REGIONAL GROUNDWATER POTENTIAL
FOR
SUPPLYING IRRIGATION WATER: 1985

UNION BAY TO OYSTER RIVER

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Ministry of Agriculture and Food
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ACKNOWLEDGEMENTS

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1. INTRODUCTION

The Ministry of Agriculture and Food in conjunction with the Agricultural Land Commission are involved in a detailed assessment of the agricultural capability of the east coast of Vancouver Island. An analysis of the hydrological data was identified as an important requirement in the above assessment with groundwater being a major component.

This report, accompanying maps, cross-sections and fence diagrams provides a discussion and analysis of developed and potential aquifers, for the areas between Union Bay and Oyster River, based on presently available groundwater and geologic data. The map sheets which cover the study area include 92F.065, 066, 075, 076, 084 and 085 (1:20,000 scale). These map sheets are identified as Figures 1, 2, 3, 4, 5 and 6.

The hydrogeological information, thematically presented on the map sheets, cross-sections and fence diagrams are based on the tabulated data from 1250 water well records, water well location maps (both on file with the Groundwater Section, Ministry of Environment), published surficial geology maps and reports (Fyles, 1963; Muller and Atchison, 1971), terrain maps (Ministry of Environment, British Columbia) and soil maps and reports (Ministry of Agriculture and Food, British Columbia).

Tabulated data from water well records (e.g., aquifer characteristics, depth to bedrock, etc.) and coal exploration test holes (depth to bedrock, thickness of overburden, etc.) were transferred to water well location maps (scale 1:20,000) which were used as a working base. Surficial geology/-terrain units and glacial features (e.g., delta kames) which were considered hydrogeologically significant in terms of groundwater potential were transferred to these same maps. A synthesis of this data was then transferred to the final 1:20,000 scale base maps.

2. PHYSIOGRAPHY

The two major northwest-trending geomorphic features of the study area are the result of structural, erosional and depositional processes. These features are the eastern face of the Vancouver Island Ranges of the Insular Mountain Physiographic Division with elevations to 750 metres and an undulating coastal lowland of the Coastal Trough Physiographic Division, rising from sea level to approximately 200 metres and ranging from 10 to 19 kilometers in width.

3. BEDROCK GEOLOGY

According to Muller (1977), Vancouver Island is the main component of the Insular Belt, the westernmost major tectonic subdivision of the Canadian Cordillera. The study area contains Paleozoic rocks (a limestone formation of the Sicker Group), Lower Mesozoic rocks (a volcanic formation of the Vancouver Group) and Upper Mesozoic rocks (consisting of cyclical upward fining sequences of conglomerate, sandstone, shale and coal of non-marine or near deltaic origin, suceeded by marine sandstone, shale or thin bedded and graded shale-siltstone sequences from the Nanaimo Group) and Cenozoic rocks (small plutons and sills of the Sooke Intrusions). The coastal lowlands are principally underlain by the Nanaimo Group.

4. UNCONSOLIDATED DEPOSITS

Most of the unconsolidated materials found in the study area may be attributed to the regimen and wasting of glacial ice during the Late Pleistocene. Though some of the unconsolidated deposits are the result of older glacial (Dashwood Drift) and interglacial (Mapleguard and Cowichan Head Sediments) activity, the majority of the deposited sediments are from the Fraser Glaciation. The Fraser Glaciation probably represents the same geologic-climatic time period as the Classical Late Wisconsin Glaciation of the mid-continent region (Alley and Chatwin, 1979). Fyles (1963) has mapped the surficial unconsolidated sediments within the study area at a scale of 1:63,360.

A stratigraphic framework of unconsolidated sediments and a chronology of Late Pleistocene environments in the study area, is shown in Figure 7. The thickness and vertical variation of the unconsolidated sediments within the study area is shown by cross sections in Figures 8 and 9 and in the fence diagrams in Figures 10 and 11.

5. GROUNDWATER POTENTIAL

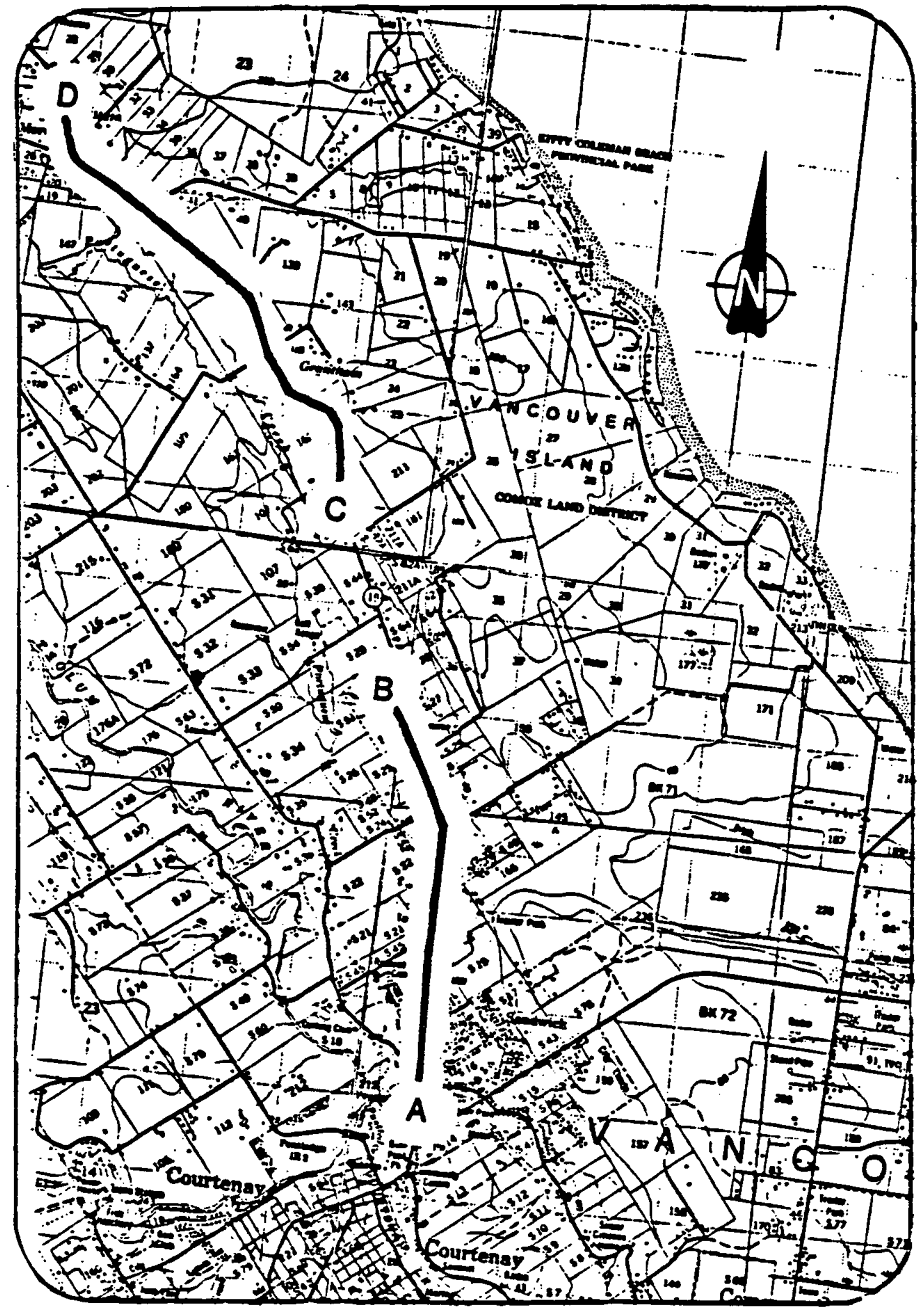
5.1 Bedrock

Groundwater within the bedrock can be found in fractures, along bedding plane partings, in the inter-flow zones of lava, in the inter-granular openings in the rock, and in the case of limestone, in the channels formed by the dissolution of the rock by water. Water wells drilled on Vancouver Island, indicate fractures, bedding plane partings and solution channels are probably the main sources of groundwater from the bedrock. All bedrock wells in the study area appear to be completed in rocks of the Nanaimo Group, principally shales and sandstones. The rapid accumulation of sediments which make up these rocks, accounts for their being poorly sorted, massive and, in general, lacking in pore spaces and conduits for the transmission of water (Halstead and Treichel, 1966). Water wells drilled in these sediments indicate fractures and bedding plane partings are the main sources of groundwater. Water wells completed in sandstone generally reported higher yields than wells completed in shales. Five wells were observed to be completed in sandstones versus twenty-six wells completed in shales.

YEARS BEFORE PRESENT (Not to Scale)	CLIMATIC UNITS	GEOLOGIC UNITS	ENVIRONMENT	STRATIGRAPHY
Present				
5,000	HOLOCENE	SALISH SEDIMENTS	FLUVIAL	Gravel, sand, silt, clay, peat; alluvial fan deposits; blocks and rubble; peat and muck
10,000		CAPILANO SEDIMENTS	MARINE AND GLACIO-MARINE GLACIO-LACUSTRINE	Silt, clay, stony clay, sandy gravel generally underlain by clay; stony gravel, stony loam Sand and gravel, laminated silty and clay
15,000	FRASER GLACIATION	VASHON DRIFT	GLACIO-FLUVIAL GLACIAL	Gravel, sand and silty forming ice-contact deltas Grey till, sand to clayey texture
20,000		QUADRA SAND	GLACIO-FLUVIAL	Sand, gravel and silt
25,000				
30,000	OLYMPIA NON-GLACIAL INTERNAL	COWICHAN HEAD FORMATION	FLUVIAL ESTURINE MARINE	Silt, gravel, sand, peat, peaty soil, and driftwood Clay, stony clay, silt containing marine shells, local basal laminated clay and silt
60,000				
	SALMON SPRINGS GLACIATION	DASHWOOD DRIFT	GLACIO-MARINE GLACIAL	Grey till, silty to sandy texture contains silty and gravel lenses
?				
	PUYALLUP NON-GLACIAL INTERVAL	MAPLEGUARD SEDIMENTS	FLUVIAL LACUSTRINE	Sand, silt, minor clay and gravel

Figure 7. CLIMATIC GEOLOGIC UNITS, STRATIGRAPHY AND LATE PLEISTOCENE ENVIRONMENTS OF THE STUDY AREA after Clague (1981, 1977 & 1976) Alley & Chatwin (1979), Armstrong et al (1965) & Halstead (1966)

GEOLOGIC CROSS SECTION



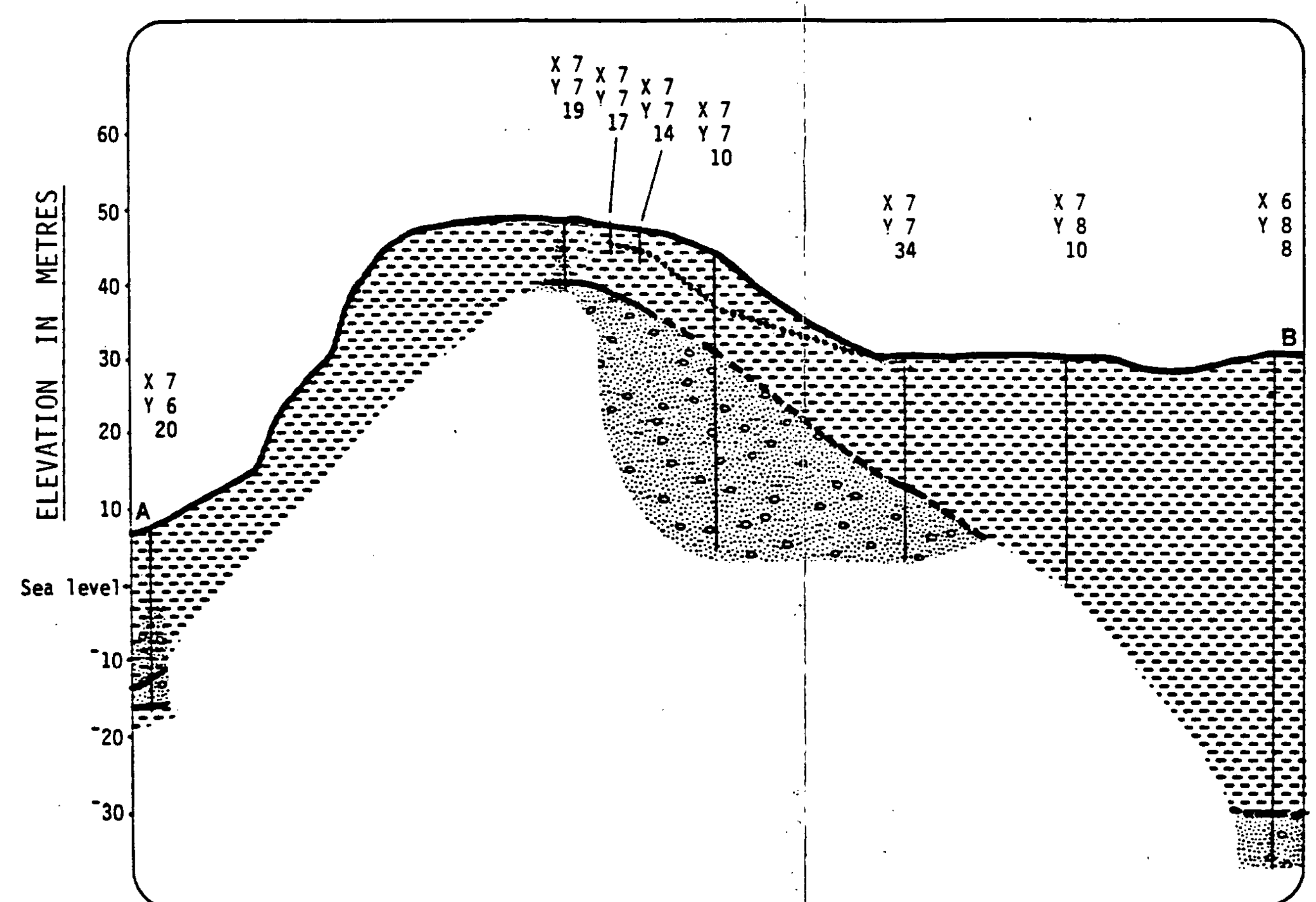
LEGEND

A ———— B = Location of Cross Section

SCALE

0 — 5000

metres



LEGEND AND SCALE

Predominantly Sand and/or Gravel

Predominantly Till, Silt and/or Clay

•••••••••• = Water Table

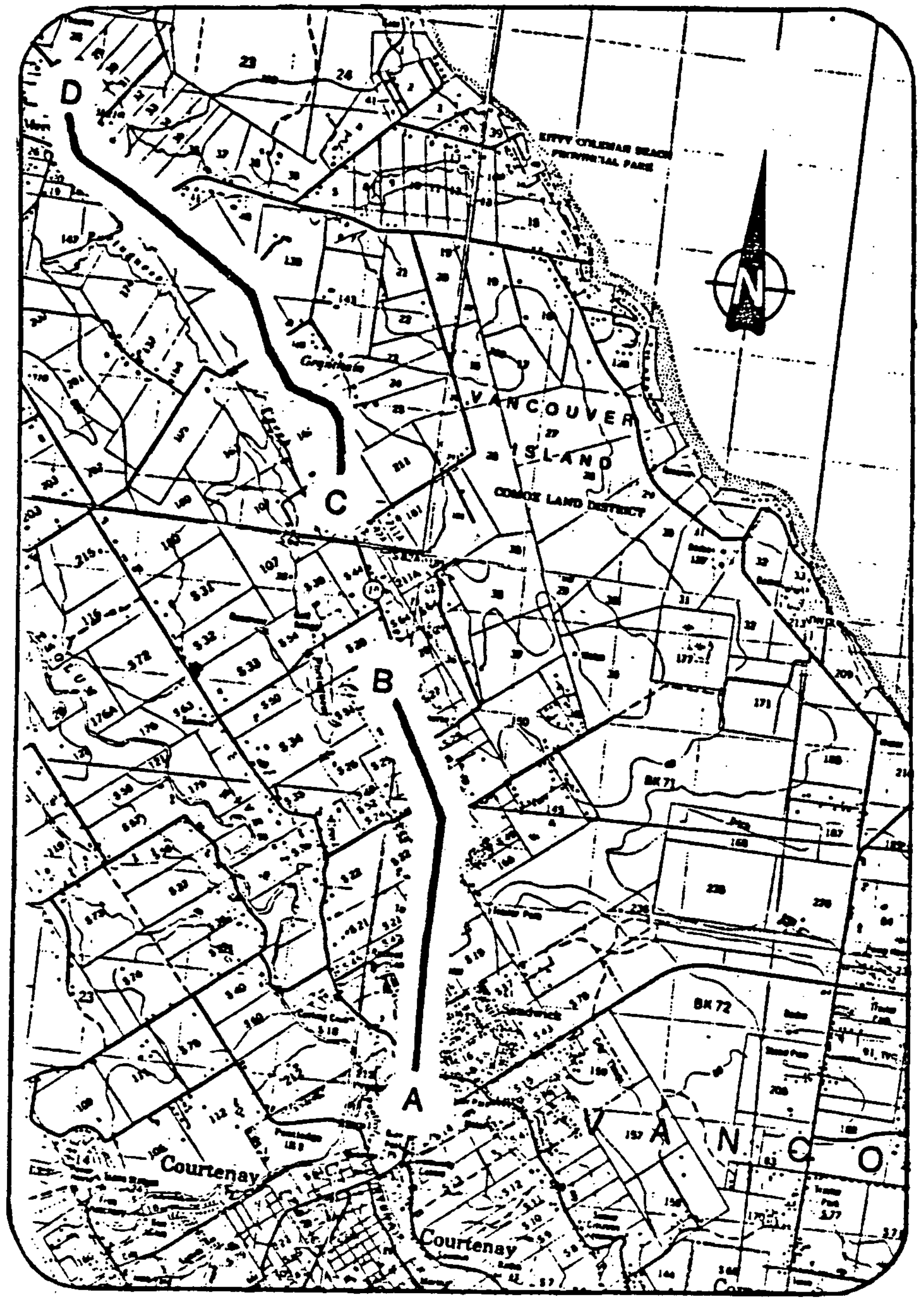
0 500 1000 1500

metres

Vertical exaggeration is approximately 25 times

X6 Y10 21 = Water Well

GEOLOGIC CROSS SECTION



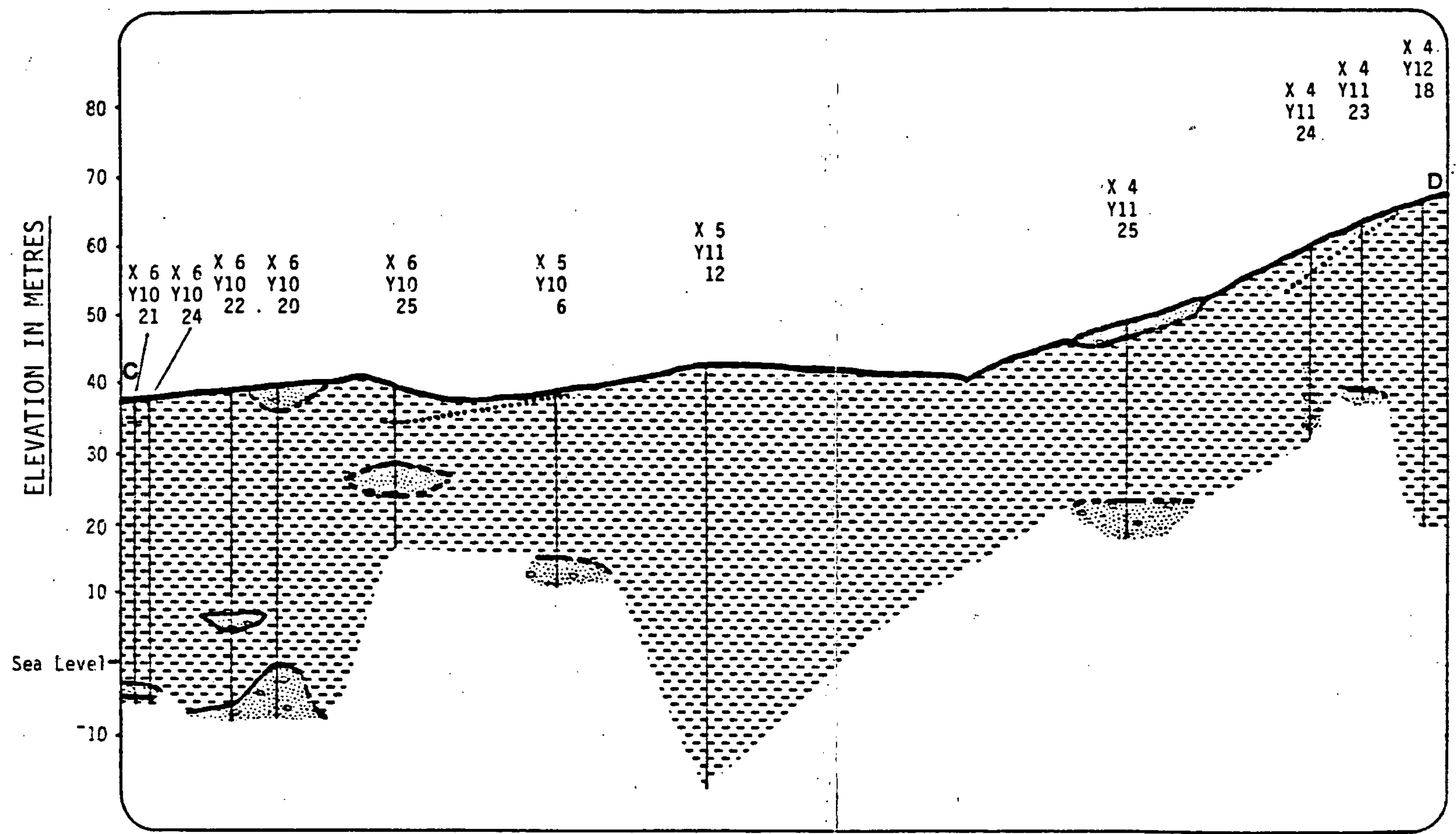
LEGEND

C ——— D = Location of Cross Section

SCALE

0 — 5000

metres



LEGEND AND SCALE

Predominantly Sand and/or Gravel

Predominantly Till, Silt and/or Clay

• • • • • • • • • = Water Table

0 500 1000 1500

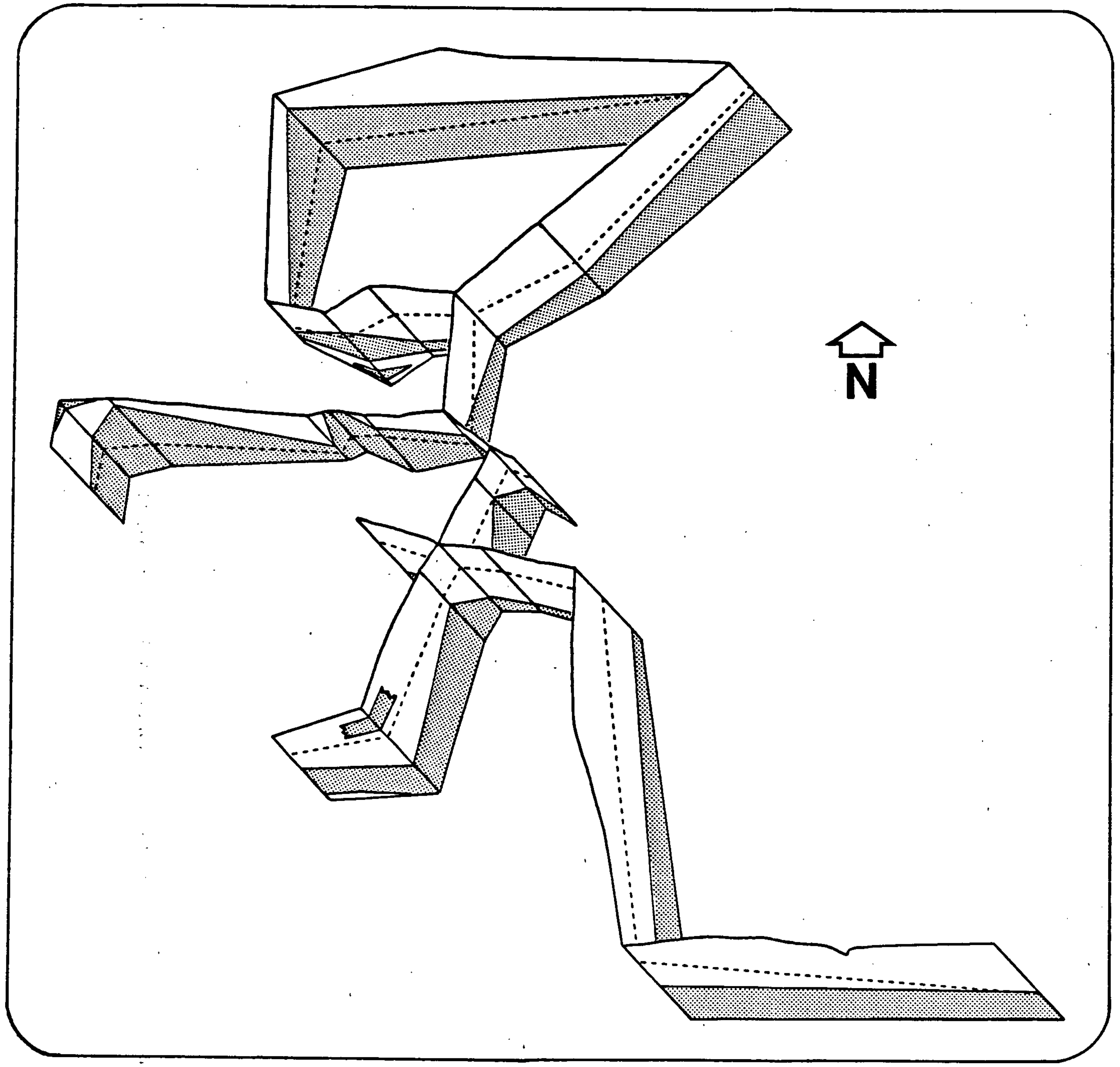
metres

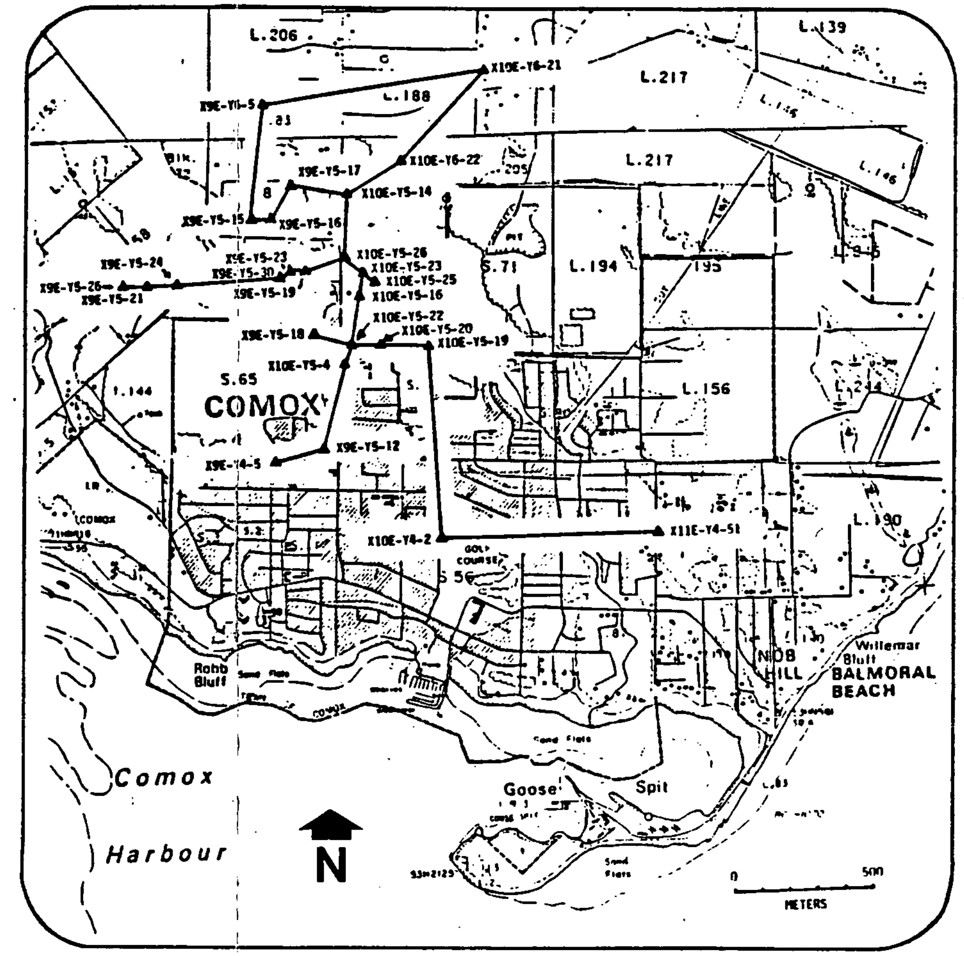
Vertical exaggeration is approximately 25 times

X6 Y10 21 = Water Well

Figure 9

FENCE DIAGRAM





PREDOMINANTLY TILL

PREDOMINANTLY SAND

WATER LEVEL

HORIZONTAL SCALE IN METRES

0 300 600 900 1,200

VERTICAL SCALE IN METRES

50 40 30 20 10 0

INDEX PLAN LEGEND

▲ X10E-Y5-19 = A WATER WELL ON FILE WITH THE GROUNDWATER SECTION, WATER MANAGEMENT BRANCH, MINISTRY OF ENVIRONMENT.

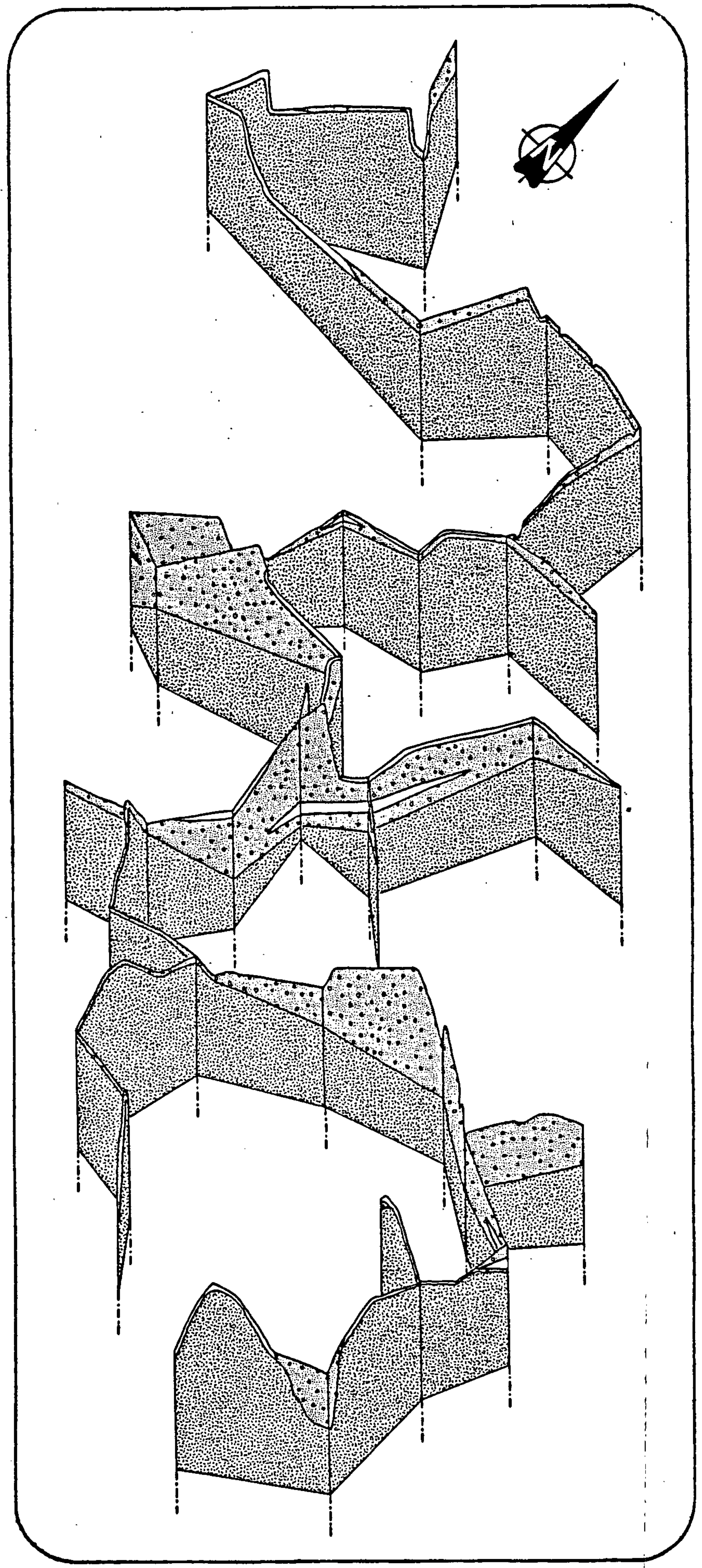
HORIZONTAL SCALE

0 300 600

METRES

Figure 10

FENCE DIAGRAM



FENCE DIAGRAM LEGEND

- Predominantly Gravel
- Predominantly Clay
- Bedrock

FENCE DIAGRAM SCALE

150
100
50
0

Vertical Scale in Metres

INSET MAP LEGEND

C 146 = A coal exploration testhole on file with the Geologic Branch of the Ministry of Energy, Mines and Petroleum Resources.

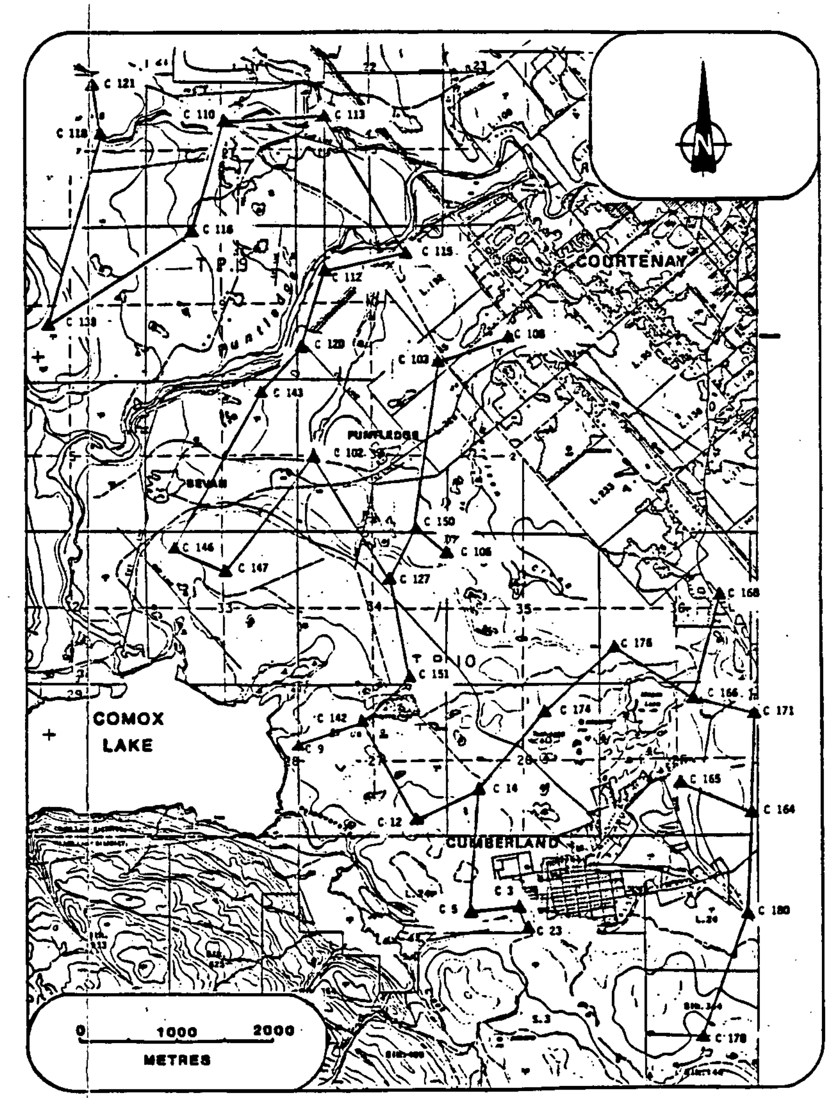


Figure 11

The possibility of obtaining adequate supplies of groundwater for irrigation purposes from these sources are generally considered to be poor and although a few bedrock wells in the study area have been reported to yield between 1 and 5 L/s (five litres per second is significant when considering irrigation requirements), long duration pumping tests would be required to verify if bedrock aquifers are capable of a sustained high withdrawal rate. A bedrock aquifer with potential exists in the Miracle Beach park area (map sheet 92F.085). Existing data reveals a sandstone formation where four wells show reported yields greater than 1 L/s and one well greater than 5 L/s.

Examples of bedrock aquifers capable of yielding sufficient supplies of groundwater for irrigation purposes can be found in the Mill Bay and Saanich regions of southern Vancouver Island where well yields up to 16 L/s have been obtained. It is not known if comparable high yielding bedrock aquifers exist in the study area. To identify such aquifers would require detailed geologic mapping, aerial photograph analysis, and possibly geophysical investigations, as well as test drilling. These procedures can be both time-consuming and expensive.

5.2 Unconsolidated Deposits

Most of the groundwater used on Vancouver Island comes from unconsolidated deposits which receive water from infiltration of either precipitation or surface water sources. The amount of water obtainable from these materials, depends on the permeability of the aquifer material, the thickness and extent of the aquifer, the rate of aquifer recharge and on well construction.

The unconsolidated deposits which are hydrogeologically significant in terms of groundwater potential for irrigation purposes are primarily comprised of sand and/or gravel. The deposits which fall into this category are listed and discussed below:

1) The shore, deltaic, fluvial and alluvial deposits of the Salish Sediments. These deposits range up to 10 metres in thickness. Thickness of any sand and/or gravel deposits 0.5 metres or greater are considered significant in terms of groundwater potential. The primary target for groundwater exploration would be the fluvial deposits near present day stream channels and deltas. These would include the valleys and/or deltas of the Oyster, Tsolum, Trend and Little Rivers.

2) Terraced fluvial deposits which include deltaic, channel, floodplain and alluvial fan deposits along with some marine and/or glacio-marine deposits of the Capilano Sediments. These deposits are significantly higher or lower (approx. 6 metres) than the present levels of similar present day deposits (Fyles, 1963). These deposits range up to 20 metres in thickness and 2000 metres across. The deltaic terraces would be primary target areas for groundwater exploration. Examples of terraced fluvial deposits can be found along the Oyster, Brown, Puntledge and Trend River Valleys. Minor terraced fluvial deposits occur along the Tsolum river, Dove Creek and just west by southwest of Cumberland.

3) The glaciofluvial deposits which include hummocky, knob and kettle, ridged, esker, terrace and pitted terrace, kame terrace, kame delta and ice contact alluvial fan deposits of the Vashon Drift. These deposits are found resting upon the ground moraine of the Vashon Drift. Usually located within a couple of miles of the mountain slopes, these deposits may range up to 2 kilometers wide and 7 kilometers long. One such deposit exists at the outlet of Comox Lake and locally may exceed 50 metres in thickness. The fence diagram in Figure 11 graphically portrays this sand and gravel deposit. It is

probable that a major aquifer exists within this kame deposit. The kame terraces and kame deltas would be primary target areas for groundwater exploration. Another area of glacio-fluvial deposits can be found where the Oyster River leaves the Insular Mountains.

Lenses of sand and/or gravel are associated with the ground moraine deposits of the Vashon Drift. Though these lenses are potential aquifers their location and viability must be confirmed by drilling, which can be both expensive and time consuming.

4) The glaciofluvial deposits of the Quadra Sediments (Fyles, 1963) known as the Quadra Sand (Clague, 1977). The groundwater potential of this geologic unit merits an expanded understanding of its distribution and origin.

Quadra Sand is found throughout much of the southern portion of the study area, usually below the 100 metre elevation level. Comprised predominantly of sand with minor silt and gravel these deposits locally exceed 75 metres in thickness. Water well logs have reported greater than 20 metres of sand which possibly belong to the Quadra Sand Unit. Overlain by glacial sediments (mainly till) of the Fraser Glaciation and underlain by sediments of the Olympia Interglacial interval the current theory on the origin of Quadra Sand is summarized by Clague (1977) below:

> "The sand was deposited, in part, as distal outwash aprons at successive positions in front of and perhaps along the margins of glaciers moving from the Coast Mountains into the Georgia Depression and Puget Lowland during Late Wisconsin time. After deposition at a site, but before burial by ice, the sand was dissected by meltwater and the eroded detritus

was transported farther down the basin to sites where aggradation continued."

An extensive deposit of Quadra Sand is believed to exist in a 4 to 6 kilometer wide belt from the southern part of the Comox Peninsula north to the Oyster River area. The inferred distribution of Quadra Sand is shown in Figure 12. The lower portions of the cross-section shown in Figure 8 illustrates sand and/or gravel units which probably represent the Quadra Sand. The fence diagram in Figure 10 shows an extensive lower unit comprised predominantly of sand which also probably represents the Quadra Sand Unit. This fence diagram graphically portrays an extensive confined aquifer at this location. Figure 13 is a contour map of the hydraulic head of water wells completed in the above-mentioned confined aquifer. The hydraulic head or water level elevations (in metres above sea level) provides a map which indicates directions of groundwater flow and an area of recharge. This type of information is necessary to quantify groundwater quantities and to solve problems of water quality. The extensiveness of the Quadra Sand, its thickness and locally proven yields of 6 L/s makes this deposit a primary target for groundwater exploration.

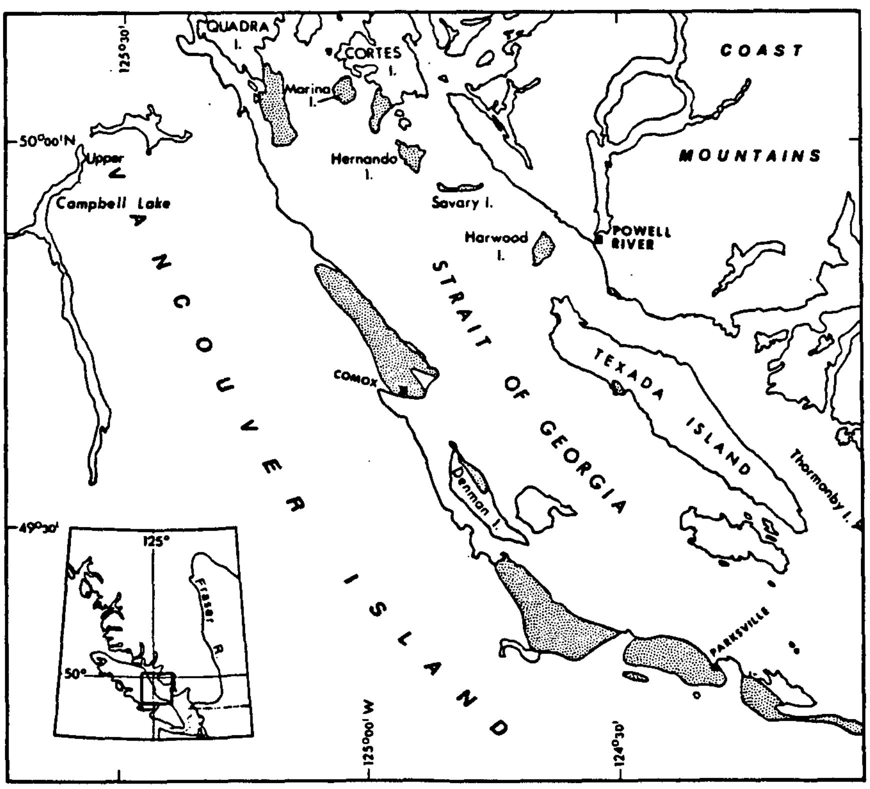


Figure 12.

Inferred distribution of Quadra Sand and Cowichan Head Formation (after Clague, 1977).

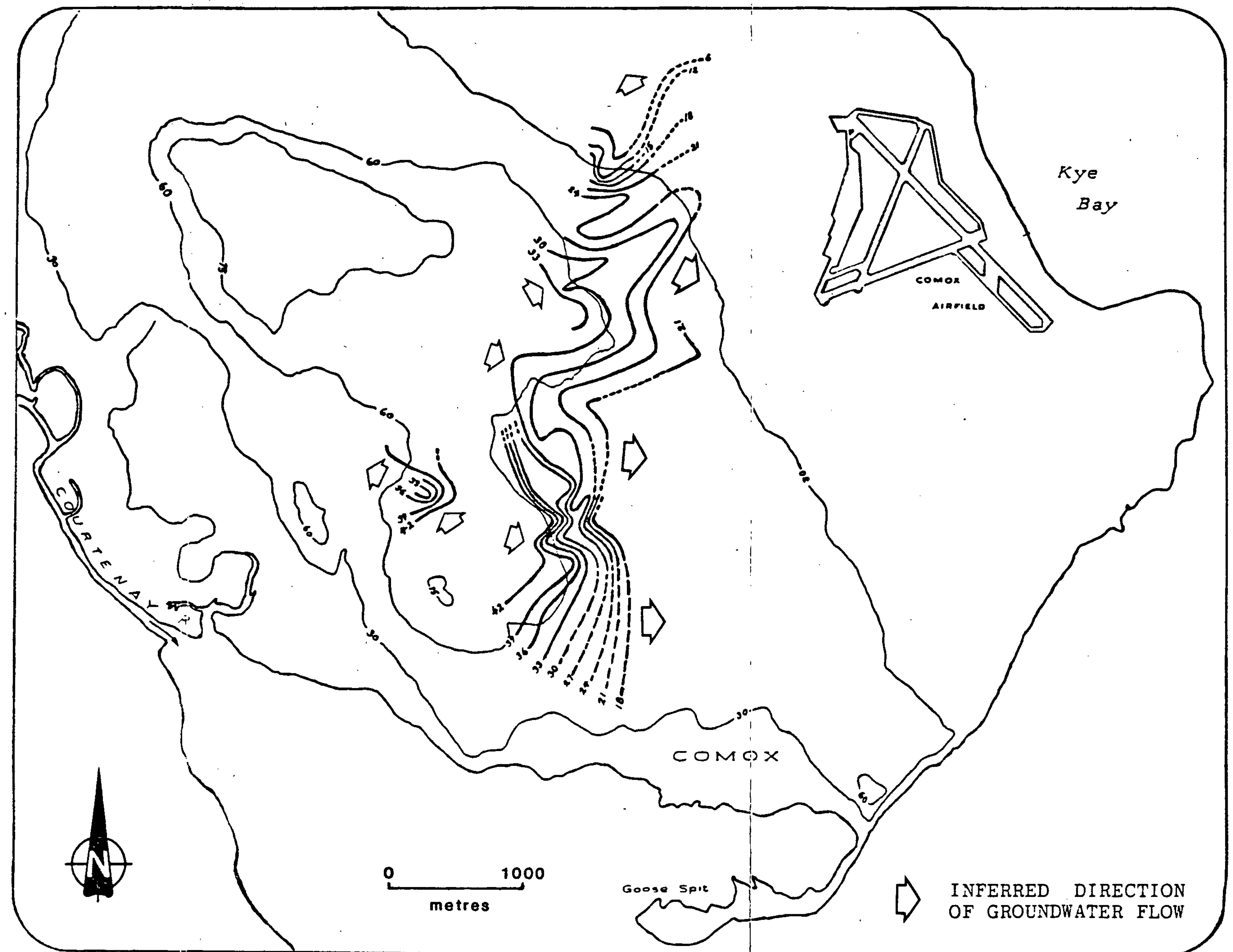


FIGURE 13: A contour map of the hydraulic head in water wells completed in a confined aquifer. The aquifer is probably in Quadra Sand . The hydraulic head or water level elevations (in metres above sea level) provides a map which indicates directions of groundwater flow in the aquifer.

5) A gravel and sand deposit found beneath glacial drift of the Fraser Glaciation but whose relationship to Quadra Sand is unknown. Deposits of this unit found south of the study area are reported (Fyles, 1963) to be 75 metres in thickness. The only known exposures of this unit to be found within the study area are located in the Oyster River Valley. The extensiveness of this unit is unknown and though there is a lack of groundwater data for this geologic unit, the composition makes it a target area for groundwater exploration.

The following is a summary of groundwater data from water well records in the study areas. Many of the wells were completed in one or more of the deposits just described.

Over 470 water well records show thickness of unconsolidated materials ranging from 1 to 110 metres and averaging 30 metres. One hundred and twenty coal exploration testholes show thickness of unconsolidated material, ranging from 0 to 50 metres and averaging 10 metres. The water wells were generally located in the lowlands where the unconsolidated sediments were thicker.

Over 440 water well records which showed wells completed in sand and/or gravel, ranged in depth from 1 to 76 metres and averaged 30 metres. The apparent depth to the top of a sand and/or gravel aquifer, based on over 440 water well records ranged from 1 to 84 metres with 26 being the average.

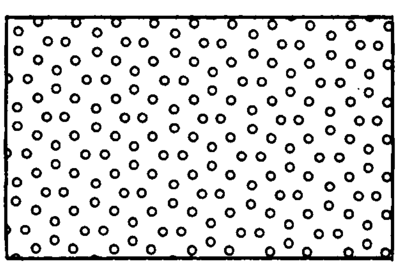
Over 440 water well records showed apparent aquifer thicknesses ranging from 0.3 to 30 metres with about 5 metres being the average. Water well records show well yields are reported to range from less than 0.1 L/s to greater than 44 L/s. Wells completed in bedrock reported average yields of

0.5 L/s and wells completed in sand and/or gravel reported average yields of 1.4 L/s. Eighteen wells completed in sand and/or gravel reported yields greater than 6 L/s. Five litres per second is significant when considering irrigation requirements.

Available data from other hydrogeological studies show springs reporting a flow rate up to 12 L/s (south of Courtenay) and wells capable of yielding greater than 40 L/s (Oyster River area). The few 24 hour pump tests available on file with the Groundwater Section showed specific capacity ratings up to 74 L/s/metre of drawdown. These ratings are significant in terms of groundwater potential.

The following is a description and the limitations of each component shown on the 1:20,000 scale base maps.

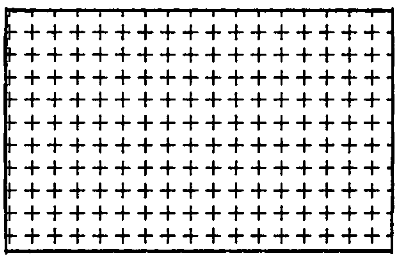
6. EXTENT OF DEVELOPED AND POTENTIAL AQUIFERS



AREA A: Area A outlines the surficial extent of unconsolidated deposits primarily comprised of sand and/or gravels. Area A outlines areas where there is a high probability of locating water-bearing sand and/or gravel aquifers but does not imply the existence of water-bearing sand and/or gravel aquifers. In some areas for example the sand and gravel deposits may be very thin and dry throughout their entire thickness.

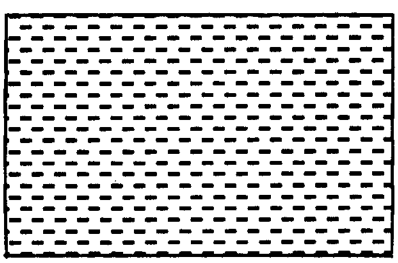
Area A outlines potential unconfined aquifers at surface, it does not show distribution at depth. This is especially relevant to the Quadra Sand and possibly to some pre-Fraser Glaciation unconsolidated sediments (e.g., Mapleguard sediments) which may underlie younger deposits (marine clays for example) in the region.

The surficial geology units which make up Area A were transferred first from 1:63,360 scale mapping to 1:12,000 scale water well location maps, and then to 1:20,000 scale cadastral maps. Minor boundary errors may exist therefore on the larger scale mapping.



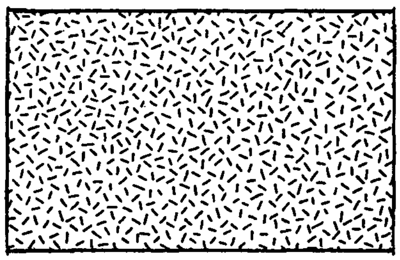
AREA B: Area B outlines regions where sand and/or gravel aquifers (greater than 0.5 metres in thickness) have been identified at depth based on water well lithology records. These aquifers may be either confined or unconfined. Figure 10 graphically shows water wells constructed in a confined aquifer.

The boundaries of Area B were arbitrarily set at a 100 metre radius from a data point (water well) which identified a sand and/or gravel aquifer greater than 0.5 metres in thickness. Where two wells, located within 400 metres of each other, show similar lithologies and the geomorphology of the area was homogeneous, Area B was extended between the two wells.



AREA C: Area C outlines areas where the unconsolidated deposits at surface (predominantly tills, silts and/or clays) are generally unsuitable as aquifer materials due to their low permeability. However, suitable aquifer materials may and do exist at depth as evidenced in many regions of Area C where site specific data are available. The fence diagram in Figure 10 graphically displays this situation. Where ground moraine deposits have been mapped in Area C, locally there may be sand and/or gravel deposits found at surface or in lenses at depth. Also, older geologic units (e.g., Quadra Sand) that are significant aquifers may be overlain by the marine and moraine deposits found in Area C. Productive aquifers may be found in these older geologic units.

The boundaries of Area C were also transferred from Fyles (1963) surficial geology maps (1:63,360 scale). Minor boundary errors therefore may exist on the larger scale mapping.



AREA D: Area D was identified where bedrock is located at or near ground surface and/or where well logs indicate bedrock aquifers. The boundaries for Area D were also arbitrarily set at 100 metre radius from a data point (e.g., bedrock well or rock outcrop). This distance was extended to 400 metres between data points if water well lithology and the surface morphology so warranted.

Water wells where yields greater than 3 L/s have been reported. Where these wells are found in Area B these areas show the highest potential for obtaining groundwater supplies to meet irrigation requirements.

Water wells where yields between 1 and 3 L/s are reported. These areas also show high potential for obtaining irrigation supplies of groundwater.

7. WATER QUALITY

The concentration and composition of dissolved constituents in a water determine its quality for irrigation use. Three of the characteristics of an irrigation water that appear to be the most important in determining its quality are the total concentrations of soluble salts, the relative proportion of sodium to other cations and the concentrations of boron and other elements that may be toxic.

The total concentration of soluble salts can be expressed in terms of its electrical conductivity and is measured in micromhos/cm at 25°C. The higher the concentration of soluble salts and minerals the higher the conductivity. The electrical conductivity of 5 of the 6 laboratory analyses of groundwaters from unconsolidated aquifers ranged from 14 to 112 micromhos/cm. These waters are in the low salinity hazard class (Richards, 1969). According to Richards (1969), these waters can be used for irrigation with most crops with little likelihood that soil salinity will develop.

A salty taste in the groundwater was recorded on 12 water well records The distribution of these wells can be seen in Figure 14. This implies a high chloride reading of greater than 300 mg/L (Anderson, 1973). Though this reading may or may not indicate a high level of total dissolved solids, the sodium absoprtion ratio is likely to be high. All of these 12 wells were completed in shale. A petroleum taste of unknown source was also reported in the water from two wells. Water quality analyses would be required to verify comments on salty or petroleum tasting groundwaters and if so, to determine if these groundwaters are within acceptable limits for irrigation use.

The relative proportion of sodium to other cations (usually calcium and magnesium) in groundwaters may make some waters undesirable for some crops. This relationship is usually expressed as the sodium absorption ratio (SAR) where $SAR = Na^{+}/\sqrt{(Ca^{++} + Mg^{++})/2}$ and can be used for identifying the suitability of groundwaters for irrigation purposes. The formula applies where all concentrations are expressed in epm. Applying the SAR formula to four laboratory analyses revealed the sodium hazard level as being low to very low from the groundwaters of these unconsolidated aquifers. Bedrock aquifers, however, may contain higher levels of sodium relative to calcium and magnesium as was the case reported in one coastal bedrock well south of the study area.

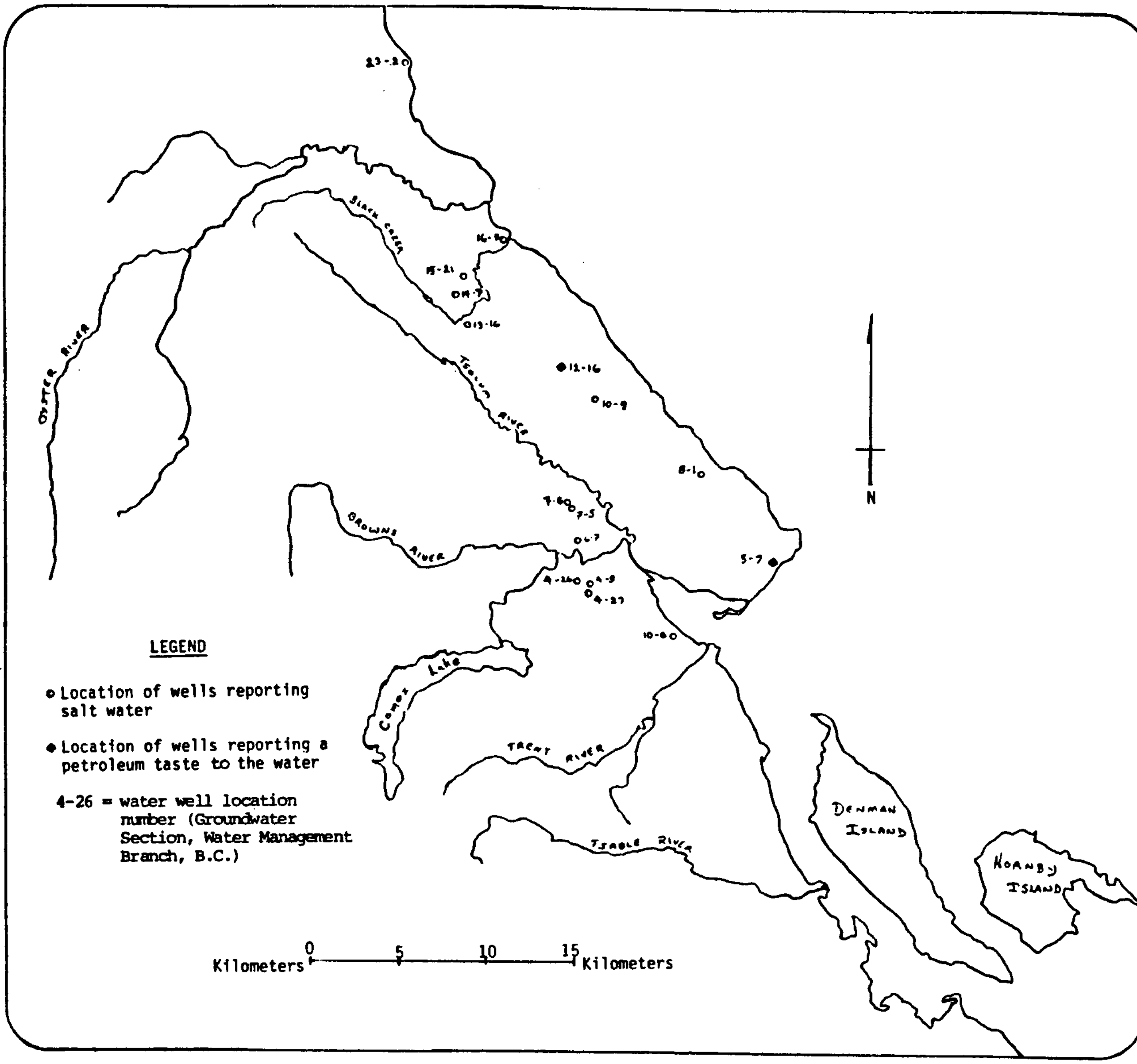


Figure 14. Water wells where either a salty or petroleum taste to the water was reported.

Another important characteristic of irrigation waters are concentrations of boron and other elements that may be toxic. The one lab analyses which tested for boron was within acceptable limits (<0.33 mg/L). Based on four low Total Dissolved Solids readings, it is probable that toxic elements found in most groundwaters from unconsolidated aquifers will be within acceptable limits. High levels of Boron (2.68 mg/L), however, have been found in the Cretaceous bedrock in other parts of Vancouver Island. It is not known if high levels of toxic elements are present in the study area, especially in the bedrock groundwaters.

More analyses (from wells completed in both unconsolidated materials and bedrock) would provide a more complete understanding of natural water quality within the study area.

8. CONCLUSIONS

On a regional basis, there is a high potential for locating groundwater supplies capable of meeting irrigation requirements in the coastal plain region of the study area. The largest groundwater reserves in the area are contained in recent alluvial deposits, terraced fluvial and deltaic deposits, and in the Quadra Sand and other sediments beneath the Vashon Drift.

Though there is a paucity of well log information available for much of the study area, suitable geologic deposits indicate the potential availability of groundwater for irrigation purposes. Even where water well log information is available, most water well logs reported yields from sand and/or gravel aquifers at less than 2 L/s. This is usually the result of the immediate needs of the water user. A single family home only requires a well yield of 0.2 L/s. A more efficient development of the same aquifer will often yield higher productivity.

Natural water quality is expected to be acceptable from the groundwaters of unconsolidated deposits. Not enough data is available on the water quality of bedrock aquifers but comments from a dozen water well logs indicate the need for more water quality. One area of concern is man induced pollution to groundwater. A number of landfill sites are located in these same sand and/or gravel deposits which contain productive aquifers. Groundwater withdrawals from these areas should always be analysed for toxic elements such as heavy metals.

This report is regional in scope and identifies areas which have the potential to supply irrigation water. It does not provide a quantitative assessment of water availability for a site specific location. To provide such an assessment, more accurate delineation of aquifer boundaries and estimation of groundwater recharge, movement, aquifer parameters and withdrawal would be required on a site specific basis.

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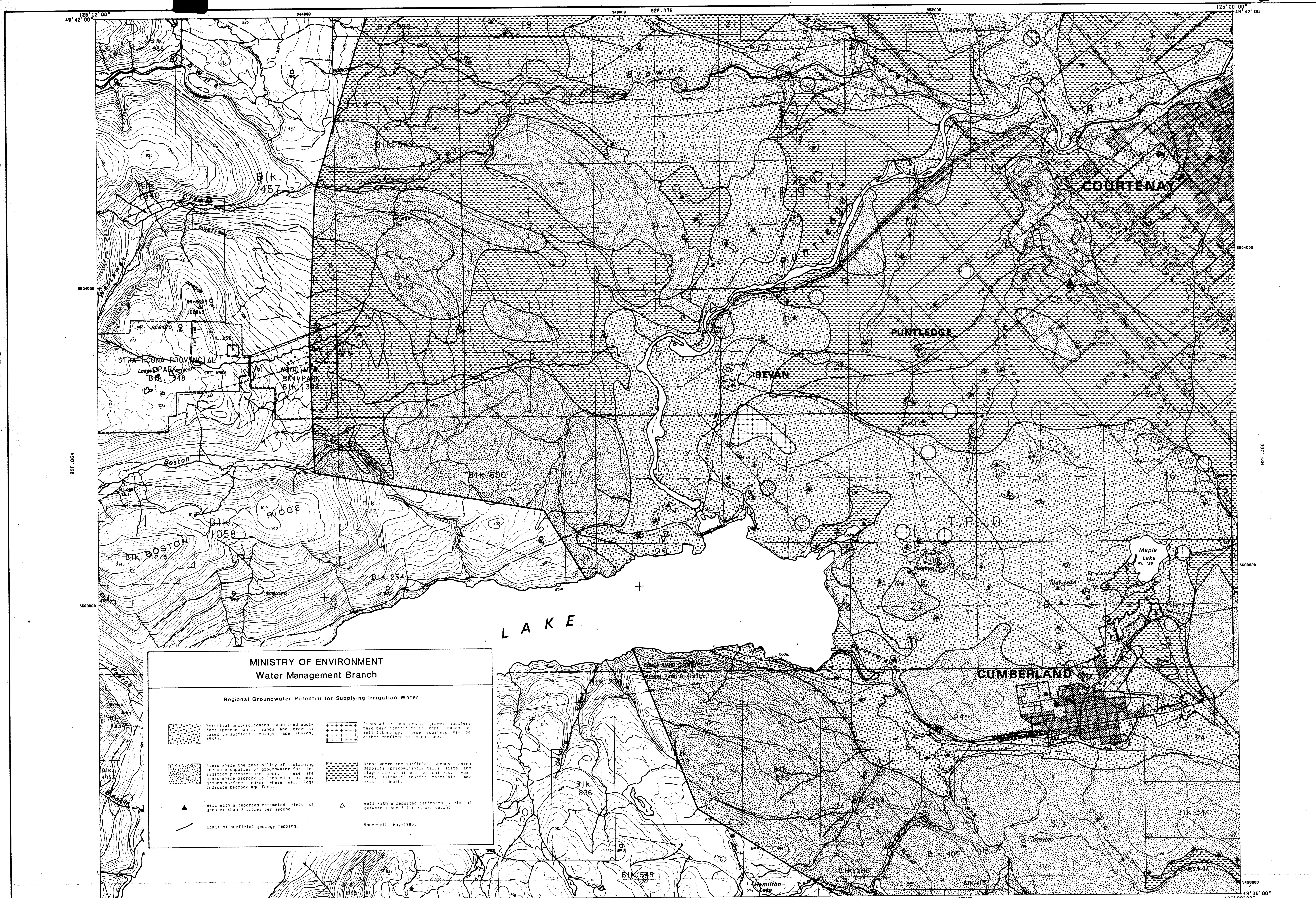


PROVINCE OF BRITISH COLUMBIA — MINISTRY OF ENVIRONMENT

MAPPING CONTROL: FEDERAL GOV'T.
DATUM OF ELEVATIONS: GEODETIC
AIR PHOTOGRAPHY: B.C. & FEDERAL
DATE OF PHOTOGRAPHY: 1976-81
U.T.M. GRID: ZONE 10 (1975)
SHORELINE AS AT DATE OF PHOTOGRAPHY

BASE COMPLETED:
BASE SOURCE: PHOTOGRAMMETRIC
REVISION DATE:
LATEST PLAN No.:
LAND DISTRICTS: COMOX & NELSON
LAND TITLE DIST.: VICTORIA

DIST. LOT & TP. SEC.
SUBDIVISION LOT

TRIANGULATION STATION WITH ELEVATION
SURVEYED CONTROL POINT WITH ELEVATION
BENCH MARK
AIR PHOTO CENTRE
SURVEYED LOT TIE

BUILDING
CONTOURS & ELEVATION
APPROX. CONTOUR
WOODED AREA
SWAMP
CULTIVATED
DEPRESSION
SCRUB
TREED SWAMP
ORCHARD

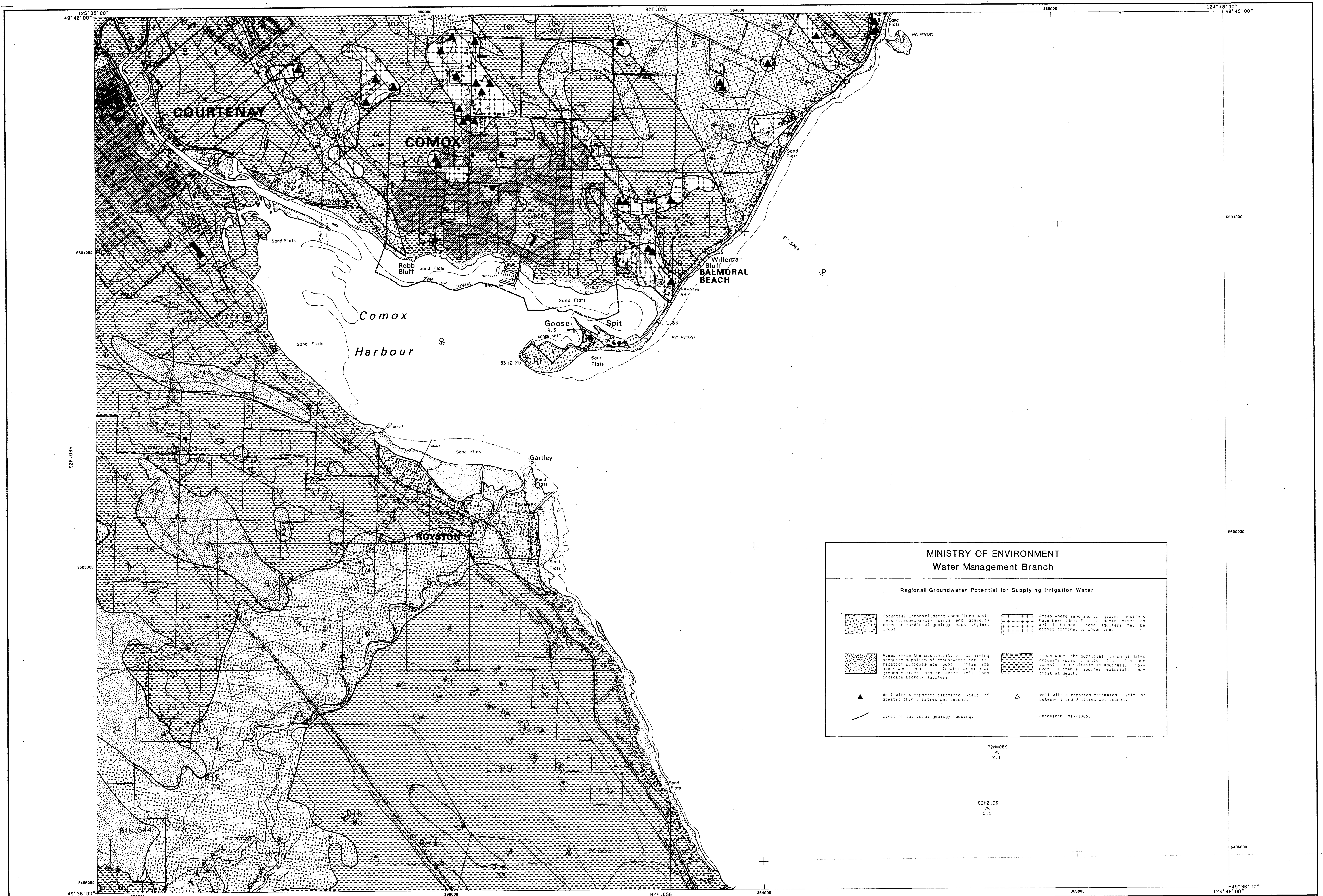
ROADS PAVED / ROUGH / GRAVEL / TRAIL
RAILWAY
POWER LINE ON POLE / ON TOWER
FENCE
FLUME

SCALE : 1:20000
CONTOUR INTERVAL 20 METRES

PLANIMETRIC NEG. No. 214909
CADASTRAL DIGITAL
CONTOUR SCRIBECOAT

SEE INDEX 92F
PROJECT No. 81-023P-C

92F.065



PROVINCE OF BRITISH COLUMBIA — MINISTRY OF ENVIRONMENT

MAPPING CONTROL: FEDERAL GOV'T.
DATUM OF ELEVATIONS: GEODETIC
AIR PHOTOGRAPHY: B.C. & FEDERAL
DATE OF PHOTOGRAPHY: 1976-81
U.T.M. GRID: ZONE 10 (1975)
SHORELINE AS AT DATE OF PHOTOGRAPHY

BASE COMPLETED:
BASE SOURCE: PHOTOGRAMMETRIC
REVISION DATE:
LATEST PLAN No.:
LAND DISTRICTS: COMOX, NANAIMO & NELSON.
LAND TITLE DIST.: VICTORIA

DIST. LOT & TP. SEC.
SUBDIVISION LOT

TRIANGULATION STATION WITH ELEVATION
SURVEYED CONTROL POINT WITH ELEVATION
BENCH MARK
AIR PHOTO CENTRE
SURVEYED LOT TIE

BUILDING
CONTOURS & ELEVATION
APPROX. CONTOUR
WOODED AREA
SWAMP
CULTIVATED
DEPRESSION
SCRUB
TREED SWAMP
ORCHARD

ROADS — PAVED, ROUGH, GRAVEL, TRAIL
RAILWAY
POWER LINE — ON POLE, ON TOWER
FENCE
FLUME

SCALE : 1:20000
METRES
CONTOUR INTERVAL METRES

PLANIMETRIC
NEG. No. 214917
CADASTRAL
DIGITAL

SEE INDEX 92F
PROJECT No. 81-023P-C

92F.066

MINISTRY OF ENVIRONMENT
Water Management Branch
Regional Groundwater Potential for Supplying Irrigation Water
Potential unconsolidated unconfined aquifers (predominantly sands and gravels) based on surficial geology maps (Fyles, 1963).
Areas where sand and/or gravel aquifers have been identified at depth based on well lithology. These aquifers may be either confined or unconfined.
Areas where the possibility of obtaining adequate supplies of groundwater for irrigation purposes are poor. These are areas where bedrock is located at or near ground surface and/or where well logs indicate bedrock aquifers.
Areas where the surficial unconsolidated deposits (predominantly tills, silts and clays) are unsuitable as aquifers. However, suitable aquifer materials may exist at depth.
Well with a reported estimated yield of greater than 3 litres per second.
Well with a reported estimated yield of between 1 and 3 litres per second.
Limit of surficial geology mapping.
Ronneseth, May/1985.
Blk.914
Blk.1340
Blk.1341
Blk.1223
Blk.1450
Blk.975
Blk.958
Piggott Creek
McKay
MT WASHINGTON
Divers Lake
Goss
Battleship Lake
Lake Helen MacKenzie
MT BROOKS
Simms Lake
STRATHCONA
STRATA MTN
PROVINCIAL
PARK
MT ELMA
Lady Lake
Amphitheatre Lake
McPhee Lake
Browns
River
Creek
FORBIDDEN PLATEAU
Murray Meadows
PROVINCE OF BRITISH COLUMBIA
SCALE 1:20000
CONTOUR INTERVAL METRES
PLANIMETRIC
NEG. No. 214989
CADASTRAL
DIGITAL
SEE INDEX 92F
PROJECT No. 81-029P-C
92F.074

92F.085
TP. 7
TP. 6
CONSTITUTION HILL
Wolf Lake
Blk. 1357
Blk. 76
Blk. 29
MERVILLE
HEADQUARTERS
GRANTHAM
TP. 9
Blk. 597
Anderson Lake
MINISTRY OF ENVIRONMENT
Water Management Branch
Regional Groundwater Potential for Supplying Irrigation Water
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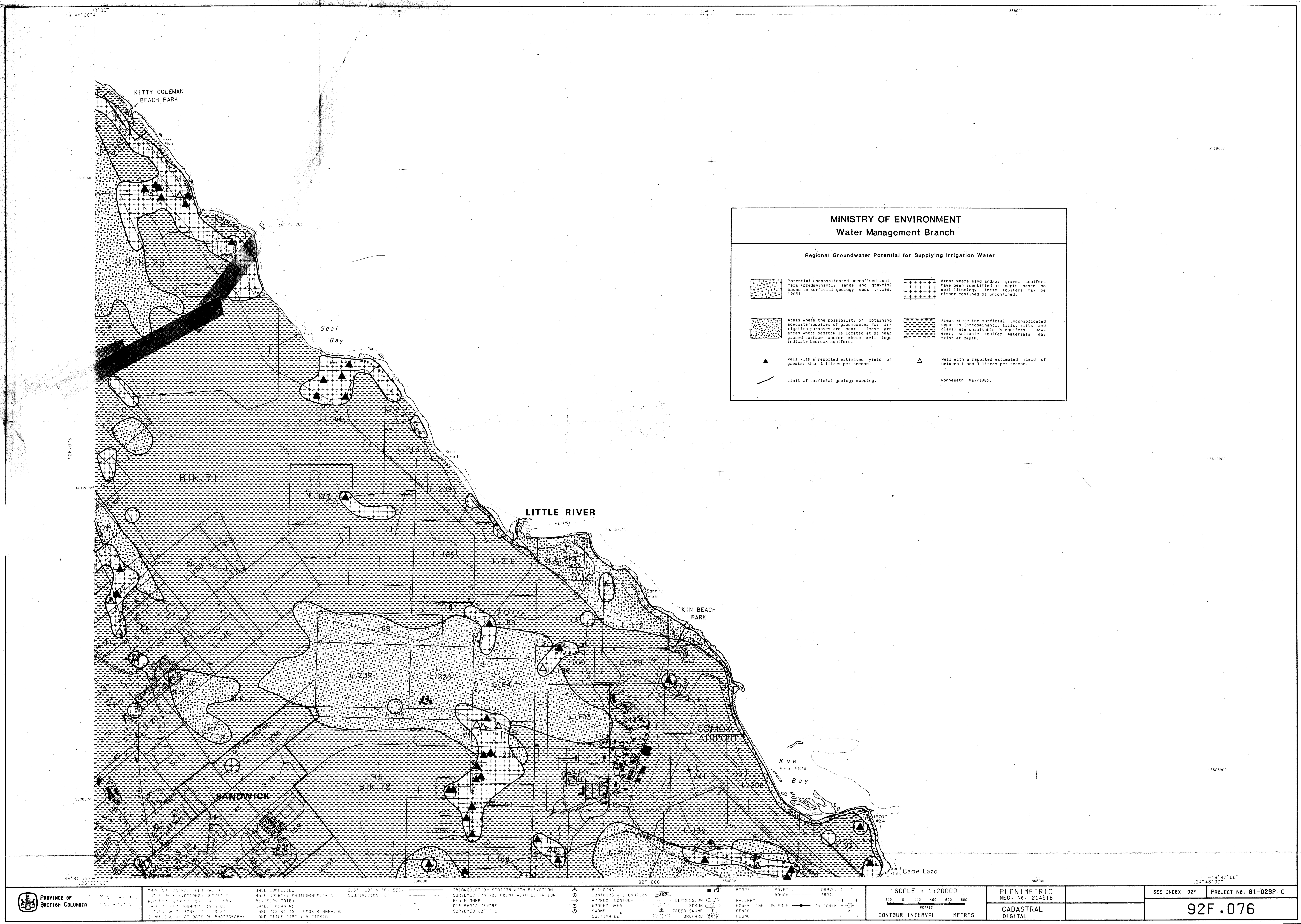
Well with a reported estimated yield of greater than 3 litres per second.
Well with a reported estimated yield of between 1 and 3 litres per second.
Limit of surficial geology mapping.
Ronneseth, May/1985.
49°48'00"
125°12'00"
49°42'00"
125°00'00"
PROVINCE OF BRITISH COLUMBIA
SCALE : 1:20000
200 0 200 400 600 800
METRES
CONTOUR INTERVAL METRES
PLANIMETRIC
NEG. No. 214910
CADASTRAL
DIGITAL
SEE INDEX 92F
PROJECT No. 81-023P-C
92F.075


KITTY COLEMAN
BEACH PARK
Seal
Bay
LITTLE RIVER
KIN BEACH
PARK
COMOX
AIRPORT
Kye
Bay
SANDWICK
Cape Lazo
MINISTRY OF ENVIRONMENT
Water Management Branch
Regional Groundwater Potential for Supplying Irrigation Water
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Well with a reported estimated yield of greater than 3 litres per second.
Well with a reported estimated yield of between 1 and 3 litres per second.
Limit of surficial geology mapping.
Ronneseth, May/1985.
Province of
British Columbia
SCALE : 1:20000
200 0 200 400 600 800
METRES
CONTOUR INTERVAL METRES
PLANIMETRIC
NEG. No. 214918
CADASTRAL
DIGITAL
SEE INDEX 92F
Project No. 81-023P-C
92F.076

MINISTRY OF ENVIRONMENT
Water Management Branch
Regional Groundwater Potential for Supplying Irrigation Water
Potential unconsolidated unconfined aquifers (predominantly sands and gravels) based on surficial geology maps (Fyles, 1963).
Areas where sand and/or gravel aquifers have been identified at depth based on well lithology. These aquifers may be either confined or unconfined.
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Areas where the surficial unconsolidated deposits (predominantly tills, silts and clays) are unsuitable as aquifers. However, suitable aquifer materials may exist at depth.
Well with a reported estimated yield of greater than 3 litres per second.
Well with a reported estimated yield of between 1 and 3 litres per second.
Limit of surficial geology mapping.
Ronneseth, May/1985.
Wowo Lake
Blk.149
Blk.28
Blk.95
Blk.147
Blk.150
Blk.94
Blk.151
Blk.29
T.P.3
T.P.4
Oyster
92F.094
92F.074
49°54'00"
49°48'00"
125°24'00"
125°12'00"
PROVINCE OF BRITISH COLUMBIA
MINISTRY OF ENVIRONMENT
SCALE : 1:20000
METRES
CONTOUR INTERVAL METRES
PLANIMETRIC
NEG. No. 214903
CADASTRAL
DIGITAL
SEE INDEX 92F
PROJECT No. 81-023P-C
92F.084

MINISTRY OF ENVIRONMENT
Water Management Branch
Regional Groundwater Potential for Supplying Irrigation Water
Potential unconsolidated unconfined aquifers (predominantly sands and gravels) based on surficial geology maps (Fyles, 1963).
Areas where sand and/or gravel aquifers have been identified at depth based on well lithology. These aquifers may be either confined or unconfined.
Areas where the possibility of obtaining adequate supplies of groundwater for irrigation purposes are poor. These are areas where bedrock is located at or near ground surface and/or where well logs indicate bedrock aquifers.
Areas where the surficial unconsolidated deposits (predominantly tills, silts and clays) are unsuitable as aquifers. However, suitable aquifer materials may exist at depth.
well with a reported estimated yield of greater than 3 litres per second.
well with a reported estimated yield of between 1 and 3 litres per second.
Limit of surficial geology mapping.
Ronneseth, May/1985.
OYSTER RIVER
Kuhushan Pt
SARATOGA BEACH
Elma Bay
BLACK CREEK
WILLIAMS BEACH
COPAWAGA BEACH
T.P.4
T.P.5
T.P.6
T.P.7
Blk.29
PROVINCE OF BRITISH COLUMBIA
SCALE : 1:20000
METRES
CONTOUR INTERVAL METRES
PLANIMETRIC
NEG. No. 214911
CADASTRAL
DIGITAL
SEE INDEX 92F
PROJECT No. 81-023P-C
92F.085