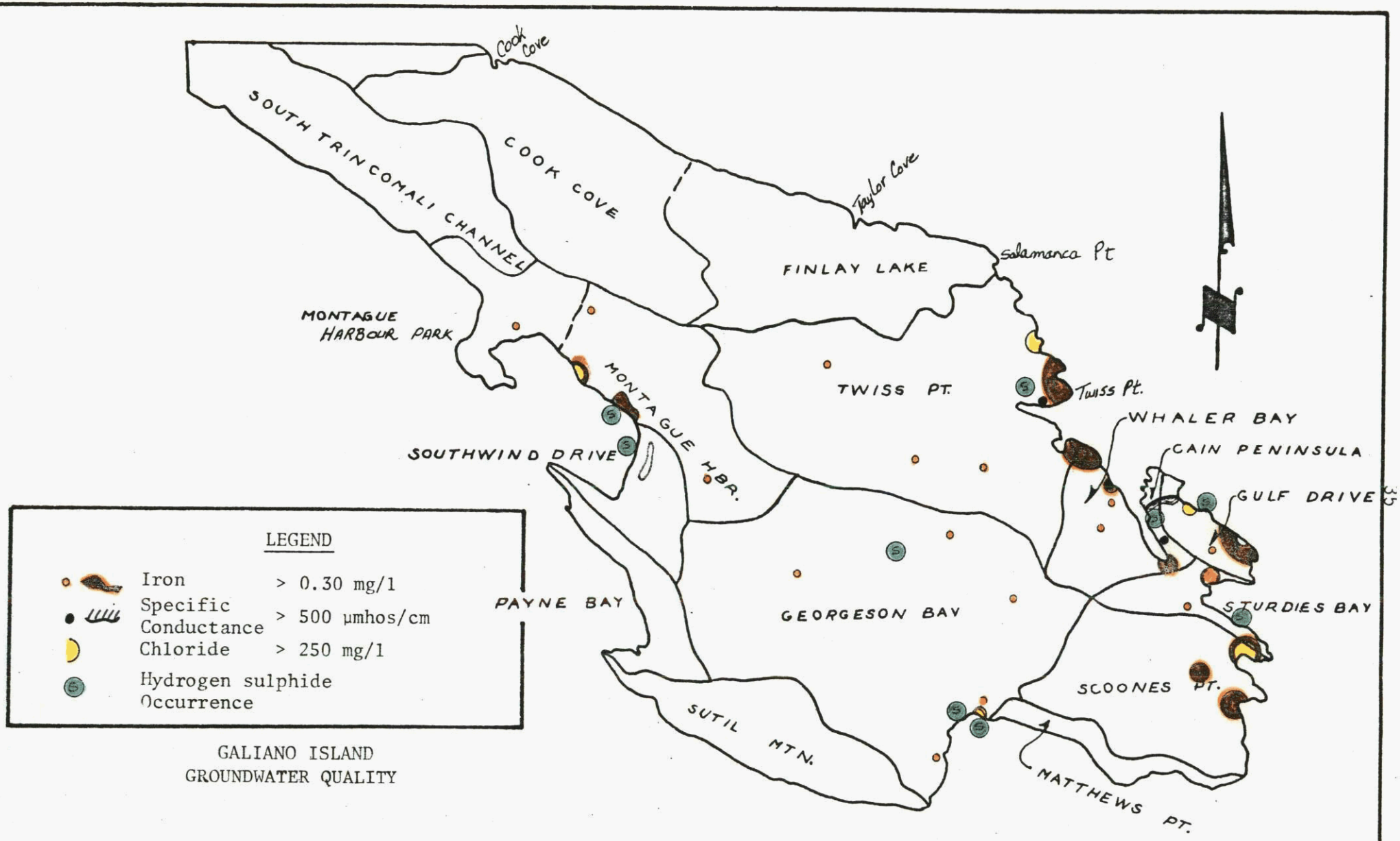
BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT ENVIRONMENTAL AND ENGINEERING SERVICES WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON A Review of Groundwater Conditions on Galiano Island	SCALE: VERT. HOR. 1" = 4000'	DATE May 1983
			ENGINEER
		FILE No. 92 B 14	DWG. No. Figure 5



GALIANO ISLAND
GROUNDWATER QUALITY

BRITISH COLUMBIA
MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL AND ENGINEERING SERVICES
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
A Review of Groundwater Conditions on Galiano Island

SCALE: VERT.
HOR. 1" = 4000'

DATE
May 1983

ENGINEER

FILE No. 92 B 14 DWG. No. Figure 6

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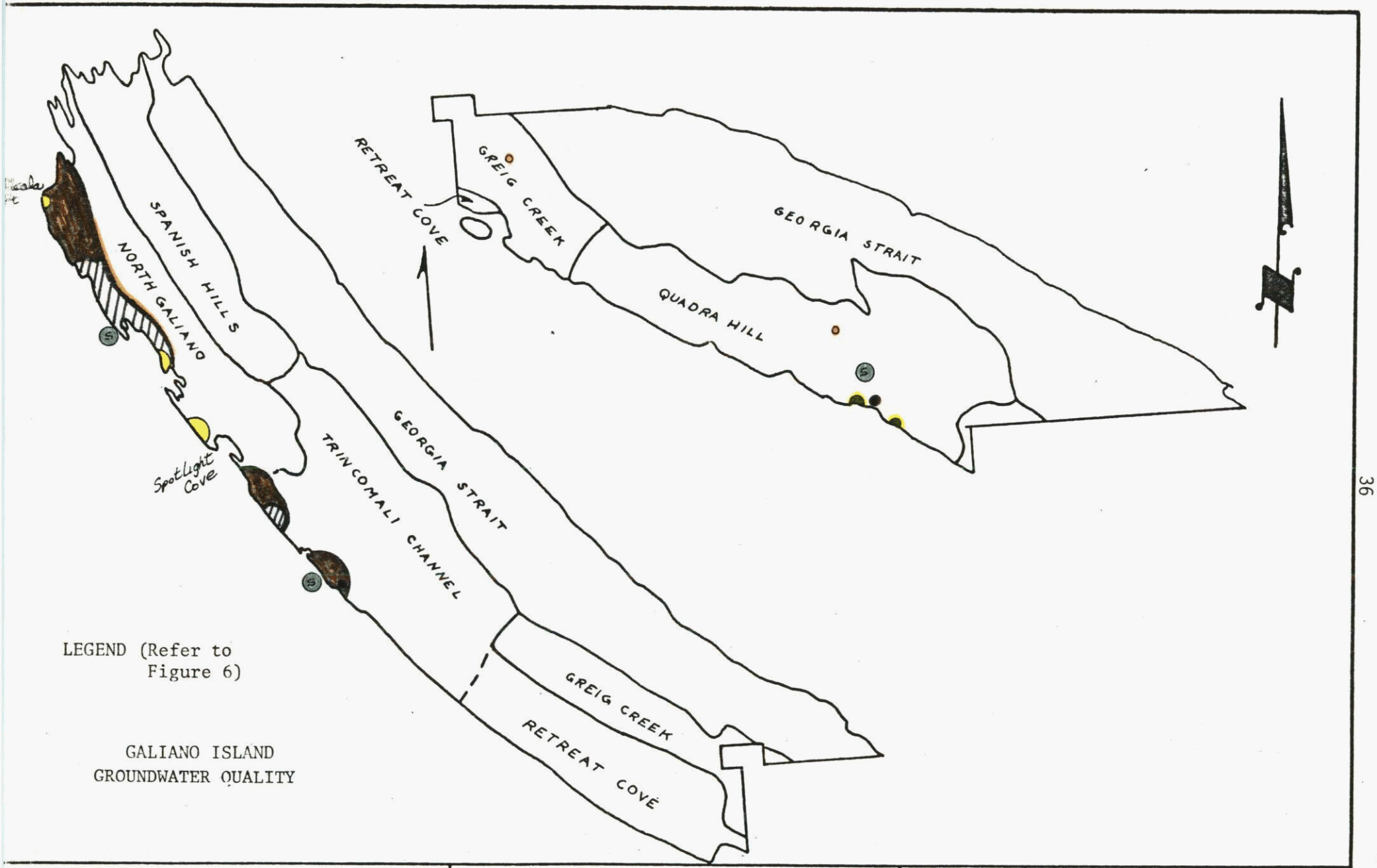

LEGEND (Refer to Figure 6)

GALIANO ISLAND
GROUNDWATER QUALITY

BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT ENVIRONMENTAL AND ENGINEERING SERVICES WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON A Review of Groundwater Conditions on Galiano Island	SCALE: VERT. HOR. 1" = 4000'	DATE May 1983
		ENGINEER	
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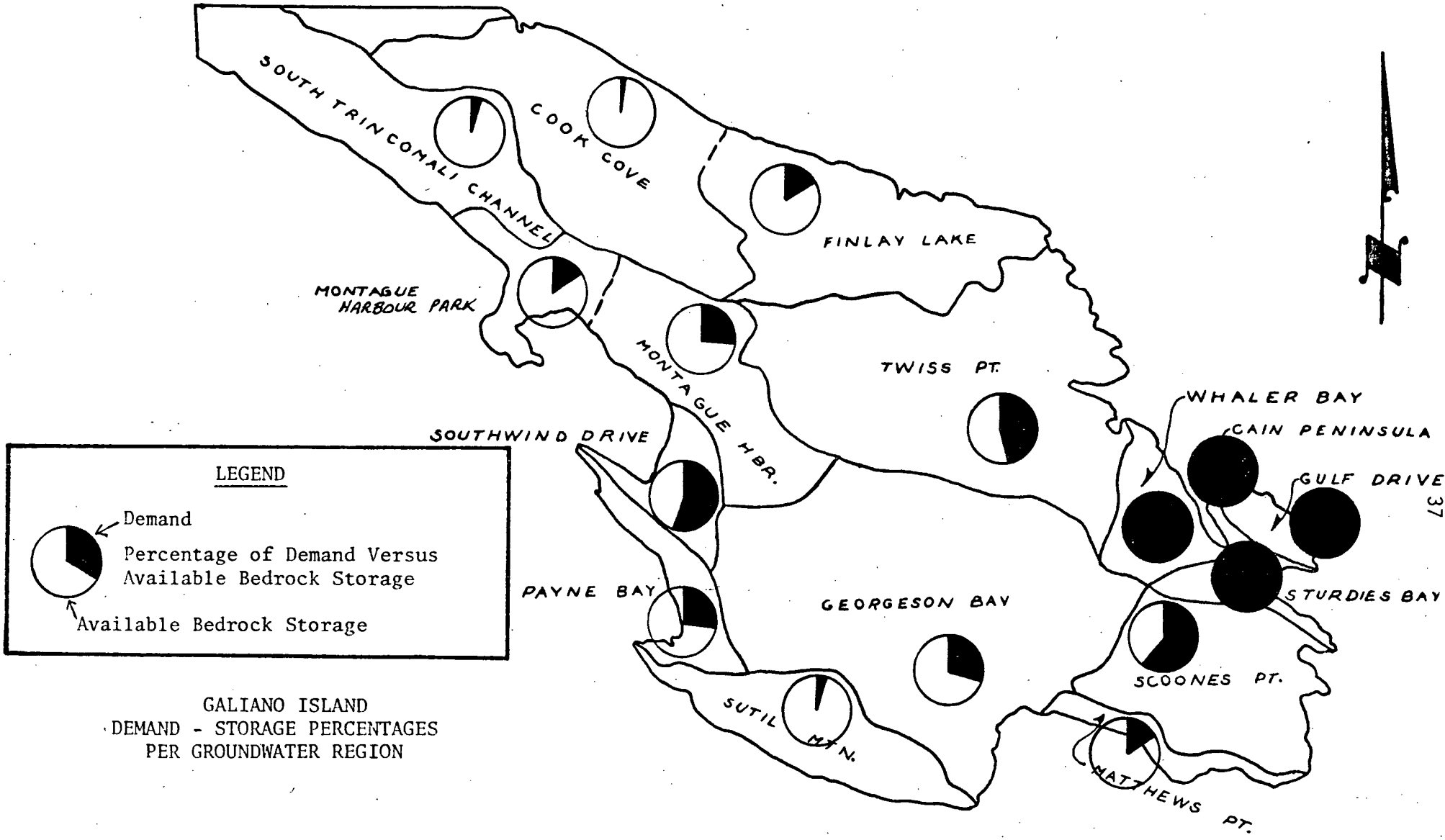

GALIANO ISLAND
DEMAND - STORAGE PERCENTAGES
PER GROUNDWATER REGION

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BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT ENVIRONMENTAL AND ENGINEERING SERVICES WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON A Review of Groundwater Conditions on Galiano Island	SCALE: VERT. HOR. 1" = 4000'	DATE May 1983
			ENGINEER
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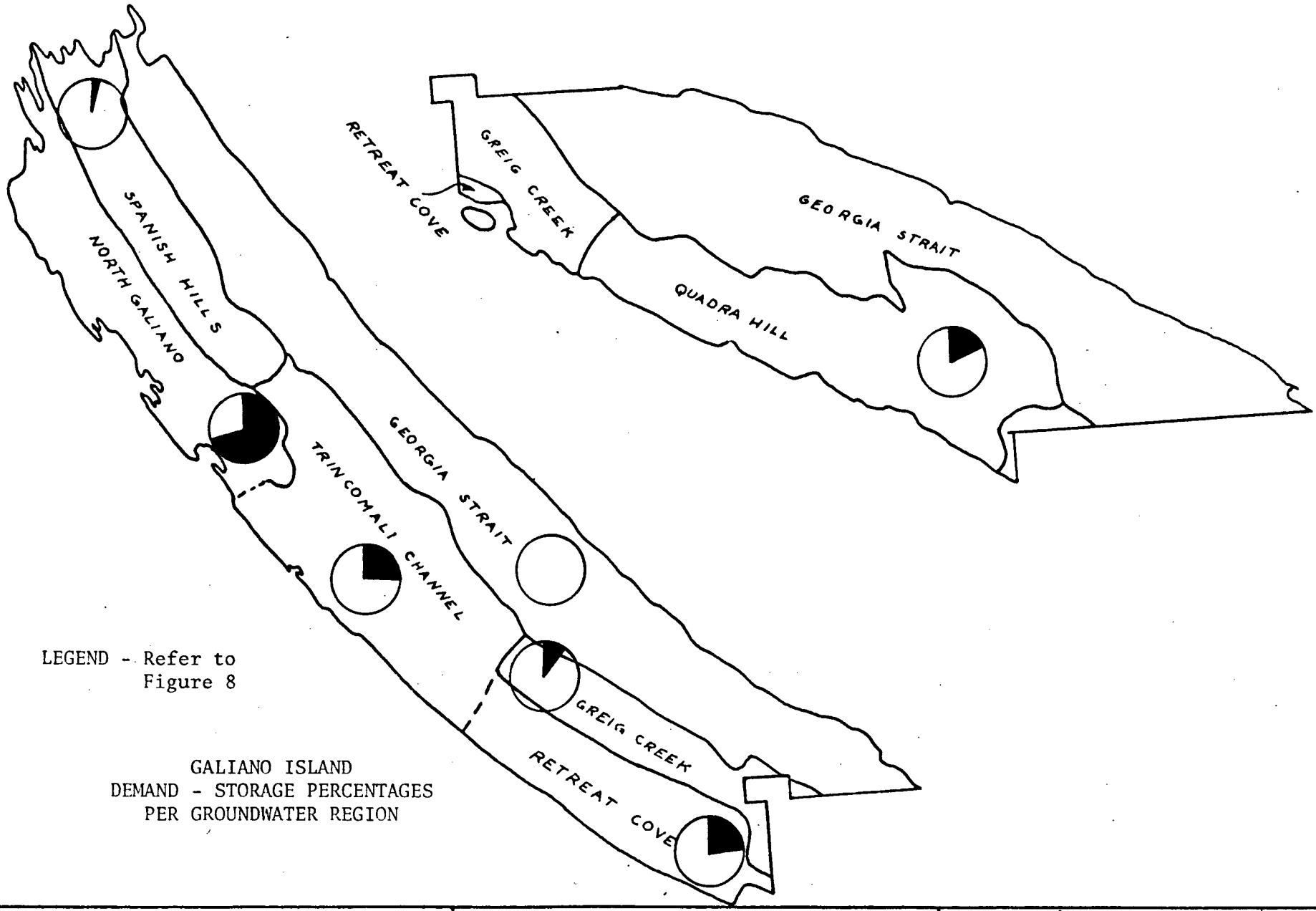

LEGEND - Refer to Figure 8

GALIANO ISLAND
DEMAND - STORAGE PERCENTAGES
PER GROUNDWATER REGION

BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT ENVIRONMENTAL AND ENGINEERING SERVICES WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON A Review of Groundwater Conditions on Galiano Island	SCALE: VERT. ..... HOR. 1" = 4000'	DATE May 1983
		ENGINEER	
		FILE No. 92 B 14 DWG. No. Figure 9	

TABLE 1

Galiano Island

Groundwater Regions. Plotted Wells & Springs

Groundwater Region	Wells		Springs	Total
	Drilled	Dug		
1. North Galiano	43	7	2	52
2. Spanish Hills	1	0	1	2
3. Georgia Strait	0	0	0	0
4. Trincomali Channel	28	0	0	28
5. Retreat Cove	11	0	2	13
6. Greig Creek	3	4	1	8
7. Quadra Hill	16	2	3	21
8. South Trincomali Channel	1	0	2	3
9. Montague Harbour Park	3	0	1	4
10. Cook Cove	0	0	1	1
11. Finlay Lake	13	1	0	14
12. Montague Harbour	15	1	0	16
13. Twiss Point	63	11	0	74
14. Southwind Drive	8	2	1	11
15. Payne Bay	5	0	1	6
16. Georgeson Bay	39	11	10	60
17. Sutil Mountain	1	0	1	2
18. Cain Peninsula	16	2	0	18
19. Gulf Drive	35	2	2	39
20. Whaler Bay	31	1	0	32
21. Sturdies Bay	48	1	3	52
22. Scoones Point	34	6	1	41
23. Matthews Point	1	1	0	2

TABLE 2

Galiano Island

Groundwater Regions. Well Completion Dates, Pre-1960 Up To 1980

Groundwater Region	Pre-1960	1960-64	1965-69	1970-74	1975-76	1977-80	Total
1. North Galiano	1	3	12	17	7	8	48
2. Spanish Hills						1	1
3. Georgia Strait							0
4. Trincomali Channel		1	7	13	1	5	27
5. Retreat Cove				3	5	3	11
6. Greig Creek				1	2	1	4
7. Quadra Hill			2	3	3	7	15
8. South Trincomali Channel						1	1
9. Montague Harbour Park			1	1			2
10. Cook Cove							0
11. Finlay Lake			8	3		2	13
12. Montague Harbour		2	7	3		1	13
13. Twiss Point	10	6	20	20	4	5	65
14. Southwind Drive	1	1	4	1	1	1	9
15. Payne Bay			4				4
16. Georgeson Bay	1		12	8	3	9	33
17. Sutil Mountain			1				1
18. Cain Peninsula	3		3	4	1	2	13
19. Gulf Drive	9	3	3	8		7	30
20. Whaler Bay	8		5	5		9	27
21. Sturdies Bay	12	6	7	8	3	6	42
22. Scoones Point	8	1	9	7	3	6	34
23. Matthews Point						1	1

TABLE 3

Galiano Island

Groundwater Regions. Rate of Well Development

Groundwater Region	Total Number of Wells	No. of New Wells drilled between 1977-1980)	Well Development expressed as a percent between 1977 and 1980
1. North Galiano	52	8	15.4
2. Spanish Hills	2	1	50.0
3. Georgia Strait	0	0	0.0
4. Trincomali Channel	28	5	17.9
5. Retreat Cove	13	3	23.1
6. Greig Creek	8	1	12.5
7. Quadra Hill	21	7	33.3
8. South Trincomali Channel	3	1	33.3
9. Montague Harbour Park	4	0	0.0
10. Cook Cove	1	0	0.0
11. Finlay Lake	14	2	14.3
12. Montague Harbour	16	1	6.3
13. Twiss Point	74	5	6.8
14. Southwind Drive	11	1	9.1
15. Payne Bay	6	0	0.0
16. Georgeson Bay	60	9	15.0
17. Sutil Mountain	2	0	0.0
18. Cain Peninsula	18	2	11.1
19. Gulf Drive	39	7	18.0
20. Whaler Bay	32	9	28.1
21. Sturdies Bay	52	6	11.5
22. Scoones Point	41	6	14.6
23. Matthews Point	2	1	50.0

TABLE 4

Galiano Island

Groundwater Regions. Average Well Depths and Yields

Groundwater Region	Springs		Wells 25' Deep (mainly dug)		Wells 25' Deep (mainly drilled)		Total No. of Springs & Wells	Average Drilled Well Depth (feet)	Average Yield All Wells (USgpm)
	Number	% of Region	Number	% of Region	Number	% of Region			
1. North Galiano	2	3.9	6	11.5	44	84.6	52	108	3.9
2. Spanish Hills	1	50.0			1	50.0	2	125	0.7
3. Georgia Strait							0	0	0
4. Trincomali Channel					28	100.0	28	109	4.0
5. Retreat Cove	2	15.4	1	7.7	10	76.9	13	198	2.6
6. Greig Creek	1	12.5	3	37.5	4	50.0	8	170	18.0
7. Quadra Hill	3	14.3	1	4.8	17	81.0	21	151	6.2
8. South Trincomali Channel	2	66.7			1	33.3	2	207	6.0
9. Montague Harbour Park	1	25.0			3	75.0	4	104	8.8
10. Cook Cove	1	100.0					1		
11. Finlay Lake			1	7.1	13	92.9	14	167	4.8
12. Montague Harbour			1	6.3	15	93.8	16	139	5.0
13. Twiss Point			7	9.5	67	90.5	74	141	6.2
14. Southwind Drive	1	9.1	2	18.2	8	72.7	11	145	9.7
15. Payne Bay	1	16.7			5	83.3	6	233	2.5
16. Georgeson Bay	10	16.7	8	13.3	42	70.0	60	182	2.5
17. Sutil Mountain	1	50.0			1	50.0	2	340	0.25
18. Cain Peninsula			1	5.6	17	94.4	18	159	1.9
19. Gulf Drive	2	5.1	2	5.1	35	89.7	39	127	4.7
20. Whaler Bay				3.1	31	96.9	32	162	6.6
21. Sturdies Bay	3	5.8	1	1.9	48	92.3	52	137	7.0
22. Scoones Point	1	2.4	4	9.8	36	87.8	41	157	3.8
23. Matthews Point					2	100.0	2	290	0.5

TABLE 5

GALIANO ISLAND

QUANTITATIVE ESTIMATES OF PRESENT GROUNDWATER USE VERSUS AVAILABLE STORAGE

GROUNDWATER REGION	AREA OF REGION		RECHARGE IN ACRE-FEET BASED ON ONE INCH OF ANNUAL PRECIP. FOR GROUNDWATER RECHARGE	RECHARGE IN US GALLONS BASED ON ONE INCH OF ANNUAL PRECIP. AVAILABLE FOR GROUNDWATER RECHARGE	NUMBER OF PLOTTED WELL AND SPRINGS IN REGION	GROUNDWATER USAGE IN GALLONS BASED ON 500 US GPD PER 100 DAYS PUMPING	PRELIMINARY ESTIMATES OF GROUNDWATER SUPPLIES IN STORAGE AND RECOVERABLE BY PUMPING EXPRESSED AS %, BEDROCK VOLUME IN AC-FT (ASSUMING DEPTH OF 200')	AVAILABLE BEDROCK STORAGE BASED ON 0.01% IN GALLONS (US)	ESTIMATED GROUNDWATER USAGE VERSUS GROUNDWATER IN STORAGE EXPRESSED AS A PERCENTAGE
	ACRES	HECTARES							
1. North Galiano	566	229	47	15.3×10^6	52	2.6×10^6	11.32	3.69×10^6	70.46
2. Spanish Hills	446	181	37	12.1×10^6	2	0.1×10^6	8.92	2.91×10^6	3.44
3. Georgia Strait	3,229	1,307	269	87.6×10^6	0	0×10^6	64.58	21.04×10^6	0.00
4. Trincomali Channel	834	338	70	22.8×10^6	28	1.4×10^6	16.68	5.43×10^6	25.78
5. Retreat Cove	468	189	39	12.7×10^6	13	0.7×10^6	9.36	3.05×10^6	22.95
6. Greig Creek	589	238	49	16.0×10^6	8	0.4×10^6	11.78	3.84×10^6	10.42
7. Quadra Hill	941	381	78	25.4×10^6	21	1.1×10^6	18.82	6.13×10^6	17.94
8. South Trincomali Channel	646	262	54	17.6×10^6	3	0.2×10^6	12.92	4.21×10^6	4.75
9. Montague Harbour Park	202	82	17	5.5×10^6	4	0.2×10^6	4.04	1.32×10^6	15.15
10. Cook Cove	838	339	70	22.8×10^6	1	0.1×10^6	16.76	5.46×10^6	1.83
11. Finlay Lake	666	270	56	18.2×10^6	14	0.7×10^6	13.32	4.34×10^6	16.13
12. Montague Harbour	469	190	39	12.7×10^6	16	0.8×10^6	9.38	3.06×10^6	26.14
13. Twiss Point	1,228	497	102	33.2×10^6	74	3.7×10^6	24.56	8.00×10^6	46.25
14. Southwind Drive	166	67	14	4.6×10^6	11	0.6×10^6	3.32	1.08×10^6	55.56
15. Payne Bay	168	68	14	4.6×10^6	6	0.3×10^6	3.36	1.09×10^6	27.52
16. Georgeson Bay	1,565	634	130	42.4×10^6	60	3.0×10^6	31.30	10.20×10^6	29.41
17. Sutil Mountain	377	153	31	10.1×10^6	2	0.1×10^6	7.54	2.46×10^6	4.07
18. Cain Peninsula	24	10	2	0.7×10^6	18	0.9×10^6	0.48	0.16×10^6	562.50
19. Gulf Drive	87	35	7	2.3×10^6	39	2.0×10^6	1.74	0.57×10^6	350.88
20. Whaler Bay	196	79	16	5.2×10^6	32	1.6×10^6	3.92	1.28×10^6	125.00
21. Sturdies Bay	182	74	15	4.9×10^6	52	2.6×10^6	3.64	1.19×10^6	218.49
22. Scoones Point	526	213	44	14.3×10^6	41	2.1×10^6	10.52	3.43×10^6	61.22
23. Matthews Point	99	40	8	2.6×10^6	2	0.1×10^6	1.98	0.65×10^6	15.38
TOTAL	14,512	5,876	1,208	393.6×10^6	499	25.3×10^6	290.24	94.59×10^6	26.75