Province of
British Columbia

MEMORANDUM

To: A. P. Kohut
Senior Geological Engineer
Groundwater Section

Date: March 16, 1978

File: 92-B-13

Re: Cowichan Estuary Task Force (1978) - Preliminary Groundwater Study

INTRODUCTION

At the request of Mr. Bryan R. Gates, Chairman of the Cowichan Estuary Task Force (1978) in a letter dated February 27, 1978 to Mr. Brady, I have reviewed within the two-week time frame allowed all available information regarding groundwater in the lower floodplain and estuary of the Cowichan-Koksilah Rivers. This information is not intended to be a detailed report on the groundwater situation in the area but simply a preliminary review of available groundwater reports, existing well card data from our Groundwater Section files, geological reports, aerial photographs and a one-day site visit of the study area. Also, this review comments on the quantity of groundwater in storage in the study area and the probable influence of industry, landfills and road construction (paving) on the groundwater regime.

GEOLOGY

The Cowichan-Koksilah floodplain and estuary occur within a former glaciated valley underlain by a moderately thick succession of unconsolidated Pleistocene and younger sediments. Flanked by bedrock uplands, the main valley occupied by permeable valley fill deposits is considered the most important groundwater source and these are discussed below.

Most of the unconsolidated deposits in this area are believed to be Pleistocene in age (Halstead, 1967). According to Halstead (1966), the unconsolidated deposits are related to the regimen and wasting of the last major ice sheet that occupied Vancouver Island. The ice moved in a general south to south-east direction, as indicated by striae, flutings, and stoss and lee topography. Deglaciation was accomplished by rapid down-melting and wasting of the ice sheet. Cowichan Valley was also occupied by a valley glacier or ice tongue, which during the later phases of glaciation, moved eastward more or less parallel to its valley walls, to a point beyond Cowichan Bay. At this point the Cowichan ice tongue encountered the southern retreating terminus of the Strait of Georgia glacier, which was bordered by marine waters. The land was isostatically depressed due to weight of the ice, but sea-level was lowered as a result of water being locked up in the glacial ice. The Cowichan ice tongue, partly grounded and partly floating, stagnated and with

97
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JPK 17 March 78

melting, large volumes of water quickly returned to the seas that now occupied the depressed areas bordering the ice margins. As a result, much of the deposition attendant upon deglaciation was in a marine environment. Upon final retreat and wasting, the ice tongue directed the meltwaters in deposition of coarse gravels and sands in deltas where the river reached the sea. Then, as sea level lowered, the deltas were breached, terraced and younger deltas built seaward until sea-level dropped to present or near-present level. The "Cowichan" River reached grade by downcutting throughout much of its length on bedrock, but within five miles of its mouth, which is now occupied by tidal flats, extensive outwash deposits of gravel and sands were deposited (Halstead, 1967).

The glacial deposits consist of till, clay, silty clay, sand and gravel deposited in continental and marine environments directly by ice or from its meltwaters. Two tills are recognized in well records in the Duncan area and these are interpreted by Halstead (1967) as Cowichan and Vashon Till. Stratigraphically, the Vashon Till constitutes the youngest (uppermost) till and in places, it directly overlies the Cowichan Till making it difficult to distinguish between the two. At this time, the maximum thickness of the unconsolidated surficial deposits in the valley are not exactly known, but well no. X3-Y13-2 located in the north-central portion of the study area was drilled to a depth of 200 feet without encountering bedrock. The distribution of the unconsolidated surficial deposits in the area is shown in Figure 1.

HYDROGEOLOGY

Well Card Data:

An inventory of the available data from our Groundwater Section files regarding wells drilled within the study area (Figure 2) has been made, and a summary of this inventory is found on Table 1. A review of this data indicates that within this area there are three major aquifers which may be tentatively referred to as the lower, middle and upper valley aquifers. The lower confined sand and gravel aquifer is the most productive, capable of providing to a well a yield of 1,500 U.S.gpm (well no. X3-Y13-3). The middle confined aquifer, being approximately 50 feet thick, is capable of providing up to 400 U.S.gpm (well no. X1-Y11-2), to individual wells, and the upper unconfined aquifer is capable of providing 100 U.S.gpm (well no. X3-Y12-1) to the individual wells. These figures are based on reported yields for individual wells and may not reflect the average or optimum yields for the respective aquifers because of heterogeneities in aquifer materials.

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A[illegible]. Kohut March 16, 1978

Data regarding the water quality of the water from these aquifers indicates that the water is generally moderately soft and low in mineralization. The only record of salty water in the area occurs in well nos. X2-Y14-1,2 which were drilled into the bedrock.

Most of the well cards include the driller's log of the hole, describing in "driller's" terms the lithology of the materials encountered. Figure 3 is a cross-section (shown as A-A' in Figure 2) containing several wells within the area. An attempt has been made to correlate the lithological descriptions from the well driller's logs. It is evident from this attempt that the stratigraphy can be somewhat complex in certain areas, lending itself to various interpretations.

Groundwater Potential:

In order to determine the groundwater potential of an area, there are essentially three factors which must be considered, namely:

1) The nature, thickness and extent of water-bearing materials or aquifers.
2) The source of recharge to this aquifer.
3) Groundwater movement through the aquifer(s) under natural and pumping conditions.

A review of the existing well card data from our Groundwater Section files indicates that the sands and gravels confined beneath deposits of Cowichan and Vashon Till, and the sands and gravels occurring as permeable outwash and fluvial deposits along the Cowichan River constitute three major aquifers in this area. All of these aquifers provide excellent storage facilities for good quality groundwater. Based on the study area, for example, of 1,800 acres of highly porous and permeable sand and gravel deposits and assuming a total aquifer thickness of 100 feet, storage factor of 20%, the volume of groundwater in storage for this volume of aquifer material would be approximately 40,000 acre-feet. However, this figure is probably optimistic since within the aquifers there are zones of silty and clayey materials which tend to reduce the effective porosity, and hence the volume of groundwater in storage. The silt and clays also tend to reduce the permeability of the aquifer material which is a basic factor in determining the amount of water that can be withdrawn.

As was previously stated, the lower aquifer is capable of yielding 1,500 U.S.gpm to individual wells (Doman Industries wells). From pump test data the transmissivity was calculated to be approximately 50,000-200,000 U.S.gpd/ft.

which indicates that the well yield is adequate for industrial purposes. How extensive and continuous this aquifer is, is not yet known, but the source of recharge is probably the Cowichan River. According to Haltstead (1967) the outwash areas near the tidal marsh at the mouth of the Cowichan River provide storage for groundwater that is in part recharged during flood stages in winter months, and by induced infiltration from the river at other times. Furthermore, according to Foweraker (1976), the very high transmissivity values (26,000-900,000 U.S.gpd/ft.) obtained from pumping tests of several wells south of Duncan, and the similarity in the hydrograph curves for observation wells and river stage suggest that there is good hydraulic continuity between the Cowichan River and the upper aquifers. What is not known is whether there is any hydraulic continuity between the "lower" aquifer and the Cowichan River. In a recent field trip, no springs were found in the estuary but there are several artesian flowing wells which indicate the aquifers in the estuary are being recharged at higher elevations, possibly upstream along the Cowichan Valley near Duncan.

DISCUSSION

As was previously mentioned, there is a good hydraulic continuity between the Cowichan River and the "middle" aquifer (Foweraker, 1976) near Duncan. Of concern is how would groundwater withdrawals affect the surface flows in the Cowichan River. As the Cowichan River is a major fish spawning stream and as low flows are critical to maintenance of the fishery, it would be important to monitor any major groundwater withdrawals and relate the results to any river level fluctuations.

Drilling of the Doman Industries wells (X3-Y13-2,3,4,5) revealed that salt water was encountered in the first 80 feet of drilling (according to a Doman Industries supervisor). Since very little is known about the salt water-fresh water interface in the estuary, it is difficult to comment on the possibility of future salt water encroachment into wells completed in the lower aquifer as a result of pumping. Monitoring and test well drilling, as well as pump testing, would be required to determine this information. A water quality test was performed in December, 1975 on a sample of fresh water from well no. X3-Y13-3 (Doman Industries well) which indicated that the chloride content was 71.6 mg/L. During a recent field trip (March, 1978) the chloride content was determined by a Hach chemical test kit and found to be 106 mg/L. Although both these figures are within the standard limits for drinking water, it appears that there has been a slight increase in the chloride content over a two-year period. Further testing should be done to confirm whether this is related to natural seasonal fluctuations or caused by pumping.

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A[illegible]. Kohut March 16, 1978

It has been previously stated that the unconsolidated surficial deposits contain two till layers which act as relatively impermeable boundaries to vertical flow. Even though the extent and continuity of the upper till within the study area is not exactly known, any contaminants in this area (from landfills for example) finding their way into the groundwater system will probably be limited to the upper aquifer. The Cowichan River throughout most of the year is contributing to groundwater storage upstream of the estuary, but during seasons of low discharge may be receiving water from groundwater storage. Any contaminants introduced to the shallow groundwater aquifers could find their way into the river system. Similarly, effluent or waste which is discharged into the Cowichan River upstream of the estuary area may enter the groundwater regime in the area of recharge and eventually the lower aquifer in the study area. By careful monitoring of the groundwater by use of piezometers around a landfill, a better assessment of a particular landfill's effect on the groundwater regime can be determined.

The Cowichan estuary is not considered to be in a groundwater recharge area, so that the effect of large areas of pavement should have very little, if no effect on the groundwater system. Fluctuating water levels, however, may have an adverse effect on road foundations, for example.

Marc Zubel.

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Attach.

A. P. Kohut March 16, 1978

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"Well Card Data", Groundwater Section files, Water Investigations Branch, Ministry of the Environment, Province of British Columbia.

TABLE 1

SUMMARY OF WELL CARD DATA FOR STUDY AREA

LOCATION	WELL NO.	YIELD (gpm)	DEPTH OF HOLE (ft.)	AQUIFER MATERIAL[1]	DEPTH TO WATER (ft.)[2]	WATER QUALITY DATA[3]			
						Fe	Cl	$CaCO_3$	pH
X1-Y10	1	6	59	S+G	0				
	2	15	66	S+G	49				
X1-Y11	1	35	26	G(SILTY)	6				
	2	400	43	S+G	6.7				
X2-Y10	1	396	160	S+G	+6 (F)	<0.5	45	86	7.9
X2-Y11	1	10	26	S+G	9				
	2	?	23	S+G	7	<0.5	15	34	6.5
	3	40	139	S+G	+6 (F)				
X2-Y14	1	10	200	SST	?	Fresh at 167 ft., salty at 200'.			
	2	2	100	SST	?	Salty.			
X3-Y12	1	100	21.5	S+G	2-6				
X3-Y13	2	35	200	S+G+C	6	10.4	105	45	8.3
	3	1,500	160	S+G	2	0.2	72	39	8.0
	4	1,500	166	S+G	5				
	5	135	146	S+G	+5 (F)	0.1	75	40	8.5

[1]Aquifer Material: S = SAND, G = GRAVEL, C = CLAY.

[2]Depth to Water: With respect to ground, (F) = flowing well.

[3]Water Quality: Fe, Cl, $CaCO_3$ figures in mg/L.

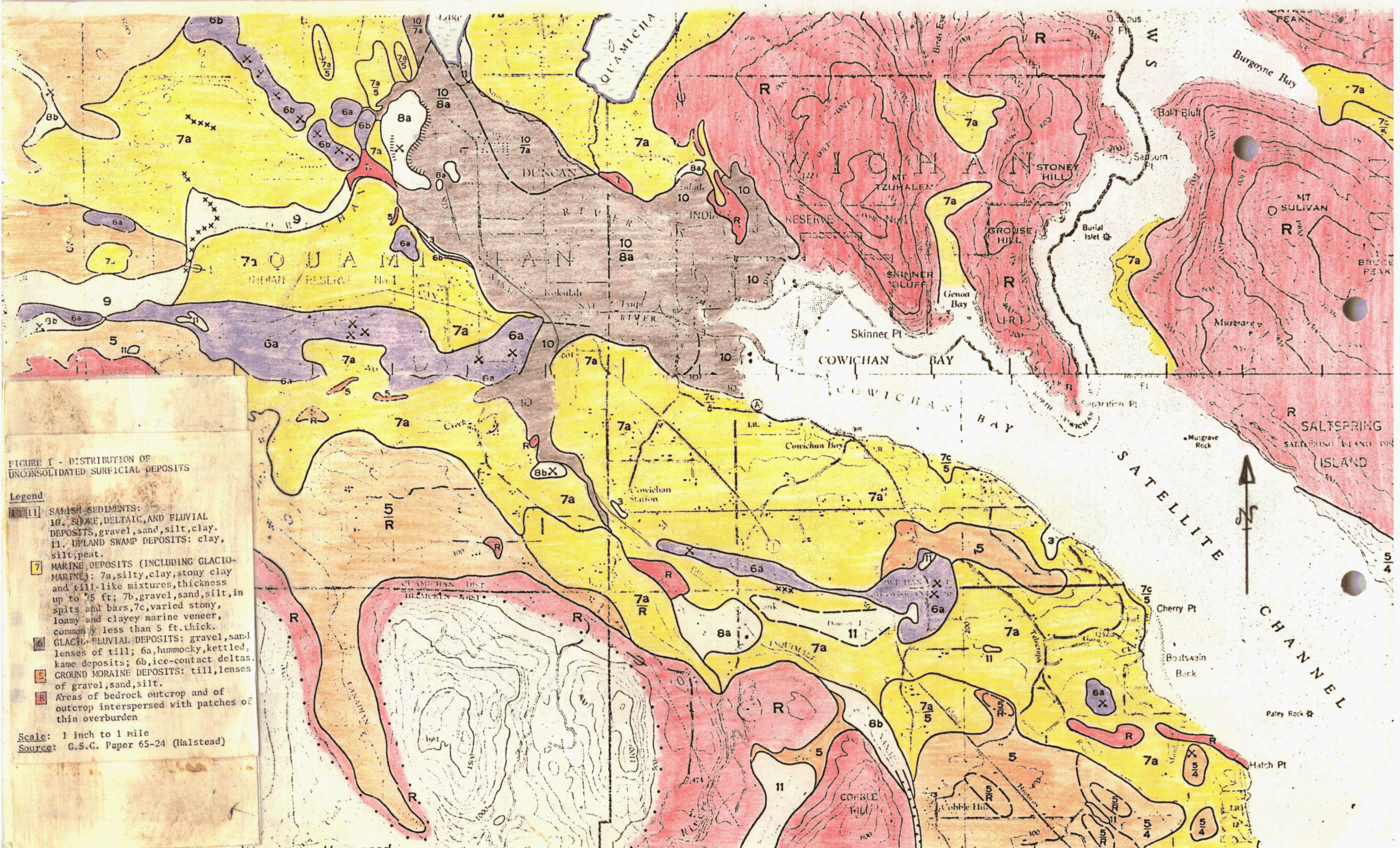


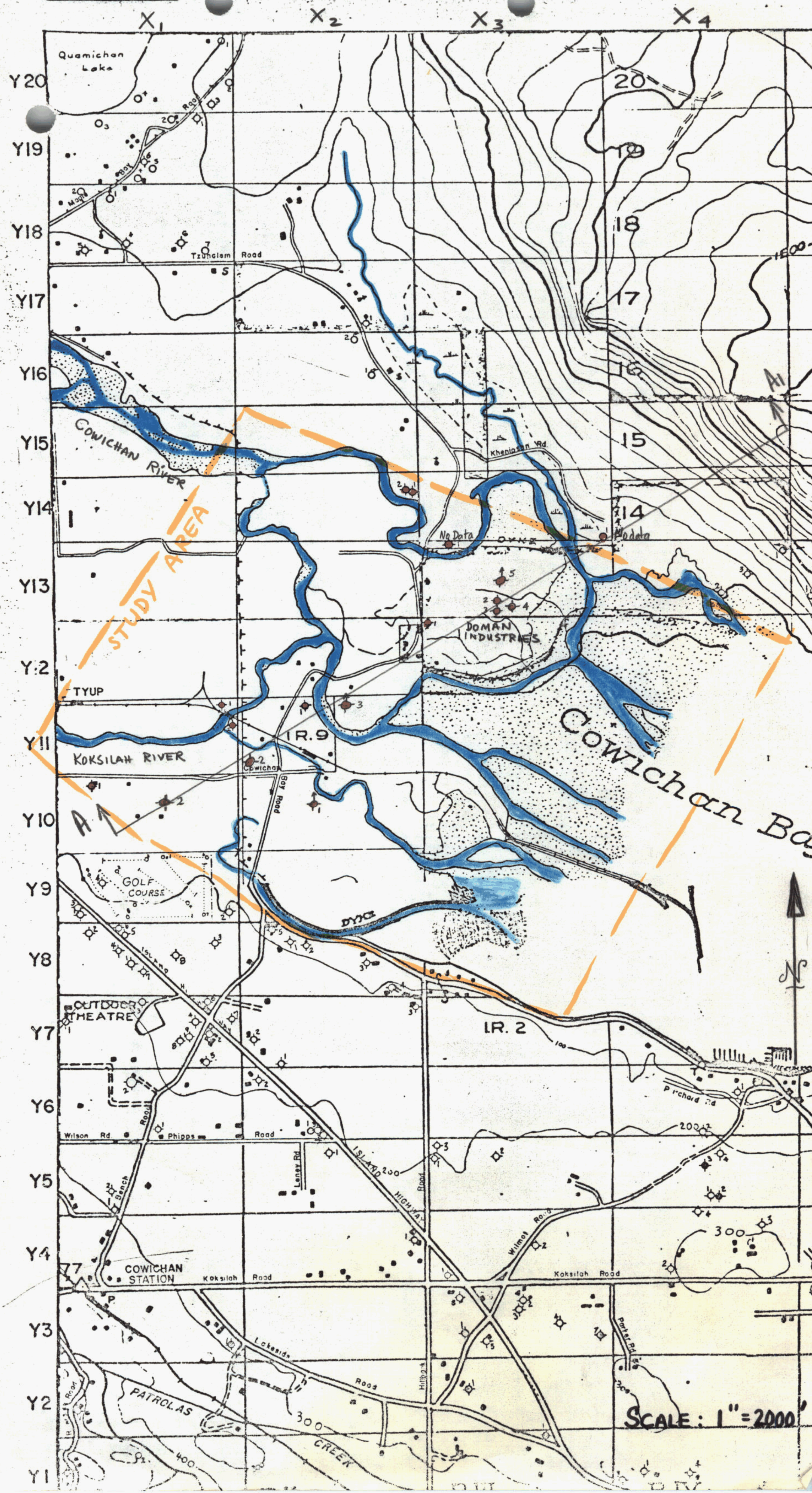
FIGURE I - DISTRIBUTION OF UNCONSOLIDATED SURFICIAL DEPOSITS

Legend

- 10 11 SALISH SEDIMENTS: 10. SHORE, DELTAIC, AND FLUVIAL DEPOSITS, gravel, sand, silt, clay. 11. UPLAND SWAMP DEPOSITS: clay, silt, peat.
- 7 MARINE DEPOSITS (INCLUDING GLACIO-MARINE): 7a, silty, 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.
- 6 GLACIO-FLUVIAL DEPOSITS: gravel, sand lenses of till; 6a, hummocky, kettled, kame deposits; 6b, ice-contact deltas.
- 5 GROUND MORAINE DEPOSITS: till, lenses of gravel, sand, silt.
- R Areas of bedrock outcrop and of outcrop interspersed with patches of thin overburden

Scale: 1 inch to 1 mile
Source: G.S.C. Paper 65-24 (Halstead)

FIGURE 2: WELL LOCATION MAP



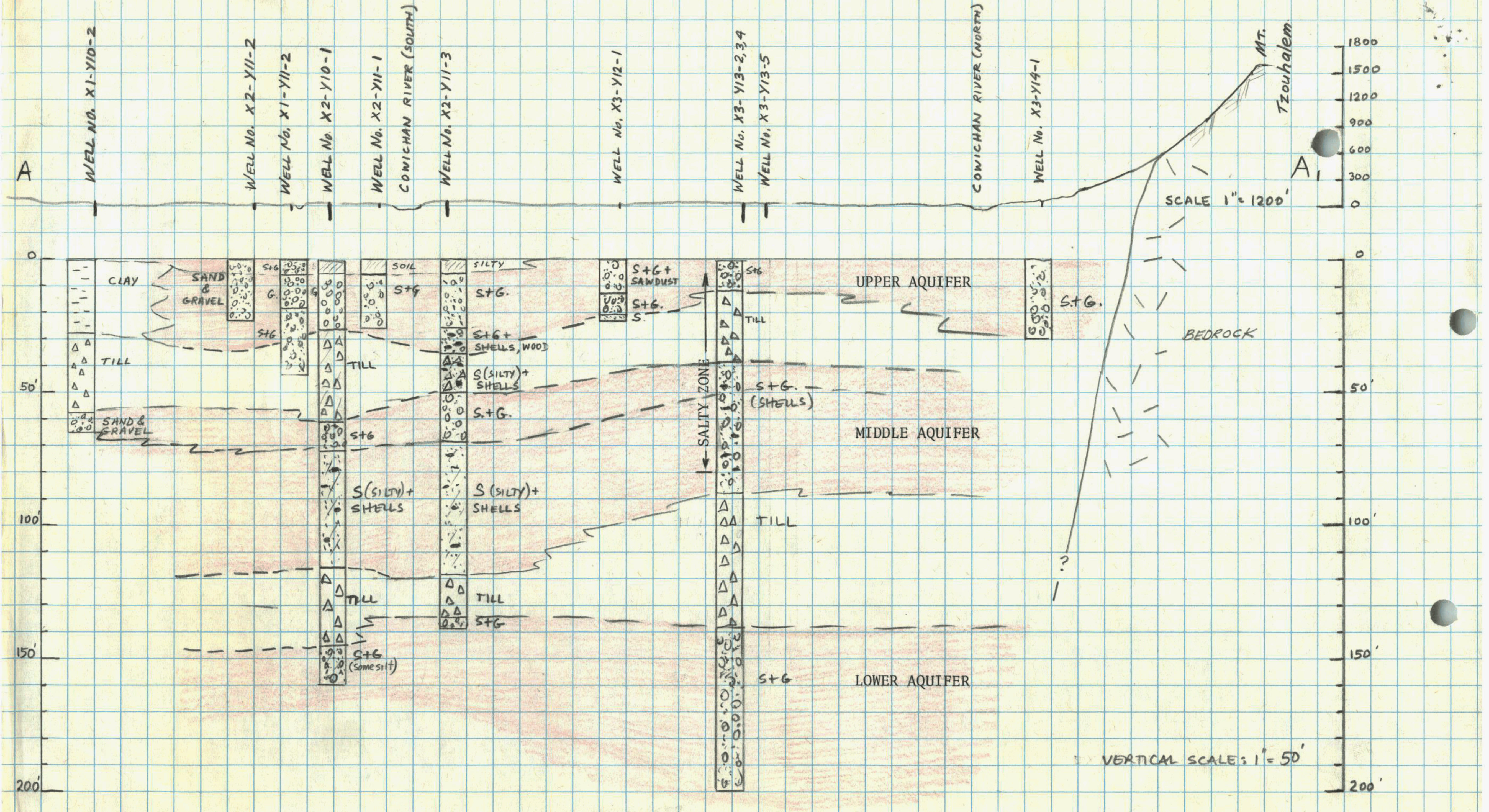


FIGURE 3 : CROSS-SECTION A-A1 LOOKING NORTHWEST ACROSS COWICHAN ESTUARY, INCLUDING WELL HOLES.