DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES

WATER RESOURCES SERVICE

THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

GROUNDWATER INVESTIGATIONS ON MAYNE ISLAND

REPORT NO. 1

EVALUATION, DEVELOPMENT AND MANAGEMENT OF THE GROUNDWATER RESOURCE ON MAYNE ISLAND

DATE February, 1974

J. C. Foweraker

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THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

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YOUR REF.:

DEPARTMENT OF ENVIRONMENT

August 11, 1976

Mrs Hilary Brown
Chairman
Islands Trust
Parliament Buildings
Victoria, B.C.

Dear Mrs Brown:

Re: North Pender Island

Further to the reports of June 30, 1976 prepared by the Groundwater Section on the above subject and following discussions with D. Morris, Planner with your staff, the Groundwater Section recommends that any additional groundwater development contemplated for the island should be undertaken in a systematic manner. At present it appears that current groundwater use in the Port Washington and west of Hope Bay areas may exceed the natural groundwater recharge rate. In consideration of the Section's studies on nearby Mayne Island where a good deal of information has been collected on the geology, hydrochemistry and water-bearing properties of the fractured bedrock aquifers and where geologic conditions are similar to North Pender Island, it would be prudent to consider only limited groundwater development on North Pender. Utilizing the Mayne Island model where an allowance is made for available groundwater storage suggests for initial planning only 10 additional development units be considered for the area north of Shingle Bay, 15 additional units for the area north of Port Browning and 14 for the area southeast of Hope Bay. These figures represent about one-half the original estimate of 80 additional residential units based on 350 gpd for each unit over 100 days contained in the June 30, 1976 report, and may be more applicable for direct planning purposes. The Section also recommends that development be conducted in phases with a required program of groundwater monitoring. Monitoring of consumption and water level fluctuations for example within the development could be used to determine whether groundwater depletion is occurring or whether additional groundwater is warranted.

As development proceeds on the island the Groundwater Section would be prepared to discuss further with you any groundwater problems which may arise.

Yours very truly

P. M. Brady
Director
Water Investigations Branch

GROUNDWATER INVESTIGATIONS

ON MAYNE ISLAND

REPORT NO. 1

EVALUATION, DEVELOPMENT AND

MANAGEMENT OF THE GROUNDWATER

RESOURCE ON MAYNE ISLAND

by J.C. FOWERAKER

REPORT NO. 2

GROUNDWATER CHEMISTRY AND MOVEMENT ON MAYNE ISLAND

by J.C. HEISTERMAN

REPORT NO. 3

GROUNDWATER EXPLORATION ON MAYNE ISLAND

by M.C. MONCUR

February, 1974.

WATER INVESTIGATIONS BRANCH
BRITISH COLUMBIA WATER RESOURCES SERVICE
DEPARTMENT OF LAND, FORESTS AND WATER RESOURCES
PARLIAMENT BUILDINGS
VICTORIA, BRITISH COLUMBIA

R.A. Williams, Minister

WATER RESOURCES SERVICE
B.E. Marr, Acting Associate
Deputy Minister

WATER INVESTIGATIONS BRANCH
Acting Director, P.M. Brady

GROUNDWATER INVESTIGATIONS

ON MAYNE ISLAND

REPORT NO. 1

EVALUATION, DEVELOPMENT AND MANAGEMENT OF THE GROUNDWATER RESOURCE ON MAYNE ISLAND

February 1974

by-J.C. Foweraker, Chief
Groundwater Division
Water Investigations Branch

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ABSTRACT

An evaluation of the Groundwater Resources of Mayne Island has been recorded on three reports. The study includes an investigation of the Island's groundwater potential, distribution quality and quantity. Report No. 1, this report, outlines the geography and geology of the Island and also a discussion on the construction of a theoretical model of the Island which is used for estimating the storage of available potable water, the water demand/storage ratios for individual "groundwater regions" and the projected density limits for residence development.

The goal of a groundwater development and management program on Mayne Island should be the optimum use by the community of the potable groundwater resource without endangering the quality or exceeding its annual replenishment. To this end the use of higher capacity wells on the Island should be regulated by Government procedures, and up to seven "Groundwater Development Reserves" should be set aside for orderly development and management practices. A long term monitoring program already initiated should be continued.

INTRODUCTION

1. Purpose of the Study

The groundwater investigations carried out on Mayne Island are the first steps in a larger groundwater study underway on the Gulf Islands. The purpose of these studies is to investigate the groundwater potential, distribution, quantity and quality of groundwater in the Gulf Islands in order to determine if licencing and regulation of groundwater is necessary for the future management of the resource. The results of the Groundwater investigations on Mayne Island will give some direction for further work to be carried out in the other Gulf Islands.

2. Scope of the Study

The evaluation of the groundwater resources of Mayne Island has been recorded in three reports.

This report (Report No. 1) describes the geography, geology and groundwater features on the island. Quantitative groundwater studies include the setting up of a theoretical model to arrive at estimates of groundwater storage within the potable water bearing zone of Mayne Island. Based on the theoretical model, demand/storage percentages and present/ future residences percentages are given. Recommendations are made for "groundwater development reserves," permitting of larger production wells for community supply, observation wells, etc.

Report No. 2 (separate report) is a detailed account of the hydrochemistry of Mayne Island by J. Heisterman.

Report No. 3 (separate report) is an account of the 1972 test well drilling program, pumping tests and analyses carried out on Mayne Island, by M.C. Moncur.

3. Methods of Investigation

Preliminary investigations commenced in 1971 at the request of the Director, Mr. B.E. Marr, of the Water Investigations Branch.

A door to door inventory of water wells was first completed on the island. Well information from this inventory and from information obtained from well drillers and previous work was recorded on well record cards and on new 500 and 1,000 feet to the inch maps. The data was also summarized by the use of hydrogeological symbols on work sheets. Precipitation data was compiled in tabulated form from the records available. A limited number of samples of ground water were analysed with a Hach Engineers Laboratory Kit for major ions and these results were tabulated.

Reference was made to available geological and groundwater maps and reports. Air photos were used to supplement these studies.

During late 1971 pumping tests were carried out on two existing wells on Mayne Island by Groundwater Division personnel using Division test equipment. In January 1972, a preliminary report on the Mayne Island study was completed.

During the 1972 field season a short experimental geophysical survey was carried out to determine methods for delineating water bearing fault zones on the island. A short electrical resistivity survey was run across known fault lines to see if measurable differences existed between more fractured water bearing fault zones and surrounding less fractured rock. The geophysical consultants report indicated that more sophisticated geophysical equipment was needed together with a more detailed survey coverage if fault zones were to be delineated with some reliability. A seismic survey was run across known fault lines, but was unsuccessful and the consultant's report indicated that the use of other equipment and methods to give better data would be very expensive. The consultant's report is appended to Report No. 3.

Test well drilling, observation well construction, downhole electric logging and pumping tests were carried out during the 1972 field season - see Report No. 3 for details.

A comprehensive sampling program of ground water from wells and springs was undertaken and chemical analyses for major ions were made by Groundwater Division staff using the Hach Engineers Laboratory Kit. Additional samples were sent to the Water Resources Laboratory for analysis.

The results and interpretation are given in Report No. 2.

Hydrogeological mapping, investigation of jointing and faulting along the coastline and mapping and investigation of groundwater field features were carried out as time permitted.

4. Previous Investigations

Previous investigators who have carried out groundwater studies on Mayne Island include E.C. Halstead; Research Scientist; Inland Waters Branch; Department of the Environment; E. Livingston, Consulting Groundwater Geologist; W.L. Brown, Consulting Groundwater Geologist; Matson, Peck and Topless Engineering Limited, Vancouver, British Columbia.

5. Acknowledgements

The writer wishes to acknowledge the interest shown by the Director of the Water Investigations Branch in the Mayne Island study and for furnishing funds and staff to permit the completion of the present reports.

The writer wishes to acknowledge Mr. J. Heisterman for contributions and assistance in the preparation of the present report;

Mr. M. Moncur for pumping test supervision and report editing; Mr. J. Gulliver, formerly Head Technician of the Groundwater Division, for field supervision of test well drilling and pumping tests; Mr. D. Johanson, Head Technician, for field supervision of pumping tests; Mr. J. Jaundrew for supervision of test well drilling; Mr. E. Tradewell and Mr. B. DeBeck for field assistance and help with collecting water samples for analysis and for office computations and compilation of data; Mr. A. Quin, formerly with the Division, and Mr. W. McInnes, with the Draughting Section, for the preparation of map drawings and figures; Mr. A. Allport for preparation of hydrographs and for design of fig. 1.2; Mr. R. Wyman, Hydrology Division for assistance with computer programming and processing for regression analyses; appreciation for helpful comment and suggestions to Mr. D.M. Callan, formerly Senior Geological Engineer, and especially my thanks to Mr. E.G. LeBreton, Senior Geological Engineer, with the Groundwater Division, for encouragement, helpful discussions and report editing.

Acknowledgement is made to Mr. R. Cunningham for permission to test his well in 1971; Mr. M.J. Chamberlain, Mr. J. Ferguson, Matson, Peck and Topless Engineering Limited, Vancouver, for permission to use their wells for monitoring during pumping tests in 1971; Pacific Coast Realty for permission to test and sample their well located on Mount Parke; Village Point, Gulf Lands Corporation for permission to sample wells on their properties, my thanks to all the residents of Mayne Island for their cooperation in allowing samples to be taken from their wells and springs and for supplying much local information. Particular mention should be made of the cooperation and assistance provided by larger property owners on the Island - Mr. John Rainsford, Mr. Wilbur Deacon, Mr. Ken Robson and Mr. Alan Steward in agreeing to test well drilling and pumping tests being carried out on their properties in 1972. Special thanks to Mr. J. Rainsford and Mr. A. Steward for their assistance in monitoring the observation wells and collecting other data. The writer wishes to acknowledge the assistance and helpful advice and well logs provided by Mr. K. Halverson. The writer wishes to thank Mr. E.C. Halstead, Research Scientist, Hydrologic Sciences Division, Inland Waters Branch, Department of the Environment, for helpful comments and for the use of two wells for well testing and monitoring; Mr. E. Livingston, consulting groundwater geologist, Vancouver, Mr. W.L. Brown, consulting groundwater geologist, Vancouver and Matson, Peck and Topless Engineering Limited for their cooperation in making available data and reports on groundwater investigations and testing carried out on the island; Dr. J.E. Muller, Geological Survey of Canada, for assistance in the location of faults on the island and for editing the geology section and Map No. 1-3 of this report; the Petroleum and Natural Gas Branch in Victoria for unpublished information on the island geology; the Capital Regional District for information and Mr. J.O. Moore, Department of lands, for information on number and distribution of residences on the island.

Acknowledgement is made to the drilling contractor, Mr. Ken Keating of Ken's Drilling, for personally undertaking the testwell

drilling on Mayne Island; to Roke Oil Enterprises of Calgary and the owner-manager, Mr. K. Banks for downhole logging geophysical services also Mr. Earl E. Outcalt of Geosearch Exploration Limited, Calgary, for surface geophysical surveys.

GEOGRAPHY

1. Location Topography and Drainage

Mayne Island lies in the outer chain of the Gulf Islands which are located off the southeast coast of Vancouver between Victoria and Nanaimo (See Map No. 1.1). The outer chain of islands includes Gabriola, Valdes, Galiano, Mayne and Saturna Islands. The area of Mayne Island is approximately 8.9 square miles.

Mayne Island, like the other outer Gulf Islands, has steep south-west facing cliffs and more gentle sloping surfaces to the northeast which reflects the direction of dip of the underlying bedrock. The drainage pattern on the island can be seen by referring to the watershed map (Map No. 1.2) where fifteen sub-basin or watersheds have been outlined. The pattern is one of short creeks, less than a mile long draining individual watersheds. The watershed boundaries which represent the topographic divides between sub-basins are clearly marked on Map 1.2. The largest watershed is the Horton Bay Watershed and covers 1,022 acres.

During the middle and late summer surface water flows in creeks are limited to seepages fed from springs. Surface water licences are related to direct spring discharge areas or wells developed in spring areas.

The two highest topographic features on the Island are Mount Parke and Hall Hill which rise to elevations of 856 and a little over 600 feet respectively.

2. Climate

The outstanding feature of the climate of Mayne Island is the mildness of the winters for the latitude. Rains decrease after March and are least in July and August which form a pronounced dry season. The air is warm but the sea breeze checks any great heat in the afternoon. The mean annual temperature is about 50°F. This figure is based on the readings taken on Saltspring Island nine miles to the southwest where the mean annual temperature is 49.3°F.

Only two complete years of precipitation records are available at this time for Mayne Island namely for 1971 and 1972; precipitation totalled 32.83 and 35.08 inches respectively in these two years. This gives an average value of 33.95 inches for the two years of record.

Based on the above figure and the longer period of record for Saltspring Island of 35.94 inches taken over a 10-year period and South Pender Island of 30.93 inches for 6 years, the mean annual precipitation for Mayne Island has been taken as 33 inches for this report. The precipitation records show that the Gulf Islands lie in a rain shadow, because of their location leeward of Vancouver Island. On the windward side of Vancouver Island the mean annual precipitation exceeds 100 inches.

Precipitation records for Mayne Island, South Pender Island and Saltspring Island are given in Table No. 1.1. The location of the Hydrometric Station on Mayne Island is shown on Figure No. 1.2.

GEOLOGY

1. Bedrock Geology

Mayne Island is made up of sediments belonging to the Nanaimo Group. These clastic sediments form a series of conglomerates, sandstones, shales and siltstones. According to Muller and Jeletzky (1970), the Nanaimo Group sedimentary succession may be viewed as a series of transgressive cycles and the cycles alternate between deltaic and marine and are classified as follows:

Cycle	Formation	Rock Type
Deltaic	Gabriola	sandstone, conglomerate
Marine	Spray	shale,
Deltaic	Geoffrey	sandstone, conglomerate
Marine	Northumberland	shale, siltstone
Deltaic	De Courcy	conglomerate, sandstone
Marine	Cedar District	shale, siltstone, sandstone
Deltaic	Extension	conglomerate, sandstone
Lagoonal	Protection	sandstone, shale coal
Marine	Haslam	shale, siltstone, sandstone
Lagoonal	Comox	sandstone, shale, coal

The sediments of the Gulf Islands are described by Halstead (1967) as follows: "The sandstones and conglomerates consist of angular to subangular fragments closely packed and well cemented with calcareous and ferruginous cements. The shales consist chiefly of dark grey, concentrically weathered carbonaceous, ferruginous and in places calcareous fine sandy shales with a great number of thin interbeds of brownish grey rather fine-grained sandstones. The sedimentary rocks are characterized by low porosity and permeabilities near zero; thus movement of water is confined to structures such as bedding planes, faults and joints".

Map No. 1.3, Mayne Island Bedrock and Structural Geology Map, was prepared by the writer on the basis of GSC Paper No. 69-25 by Muller and Jeletzky and unpublished information obtained from Dr. Muller and from the Petroleum, Natural Gas Branch, from well records on file with the Groundwater Division, from air photo interpretation, field and office work carried out by the writer. A trip was also made by boat around the Island to obtain information on joints and faults in less accessible areas of the Island.

One of the most noticeable relationships on the island between topography and geology is shown in the way the prominent valleys are carved out of less resistant shale beds, and the prominent ridges and topographic highs are composed of resistant and less fractured sandstone and conglomerate. Their relationships can be seen on the map and geological sections of Map 1.3. The areas of low relief existing between Miners Bay and Bennett Bay are carved out of less resistant shales with sandstone bands of the Spray Formation. The prominent east west valleys between Village Bay and Horton Bay are eroded in the less resistant shales of the Northumberland Formation.

The island valleys were probably eroded by ice during Pleistocene glaciations. The larger embayments and beaches are generally found to be located in shale sequences and indicates their susceptibility to marine erosion. Within the shale sequence can be found many thin beds of sandstone. This can be seen from rock exposures and from an inspection of well logs.

Mount Parke is the most prominent topographic feature of Mayne Island and is composed of erosion resistant sandstone capped with conglomerate the dip of the beds is NNE. The escarpment along the south side of Mount Parke is very pronounced.

It should be kept in mind that the lithology is not as simplified as that shown on Map No. 1.3. Shale contains numerous sandstone band of varying thickness, sandstone contains bands of shale, conglomerate is found mixed with sandstone and so on. These variations are perhaps to be expected knowing that the succession alternates between a deltaic and marine environment with many fluctuations in the mode of deposition of the sediments. The variations within rock types, in part, may help to explain the apparent inconsistencies found on some well logs when an attempt is made to relate them to the geology. The formations shown on Map No. 1.3 for Mayne Island were originally named by Clapp (1912, 1914) and Usher (1952).

2. Structural Geology

The structure of the Nanaimo basin is relatively uncomplicated in the general area of Nanaimo and Gabriola Island but the structure becomes increasingly complex and tighter southward towards Mayne, Pender and Saturna Islands.

Unpublished reports from the Petroleum and Natural Gas Branch refer to anticlinal structure extending from Thetis Island south eastward for 25 Miles to the north end of Saturna Island. The axis of this anticline in the Mayne Island vicinity is below the waters of Navy Channel south of Mayne Island. The more recent work of Muller and Jeletzky states that a "broad fault zone marked by steeply northeast - dipping to southwest - overturned beds transects Saltspring. Prevost, Mayne, Pender and Saturna Islands. An asymetrical syncline with steep southwest limb offset by several cross faults occurs on north Salt-spring, Prevost, Mayne and Saturna Islands."

More detailed structural work is needed to determine more fully the nature of the faulting and folding in the Gulf Islands.

The bedrock and structural geology map of Mayne Island, shows the strike of the bedding to be west-northwest with a gentle dip to the north-northeast of generally 15^{o}-25^{o}. The map shows a number of "transverse" faults striking north to northwest, the more prominent being the central fault zone which will be referred to a number of times in succeeding sections of this report.

Some of the faults can be delineated or inferred from aerial photographs and field features such as ponds, abrupt topographic changes, depressions, springs, ditches, etc. Zones of increased jointing and fracturing have been observed by the writer near some inferred fault zones where bedrock outcrops are exposed at shoreline. For example on the east side of the fault line located between Deacon and Heck Hills, very closely spaced 6 inches to one foot near vertical jointing is observed in sandstones exposed over a distance of 250 feet along the shoreline. Six-inch to one-foot joint spacing is also observed in conglomerate and sandstone exposed for 250 feet along the shoreline to the east of the main central fault line which traverses the island. Some fairly close jointing was observed up to 250 feet to the west of the fault line also. The fault on the east side of section 11 which enters the south side of Cambell Bay cuts through a fairly massive looking sandstone outcrop and the main zone of jointing and weakness would appear to be restricted to a narrow 40-foot width inlet bounded by steep 80° west dipping joint faces.

Limited horizontal displacement of the bedrock appears to have taken place in some areas, for example in the central fault zone at the south end of the fault line in section 3 where shale is found on the west side of the fault against sandstone on the east side. Limited small adjustments along a number of vertical fracture faces in the fault zone could be the explanation of the horizontal displacement of these north dipping shales and sandstones.

There are two inferred longitudinal faults in the Hall Hill area of Mayne Island on Map 1.3. The faults are inferred to dip to the south-west and are generally expected to be tighter than transverse faults, and zones of slickensiding and fault gouge can be expected. Test Well No. 24, Section 12, located adjacent to a longitudinal fault, encountered muddy water and questionable fault gouge at a depth of 200 feet and may indicate an intersection with this fault zone.

The importance of bedrock geology and particularly structural geology on well yields will be the subject of a later section of this report.

3. Surficial Geology

Unconsolidated surficial deposits consist of clay, silt, sand, gravel and a compact material known as till which includes all of the above plus some boulders.

The greatest known thickness of overburden recorded on a well log on Mayne Island is 78 feet recorded in a test well drilled by the Groundwater Division. Generally speaking, the overburden depth is less than 20 feet and forms a thin veneer of undifferentiated deposits overlying bedrock.

The last major glaciation which overrode the Gulf Islands is called the Fraser Glaciation (Armstrong et al 1965). The main ice lobe in the Strait of Georgia according to Halstead (1967) overrode the Gulf Islands and continued south.

During deglaciation large volumes of water quickly returned to the seas and caused sea level to rise. Deposition of the unconsolidated deposits at low elevations at this time was in a marine environment. Glacio marine deposits, silt, clay and stony clay on Mayne Island filled the lowland areas in the Interior, Horton Bay and Village Bay watersheds (see Map 1.2). Isostatic adjustment after the ice receded then caused the land masses to rise relative to the sea level.

QUANTITATIVE GROUNDWATER STUDIES

1. GENERAL STATEMENT

The purpose of the quantitative studies outlined in the sections to follow is to estimate the potential, distribution and quantity of potable ground water available for use on Mayne Island.

The first two sections deal with recharge considerations and a discussion of hydrographs prepared from observation well records.

Quantitative studies include a theoretical model for the Island to give an estimate of storage within the potable water bearing zone, demand/storage ratios, etc. This theoretical model is admittedly an oversimplification of the actual case but as new data becomes available, the model can be revised.

2. ESTIMATED MINIMUM ANNUAL AVAILABLE RECHARGE TO GROUNDWATER FROM PRECIPITATION

Details of precipitation on Mayne Island have already been discussed under "Climate". The mean annual precipitation for Mayne Island has been taken as 33 inches for this report. Precipitation records are given on Table No. 1.1. At the present state of our knowledge we must assume that all recharge to potable ground water on Mayne Island comes from precipitation that falls on the Island.

The estimated annual available recharge to ground water on Mayne Island from precipitation will only be a fraction of the total annual precipitation of 33 inches. Halstead (1967) estimates only 2 inches of the total 33 inches of annual precipitation is available to replenish groundwater supplies. The average annual actual evapotranspiration is 16 inches (Figure 20, Canada Land Inventory Report No. 3), and runoff from bedrock surfaces is estimated to be 15 inches which leaves only two inches for groundwater recharge.

For the present report, the estimated annual available recharge to groundwater from precipitation is taken as only 1 inch per acre, which is believed to be a very conservative estimate. The computed value for annual recharge to Mayne Island based on 1 inch of precipitation is 478 acre-feet, or 74.4 US gallons per day per acre. The theoretical model estimates for groundwater in storage on Mayne Island is about 190 acre-feet. This is equivalent to 29.6 US gallons per day per acre for a year or 108 US gallons per day per acre for an estimated dry summer period of 100 days when recharge is almost nil. (See Section 5.5 below). The estimate used for the theoretical model for ground water in storage are based on a storage coefficient value of $S = 1 \times 10^{-4}$.

The results indicate that even assuming a minimum value of 1 inch of precipitation per year available for recharge to ground water the estimated annual available recharge to ground water on Mayne Island is still 478 acre-feet, while the estimated storage available for ground water within the fractured bedrock media may only be in the order of 190 acre-feet, or about 40% of the minimum available recharge.

On an annual basis then, storage and permeability, and not precipitation, appear as the more immediate limiting factors controlling ground water availability on the Island.

Because of limited storage and permeability in the fractured bedrock media, and no recharge during the summer and early fall, it follows that excessive use of groundwater supplies during this period will cause localized depletion of storage until recharge commences in late fall.

3. HYDROGRAPHS PREPARED FROM OBSERVATION WELL RECORDS

3.1 Discussion

Details of the observation wells discussed below are to be made available later in 1974 in a Water Investigations Branch Publication entitled Groundwater Observation Wells of British Columbia. The information is also available in the files of the Groundwater Division.

In Figure 1.2, entitled "Hydrographs Prepared from Observation Well Records", the location of the observation wells are shown in the key plan, together with recorder hydrographs prepared from Stevens recorder graphs, hydrographs of manual readings of groundwater levels, precipitation graphs and barometric pressure graphs.

The locations of the precipitation gauge operated by the Department of the Environment and also the barometric station are shown on the key map of Figure 1.2. The barometer, which is fitted with a recorder, is owned by the Groundwater Division, and is maintained by a Mayne Island observer.

Before proceeding to a discussion of the individual hydrographs, a short digression should be made to discuss groundwater flow systems on Mayne Island.

In Report No. 2, Hydrochemistry of Mayne Island, cross sections are given to slow a interpretation of the groundwater flow system based on hydrochemistry and topography.

In the cross section (Figure 2.4 of Report No. 2) groundwater is shown to move downward from the topographic "highs" (areas of groundwater recharge) and then move upward into the valley floors and bottom valley side slopes (areas of groundwater discharge). Such a flow system would account for the fact that often near the surface on the low areas of the Island, one can find water samples which have a high total dissolved solid content and far more advanced chemically than those obtained higher in the surrounding hillsides. The flow system can be expected to be modified locally by the geology, more resistant or less fractured beds will modify the directions of groundwater flow at least locally. However, there is not enough data to draw distinctions on the effect of different rock types with their associated fracturing on the movement of groundwater and on groundwater storage capacities. How the interpretation of groundwater flow systems give in Report No. 2 can be used to help explain the behaviour of the hydrographs prepared from observation well records is discussed below.

3.2 Observation Well WR-111-73

Description: Section No. 15, WER No. 13, Depth 225 feet.

The recorder hydrograph shows a good response to precipitation. After the limited precipitation in late November of 1972 the hydrograph responded but again dropped several inches before rising steeply in response to precipitation in December. The hydrograph peaks correspond to periods of maximum precipitation during the months of December and January. A period of minimum precipitation in early January was reflected in a drop of about 1½ feet in the groundwater level. Groundwater levels declined from a peak of about 6 inches below ground surface in January 1973, down to a low of about 8½ feet in the latter part of September 1973. The hydrograph shows a good response to precipitation throughout this period.

From the above and the fact that good quality water is found in this well, there is a good indication of rapid groundwater movement through the fractured bedrock media to give a rapid response in this well to local recharge from precipitation.

3.3 Observation Well WR-109-73

Description: Section No. 12, Well No. 24, Depth 223 feet.

The recorder hydrographs show a later response to precipitation up to as much as one week. This is in contrast to the hydrograph for the previously described Well No. WR-111-73. The groundwater level remained above ground surface until about mid-June. The maximum head for the period of record is less than four feet and occurred in early January 1973. The low point in the hydrograph record was reached at about one foot below ground surface in October, 1973 unfortunately the recorder clock became inoperative during this period so the precise date and depth of the low point can only be given approximately.

The slower response to precipitation is interpreted here as indicating that the well is not responding to a local flow system but to an intermediate depth flow system (see Figure 2.4, Report No. 2). The water quality in this well (Stage No. 4 of the Theoretical Hydrochmeical Progression) could indicate ground water from a deeper flow system.

3.4 Observation Well WR-108-73

Description: Section No. 11, Well No. 6, Depth 200 feet.

The hydrograph of the manual readings of groundwater levels shows a peak in late December 1972. This indicates a rapid response to precipitation in the second half of December. The fact that the hydrograph shows no corresponding peak to January precipitations, may be due to the lack of observer readings during that period (cf. WR-111-73). The maximum head recorded for the period of record is 12 feet above ground surface. The static water level remained above ground surface for the period of record. The low point on the hydrograph record is shown to be early October, but as in the case of WR-111-73, where the manual readings show peaks later than the recorder readings, the low point could in fact have occurred several weeks earlier.

The hydrographs of the manual readings show a very good response to precipitation. The groundwater quality in this well (Stage No. 4 of the Theoretical Hydrochmical Progression in Report No. 2) indicates ground water from a intermediate flow system. This is shown on the cross section of ground water flow (Figure 2.4 Report No. 2).

The apparent inconsistencies can perhaps be resolved by realizing that the <u>major</u> water bearing fracture was encountered in the first 10 feet of bedrock below 40 feet of clay. The well is responding to local recharge from precipitation through this shallow bedrock fracture zone.

It is interesting at this point to make a digression to mention well No. 7 in Section 11, located about 500 feet from the observation well WR-108-73 Well No. 7 shows a good response to precipitation; during the winter period the water level rose to over 32 feet above ground surface. The water quality in this well is poor, however, and the total dissolved solids were found to be 1,600 parts per million. The water level fluctuations in well No. 7 were observed during an eight day test on well WR-108-73. The levels after the first two days of the test responded very eratically. An explanation of this well behaviour particularly its rapid response to precipitation and the high T.D.S. content will be postponed until records for a one to two year period are available. Records to date have been unsatisfactory and new recorder equipment is to be installed.

Mixing of local freshwater recharge with the upward moving non-potable groundwaters within a complex fracture system is a possibility. The problem is compounded by the limited fractures and minimal yield obtained from this well and the associated problems of entrapped air possibly from air drilling escaping into the well during the pumping test when the head was lowered. Further observations are being collected on this well.

3.5 Observation Well WR-110-73

Description: Section No. 11, Well No. 3, Depth 235 feet.

The recorder hydrograph shows a markedly slow response to precipitation and appears to peak in the first half of March 1973, at about 18 inches below ground surface. The low point on the hydrograph occurred during the early part of November and at about 6½ feet below ground surface.

The water quality in this well is non-potable, i.e., over 1,000 parts per million total dissolved solids (Stage No. 6 of the Theoretical Hydrochemical Progression in Report No. 2). The non-potable water quality and the 2½ month lag time in the hydrograph peak response to precipitation is interpreted as indicating the observation well is completed in the upward path of a deep flow system.

The major water producing fractures are found below the 150-foot level and the well could be responding to a deeper flow system.

3.6 Observation Well WR-104-73

Description: Section No. 8, Well No. 7, Depth 100 feet.

This recorder hydrograph shows a rapid response to precipitation in November of 1972. Two peaks in early and late November on the hydrograph correspond closely to increased precipitation, as also do peaks in December. Commencing in January 1973, the hydrograph peaks fall behind the periods of increased precipitation by one or two days. The low point on the hydrograph is reached in late August and the total drop in water table is less than 3 feet for the period of record shown.

The water quality in this well is non-potable, i.e., over 1,000 parts per million total dissolved solids. (Stage No. 6 on the Theoretical

Hydrochemical Progression of Report No. 2). The non-potable water quality in this well indicates an upward movement of a deep flow system into, and probably along, the central fault zone.

The steep valley sides adjacent to the observation well site would mean additional runoff onto the well site area and this could cause a more rapid response to local recharge affects than would be expected from the deep flow system.

The effects of the local groundwater levels may therefore be masking the deep flow system response curve over the precipitation period.

3.7 Conclusions

The hydrographs prepared from observation well records have been discussed in terms of a simplified interpretation of the groundwater flow systems of Mayne Island. Inconsistencies are explained in terms of local recharge effects topography, geology and structure.

The hydrograph records in all cases except one show a total annual change in groundwater levels of less than 10 feet. These wells are located in the discharge areas of the groundwater flow system, i.e., valley floors and bottom valley side slopes. One might expect that observation wells located in the recharge areas, i.e., areas of greater relief would experience greater total fluctuation in water levels.

4. COEFFICIENTS OF TRANSMISSIVITY AND STORAGE

The hydraulics of groundwater movement in a fractured bedrock media are not governed by the usual mathematical models and present complex hydrologic setting on which to predict the sustained yield of individual wells or groups of wells. A well yield in this bedrock is determined more by the position of the water table with respect to fracture openings than to the thickness of saturated rock penetrated by the well bore. In other words the well yield in bedrock is determined more by the available drawdown between water level and water bearing fracture zones than on the amount of stored groundwater in the well below the lowest producing fracture zone in the well.

Todd (1959) has stated that rock aquifers with secondary openings exhibit homogeneous characteristics when sufficiently large volumes are considered. Thus, pumping tests can be applied to the determination of the characteristics of rock aquifers. However, results as might be expected are often not suited to analysis by conventional methods. The non-equilibrium method of analysing pumping test data (Cooper and Jacob 1946) for confined aquifers was applied to our data for the bedrock situation on Mayne Island, but generally speaking this non-equilibrium method of analysing pumping test data should only be applied to unconfined aquifers when the drawdown is small in relation to the saturated thickness.

The coefficient of transmissivity "T", is defined as the rate of flow of water, in gallons per day, through a vertical strip of the aquifer one foot wide and extending the full saturated thickness under a hydraulic gradient of the one foot per foot at the prevailing temperature of the water. "T" indicates the capacity of an aquifer to transmit water through its entire thickness and is equal to the coefficient of permeability multiplied by the saturated thickness of the aquifer "m", in feet.

The coefficient of storage "S" of an aquifer has been defined by Walton (1970) as the volume of water the aquifer releases from or takes into storage per unit surface area of the aquifer per unit decline or rise of head. Under water table conditions, the coefficient of storage is equal to the specific yield, provided gravity drainage is complete. The coefficient of storage of water table aquifers ranges from about 0.02 to 0.30 although rigid limits cannot be established the storage coefficients of artesian aquifers may range from about 1×10^{-5} to 1×10^{-3}. Methods used to obtain the data tablulated in Table No. 1.2 are outlined in Report No. 3. The values for "T" are low to very low, and with three exceptions, range, generally between 100 and 400 US gallons per day per foot width."S" values on the other hand appear to be similar and range from 1×10^{-4} to 4×10^{-4}. Because there is only a limited amount of existing pump test information, it is difficult to make predictions relating changes in storage to variations in fracture density and different rock types. Also, the proximity of a test well to a fault may be known only very approximately. Therefore in view of the limited available data one storage coefficient value of 1×10^{-4} is used for all subsequent computations of groundwater storage on Mayne Island. A value of 1×10^{-4} for "S" is indicative of a confined aquifer, this may approximate more closely the fractured bedrock situation below till or stoney clays on Mayne Island.

5. THEORETICAL MODEL OF MAYNE ISLAND

5.1 General Statment

The difficulties in establishing the limits of the potable water bearing zone outside areas of known control on Mayne Island have made it necessary to construct a theoretical model of Mayne Island. The model is based on data we have available at the present time. The model admittedly has over simplified the actual conditions within the saturated fractured bedrock media. As new field data becomes available it will be possible to revise the model to more closely approximate the field conditions. In order to construct this model it was first necessary to determine the elevation of the top and the bottom of the potable water bearing zone. The top of the zone is defined by the ground level contour elevations. The bottom of the zone is defined as the level at which water quality has deteriorated to the point where it is no longer potable Potable water is defined in this report as water not exceeding 1,000 parts per million total dissolved solids.* Estimates were next made of the groundwater in storage within the potable water bearing zone and from this demand/storage percentages were calculated from the theoretical island model.

5.2 Mayne Island Groundwater Regions

In later sections of the report (and as discussed elsewhere in Report No. 2 on the Hydrochemistry of Mayne Island), there is a zone of poor quality water along much of the central fault zone of the Island. Hydrochemical studies indicate this fault zone has a considerable influence on the groundwater flow systems. The presence of non-potable water at shallow depth in this zone is interpreted as an upward movement of deeper waters into the fault zone. As a first step towards the formation of a theoretical model of the potable groundwater supplied on Mayne Island, a groundwater regions map (Map No. 1.4) has been prepared. The boundaries generally follow the watersheds except on the central fault zone where the fault line cuts across the watershed boundaries. Additional modifications were made in regions No. 13, 14 and 15. The Groundwater Regions Map is a means of dividing the Island into meaningful segments for quantitative groundwater studies and model analysis.

5.3 Lower Limit of the Potable Water Bearing Zone

A relationship between chloride ions and total dissolved solids

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* Recommended Water Quality Standards, Division of Public Health Engineering, Health Branch.

(T.D.S.) for water samples analysed on Mayne Island is shown on Figure 1.1. The accepted standard of less than 250 parts per million chloride ion in Figure 1.1 is shown to coincide with the maximum accepted standard of 1,000 ppm for T.D.S. This indicates the close relationship between the maximum standards for chloride and T.D.S. The average depth of the potable water bearing zone within the area of known control can be estimated for the theoretical model by observing the 1,000 ppm T.D.S. contours on Maps Nos. 2.1, 2.2, and 2.3 in Report No. 2. For the theotretical model the average depth below ground surface to the bottom of the potable water bearing zone has been changed to read average elevation in feet on the bottom of this zone. Three average elevations: +75 feet, +35 feet, and -50 feet are given on Map No. 1.5, which corresponds to the average elevations for three coloured areas on the map where there are known control points.

An attempt has been made, to extrapolate the available data to give elevations on the bottom of the potable water bearing zone outside the known area of control. The available data indicated that outside the area of known control the island model would have to be divided in two areas, and regression analyses run separately on the data in each area.

Regression analysis were run with the aid of a computer and plots made of elevation on the bottom of wells samples against total dissolved solids obtained from the respective analyses of the samples. The data plot for the east area of the Island shown in blue on Map No. 1.5 is given on Figure 1.3. Result of the regression analysis for this area show a mathematical expression relating water quality and the elevation of the bottom of the well sampled. The equation of the regression line is: elevation = -0.2411 T.D.S. + 88.51. The regression line intersects the 1,000 T.D.S. line at -152.6 feet elevation. The correlation coefficient, however, is very low 0.53, and this is in part due to the scatter of the sample points and to the oversimplification of the problem to only two variables. More detailed work in a limited area, involving other variables and further data control would improve the correlation coefficient. However, from the relationships shown in Figure 1.3, which the writer accepts as being valid from the data available, a value of -150 foot elevation has been selected for the theoretical model as the average elevation of the bottom of the potable water bearing zone in the east area coloured in blue on Map No. 1.5 of Mayne Island.

The data plot for the west area of the island shown in white on Map No. 1.5, is given in Figure 1.4. Results of the regression analyses show very little relationship relating water quality and the elevation on the bottom of the well sampled. The equation of the regression line obtained with the computer is: elevation = 0.6177 T.D.S. + 153.3. The regression line intersects the 1,000 T.D.S. line at -464 feet elevation. The correlation coefficient however, is very weak, 0.47, which is to be expected because of the data point scatter. (see in Figure 1.4.) Nevertheless the trend indicates that T.D.S. increases as elevation decreases.

From these results and in view of the extrapolation required, a conservative value of -200 feet elevation has been selected for the theoretical model as the average depth to the bottom of the potable water bearing zone on the west area coloured white on Map No. 1.5.

Groundwater flow systems on the west area of Mayne Island have a lower elevation limit to the potable water bearing zone than those on the east area of the island. The circulation of potable water would be expected to be deeper on the west side because of the higher relief and the effect of increased hydraulic head and recharge area on the system. It should be noted that non-potable waters may be found at shallower depth near coastal areas.

The estimates of the lower limits of the potable water bearing zone on Mayne Island, are based on a simplified extrapolation of the existing hydrochemical data. When new field data becomes available the model may have to be further revised.

5.4 Upper Limit of the Potable Water Bearing Zone (Groundwater Level Contours).

The upper limit of the potable water bearing zone on Mayne Island is defined for the theoretical island model in terms of groundwater level contours on Map No. 1.6. The "inferred" groundwater level contours are based on data control points and surface topography. The "extrapolated" groundwater level contours are based mainly on surface topography and were drawn in areas of no control.

Where springs are located on Map No. 1.6, the elevations of the groundwater level contours at that point are shown to be outside the corresponding land surface topographic contour. The groundwater level contours show the water level to be further below the ground surface near areas of higher relief and approach ground surface more closely in the valley bottoms.

The areas of higher relief are interpreted as being the areas of groundwater recharge where groundwater movement is downward, and the areas associated with valley bottoms as being in discharge areas where groundwater movement is upwards.

5.5 Estimates on Groundwater Storage within the Potable Water Bearing Zone

In order to compute the variable thickness of the potable water bearing zone, as defined in the previous sections by lower limits and upper limits, an isopach work sheet was constructed to give the thickness at any point on the theoretical model for the potable water bearing zone. The isopach work sheet was constructed by determining, the thickness between the groundwater level elevations of Map No. 1.6 and the lower limit of the potable water bearing zone shown as Map No. 1.5. The contours on the isopach work sheet indicate the thickness of the potable water bearing zone. Next, the areas within successive contour intervals were measured by planimeter and the volume of bedrock within the potable water bearing zone was computed for each groundwater region and tabulated according to Table No. 1.4.

The estimates used for groundwater in storage are based on a storage coefficient value of $S = 1 \times 10^{-4}$. The estimate for total potable groundwater in storage is about 190 acre feet. This estimate is tabulated according to groundwater regions in Table No. 1.4. Further discussion of these results is reserved for later sections of this report.

5.6 Estimated Groundwater Demand for Residences

The previous section gives a theoretical model estimate for the groundwater in storage within the potable water bearing zone. In Table No. 1.5, the estimated groundwater demand for residences is given in acre/feet, for each groundwater region, based on 100 days of continuous pumping during the summer period at a rate of 300 U.S. gallons per day, per residence.* The selection of 300 U.S. gallons per day per residence represents a minimum demand requirements for planning purposes. The selection of 100 days as the period of continuous pumping during the summer represents the maximum dry period of very little or no recharge from precipitation. Maximum depletion of the groundwater within the fractured bedrock media is expected during this dry period because it coincides with the period of maximum groundwater demand.

* The total number of residences on the island in each groundwater region was obtained from the Department of Lands Assessment Roles of the Department of Lands. Any property showing an assessed improvement was considered to be a "residence" or a "potential residence" for this study.

During the remainder of the year recharge should be adequate or well in excess of existing demands, bedrock fractures become filled and vacant summer residences will result in a reduced water demand over the winter period.

According to these estimates, the groundwater regions showing the greatest summer demand are Nos. 19 and 20 in the Bennett Bay area. These regions have a combined total demand of 11.2 acre feet. Region No. 6 in the Miners Bay area requires 6.1 acre feet and Region No. 2, in which are located the Light House Point and Skana Subdivision, requires 7.3 acre feet according to these estimates. The present water demand for the whole island, on the same basis, is 41 acre feet. While it is recognized that the above is simplification of the actual water demand, more detailed estimates are outside the scope of this study.

5.7 Demand/Storage Percentages

In table No. 1.5, the estimated water demand for each hydrologic region is expressed as a percentage of groundwater in storage. Map No. 1.7, based on this part of Table No. 1.5, illustrates the demand/storage percentages for each groundwater region. A pie diagram in each region shows the demand in black as a percentage of storage. The figure shown to the upper left of each pie diagram are estimated groundwater demand in acre/feet (above line), and estimated groundwater in storage in acre/feet (below line).

Groundwater development reserves (which are discussed in a later section), are shown on Map No. 1.7, so that their location can be seen in relationship to those groundwater regions where the demand/storage percentage is high.

In groundwater regions, Nos. 19 and 20, the demand/storage percentage of over 100% is unrealistic. This anomaly can be explained as an over estimate of groundwater demand based on simplified figures of 300 U.S. gallons per day instead of say, perhaps, 150 U.S. gallons per day. It is also possible that the number of residences allowed for in the water demand estimates should be reduced to 75% of the figure given, also conservative groundwater storage figures used for estimating the storage available in the fractured bedrock media cannot be estimated as simply as has been done for this island mode. Nevertheless, the relative value of the demand/storage percentages are believed to be valid and serve to point out the problem areas.

The demand/storage percentage of 100 in regions No. 19 and 20, may mean that groundwater supplies available in the groundwater development reserve of Region 18, may someday have to be tapped to supply regions Nos. 19 and 20.

The 81% for demand/storage ratio in groundwater region No. 2, is also perhaps excessive. The role of the central fault in groundwater movement and storage in this region could increase the potential groundwater supply. The lighthouse Point Water Works District along the northern coastline of Region 2, has experienced water shortages but the demand/storage ratio indicates over 50% of the available storage is untapped. Further groundwater exploration may be required further back on the slopes of Hall Hill.

In groundwater region No. 8, the Village Bay Subdivision belonging to Gulf Lands only 17% of the demand has been utilized due to the limited development that has taken place to date on this subdivision. It is not clear at the present time to the writer what is to be the eventual number of residence allowed for this subdivision. Two groundwater development reserves are shown here, the larger is already being developed to supply this subdivision.

In summary, an analysis of the demand/storage percentages obtained from the island model show one critical area in the Bennett Bay area, otherwise there is adequate storage available for the existing water demand.

5.8 Present/Future Residence Percentages

Present/Future residence percentages are defined as the total number of existing residences in each groundwater region expressed as a percentage of the maximum number of residences the theoretical island model can support in each groundwater region. The estimates are based on water demand/storage data and the results are tabulated in Table No.

1.5. Map No. 1.8, illustrates the results for each groundwater region. The pie diagram for each region shows the total number of existing residences in black expressed as a percentage of the maximum number of future residences the theoretical model can support. The figures shown to the upper left of each pie diagram indicate values for total number of present residences (above line), and maximum number of residences allowed for in the model (below line). Because these percentages are based on demand/storage data, the relationship obtained closely parallels the demand/storage results. For example the extremely high value for demand/storage percentages in groundwater regions Nos. 19 and 20, is reflected in a similar anomaly in the residence percentages - see the previous section for a discussion on this also.

From Tables Nos. 1.4 and 1.5 we can obtain an estimate of the number of acres per residence for Mayne Island. At the present time it is 13 acres per residence. If we take the theoretical model figure for the projected density limit for residence development this ratio drops to about three acres per residence - a useful guideline.

LICENCING AND REGULATION OF WATER WELLS ON MAYNE ISLAND

1. General Statement

The following together with the next section "Recommended Groundwater Development Reserves on Mayne Island", is a concept for the development and management of the groundwater resource on Mayne Island.

1.1 The goal of a groundwater development and Management program on Mayne Island should be the optimum use by the community of the potable groundwater resource without endangering the quality or exceeding its annual replenishment.

1.2 The use of higher capacity wells up to 10 gallons per minute (or more) should be licenced and regulated by Government procedures in accordance with this goal.

1.3 The cost of investigation development and analyses of the groundwater resource should be carried by those who wish to develop and use the resource in as far as this is economically practical and feasible.

2. Domestic Well Fields in Fractured Bedrock

The licencing and regulation of small domestic wells may be required at this time for effective management and development of the resource on Mayne Island. The economic and administrative reasons for groundwater licencing and regulation of small domestic wells on the island are, however, outside the scope of this report, but from a technical view point, however, there are some problems inherent in the regulation of small domestic well fields in bedrock aquifers, particularly when meaningful test data must be obtained to solve well field interference problems. To be more specific domestic bedrock wells obtain their yields from groundwater in fractures in the bedrock. It is difficult to apply normal groundwater theory to the solution of complex problems of well hydraulics in a fractured bedrock media. In a specific problem area where one domestic well is thought to be interferring with the supply from another well it is also very difficult to obtain a meaningful test condition i.e. one where all domestic wells within a specific test area can be shut down during and after a pumping test of several days duration during the dry summer period and when many are using their residences for summer holidays. The length of the test period may also be quite unacceptable to the residents involved. Also to supply these residents with water during the test and observation period may only in part solve the problem of supply. A well with limited storage in the bedrock fractures may be pumped dry during a test and remain with an insufficient operating static level until the fall precipitation begins and recharge to the well is effected. Future licencing and regulating procedures should be prepared with the above in mind.

3. Higher Capacity Production Wells in Fractured Bedrock

Larger capacity bedrock production wells - wells capable of producing up to 10 US gallons per minute continuously during the summer season should, in the writer's opinion, be under Government regulation and licence. This is thought necessary because available information indicates that there are only a limited number of areas on Mayne Island which have the potential of highery capacity well yields and these should be developed and managed in an orderly way.

Specific Recommendations are as follows:

3.1 Owners of all higher capacity wells who are proposing a distribution system to five or more connections should be required to obtain a permit from the Comptroller of Water Rights prior to carrying out test well drilling.

3.2 The Comptroller of Water Rights should have available to him when needed the services of a Groundwater Division specialist to advise the Comptroller on all technical aspects regarding the above mentioned permit. This man should be an expert in mathematical theory associated with aquifer testing, interpretation, and in well field engineering. He must have the necessary expertise to present arguments for or against the opinions and report presented by other consultants on a particular permit problem. He must above all be allowed the singlemindedness and engineer project time required for an adequate study of permit applications as they arise, including a time provision for field inspection and investigations as required.

3.3 An application for a production well drilling permit should include plans and specifications of the proposed drilling program, observation well, test production well, etc., maximum depths anticipated to make optimum use of the potable water bearing zone, well design, grouting and sealing procedures particularly on deeper wells liable to penetrate the lower limit of the potable water bearing zone, anticipated drilling site locations and alternative site locations, details of proposed pumping tests and duration, design capacity anticipated for the well, proposed action to be taken to supply water to adjacent well owners if affected by the production well pumping, etc. The above details would have to be drawn up by a Consultings Groundwater Engineer hired by the owner of the higher capacity well (Water Works District, etc.).

3.4 Following granting of the above permit application by the Comptroller of Water Rights and the satisfactory completion of drilling, pumping tests and construction of higher capacity wells, a completion report would be submitted by the consulting groundwater engineer responsible for the project, to the Comptroller of Water Rights. The Comptroller, following a review of the completed report by the groundwater specialist and further discussions and reviews necessary would proceed to a decision regarding a permit for the operation of the completed production well. Certain provisions or instructions regarding the operation of a monitor well, maximum production well yield, provisions regarding supply of water to owners of adjacent wells affected, etc. could be appended to the permit.

RECOMMENDED GROUNDWATER DEVELOPMENT RESERVES ON MAYNE ISLAND

The concept outlined in the previous section on "Licencing and Regulation of Water Wells on Mayne Island", does not cover one important aspect of groundwater management on the island - namely the right of the individual landowner who wishes to develop a higher capacity well for small irrigation use on his land, versus the rights of a community or water works District wishing to develop a water supply from the same groundwater source.

At the present state of our knowledge, there are only a limited number of areas which have the potential of higher capacity well yields. Some of these areas are restricted to individual well site others through preliminary hydrological investigation and testing show potential of greater groundwater development. The latter areas are shown on Map No. 1.9, as groundwater development reserves.

In order to assist in the orderly development and future management of the groundwater resource on Mayne Island, it is suggested by the writer that groundwater reserves be set aside on Mayne Island, according to the boundaries shown on Map No. 1.9. These reserves cover presently known well field development areas and potential areas only, not the associated watershed which recharges the reserve area.

On Map No. 1.9, the reserve coloured in orange denotes a reserve where individual well yields up to 10 U.S. gallons per minute are possible, green denotes a reserve wherin the Groundwater Division has constructed an observation well with a Q100 yield of 30 U.S. gallons per minute; yellow denotes a potential reserve based on hydrogeological and topographical information only. No test data is available and the potential yields of wells in this latter case is unknown.

Specific recommendations by the writer on groundwater development reserves are as follows:

1. A permit would be required for any person, group, water works district, landowner etc., to drill on a groundwater development reserve. Permits would follow the procedures outlined under the previous section.
2. The order of priorities, as to the development of the reserve would be made by the Comptroller of Water Rights.
3. The potential of the groundwater development reserves is only known to the extent outlined on Map 1.9. The estimated total potential of the reserves must therefore be found by wise and progressive development together with adequate testing well spacing and monitoring procedures for both water quantity and water quality - particularly with respect to any fluctuations of the lower limit of the potable water bearing zone.
4. Further details of this concept are outside the scope of this report. It might be mentioned that test well site agreements and options to purchase 50' x 50' plots of land would have to be obtained from landowners for well house construction and installations, together with access rights for power, pipe, vehicles and maintenance crews.

The landowner should receive adequate compensation for both land lost and inconvenience. Presumably land could be expropriated for a well site and access as a last resort, if it is necessary and in the interest of the community.

The reserve test well sites and permanent well site locations should as far as possible be sited to cause minimum inconvenience and hardships to the landowner.

THE CASE FOR A LONG CHANGE MONITORING PROGRAM OF GROUNDWATER LEVEL FLUCTUATIONS AND WATER QUALITY CHANGES

The quantitative groundwater studies have shown the difficulties in attempting to assess the potable groundwater supplies available for use on the Island. The theoretical island model constructed to show these supplies is simplified and because it is based on insufficient data at depth needs verification from further deeper well drilling and testing.

The lower limit of the potable water bearing zone on the eastern and western areas of the Island model needs to be established by the construction of a deep observation well in each of these two areas.

The existing observation wells on Mayne Island (see figure 1.2), should be retained especially those on groundwater development reserves so that a continuous hydrograph record is available before major development takes place.

A water quality monitoring program should be set up for all observation wells in conjunction with the observation well monitoring of groundwater level fluctuations.

FOOTNOTE:

Groundwater development reserves are recommended to be confined to the well field areas only. However, the writer sees a need to preserve the watersheds, particularly at the higher elevations from tree cutting and excessive development.

With increased development there will be more tile fields and septic tanks and the problems of effluent disposal into shallow overburden, overlying the saturated fractured bedrock media, will become more acute. This is a problem in itself and is outside the scope of the present study.

CONCLUSIONS

Limited storage and lack of summer precipitation are two key factors controlling groundwater supplies on Mayne Island. It is difficult, however, to make predictions relating the amount of groundwater in storage to the facture density or to the rock types because of the limited amount of existing pump test information available on the island. In view of this data limitation only one storage value of $S = 1 \times 10^{-4}$ is used for all computations on groundwater storage. The difficulties in establishing the limits of the potable water bearing zone outside areas of known control on the Island, have made it necessary to construct a theoretical model. The groundwater in storage within the potable water bearing zone of this model has been estimated at 190 acre feet. The groundwater demand on the Island for the summer 100-day dry period is estimated at 41 acre feet using 300 US gallons per day for each residence. Demand/Storage percentages have been calculated for each groundwater region of the theoretical island model. The analyses shows the Bennett Bay area to be a critical one, otherwise the estimates show adequate groundwater storage is available in each groundwater region to meet present water demands. Based on the estimated number of residences and the area of Mayne Island, there is at the present time one residence for every 13 acres of land on the Island. If we take the theoretical island model estimate for the "maximum allowable" number of future residences then this ratio drops to about one residence for every 3 acres of land on the Island.

The goal of a groundwater development and management program on

Mayne Island should be the optimum use by the community of the potable groundwater resource without endangering the quality or exceeding its annual replenishment. The use of higher capacity wells on Mayne Island should be licenced and regulated by Government procedures in accordance with this goal. The cost of investigation, development and analyses of the groundwater resource should be carried out by those who wish to develop and use the resource in as far as this is economically practical and feasible. The licencing and regulation of small domestic wells may be required at this time for effective management and development of the resource on Mayne Island. The economic and administrative reasons for such a move are outside the scope of this report. From a technical point of view, however, there are problems inherent in the regulation of small domestic well fields in bedrock aquifers particularly, when for example, meaningful test data must be obtained to solve well field interference problems. Future licencing and regulatory procedures should be prepared with the above in mind.

To ensure the orderly development and management of limited, but potentially important aquifers on Mayne Island, it is recommended that up to seven "Groundwater Development Reserves" be set aside. These reserves are delineated in the report. These reserves would cover presently known potential well field and development areas, but not the surrounding catchment areas. Existing observation wells, particularly those located on reserves, should be retained for long term monitoring, two further deep observation wells should be drilled when funds allow it. A water quality monitoring program should be run on all observation wells in conjunction with the recording of the observation well level fluctuations. Finally there is a need to preserve the island watersheds, particularly at the higher elevations, from tree cutting and excessive development.

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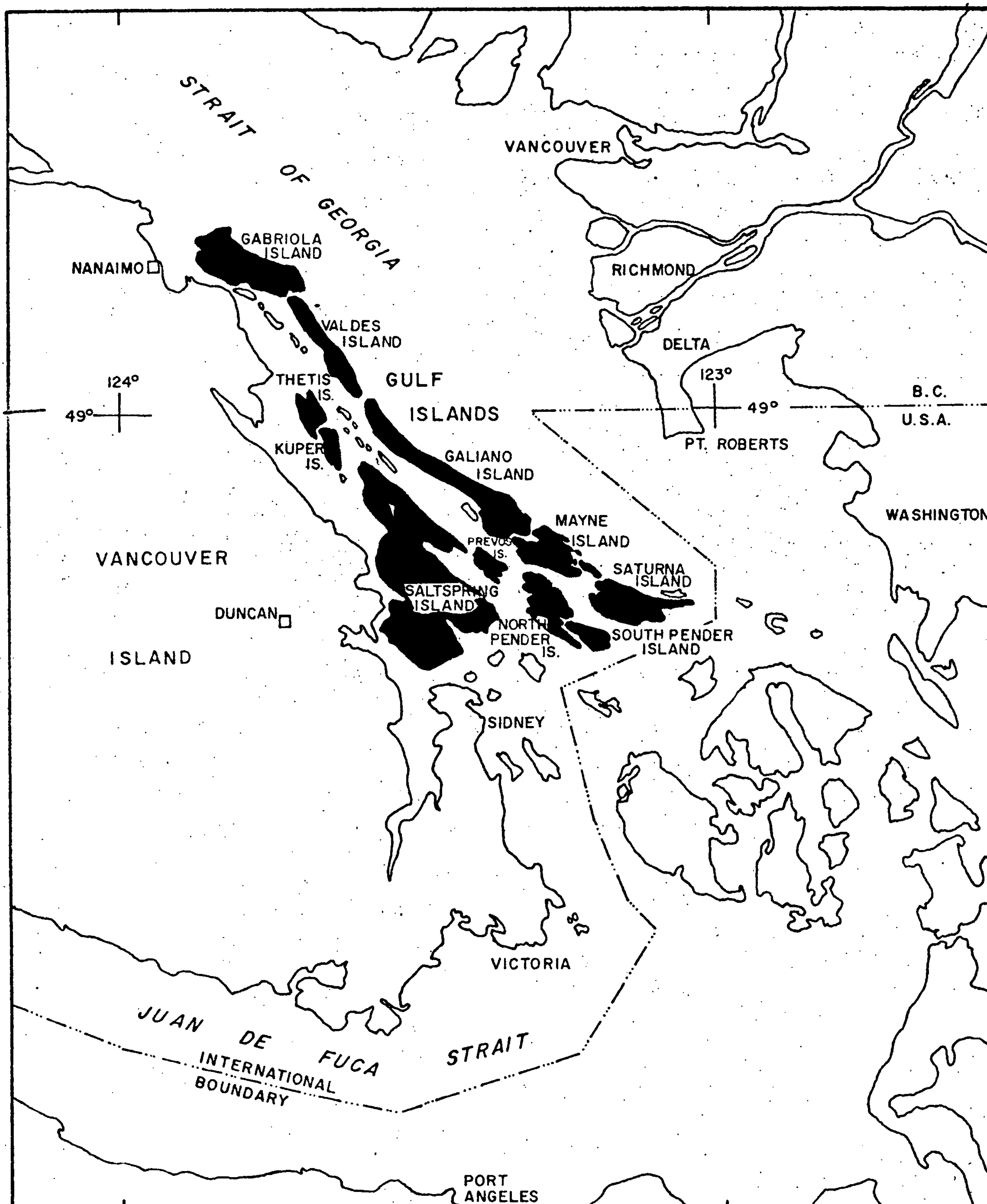

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WATER INVESTIGATIONS BRANCH

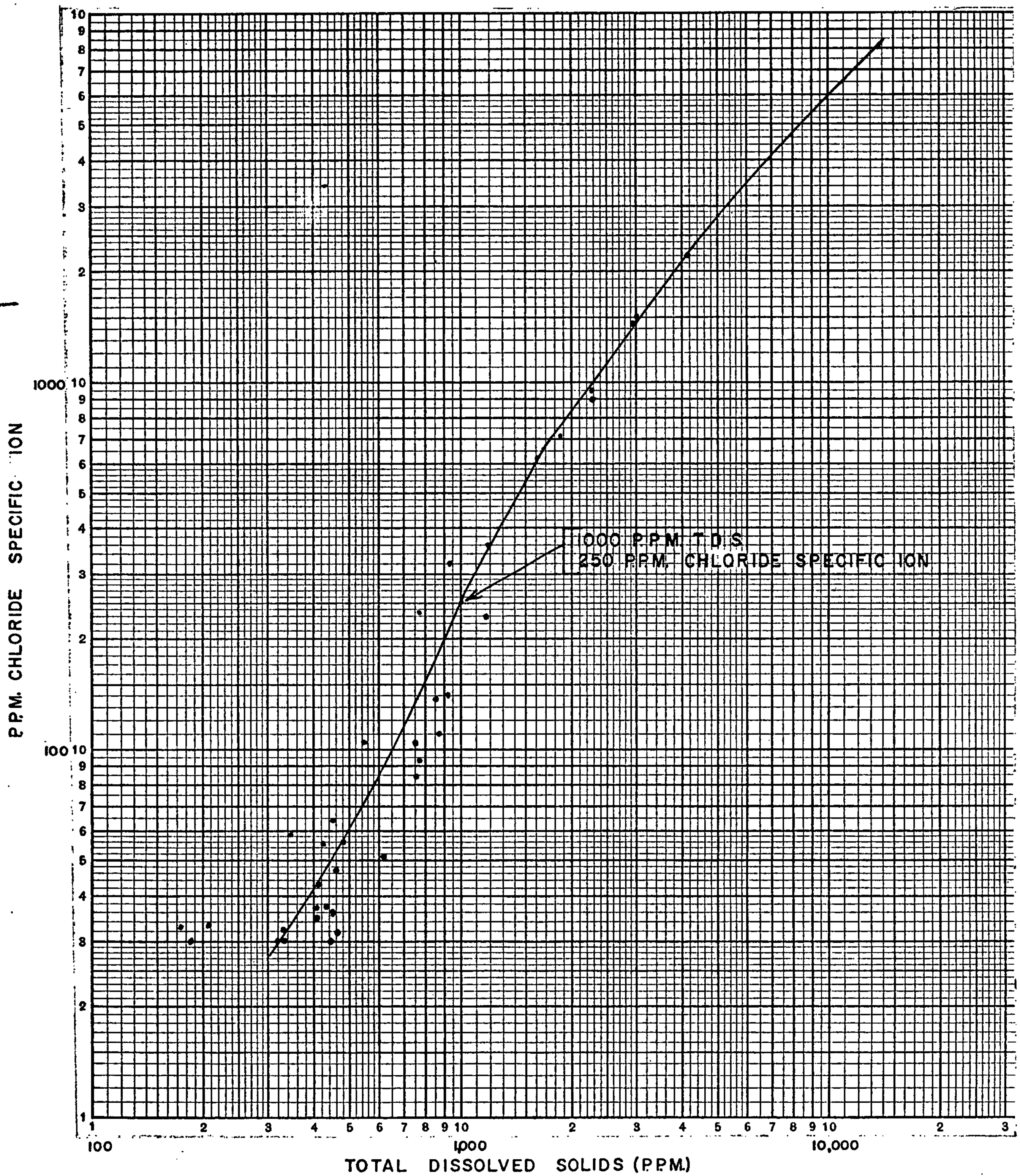
INDEX MAP OF THE GULF ISLANDS

SCALE: 1 INCH = 10 MILES

DATE: JAN. 1974

ENGINEER

FILE No. 0239013 DWG. No. 5007- MAP I-1

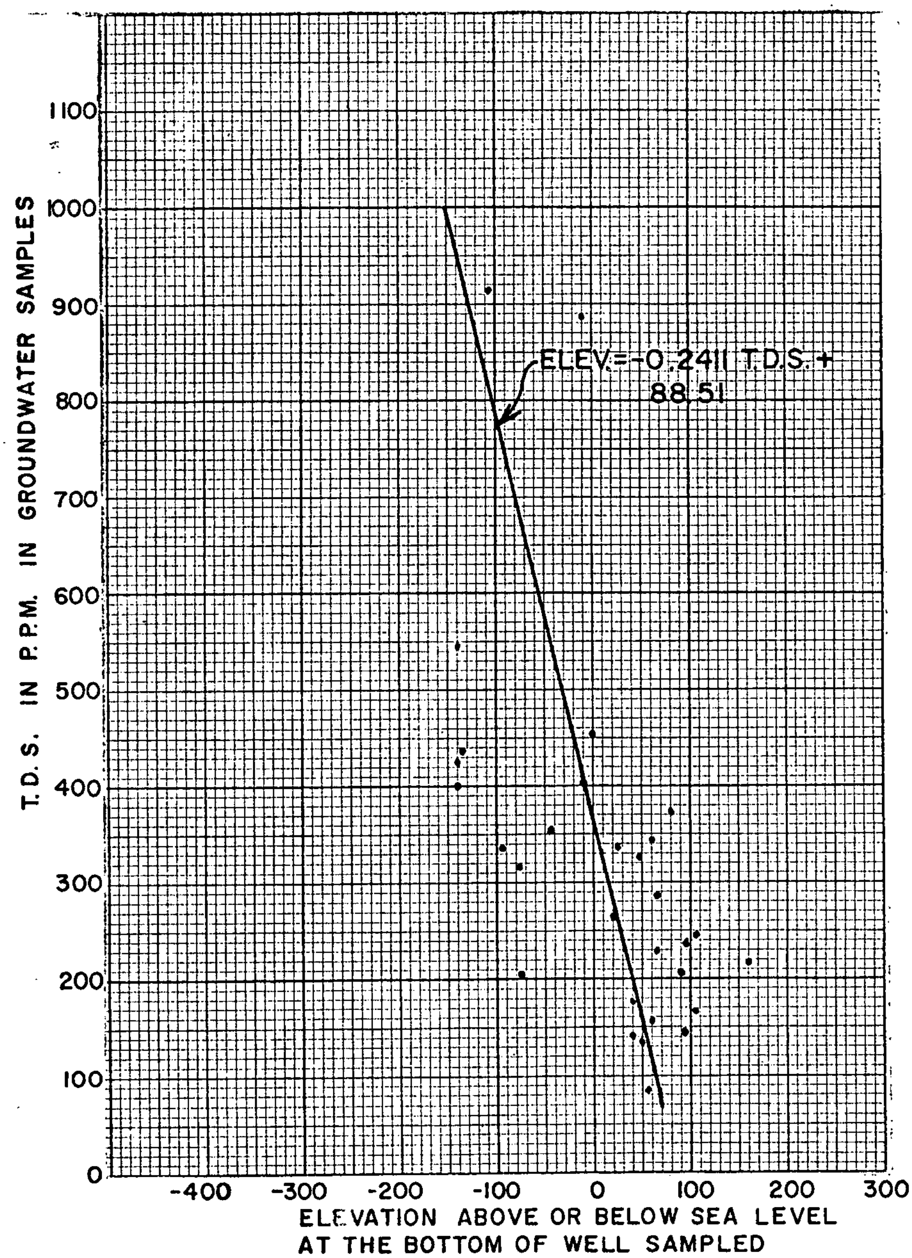


BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

RELATIONSHIP BETWEEN CHLORIDE IONS AND TOTAL DISSOLVED SOLIDS FOR WATER SAMPLES ANALYZED ON MAYNE ISLAND

SCALE: VERT. AS SHOWN HOR.	DATE OCT. 7, 1973	J. HEISTERMAN FILE No. 0239013 DWG. No. 5007- FIG. I-1

RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS (T.D.S.) AND ELEVATION FOR EAST AREA OF MAYNE ISLAND (COLOURED BLUE ON MAP No. 1-5)



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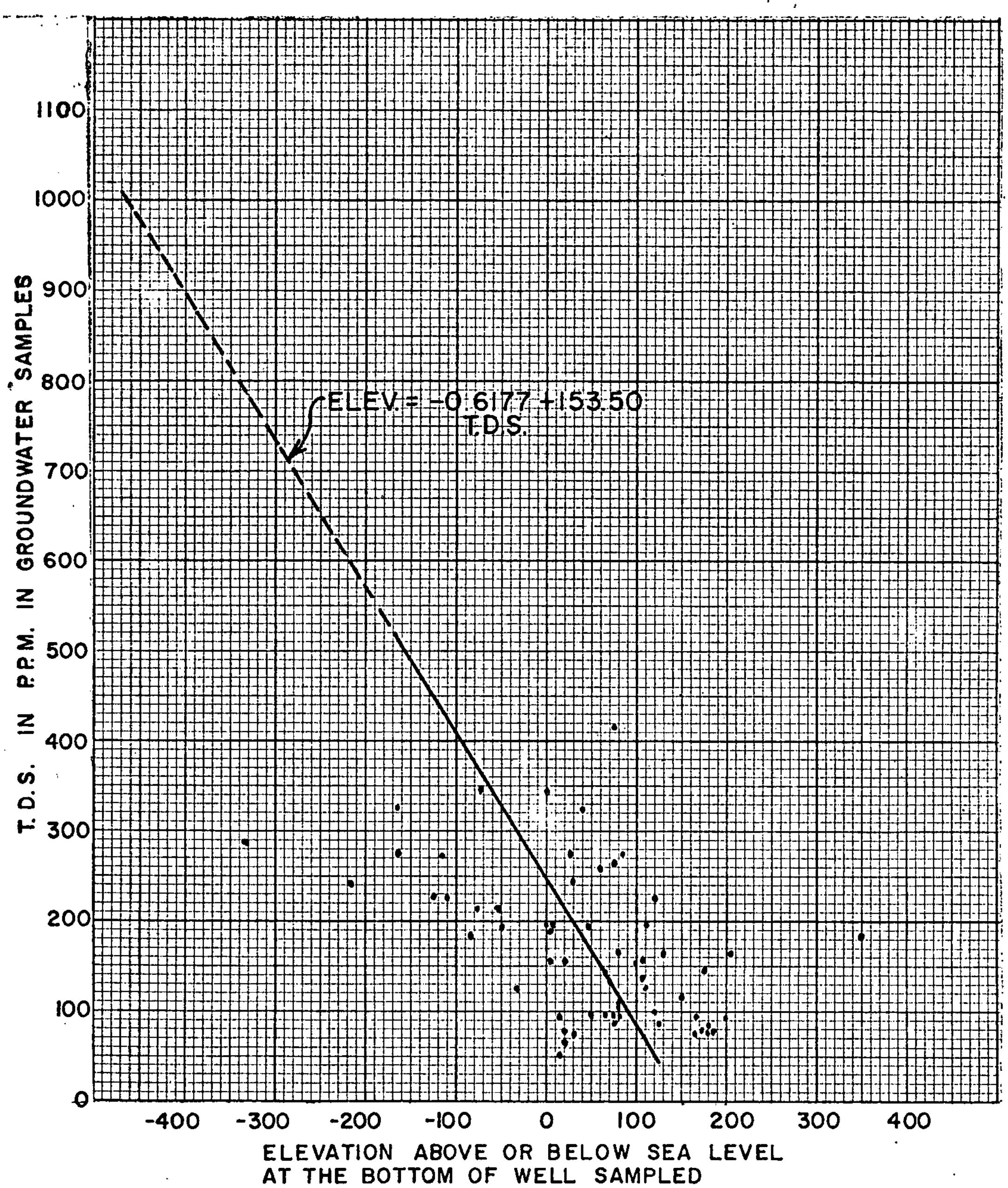
WATER INVESTIGATIONS BRANCH

SCALE: VERT. AS SHOWN HOR.	DATE	J. Foweraker ENGINEER FILE No. 0239013 DWG. No. 5007-FIG. 1-3

RELATIONSHIP BETWEEN TOTAL DISSOLVED SOLIDS (T.D.S.) AND ELEVATION FOR WEST AREA OF MAYNE ISLAND (SHOWN IN WHITE ON MAP No. 1-5)



BRITISH COLUMBIA
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WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

SCALE: VERT. AS SHOWN HOR.	DATE	J. Foweraker ENGINEER FILE No. 0239013 DWG. No. 5007-FIG. 1-4

TABLE 1.1

MONTHLY PRECIPITATION TABLES

from Monthly Records of

Environment Canada

	MAYNE ISLAND				SOUTH PENDER ISLAND							SALTSPRING ISLAND						
Year	1970	1971	1972	1973	1967	1968	1969	1970	1971	1972	1973	1967	1968	1969	1970	1971	1972	1973
January		4.86	3.20	3.80	7.73	6.34	3.51	4.22	5.78	2.83	3.23	10.57	11.19	5.31	6.10	6.86	5.12	5.42
February		3.56	4.67	1.22	1.90	3.58	1.13	2.18	3.23	4.55	1.24	1.72	5.34	3.36	3.00	4.28	5.95	2.06
March		4.67	4.47	1.37	1.86	3.61	2.48	1.34	4.47	4.17	1.18	4.39	6.04	3.27	2.97	7.18	6.42	1.32
April	3.03	0.56	1.63	.42	0.99	0.92	2.46	2.77	0.75	1.77	.56	2.20	1.16	4.12	2.73	1.03	3.12	.33
May	0.74	1.03	.49	.76	1.07	1.45	0.88	0.73	1.15	.59	.60	1.40	1.43	1.09	0.82	1.43	.46	1.05
June	0.62	2.55	1.16	.86	0.84	1.35	0.48	0.68	2.37	1.38	1.15	0.56	1.88	0.91	0.79	2.33	1.33	1.41
July	0.77	0.81	1.91	.24	0.40	0.80	0.33	0.97	0.63	2.18	.19	0.51	0.79	0.46	0.91	0.57	2.18	.49
August	0.22	0.23	1.13	.59	0.07	1.81	0.95	0.22	0.51	1.20	.73	0.11	3.11	1.45	0.18	0.50	1.27	.49
September	2.19	2.73	3.30	1.07	2.08	1.64	3.05	2.07	2.20	2.65	1.36	2.37	2.25	4.58	1.94	2.80	3.20	1.06
October	1.20	1.80	1.50		7.37	4.66	2.07	1.08	2.14	1.45		8.20	5.87	2.12	1.99	2.69	1.33	
November	4.85	4.63	2.08		2.78	4.72	2.43	4.08	6.00	1.58		2.81	6.53	2.56	6.71	5.38	3.57	
December	5.26	5.40	9.54		5.10	6.61	4.34	3.96	4.91	9.01		6.80	10.12	8.56	7.88	7.35	12.62	
Total		32.83	35.08		32.19	37.49	24.11	24.30	34.14	33.36		41.64	55.71	37.79	36.02	42.40	46.57	

Mayne Island: Average precipitation for 2 years 33.95.

South Pender Island: Average precipitation 30.93 taken over 6 years.

Saltspring Island: Average precipitation 35.94 taken over 10 years.

TABLE 1.2

COEFFICIENTS OF TRANSMISSIVITY AND STORAGE OBTAINED
FROM WELL TESTS ON MAYNE ISLAND
(Data from Report No. 3)

Well No.	Drawdown Ft.	Coefficients S (Storage)	Used T USgpd/ft.	Q(100) USgpm
7-5	33	10^{-4}	320	4.65
11-3	100	10^{-4}	2.5	0.14
11-4	180	10^{-4}	7.5	0.73
12-24	200	10^{-4}	92	9.35
11-5 Test No. 1	150	10^{-4}	352	23.1
11-5 Test No. 2	150	$1.09x10^{-4}$	420	27.2
11-6 Test No. 2	150	$1.09x10^{-4}$	470	30.5
11-5 Test No. 3	150	$2x10^{-4}$	328	22.5
11-6 Test No. 3	150	$2x10^{-4}$	340	23.0
2-19	70	$1.63x10^{-4}$	88	3.21
15-2	85	10^{-4}	12	0.595

TABLE 1.2 (CONTINUED)

COEFFICIENTS OF TRANSMISSIVITY AND STORAGE OBTAINED
FROM WELL TESTS ON MAYNE ISLAND
(Village Bay Subdivision Pump Test Results by Consultant)

Well No.	Coefficients Calculated		
	S Storage	T US gpd/ft.	Q(100) US gpm
4-1	-	466	
	-	663	
	$4.1x10^{-5}$	344	
	$7.0x10^{-5}$	180	4.8
6-2	-	123	
	-	161	9.6
6-4	-	83	
	-	102	
	-	220	
	-	46	
	-	165	4.2
7-1	-	101	
	-	93	3.0
	$6.0x10^{-5}$	332	
7-2	$5.3x10^{-5}$	440	
	$1.3x10^{-4}$	232	
	-	255	
	$4.3x10^{-5}$	750	
	-	188	3.6
7-3	-	240	
	-	347	6.0
	$6.85x10^{-5}$	425	
7-4	-	385	
	-	244	
	-	55	
	-	400	
	-	127	7.2

TABLE NO. 1.3

Table of elevations on the bottom of wells sampled and total dissolved solids (TDS) obtained from the respective analyses of the samples.

TABULATION OF DATA FOR EAST AREA SHOWN IN

BLUE ON MAP NO. 1.5 (-150 ZONE)

Section	Well	Sample	Elevation	TDS
1	1	50	-75	206
2	3	4	-108	914
	4	130	60	341
	5	131	25	335
	15	1	-10	887
	22	51	40	177
	24	2	-77	318
	26	81	65	230
	27	80	50	138
8	9	14	95	238
	10	140	90	306
	17	141	60	155
	19	165	103	167
	20	137	97	148
9	1	413	-44	353
	4	149	-10	401
	7	150	-140	400
	8	148	-95	338
	11	147	47	327
	22	162	160	219
	23	115	20	266
	26	417	?	613
	28	109	65	283
	29	142	80	373
	30	143	?	185
	31	144	105	242
	34	116	?	105
11	5	180	0	453
		184	-135	437
	6	191	-140	423
		406	-140	544
	11	117	40	140
	13	60	55	80

TABLE NO. 1.3 (continued)

Table of elevations on the bottom of wells sampled and total dissolved solids (TDS) obtained from the respective analyses of the samples.

TABULATION OF DATA FOR WEST AREA SHOWN IN WHITE

ON MAP NO. 1.5 (-200 ZONE)

Section	Well	Sample	Elevation	TDS
3	2	90	-50	193
	55	8	-165	323
	8	408	85	275
	14	52	70	134
	Sample	91	120	100
4	1	167	0	192
	2	92	150	113
5	1	53	-77	214
6	2	11	-115	273
	11	54	80	110
		5.93	110	125
		5.94	100	152
		5.96	75	89
7	1	169	30	75
	2	158	4	158
	3	170	3	192
	4	166	-32	126
	5	404	205	164
	6	101	350	184
	7	56	180	78
		5.98	175	148
		5.100	200	91
8	1	12	167	95
	3	135	60	260
	4	159	73	415
	5	136	75	261
	6	134	25	276
	8	59	130	162
	13A	58	165	73
	13	57	185	79
	14	104	125	87
	18	163	80	268

TABLE NO. 1.3 (continued)

Section	Well	Sample	Elevation	TDS
11	1	20	0	343
	2	61	120	228
	8	126	80	105
		5.124	110	199
12	11	67	65	142
	14	152	108	159
	15	418	20	153
	16	154	-51	213
	17	66	20	79
	24	403	-72	347
	33	21	48	195
	43	68	-110	225
	44	70	5	191
	52	22	15	96
	57	63	50	99
	58	121	180	82
	59	122	175	79
	60	62	105	135
	61	64	80	96
	62	65	75	93
13	1	71	40	322
	2	72	?	76
14	13	156	-85	183
	17	24	68	98
15	4	29	-216	240
	5	30	-125	228
	9	26	21	65
	10	414	30	243
	13	161	-335	289
	14	73	-165	271
	15	75	15	51

TABLE 1.4

QUANTITATIVE GROUNDWATER STUDIES

MAYNE ISLAND THEORETICAL MODEL

TABULATION OF DATA

Groundwater Regions	Areas in Acres Covered by Different Depth Zones on Theoretical Model (1) Depth Zones with the Elevation of the Lower Limit of the P.W.B.Z. Set by Known Control Points	(2) Depth Zone with the Elevation of the Lower Limit of the P.W.B.Z. Based on Theoretical Model Analyses	(3) Depth Zone with the Elevation of The Lower Limit of the P.W.B.Z. Based on Theoretical Model Analyses	Total Area in Acres	Total Volume of Bedrock within the Potable Water Bearing Zone of the Theoretical Model in Acre-Feet	Model Estimates for Groundwater in Storage in Acre-Feet Based on a Value for Coefficient of Storage of $S = .1 \times 10^{-4}$
1		58.5		58.5	16,339	1.6
2		461.4		461.4	156,249	15.6
3		96.4		96.4	29,717	3.0
4		64.3		64.3	31,129	3.1
5		163.0		163.0	69,851	7.0
6		614.1		614.1	248,973	24.9
7		359.3		359.3	105,658	10.6
8		493.6		493.6	190,300	19.0
9		274.3		274.3	84,991	8.5
10		146.9		146.9	60,634	6.1
11		83.3		83.3	35,422	3.5
12		83.6		83.6	33,074	3.3
13		158.4	99.9	258.3	92,062	9.2
14			189.4	189.4	50,642	5.1
15	61.0	123.0	345.1	529.1	133,556	13.4
16	36.8	436.6	68.8	542.2	221,584	22.2
17	48.2	289.5	34.4	365.0	140,834	14.1
18	215.5	12.6	236.8	464.9	95,339	9.5
19	9.4	-	284.9	294.3	66,339	6.6
20	-	-	93.0	93.0	17,877	1.8
21	-	6.2	96.0	102.2	20,896	2.1
				5,737.1	1,901,466	190.2

TABLE NO. 1.5 QUANTITATIVE GROUNDWATER STUDIES

MAYNE ISLAND THEORETICAL MODEL

TABULATION OF DATA

Groundwater Regions	Model estimates for groundwater in storage in acre feet based on value for coefficient of storage of $S = 1 \times 10^{-4}$	Total number of residences or properties with improvements	Estimated groundwater demand for residences based on 100 days continuous summer use at 300 US g.p.d. per residence expressed in acre feet	Estimated water demand expressed as a percentage of groundwater in storage as estimated for the theoretical model	Maximum number of residences allowed for in the theoretical model based on 300 US g.p.d. per residence and model estimate for total groundwater in storage	Total number of residences expressed as a percentage of the maximum number of residences allowed for in the theoretical model.
1	1.6	14	1.3	81	17	82
2	15.6	79	7.3	47	169	47
3	3.0	1	0.1	3	33	3
4	3.1	0	0.0	-	34	-
5	7.0	2	0.2	3	76	3
6	24.9	66	6.1	24	270	24
7	10.6	0	0.0	-	115	-
8	19.0	36	3.3	17	206	17
9	8.5	1	0.1	1	92	1
10	6.1	20	1.8	29	66	30
11	3.5	25	2.3	66	38	66
12	3.3	12	1.1	33	36	33
13	9.2	3	0.3	3	100	3
14	5.1	2	0.2	4	55	4
15	13.4	30	2.8	21	145	21
16	22.2	3	0.3	1	241	1
17	14.1	16	1.5	11	153	10
18	9.5	12	1.1	12	103	12
Grouped together see text (19	8.4 (6.6	121 (92	11.2 (8.5	133 (129	91 (72	133 (128
(20	(1.8	(29	(2.7	(150	(19	(153
21	2.1	0	0	-	23	-
Totals	190.2	443	41.0		2063	

LEGEND
WATERSHED BOUNDARIES

DATE
DESIGNED J. FOWERAKER
DRAWN W. McINNES
TRACED
CHECKED
DATE

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND

WATERSHED MAP

ENGINEER
APPROVED DIV. CHIEF

FILE No 0239013
SCALE
DWG. No 5007-MAP I-2
SHEET of

LEGEND	
UPPER CRETACEOUS NANAIMO GROUP	
GABRIOLA FORMATION	FAULT
SPRAY FORMATION	25° OBSERVED DIP
GEOFFREY FORMATION	LITHOLOGY
NORTHUMBERLAND FORMATION	SHALE WITH SANDSTONE BANDS
DECOURCY FORMATION	SANDSTONE WITH THIN SHALE BANDS
CEDAR DISTRICT FORMATION	SANDSTONE AND CONGLOMERATE
	CONGLOMERATE

DATE
DESIGNED J. FOWERAKER
DRAWN W. McINNES
TRACED
CHECKED
DATE

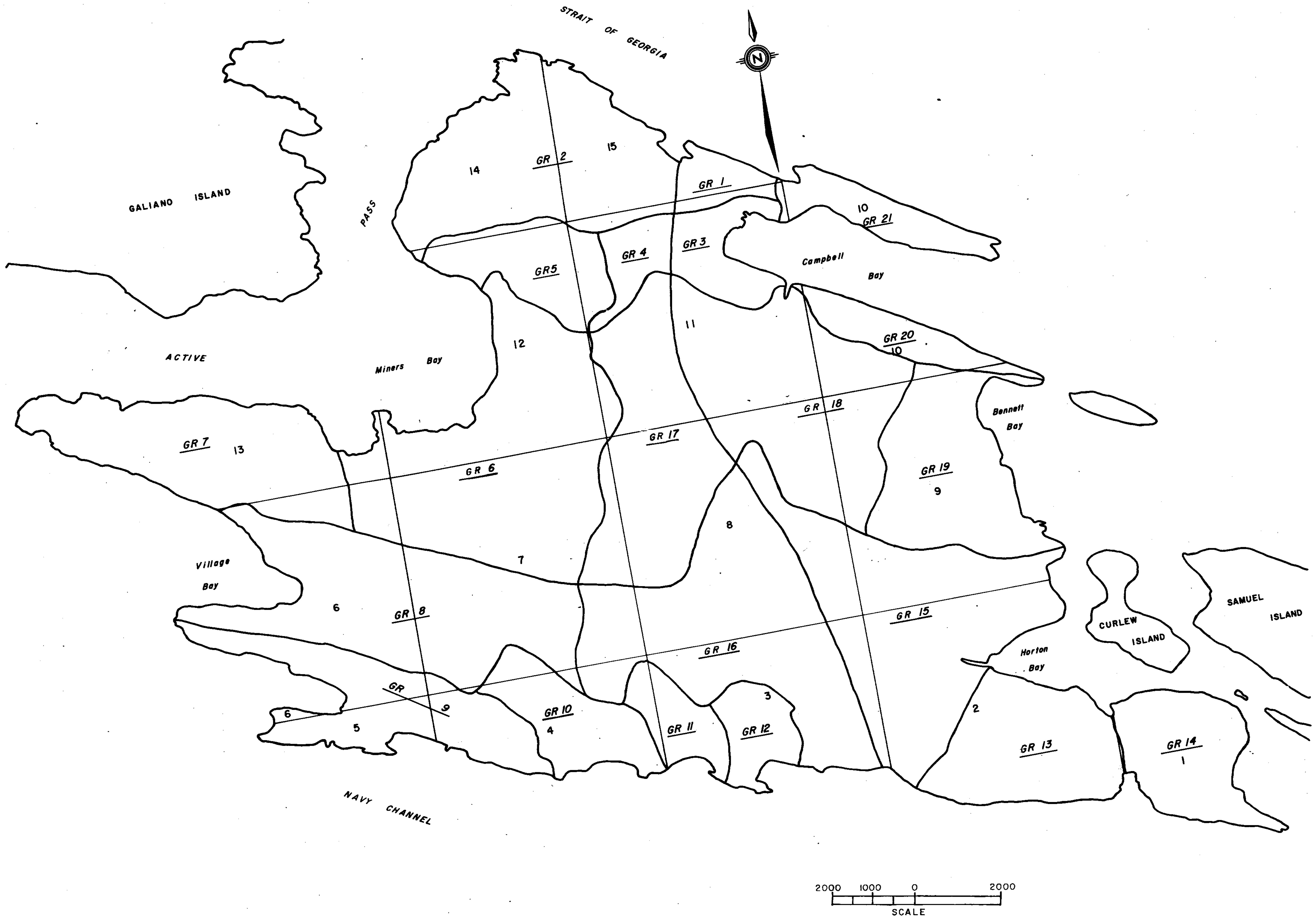
BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND BEDROCK AND STRUCTURAL GEOLOGY MAP

(GEOLOGY BY GROUNDWATER DIVISION PERSONNEL, FROM GSC PAPER 69-25 BY MULLER & JELETSKY, AND FROM OTHER UNPUBLISHED SOURCES)

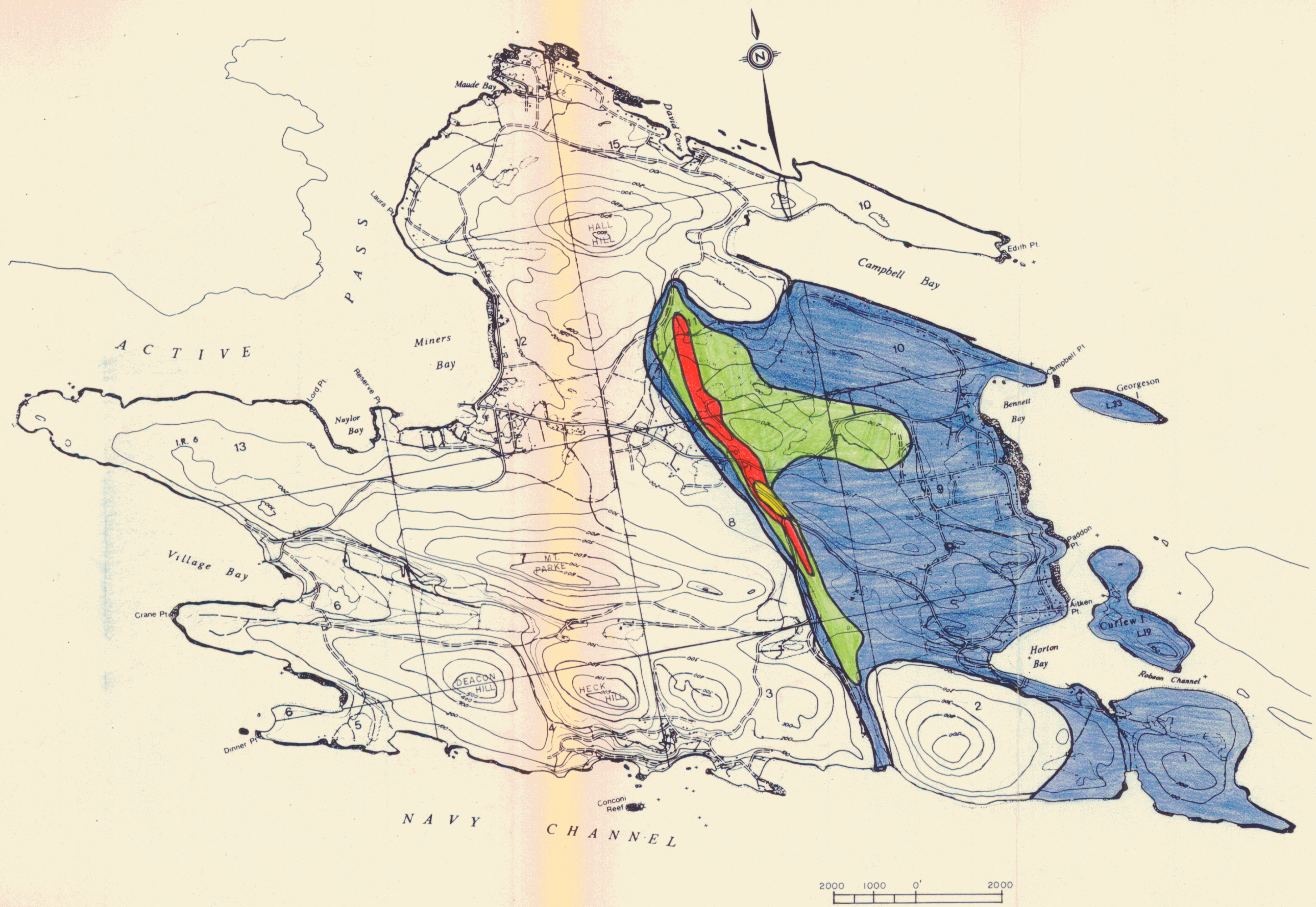
ENGINEER
APPROVED DIV. CHIEF

FILE No 0239013
SCALE
DWG. No 5007-MAP I-3
SHEET OF



LEGEND
GR 12 Groundwater Region number and boundary

SURVEYED DATE	BRITISH COLUMBIA DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES WATER RESOURCES SERVICE WATER INVESTIGATIONS BRANCH GROUNDWATER DIVISION	FILE NO 0239013
DESIGNED. J.H. DRAWN TRACED W. McInnes CHECKED: DATE	MAYNE ISLAND THEORETICAL MODEL **GROUNDWATER REGIONS MAP** NUMBERS CORRESPOND TO REGIONS DISCUSSED IN TEXT	SCALE: 1" = 2422' DWG NO 5007-MAP1-4
	ENGINEER	APPROVED DIVISION CHIEF	SHEET of



DERIVED FROM M 234 - SHEET 9

LEGEND		
		AVERAGE ELEVATION IN FEET TO THE BOTTOM OF THE POTABLE WATER BEARING ZONE *
ELEVATIONS FROM KNOWN CONTROL POINTS	(yellow)	+75
	(red)	+35
	(green)	-50
ELEVATIONS BASED ON THEORETICAL MODEL ANALYSIS	(blue)	-150
	(white)	-200
		*HIGHER ELEVATION POSSIBLE IN COASTAL AREAS

DATE AUGUST 1969
DESIGNED J. HEISTERMAN
DRAWN W. McINNES
TRACED
CHECKED
DATE

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND THEORETICAL MODEL
LOWER LIMIT OF THE POTABLE WATER BEARING ZONE

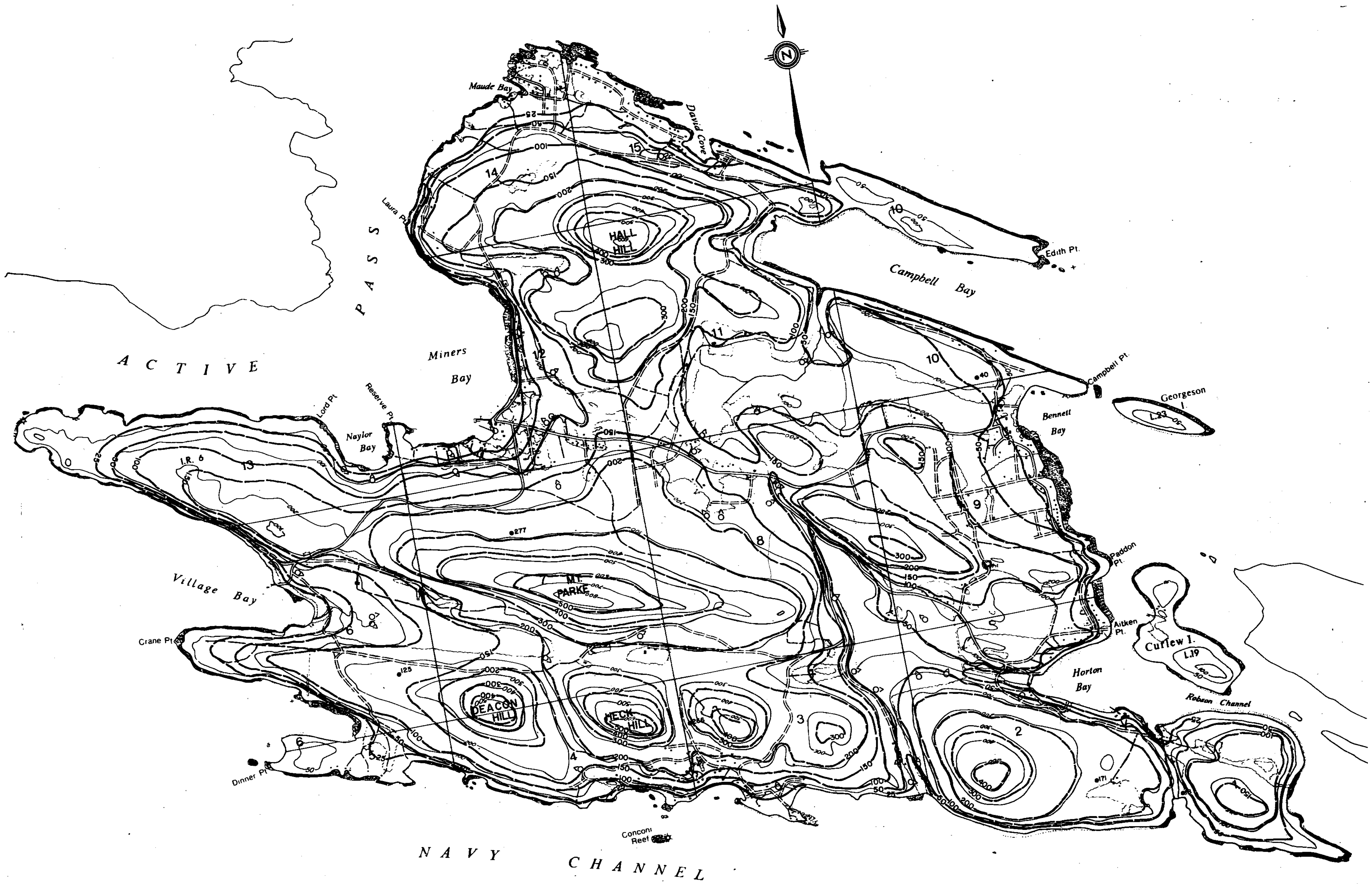
APPROVED

SCALE: 1" = 2422'
Contours - 25 feet

FILE No 0239015

DWG No 5007-MAP I-5

SHEET ___ OF ___



2000 1000 0' 2000

SCALE

LEGEND	
(solid line)	INFERRED GROUNDWATER LEVEL CONTOURS BASED ON DATA CONTROL POINTS.
(broken line)	EXTRAPOLATED GROUNDWATER LEVEL CONTOURS, NO CONTROL (SUBJECT TO REVISION)
O>	SPRINGS
●171	ISOLATED SAMPLING POINT & GROUNDWATER ELEVATION

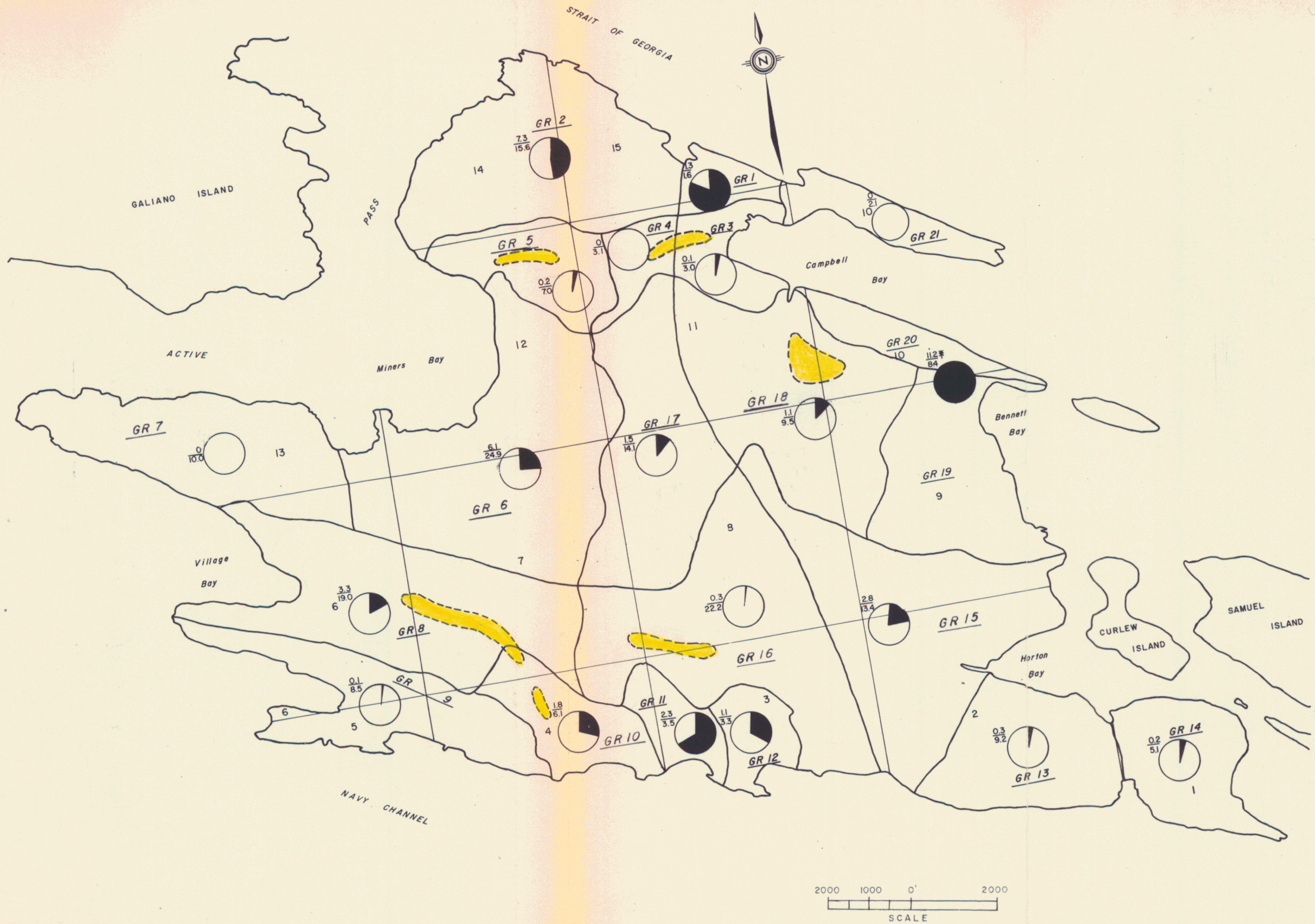
DATE ______
DESIGNED J. FOWERAKER
DRAWN W. McINNES
TRACED ______
CHECKED ______
DATE ______

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND
THEORETICAL MODEL
GROUNDWATER LEVEL CONTOURS

ENGINEER ______ APPROVED DIV. CHIEF ______

FILE No. 0239013
SCALE ______
DWG. No. 5007-MAP1-6
SHEET ___ OF ___



LEGEND

GR 12 — Groundwater Region number and boundary

Estimated groundwater demand - acre-feet — 2.3
Estimated groundwater in storage in acre-feet — 3.5

Pie diagram showing estimated water demand expressed as a percentage of groundwater in storage as estimated for the theoretical model.
* The theoretical model demand/storage percentage of over 100% is unrealistic in GR 19 & 20. This is explained in the text.

Recommended groundwater development reserve. (See Map I-9)

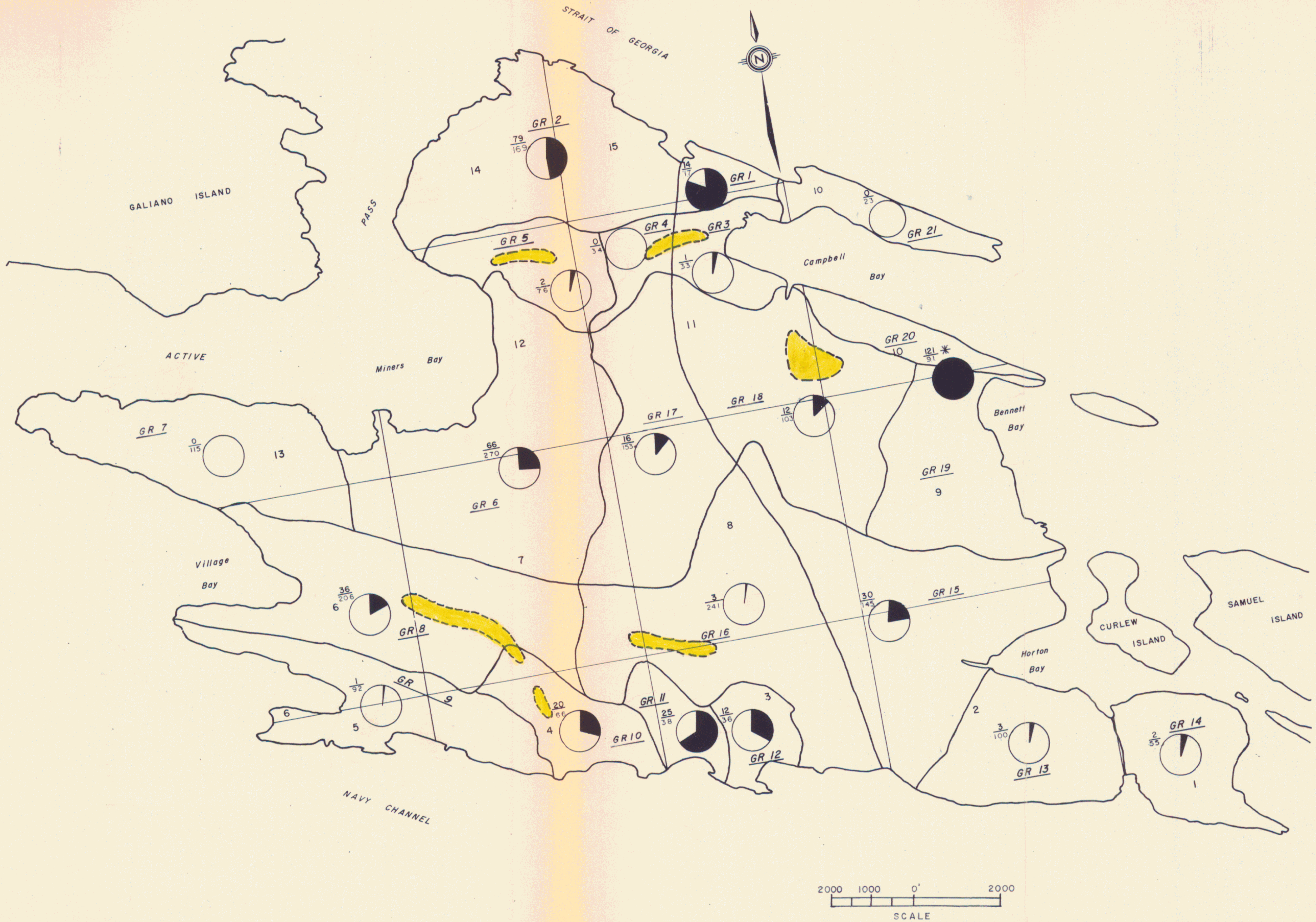
SURVEYED
DATE
DESIGNED. J. Foweraker
DRAWN
TRACED W. McInnes
CHECKED.
DATE

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND
THEORETICAL MODEL
DEMAND-STORAGE PERCENTAGES

ENGINEER
APPROVED DIVISION CHIEF

FILE NO 0239013
SCALE: 1" = 2422'
DWG NO 5007-MAP1-7
SHEET of



LEGEND

GR 12 — Groundwater Region number and boundary

Total number of residences — 25 / 38 — Maximum number of residences allowed: Pie digram showing total number of existing residence expressed as a percentage of the maximum number of future residence allowed for in the theoretical model.

Recommended groundwater development reserve. (See Map 1-9)

* The theoretical model present/future residence of over 100% is unrealistic in GR 19 & 20. Explained in text.

SURVEYED	
DATE	
DESIGNED	J. Foweraker
DRAWN	
TRACED	W. McInnes
CHECKED	
DATE	

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND THEORETICAL MODEL
PRESENT-FUTURE RESIDENCE PERCENTAGES

ENGINEER ______ APPROVED ______ DIVISION CHIEF

FILE NO	0239013
SCALE	1" = 2422'
DWG NO	5007-MAP-1-8
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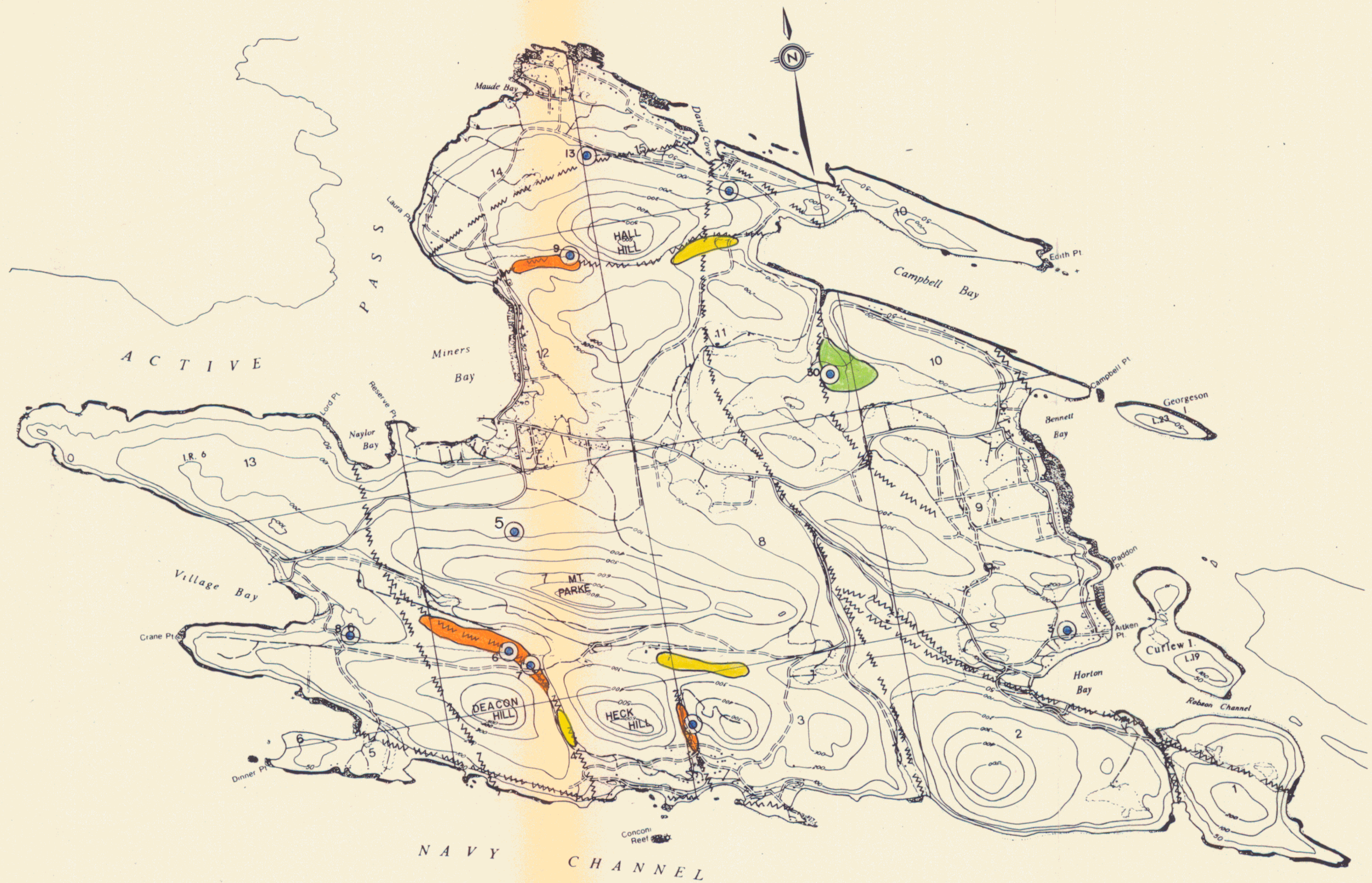


2000 1000 0' 2000

SCALE

LEGEND

6 ◉ DENOTES A Q100 WELL YIELD IN U.S. GALS./MIN., WELL HAS BEEN GIVEN A FULL PUMP TEST SUFFICIENT TO MEASURE GROUNDWATER CONDITIONS AND SIGNIFIES THE YIELD IS FOR 100 DAYS OF CONTINUOUS PUMPING DURING SUMMER PERIODS.

FAULT LINES

RECOMMENDED GROUNDWATER DEVELOPMENT RESERVES

THE NUMBER, SPACING DESIGN AND MAXIMUM YIELD OF INDIVIDUAL WELLS SHOULD BE REGULATED AND EACH RESERVE MONITORED.

- DENOTES RESERVE WHERE INDIVIDUAL Q100 WELL YIELDS UP TO 10 U.S. GALS./MIN. ARE POSSIBLE
- DENOTES RESERVE WHERE OBSERVATION WELL HAS A Q100 YIELD OF 30 U.S. GALS./MIN.
- DENOTES A POTENTIAL RESERVE BASED ON HYDROGEOLOGICAL AND TOPOGRAPHICAL INFORMATION NO TEST DATA AVAILABLE. YIELD UNKNOWN.

DATE

DESIGNED J. FOWERAKER

DRAWN W. McINNES

TRACED

CHECKED

DATE

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

GROUNDWATER DIVISION

MAYNE ISLAND

RECOMMENDED GROUNDWATER DEVELOPMENT RESERVES

ENGINEER

APPROVED DIV. CHIEF

FILE No 0239013

SCALE

DWG. No 5007-MAP1-9

SHEET of

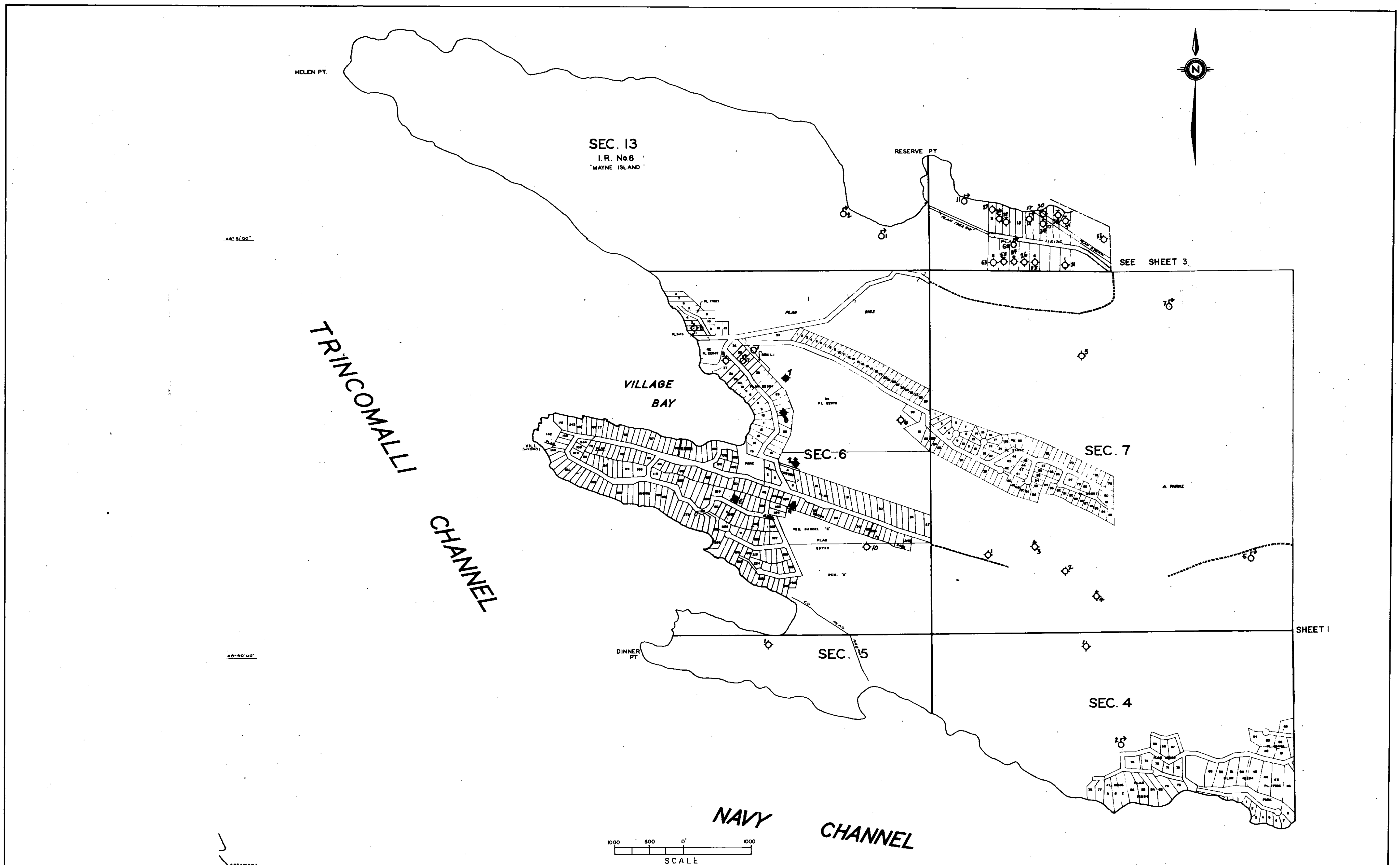
WATER INVESTIGATIONS BRANCH
WATER RESOURCES SERVICE
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
VICTORIA, BRITISH COLUMBIA

MAYNE ISLAND
WATER WELL & SPRING LOCATION MAP

FILE No. 0239013

DWG No. 5007-MAPI-10

SHT 1 OF 3



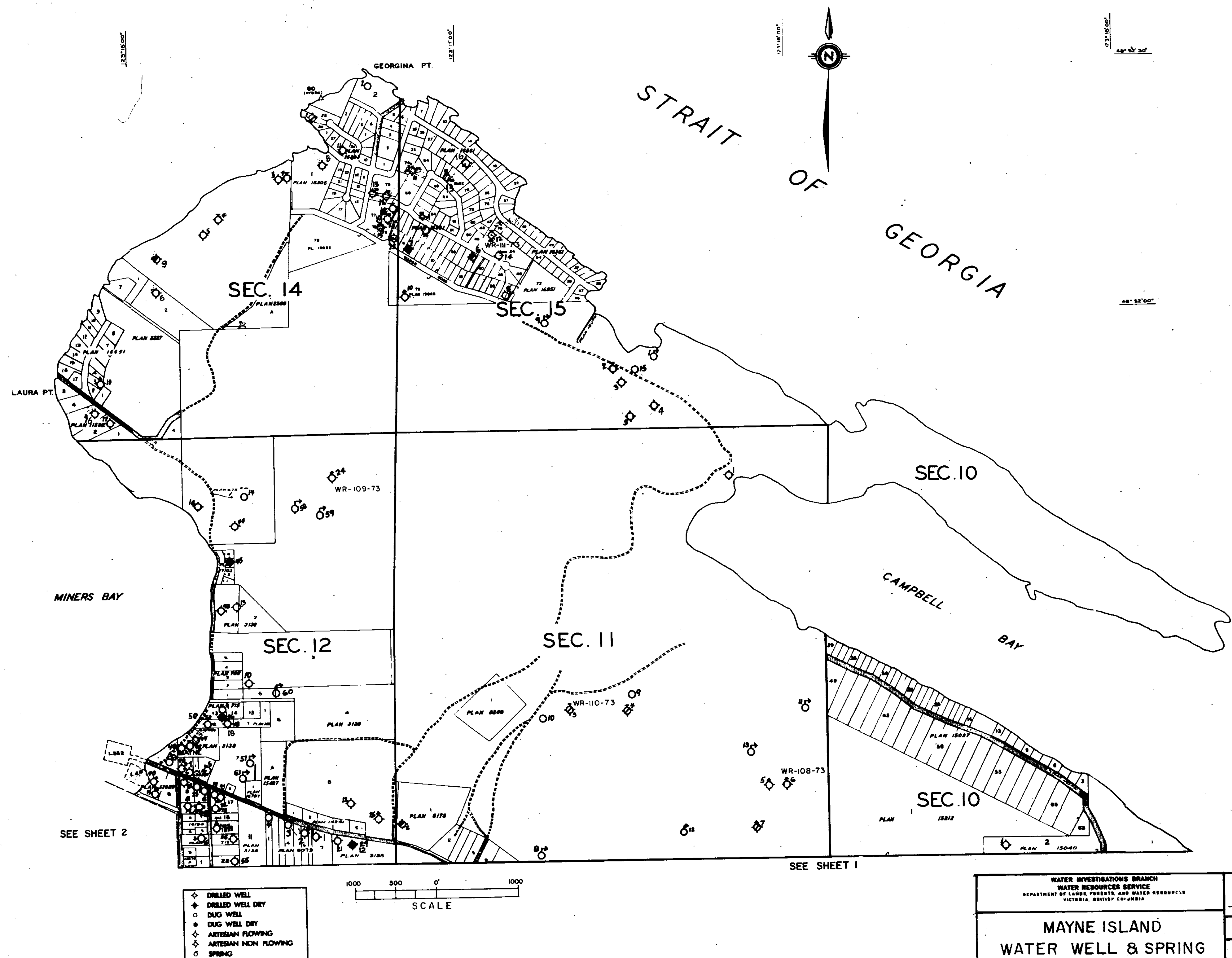
WATER INVESTIGATIONS BRANCH
WATER RESOURCES SERVICE
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
VICTORIA, BRITISH COLUMBIA

MAYNE ISLAND WATER WELL & SPRING LOCATION MAP

FILE No. 0239013

DWG No. 5007-MAP1-10

SHT 2 OF 3



WATER INVESTIGATIONS BRANCH
WATER RESOURCES SERVICE
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
VICTORIA, BRITISH COLUMBIA

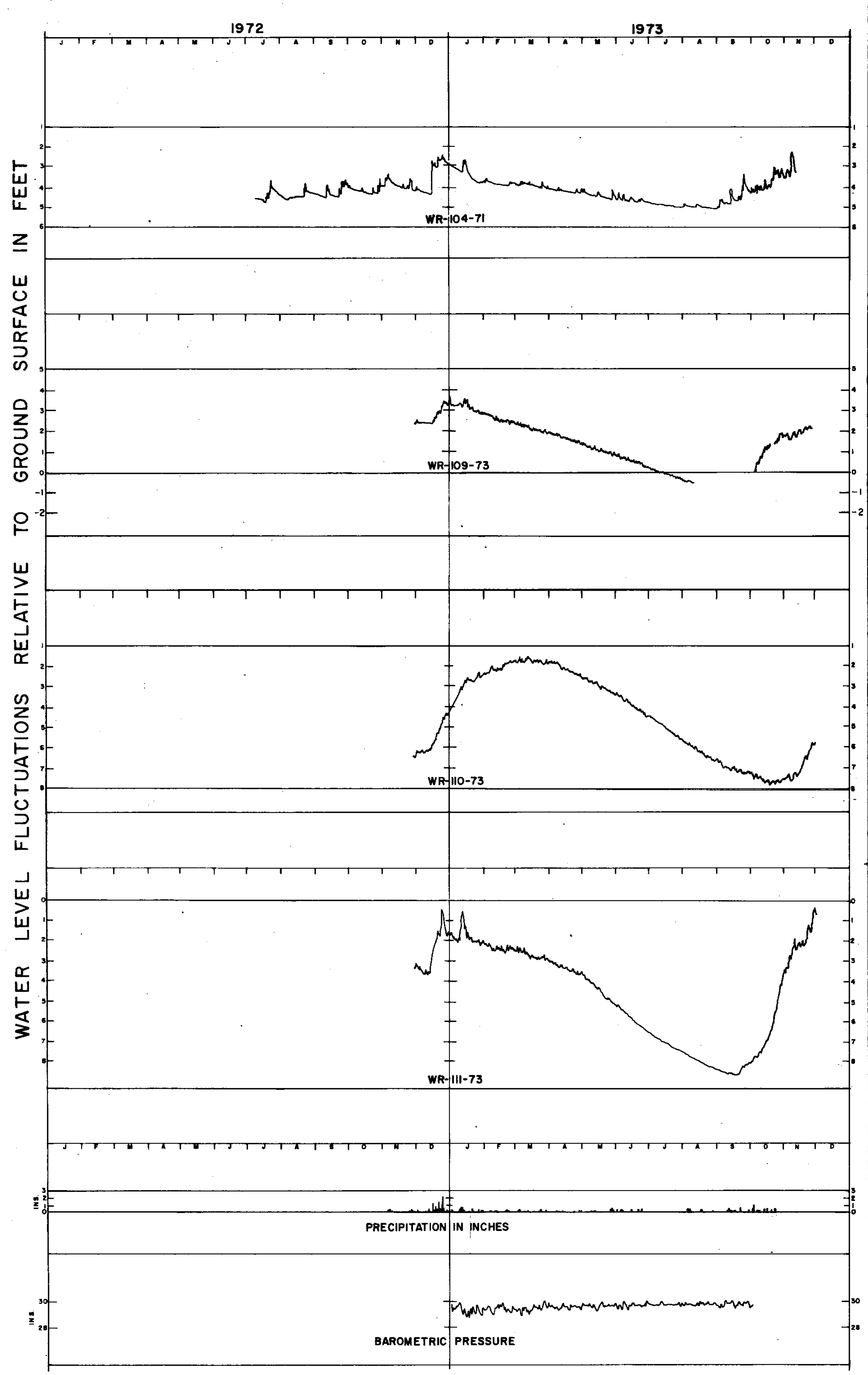
MAYNE ISLAND WATER WELL & SPRING LOCATION MAP

FILE No. 0239013

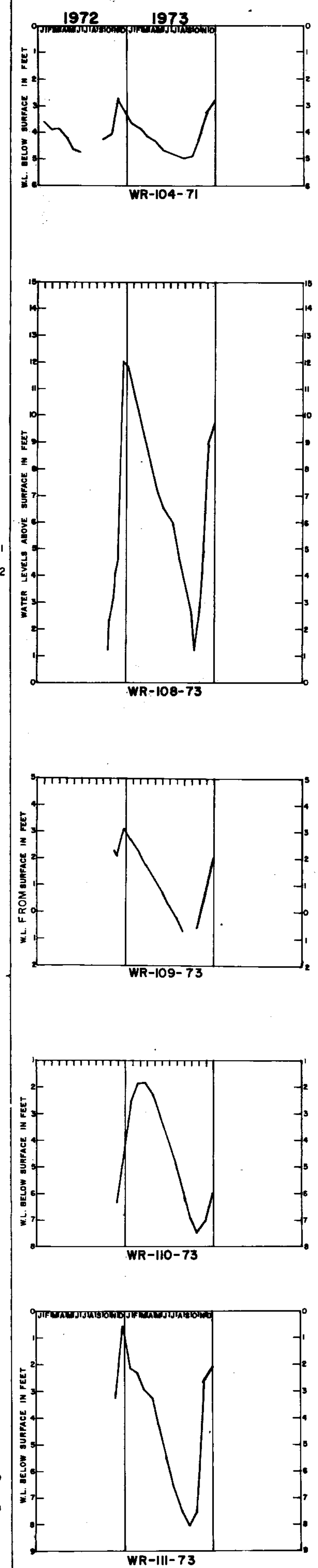
DWG. No. 5007-MAP1-10

SHT. 3 OF 3

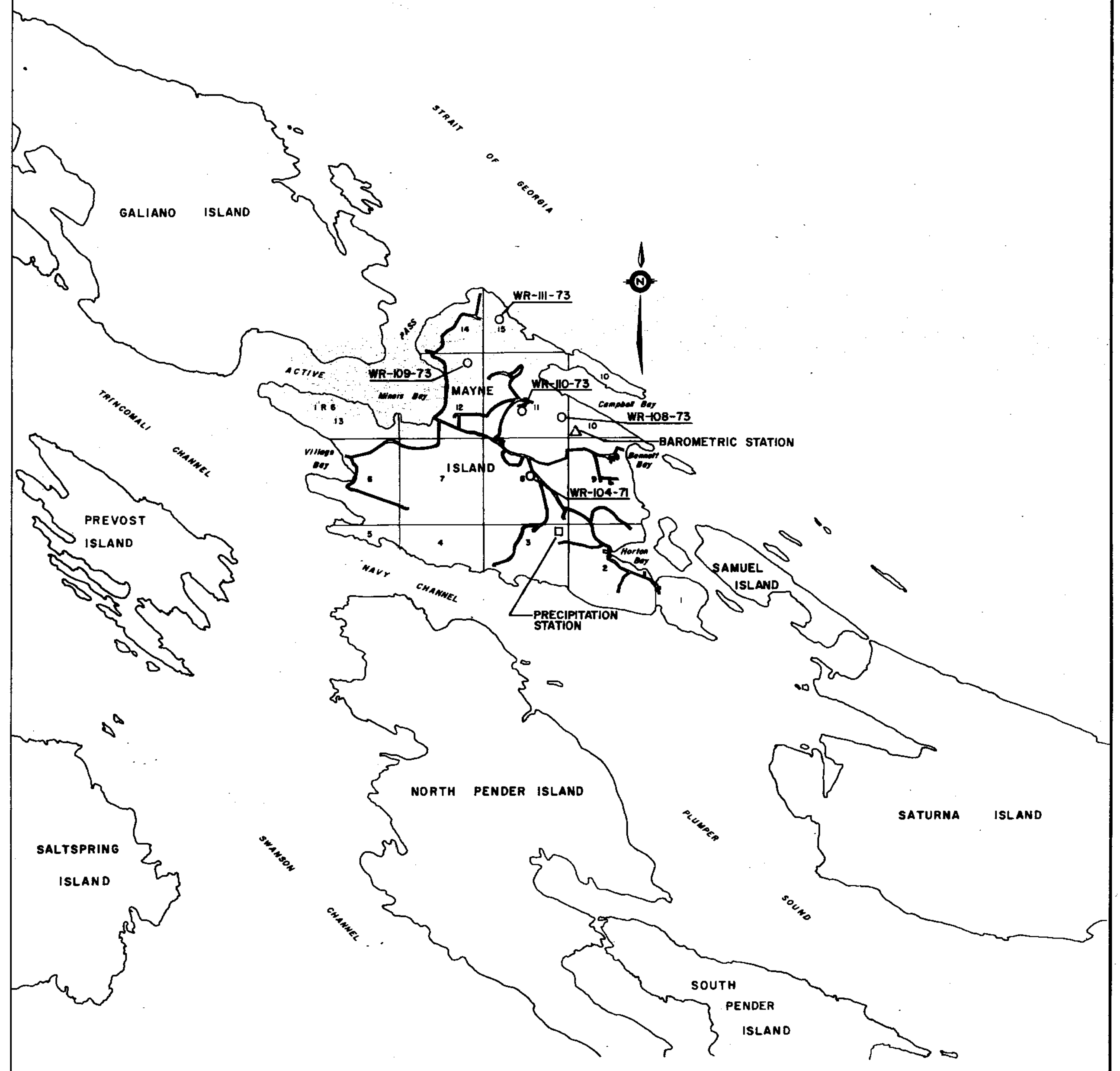
RECORDER HYDROGRAPHS



MANUAL READINGS OF WATER LEVELS



OBSERVATION WELL LOCATIONS ON KEY MAP



KEY MAP
SCALE = 1:100,000

REFERENCES			REVISIONS		
DWG. No.	DESCRIPTION	DATE	No.	DESCRIPTION	DATE

SURVEYED
DATE
DESIGNED A. ALLPORT
DRAWN W. Mc INNES
TRACED
CHECKED
DATE

BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH
GROUNDWATER DIVISION

MAYNE ISLAND

HYDROGRAPHS PREPARED FROM OBSERVATION WELL RECORDS

ENGINEER
APPROVED DIV. CHIEF

FILE No. 0239013
SCALE AS SHOWN
DWG. No. 5007-FIG.I-2
SHEET 1 OF 1