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GOVERNMENT OF BRITISH COLUMBIA

MEMORANDUM

TO Mr. S.B. Mould Senior Hydraulic Engineer Water Supply Section Water Investigations Branch	**FROM** A.P. Kohut Geological Engineer Groundwater Section December 2 1975

SUBJECT Groundwater Potential, Chemainus Area, North Cowichan Municipality.

OUR FILE 0239013

YOUR FILE

An assessment of the groundwater conditions in the Chemainus area for the purpose of selecting potential well sites has been completed. Available geologic literature on the area was reviewed and well records from the Groundwater Section's data files were examined. Air photographs at a scale of 1 inch = 1,320 feet were examined and a field trip was made on October 27, 1975 to check the hydrogeologic conditions and obtain well samples in the vicinity of the Chemainus River, specifically in Sections 4 and 5, Ranges 6, 7 and 8. A general location plan is shown in Figure 1.

Geology

Upper Cretaceous sedimentary rocks of the Nanaimo Group comprise the bedrock over most of the area shown in Figure 1. These rocks include sandstone, shale, conglomerate, arkose and coal (Rice, 1957). Jurassic and Cretaceous igneous rocks mainly granodiorite, quartz diorite and gabbro occur in the Westholme area bounded by Triassic volcanic rocks and interbedded quartzite, limestone and graywacke of the Vancouver Group to the south.

Quaternary deposits, maximum thickness of which is unknown, mantle bedrock within and adjacent to the valleys of the Chemainus River, Whitehouse Creek and Bonsall Creek (Figure 2). These deposits, consisting mainly of sand, silt, clay, glacial till and gravel, are commonly found below an elevation of 500 feet (Halstead, 1966). Locally in the Chemainus area the deposits may be extensive occupying areas between rock ridges (Figure 2). From oldest to youngest the following Quaternary deposits (Halstead, 1966) are recognized in the Chemainus area:

Unit 5:	Ground Moraine Deposits	Vashon Drift
Unit 6:	Glacial-Fluvial Deposits	Vashon Drift
Unit 7:	Marine Deposits	Capilano Sediments
Unit 8:	Fluvial Deposits	Capilano Sediments
Unit 9:	Valley Alluvium and Colluvium	
Unit 10:	Shore Deltaic and Fluvial Deposits	
Unit 11:	Upland Swamp Deposits	

A description of these units from Halstead (1966) supplemented with field observations noted October 27 are given as follows:

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Unit 5: Ground Moraine Deposits

A stony glacial till deposited during the regimen of the last major ice sheet (Vashon Stade) that occupied Vancouver Island is found adjacent to bedrock outcrops mainly in the western and southern portions of the area. The till is commonly less than 20 feet thick and may contain some lenses of gravel and silt.

Unit 6: Glacial-Fluvial Deposits

Hummocky kettled kame deposits of gravel with sand and till lenses occur in a small area south and near the town of Chemainus. The deposits probably overlie glacial till (unit 5) and may not be very thick. Deposition occurred during the wasting of the last major ice sheet.

Unit 7: Marine Deposits

Silt, clay, stony clay and till-like mixtures (7a) up to 75 feet in thickness occupy relatively extensive areas in the Chemainus area. Related deposits of gravel, sand, silt in spits and bars (7b) and a stony, loamy and clayey marine veneer (7c) commonly less then 5 feet thick may also occur. These deposits are related to a transgressing sea which accompanied deglaciation of the area.

Very hard stony stratified clays up to 60 feet thick have been observed in sections along the north side of the Chemainus River in Section 6, Ranges 6 and 7.

Unit 8: Fluvial Deposits

Deltaic deposits of gravel and sand commonly terraced as well as floodplain and channel deposits of gravel and sand occur adjacent to unit 6 near Chemainus. This material was deposited during a lowering of sea-level interval that followed the marine transgression.

Brown sand, pebbly sand and gravel which may be similar to unit 8, occurs in Section 5, Range 5 north of Whitehorse Creek. The deposit however does not appear extensive here and probably represents a thin cover over stony clay, (unit 7).

Unit 9: Valley Alluvium and Colluvium

Boulders, gravel, sand, silt, clay on terraces and as channel deposits, occur along the Chemainus River in Sections 12, Ranges 3 and 4 and Section 9,

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Range 5. These materials are of minor importance and may include patches of units 8, 10, 11 and slump debris.

Unit 10: Shore Deltaic and Fluvial Deposits

Gravel, sand, silt and clay occur within the delta and floodplain of the lower reaches of the Chemainus River. Gravel predominently comprised of cobbles occupies the channel of the river. Fine to medium-grained sands and silts overlying gravel occur on the floodplain. Locally clay and peat deposits are found in low areas on the floodplain.

Unit 11: Upland Swamp Deposits

Clay, silt and peat occur at Chemainus Lake in Sections 14 and 15, Range 5. These deposits are of minor importance.

Halstead (1966) also recognizes four additional units 1 to 4 which are older than unit 5. These are exposed outside the Chemainus area shown in Figure 2. These include till, sand and gravel outwash and sediments related to older glacial and interglacial episodes. These deposits may occur at depth in the Chemainus area.

Groundwater Prospects

On the basis of the geology the groundwater potential appears to be most favourable in the sand and gravel deposits of units 6, 8 and 10. These deposits are readily discernible at the ground surface and on air photographs and their relative extent is sufficiently known. There may be some possibilities of sand and gravel aquifers within the ground moraine deposits (unit 5), but the location and extent of such aquifers may not be determined without test drilling. Groundwater potential of fractures within the bedrock is considered poor in comparison to the more favourable prospects of the unconsolidated deposits. Areally two favourable groundwater regions are therefore recognized, (a) the area immediately west of Chemainus underlain by units 6 and 8 and, (b) the lower reaches of the Chemainus River underlain by unit 10. These have been respectively designated the northern and southern prospects for convenience.

Well Inventory

Available well data including stratigraphic logs, water levels, well yields and water chemistry were examined for the Chemainus area. Data for the northern and southern prospects are shown diagramatically in Figures 3 and 4, and are discussed below.

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Northern Prospect

Data in the area of the northern prospect is limited to 4 shallow dug wells varying from 5 to 14 feet deep in sand and gravel. Water levels are close to the ground surface; two of the wells are flowing. Maximum yield of the wells is not known and no chemical analyses are available. In wells north and south of the prospect, minimum drift thickness ranges from 152 to 72 feet respectively with water levels at 138 and 20 feet below the surface.

The magnitude of groundwater recharge to the surficial sand and gravel deposits is not known, but may include: (a) infiltration from Askew Creek and the Chemainus River, (b) direct infiltration from rainfall over the deposits, (c) southerly groundwater movement through intertill aquifers within the moraine to the north which may be contiguous with the surficial deposits, (d) infiltration along the bedrock and moraine upland to the northeast with shallow groundwater movement towards the east.

Groundwater discharge components may also be significant for example through, (a) discharge into the Chemainus River, (b) discharge into Fuller Lake and, (c) discharge into Chemainus Bay. The above possibilities would have to be assessed through field checking of possible discharge areas, and geologic conditions as well as additional well inventories to determine whether recharge to the area is significant.

Southern Prospect

Several wells both dug and drilled types have been completed within sand and gravel deposits of the Chemainus River floodplain. Most of the wells are shllow, commonly 15 to 30 feet deep. Water levels are generally high, 3 to 14 feet below ground surface. Flowing wells occur along the toe of the moraine upland to the south in Section 1, Range 6 and Section 4, Range 9 and north of the floodplain in Section 6, Range 7. The shallow sand and gravel deposits are commonly 15 to 20 feet thick overlying glacial till and may be overlain by up to 12 feet of silt. Well yields range from 5 to 180 gpm, with higher yields reported for drilled and screened wells. Available water analyses (Table I) indicate the groundwaters are low in total dissolved solids (46 to 96 mg/l), low in hardness (24.5-56.0 mg/l), with variable indications of iron being present up to 3 mg/l. Samples from the deeper drilled wells 6 and 5 in Section 4, Range 6 are higher in dissolved solids and iron content compared to the shallow dug wells. High field pH values of 10.0 obtained for wells 5 and 1 may be due to sampling from plumbing systems and not directly from the well. Possibilities of groundwater recharge for the southern prospect are particularly favourable. Apart from direct rainfall, recharge from the Chemainus River through the coarse channel deposits to similar gravels underlying the floodplain may be occurring. Wells completed in the shallow gravels near the

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river would probably induce recharge from the river. Deeper confined aquifers may underlie the floodplain and these may receive recharge from downward seepage through a confining layer from the overlying shallow aquifer and/or recharge from upland areas south and west of the floodplain. In the eastern portion of the prospect, bedrock outcrops occur in Sections 5 and 6, Range 7. The occurrence of these outcrops probably has a restricting effect on eastward groundwater flow in the Chemainus valley. This restriction probably maintains high water level conditions west of the outcrops and may be in part responsible for high yield wells observed in Sections 5 and 4, Range 7.

Recommendations

On the basis of known hydrogeologic data, three areas that warrant test drilling and designated A, B and C in order of priority, have been delineated. Areas A and B are located in the southern prospect while area C is in the northern prospect. Area A (Fig. 4) is particularly favourable for developing shallow wells near the Chemainus River which would induce river recharge. These wells however would be limited by the aquifer thickness and available drawdown. Wells farther away from the river may be equally successful since the aquifer is relatively extensive and recharge possibilities exist. Deeper confined aquifers which would afford more available drawdown may also exist. Area B offers the same opportunities as Area A except for the possibility that bedrock may be relatively close to the surface and the aquifers would be restricted in width due to the narrowing of the valley. Area C (Fig. 3) is essentially the full extent of the sand and gravel deposits. The area immediately north of Fuller's Lake is recommended. Since there is some possibility of shallow groundwater contamination by septic tanks near the town of Chemainus, exploration northeast of Fuller's Lake is not recommended. A field examination of the northern prospect is advisable before any drilling is contemplated in this area.

Standard drilling and well construction methods using a cable-tool rig are recommended with completion of 8-inch minimum diameter test holes. Drilling should be planned to determine the thickness of the surficial sands and gravels. At least one deep (100- to 200-foot) test hole should be completed to access the stratigraphic sequence and location of any confined aquifers for each area considered. A well point system utilizing 2- to 3-inch diameter wells may be appropriate in developing the shallow aquifers. The only advantage of this system would be to reduce drilling and well construction costs if several wells were required. The wells could be driven or jetted into place for example. Present requirements of 300 Igpm with future requirements of an additional 600 gpm over the next 25 years, (pers.comm. S. Mould, October 1975), however, suggest two or three standard wells could meet the demand. A collection well may be another alternative, but costs of the structure may be prohibitive.

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On the basis of a limited budget of $10,000 the following tentative drilling program is proposed:

1. Drill, case and pumptest one 8-inch diameter testwell in Area A in the following manner;

   (a) drill to the base of the shallow sand and gravel aquifer, i.e., 30 to 40 feet;

   (b) install a five-foot screen, develop and pumptest the aquifer for 12 hours.

   If the results are favourable, remove the screen and install a longer length of screen to utilize the aquifer. Another pumptest, for 24 hours, would then be completed. If initial testing is unfavourable a second testhole should be completed in the same manner above at some distance from the first hole. Should both shallow testholes prove unfavourable, one of the holes should be deepened in search of underlying aquifers which could provide more available drawdown. Any favourable aquifers encountered should be screened and pumptested and the results compared with those of the upper aquifer.

2. A third testhole should be completed as an observation well in the shallow aquifer and/or in a deeper aquifer funds permitting. This well could be cased and screened with plastic materials.

   Estimated costs of the above program are as follows:

   A. <u>Well tested initially and completed in upper aquifer</u>

(i)	Drilling and case well, 40 feet, install test screen and 12-hour pumptest	$ 3,100.00
(ii)	Redrill 5 feet, add screen, pumptest for 24 hours	$ 2,900.00

   B. <u>Well completed in upper aquifer as an observation well</u>

(i)	Drilling and case well, 40 feet, install plastic screen, develop	1,800.00

   C. <u>Well completed in lower aquifer</u>

(i)	Deepen shallow testhole to 100 feet, install test screen, 12-hour pumptest	4,000.00

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(ii)	Redrill 5 feet, add screen, pumptest for 24 hours	$ 2,900.00
(iii)	Less cost of shallow well completion, screens etc.	- 2,900.00
	Total	$11,700.00

References

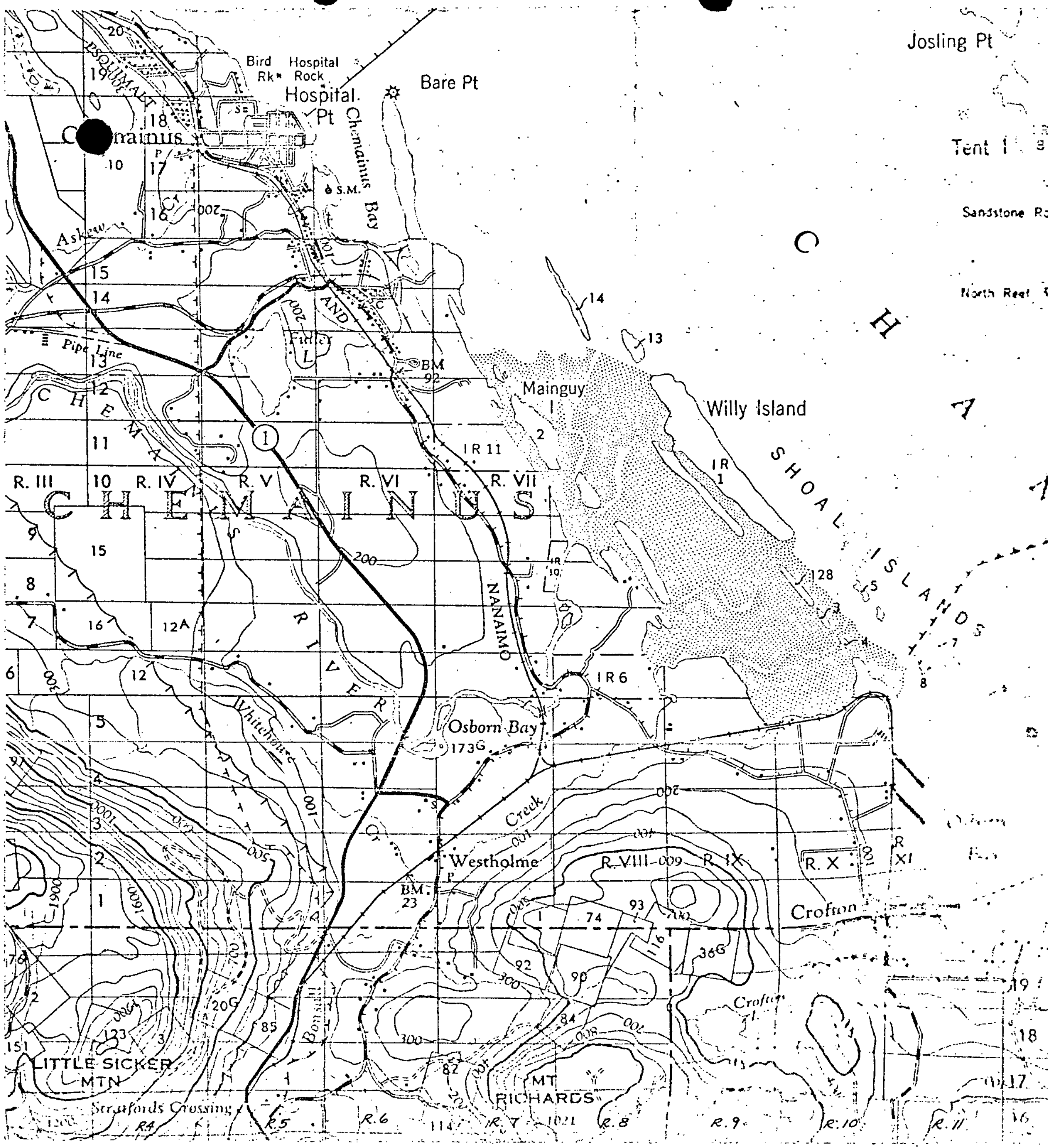
Halstead, E.C., (1966) Surficial Geology of Duncan and Shawnigan Map - Areas, British Columbia.

Rice, H.M.A., (1957) Victoria-Vancouver Sheet 92SE, Map 1069A, Geological Survey of Canada.

A.P.K.

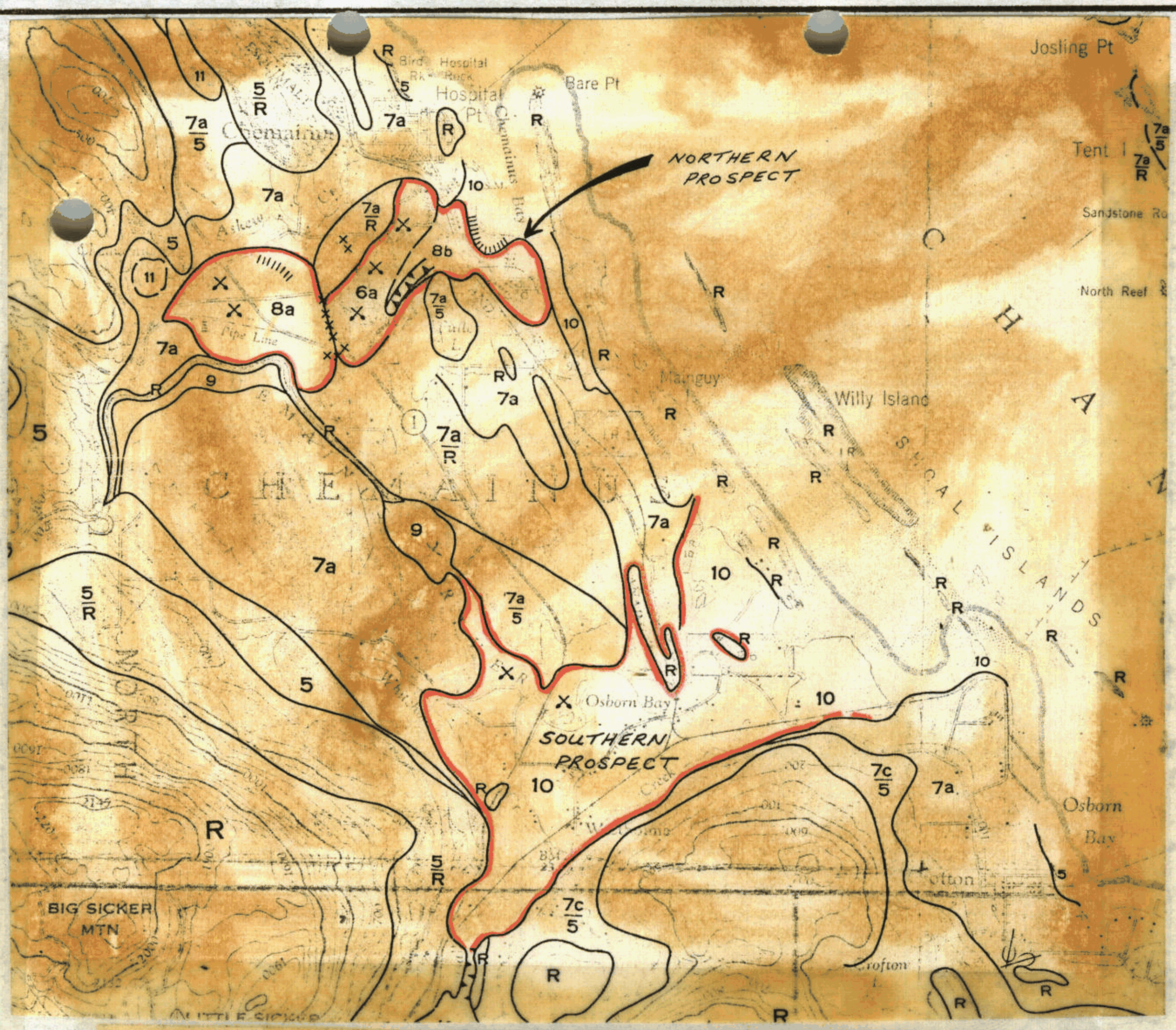
A.P. Kohut
Geological Engineer

APK/jw



BRITISH COLUMBIA DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES **WATER RESOURCES SERVICE** WATER INVESTIGATIONS BRANCH	TO ACCOMPANY REPORT ON GROUNDWATER POTENTIAL CHEMAINUS AREA LOCATION PLAN
SCALE: VERT. — HOR. 1:50,000 / DATE	APK ENGINEER FILE No. DWG. No. FIG. 1

BCIL-3661BA - W.R.S.



LEGEND

QUATERNARY

SALISH SEDIMENTS

10	11

10. SHORE, DELTAIC, AND FLUVIAL DEPOSITS: gravel, sand, silt, clay
11. UPLAND SWAMP DEPOSITS: clay, silt, peat

9

VALLEY ALLUVIUM AND COLLUVIUM: boulders, gravel, sand, silt, clay on terraces and as channel deposits; includes patches of 8, 10, 11

CAPILANO SEDIMENTS (7, 8)

8

FLUVIAL DEPOSITS: 8a, deltaic deposits, gravel and sand, commonly terraced; 8b, floodplain and channel deposits, gravel and sand; 8c, alluvial fan deposits, poorly sorted gravel, sand, silt

7

MARINE DEPOSITS (INCLUDING GLACIO-MARINE): 7a, silt, clay, stony clay and till-like mixtures, thickness up to 75 ft.; 7b, gravel, sand, silt, in spits and bars; 7c, varied stony, loamy and clayey marine veneer, commonly less than 5 ft. thick

CENOZOIC

VASHON DRIFT (4-6)

6

GLACIO-FLUVIAL DEPOSITS: gravel, sand lenses of till; 6a, hummocky, kettled, kame deposits; 6b, ice-contact deltas

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GROUND MORAINE DEPOSITS: till, lenses of gravel, sand, silt

(from Halstead, 1966)

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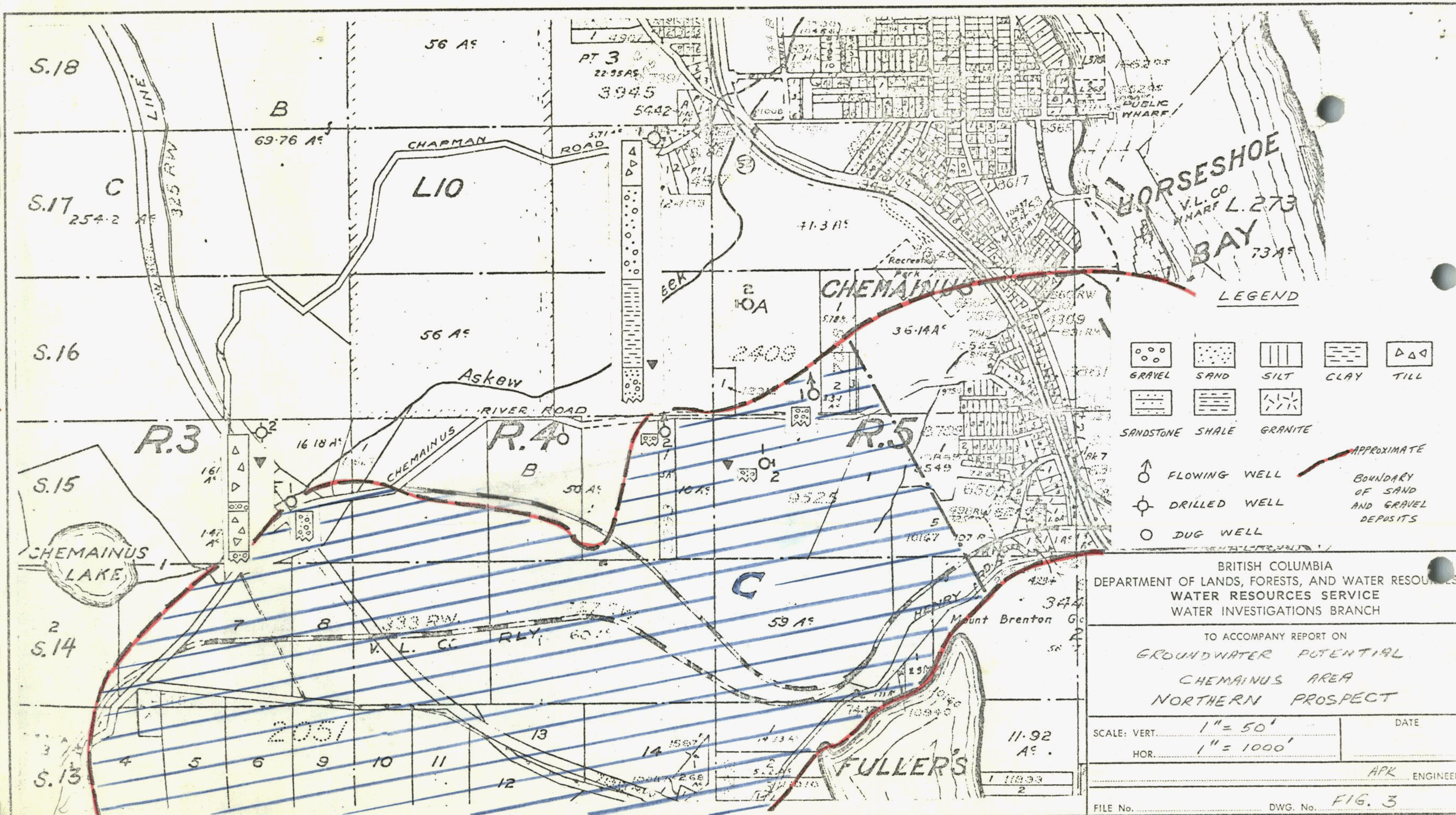
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
GROUNDWATER POTENTIAL
CHEMAINUS AREA
SURFICIAL GEOLOGY

SCALE: VERT. —
HOR. 1" = 1 MILE
DATE
APK ENGINEER
FILE No.
DWG. No. FIG. 2.

BCIL-3661A - W.R.S.



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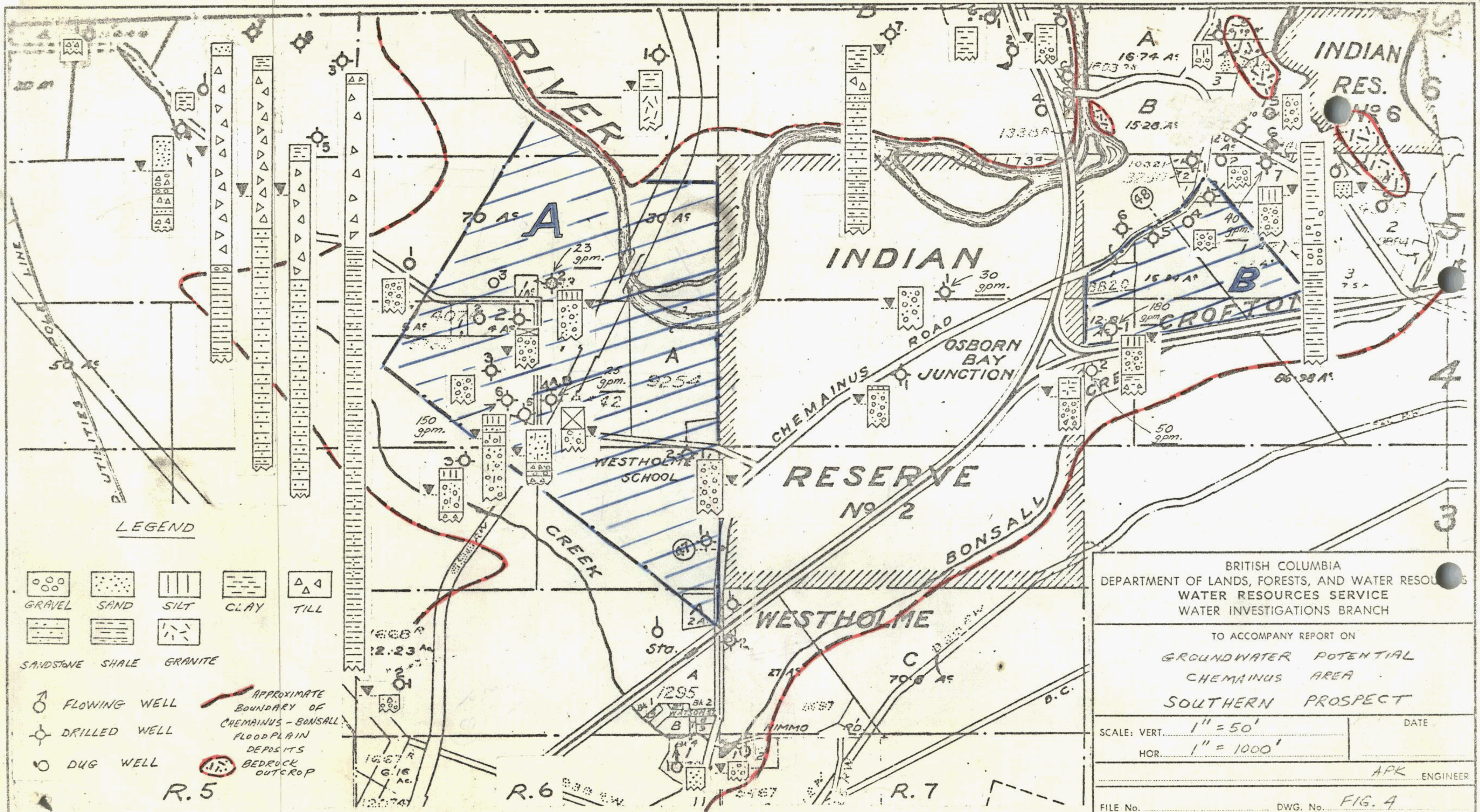
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON
GROUNDWATER POTENTIAL
CHEMAINUS AREA
NORTHERN PROSPECT

SCALE: VERT. 1" = 50' HOR. 1" = 1000'	DATE
APK ENGINEER	
FILE No.	DWG. No. FIG. 3

B.C.L. - 570A - W.R.S.



BCIL - 870A - W.R.S.

Table I. Chemical analyses of water samples, Chemainus Area.

Site	Location	Field Analysis†	Field pH	Field Iron	Laboratory Analysis†	Na+	K+	Ca^{2+}	Mg^{2+}	Cl-	SO_4^{2-}	Hardness as $CaCO_3$	Reactive Silica	Filterable Residue	Specific* Conductivity
Holman Well 2	S.5,R6	75/10/27	6.5	1.4	75/10/29	2.8	0.3	8.0	1.1	2.5	<5.0	24.5	-	48	65
Well 2	S.4,R6	73/12/13	5.5	0	74/01/07	3.6	0.9	10.5	1.55	5.4	5.6	32.6	9.7	66	89
Well 3	S.4,R6	73/12/13	6.5	0	74/01/07	2.7	0.3	7.9	1.17	3.6	<5.0	24.5	8.8	46	68
Well 5	S.4,R6	75/10/27	10.0	0.3	75/10/29	2.8	0.3	8.3	1.1	2.1	5.3	25.3	-	48	68
Well 5	S.4,R6	73/12/13	6.0	0	74/01/14	4.7	1.5	14.0	2.3	5.5	7.7	44.4	16.7	98	124
Well 4	S.4,R6	73/12/13	6.0	0.5	74/01/14	2.9	0.3	8.9	1.27	3.8	<5.0	27.5	9.0	56	77
Well 6	S.4,R6	73/12/13	7.0	3.0	74/01/07	5.9	0.7	17.0	3.3	5.3	<5.0	56.0	22.1	96	139
Well 1	S.4,R8	75/10/27	10.0	0.3	75/10/29	2.6	0.2	7.6	0.97	1.9	<5.0	23.0	-	-	61
Whitehorse Creek	S.3,R6	73/12/13	7.0	0	74/01/14	3.0	0.7	7.7	1.33	4.2	6.1	24.7	7.3	60	68

* micromhos/cm. at 25°C

† reported in mg/l except pH