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February 16th, 68

0239014A

Rotary Test Hole Drilling in the Williams Lake area - Results and Recommendations

Reference:

1. See correspondence on file 0239014A, September - December, 1967

2. "Notes on Surficial geology, well logs and a proposed rotary test drilling program at Williams Lake" by J.C. Foweraker, file 0239014A, October 5th, 1967.

3. Drilling Contract No. 32 - Williams Lake Area, dated October 12th, 1967, file 0248924

4. Water Requirements for Town of Williams Lake (see letter dated September 29th, 1967, file 0239014 from Mr. R.H. Blackwood, Municipal Clerk, to Honourable Robert Bonner, M.L.A., Parliament Buildings, Victoria, B.C.)

   At peak usage in 1967, Town of Williams Lake consumed 1,800,000 gallons per day. Assuming U.S. gallons 1,800,000 U.S. gallons per day = 1,250 U.S. gallons per minute.

General

Groundwater Division personnel in the summer of 1967, carried out a well inventory survey and field investigation on the surficial geology and groundwater possibilities of an area extending from Mile 80 on the Cariboo Highway to Williams Lake. Unfortunately, the geological field investigations had to be suspended during the season due to staff limitations.

During 1967, subsurface exploration by the Water Investigations Branch in the Cariboo area included drilling of a 500-foot rock well at 80 Mile (see memo dated June 28th, 1967 on file 0239014A). The Water Investigations Branch also completed a rotary test hole program at Williams Lake. Drilling commenced on November 18th and the test hole program was completed on December 4th, 1967. The drilling was carried out on a continuous basis, 24 hours a day, seven days a week, in order that the program could be completed before winter conditions forced a shut down.

The aim of the rotary test drilling program was to find out if there existed in the Williams Lake Valley sand and gravel deposits which might be suitable for a groundwater development project. Subsurface information was obtained during the test drilling in several ways.

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(1) from drill cutting samples
(2) from a recorded log of the drill penetration rate with time
(3) from electric logs
(4) from the driller's log
(5) from changes in drilling fluid, viscosity and weight measurements.

All this information was then tabulated and a composite log completed for each test hole (see Appendix I for composite logs). The drilling fluids used in this program enabled the test holes to penetrate less consolidated materials. The fluids were continually being checked and adjusted for varying conditions encountered in the test holes. (see notes on drilling muds for proposed rotary test drilling program at Williams Lake, file 0239014A).

Although a great deal of information was obtained from the rotary test drilling program, it is difficult in some instances to assess the clay and silt matrix content in sand and gravel formations. This is particularly the case when the matrix is friable and breaks up and goes into suspension in the drilling fluid. Where gravels and sands are encountered in rotary test drilling, it is often necessary to increase the viscosity and weight of the drilling fluid in order to penetrate through the formation. The thicker heavier fluid retains the finer fractions in suspension and makes it difficult to obtain representative samples. When these conditions occur, it is sometimes necessary to place more reliance on the electric log, driller's log, penetration rate of the drill, than on the actual sample.

Cost of the Rotary Test Drilling Program:

The original estimate for the cost of this drilling program (see file 0239014, October 5th, 1967) was $8,000.00. This allowed for six holes or 2,400 feet of drilling at $3.30 per foot (including price of drilling muds). Altogether, 1,440 feet were drilled under this program for a total cost of $8,476.15 or $5.89 per foot.

Geology

Some tentative stratigraphic boundaries have been drawn in Section 1; this section is located along Line A-A, in Figure 1.

No detailed correlation of the subsurface geology will be attempted until any test well drilling is completed.

Summary of the Results

The composite logs of the five rotary test holes show that the greatest thickness of more permeable sands and gravels lies in Test Hole No. 4, from 70 feet to 174 feet (see Appendix I, Figure 2, and Section 2).

The amount of fine matrix material in the aquifer zone and its effect on the permeability, is difficult to assess but available evidence would indicate that the percentage of fine material may be limited.

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The static level is approximately 20 feet below ground surface. However, more accurate information on the static level from the recently constructed piezometers at Williams Lake will be available shortly. An attempt will also be made to collect a water sample from the piezometers for water quality analysis. High iron concentration may be a problem in this area.

Recommendations

I would recommend that the most suitable site for a test well is close to the No. 4 rotary test hole at the west end of Williams Lake (see Figure 2). Results of the rotary test hole drilling indicate that a test well could be completed using standard cable-tool drilling methods with either a ten-inch or eight-inch diameter casing.

A ten-inch diameter "production-test" well costs more than an eight-inch diameter test well but the larger diameter gives more flexibility in well design and possibly greater yield. Therefore, two types of test well construction are proposed here and the advantages and disadvantages can be compared.

No. 1 - Eight-inch test well

Ten-inch diameter well casing could be used down to a depth of say 65 feet, then eight-inch casing could be run in and used through the aquifer zone down to a depth of 175 to 200 feet. A 20-foot length of eight-inch nominal size stainless steel Johnson's well screen could then be installed in the best section or sections of the aquifer. One disadvantage of this casing size is that if the aquifer requires a gravel pack design because of unexpected quantities of very fine materials then it would be difficult to complete a gravel packed screen with eight-inch casing. Again, if very permeable conditions are encountered on the other hand, the eight-inch test well will have a more limited capacity than a ten-inch well constructed in the same section of the aquifer.

If the permeability or water quality of the aquifer are poor however, the test well will have cost less than if the alternative proposal is adopted.

Cost estimates for an eight-inch test well are approximately as follows:

1.	Cost of drilling and casing with 10-inch diameter casing to 65 feet - 65 feet @ $14.50/foot	$ 942.50
2.	Cost of 10-inch casing shoe	62.50
3.	Cost of drilling and casing with eight-inch diameter casing from 65 to 175 feet - 110 feet at $12.00/foot	1,320.00
4.	Cost of eight-inch casing shoe	40.00
5.	Cost of 20 feet of eight-inch nominal size stainless steel Johnson's well screen (more well screen length may be required	1,258.00
6.	Hourly work for setting screens, developing well, preparing and carrying out a pumping test, 80 hrs. @ $17.00/hr.	1,360.00
7.	Mobilization and demobilization	500.00
		$ 5,483.00

No. 2 - Ten-inch Test Well

Twelve-inch diameter casing could be used to case the hole to a depth of 65 feet and then 10-inch diameter casing could be used to drill through the aquifer zone to a depth of 175-200 feet. A 20-foot ten- or eight-inch nominal size stainless steel Johnson's screen could then be installed in the best section or sections of the aquifer. If the samples taken through the aquifer show that a gravel pack design is called for, then it would still be possible to gravel pack a four-inch pipe size screen with the ten-inch casing size.

If the production-test well is a success, it could be kept as a permanent production well to supply part of the 1250 U.S. gallons per minute required for the Town of Williams Lake.

Cost estimates for the ten-inch production test well are approximately as follows:

1.	Cost of drilling and casing with 12-inch diameter casing to 65 feet - 65 feet @ $18.00/foot		$ 1,170.00
2.	Cost of 12-inch casing shoe		82.10
3.	Cost of drilling and casing with 10-inch diameter casing from 65 feet to 175 feet - 110 feet @ $15.00/foot		1,650.00
4.	Cost of 10-inch casing shoe		62.50
5.	(a) Cost of 20 feet of eight-inch nominal size stainless steel Johnson's well screen	$ 1,258.00	
	or		
	(b) Cost of 15 feet of 10-inch nominal size stainless steel Johnson's well screen and fittings	$ 1,342.00	1,342.00
	or		
	(c) Cost of 25 feet of four-inch pipe size stainless steel Johnson's well screen and fittings (for gravel pack)	$ 500.00	
6.	Hourly work for setting screens, developing well, preparing and carrying out a pumping test 80 hours @ $17.00/hour		1,360.00
7.	Mobilization and demobilization		500.00
	Total		$ 6,166.60

Sampling would be very important in any test well drilling and duplicate samples should be taken at five-foot intervals and at two-foot intervals in all permeable zones. Bailing tests should be run at several horizons to obtain some idea of the aquifer characteristics.

A pumping test should be run for at least 24-36 hours on the well and if possible readings should also be observed in the piezometer during this test. Results of a pumping test will be useful not only in predicting the future performance of the test well but in the design and construction methods of future large production wells if these are shown to be feasible.

J.C.F.

J.C. Foweraker, Chief
Groundwater Division

JCF/ls
attachments.

COMPOSITE LOGS FOR TEST HOLES NOS. 1-5
ROTARY TEST DRILLING PROGRAM IN THE WILLIAMS LAKE AREA

D.J. ✓

Test Hole No. 1

Location: See figure 1. Site is located at the west end of Williams Lake near the center line of the valley on the section line A-A.

Elevation of Collar: 1884.9 feet.

Height of Collar above lake level: 25.9 feet

General Notes: This test hole was sited on a low hill occupying the centre portion of the Valley at the west end of the Lake. The hole was terminated in a compact hard sandy silt or siltstone (?) after uniformly hard drilling had continued for nine feet. The hole was electric logged as far as 121 feet but we were unable to lower the probe the last seven feet to the bottom of the hole. Sixty-two feet of five-inch surface casing were grouted into this hole as a precaution in case flowing artesian conditions were encountered during the test drilling.

A one-inch diameter rigid wall plastic pipe piezometer was made up and installed to a depth of 114 feet in the test hole. The drilling mud was flushed out of the pipe and hole and the space between pipe and hole backfilled with sand and gravel. The piezometer appeared to be working well and a static reading taken on December 4th, 1967 measured 31.35 feet below the collar. The piezometer has been fitted with a metal cover and lock. Arrangements have been made with the Town of Williams Lake to make readings periodically on this and the other piezometers completed during this drilling program.

Composite Log in feet: (see also Section1)

0	42	Pale yellowish brown poorly sorted silt, containing grains from sand to pebble sizes. Some larger stones and boulders.
42	95	Light olive grey silt, very slightly sandy and containing gravel lenses. Electric log shows a drop in potential values between 63-73 feet, which may indicate a more silty matrix and an increase in potential values between 74-84 feet <u>may</u> indicate more sandier silts. A reduction in

42 95 (continued)		potential and resistivity values near 85 feet might indicate a more compact zone within this stony slightly sandy silt and clay (?) section.
95	119	Sand and gravel with a slightly (?) silty matrix. Slower drilling rates down to seven minuted per foot. A loss of drilling fluid at 95 feet and at 117 feet. The electric log shows potential and resistivity values increase slowly with depth, indicating possibly a diminishing silt and clay matrix content with depth.
119	128	Compact sandy silt or siltstone (?). Drilling rates uniformly hard and as slow as 12 minutes per foot with all drill collars attached. The description of this last section, 119 - 128 feet, is not based on samples. The samples show a very assorted number of rock types - broken up pebbles and rock chips, which are interpreted as "caved in" material falling down from the overlying sands and gravels.
128		End of hole.

Test Hole No. 2

Location: See figure 1. Site is located at the west end of Williams Lake on the lower valley side slope on the south side of the valley. See section A-A.

Elevation of Collar: 1871.9 feet.

Height of Collar above Lake Level: 12.9 feet

General Notes: The hole was terminated at 121 feet after 16 feet had been drilled into bedrock (?). The hole was electric logged to 107 feet but the probe could not be lowered past this depth. Sixty-two feet of surface five-inch casing were grouted into this hole as a precaution against flowing artesian conditions. No piezometer was installed in this test hole.

Composite Log in feet: (see also Section 1)

0	86	Light brownish grey to light olive grey badly sorted pebbly slightly sandy silt and clay.
86	91	Silty sand and gravel.
91	105	Light brownish grey to light olive grey badly sorted, pebbly, slightly sandy silt and clay. Electric log might indicate that the top part of this section is denser and

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91 105 (continued)		more compact as potential values are reduced and resistivity values show an increase at 91 feet. Drilling rates as slow as 4 minutes per foot.
105	121	Bedrock (?) Mainly rock chips and broken-up pebbles. Some greyish red to pale reddish brown clasts in the samples. The broken-up pebbles are considered to have come from overlying gravel and stony beds. Drilling rates are considerably slower in this section, up to 15 minutes per foot with collars attached for additional weight.
121		End of Hole.

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Test Hole No. 3

Location: See Figure 1. Site is located at the west end of Williams Lake on the north side of the valley floor. See section A-A.

Elevation of Collar: 1875.4 feet.

Height of Collar above Lake Level: 16.4 feet.

General Notes: The hole was terminated at 600 feet - the maximum depth we could go with available drill rods. The hole was electric logged to 600 feet. Forty-five feet of surface five-inch casing was placed in this hole and grouted.

A one-inch diameter rigid wall plastic pipe piezometer was made up and installed to a depth of 225 feet. We had difficulty in clearing out the drilling mud due to caving conditions in the test hole and equipment troubles so the piezometer may be plugged. A reading taken on December 4th, 1967, showed the static level in the piezometer to be at 19.0 feet. A static reading was also recorded in the space between the plastic piezometer and the five-inch surface casing as 21.86 feet. The five-inch casing and piezometer tube are cut off flush with ground level and a cap and lock have been attached for protection.

Composite Log in feet: (see also Section 1)

0	50	Light olive grey very fine sandy silt containing assorted sized stones and a boulder between 44 and 50 feet, which slowed down drilling rate from 35 to 40 minutes per foot.
50	216	Moderate yellowish brown silty gravel to stony silt. Electric log shows maximum values for potential and resistivity at 56 feet which may indicate a greater porosity

50 (continued)	216	and less fine material in the matrix at this depth. Drilling rates as high as six minutes per foot at this depth. Drilling shows softer material below 60 feet. The variations on the electric log values <u>may</u> be due to varying silt and clay content. Between 100 feet and 260 feet the slight increase in potential values with increasing depth may indicate slight increases in the porosity of this section or just less silt and clay content in the matrix and increased sand content with increasing depth. The samples in this section appear to confirm this. Above 140 feet, the stones appear to be finer grained small pebble sizes, however, the stones become larger below 140 feet.
216	260	Light olive grey badly sorted silt and clay matrix in sand and gravel. Drilling rates slower at two minutes per foot down to 245 feet and as slow as 10 minutes per foot in more compact material (till?) between 245 and 255 feet.
260	485	Compact stony light brownish grey badly sorted sand, silt and clay with stones and lenses of fine gravel. Color changes to pale yellow brown at about 350 feet. A boulder between 260 and 267 coincides with marked increases on the potential and resistivity values of the electric log. Drilling rates slowed up to 27 minutes a foot on this boulder. Between 260 feet and 380 feet there is a steady increase in potential values with increasing depth. Resistivity values remain relatively constant over this same section. At 383 feet, there is another marked step up in the potential log values.
485	525	Compact stony light brownish grey badly sorted sand, silt and clay with more stones and gravel lenses than in the previous sections between 260 and 485 feet. Material becomes more stony towards the base of this section.
525	600	Light brownish grey unsorted compact sandy silt and clay with a few stony lenses. Slight decrease with depth in potential and resistivity values which may indicate an increase in the finer silt and clay matrix.
600		End of hole.

<u>Test Hole No. 4</u>

Location: See figure 2. Site is located on "Scout Island" near the west end of Williams Lake, east of section line A-A and east of the diversion channel.

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Elevation of Collar:	1873.8 feet.
Height of Collar above Lake Level:	14.8 feet.

General Notes: The hole was terminated at 265 feet because of gravel becoming wedged between the rods and the wall on the lower section of the hole and the possibility of the drilling rods becoming permanently stuck in this section. The probe of the electric logger could not be lowered below 191 feet due to an obstruction in the hole. Forty-feet of five-inch casing were suspended in this hole, but the casing was not grouted.

A one-inch diameter rigid wall plastic pipe piezometer was made up and installed at a depth of 174 feet (?). The bottom of this piezometer is open and there are several holes drilled in the lower section of the piezometer tubing. The drilling mud was not washed out of this piezometer at the time of construction and a satisfactory static reading could not be obtained with the electric line. The static level between the five-inch casing and the piezometer on December 4th, was 20.13 feet below top of casing. Later when the mud is more diluted in the piezometer, a reading may be possible.

Composite Log in feet: (see also Section 1)

0	40	Pale yellowish brown to brownish grey poorly sorted stony slightly sandy silt. Stones at 29-30 feet, 36-40 feet. Between 34 and 40 feet, drilling rate down to six minutes per foot.
40	70	Pale yellowish brown, poorly sorted stony fine sandy silt and clay with gravel lenses. The electric log shows uniform resistivity values and potential values increasing with depth - this may indicate coarse materials and increased porosity. Samples show less silt and clay and more sand and gravel than in previous sections.
70	174	Assorted coarse sand and gravel, with minor silt and clay coloured a light brownish grey. Drilling rates fairly uniform at one foot per minute. The electric log shows increased resistivity values between 70 and 118 feet, which may indicate coarser more open material or a reduction in fine matrix. Below 118 feet the resistivity values vary in a sequence of maximum and minimum values, perhaps reflecting alternating permeable and less permeable beds. At 150 feet, the potential value is at a maximum and

70	174	the resistance value at a minimum, possibly reflecting a more porous zone compared to those lying immediately above and below. This zone, at 150 feet, appeared to drill like a coarse gravel according to the driller's report.
174	249	More compact, denser, but still friable, silt and sand. The sample returns in this section are mainly in the sand and small pebble sizes. The pebble sizes are often angular and broken. Most of these sample returns are thought to be from caving gravels in the section above. The silt and sand cuttings may have been carried away in the drilling mud and deposited out in the mud pit. The electric log shows a sudden reduction in potential values and a corresponding increase in resistivity values between 174 and 178 feet possibly this indicates a denser zone. Below 249 feet the driller reports the formation is more compact.
265		End of hole.

Test Hole No. 5

Location: See figure 3. Site is located at the east end of Williams Lake.

Elevation of Collar: The elevation of the collar is not known exactly but is probably about 1869 feet or ten feet above lake level.

General Notes: This hole was terminated at 326 feet in a compact siltstone (?) and sandstone (?) often uniformly hard drilling had continued for 12 feet. The hole was electric logged as far as 299 feet but we were unable to lower the probe below this point. 78 feet of surface casing were grouted into this hole as a precaution in case flowing artesian conditions were encountered during the test drilling.

Composite Log in feet: (see also Sec. 3):

0 - 69 Light olive gray to olive gray pebbly silt. Some shells found down to 10 feet. Some yellowish gray silt at 30 feet and minor wood (? in situ) at 50 feet.

69 - 108 Brownish gray to olive gray compact and slightly stony silt and clay (?). Some gravelly lenses. Drilling mud circulation lost between 79-87 feet. The electric log shows uniform potential and resistivity values. Drilling rates as slow as 6 minutes per foot in soft boulder (?) at 87 feet.

108 - 123 Stony dense till (?) or cemented sand and gravel. The electric log shows high resistivity values and low potential values. Drilling rates as high as 16 minutes per foot.

123 - 149 Dense sand and gravel, amount of silt not known. Electric log shows low potential values and high resistivity values. Drilling rates vary - up to 5 minutes per foot.

149 - 247 Light olive gray pebbly sandy silt and clay. Drilling rates generally less than 2 minutes per foot except between 150-160 feet and 180-190 feet. Electric log shows a reduced but uniform resistivity value, and an increased and uniform potential value. This could indicate an increase in the porosity of this section possibly due to a more friable sandy matrix.

247 - 290 Light olive gray to medium gray pebbly slightly sandy silt and clay. Compact drilling rates up to 6 minutes per foot. The electric log shows increased potential values between 260 and 270. The drilling rate is at a minimum between 260 and 270, possibly indicating a more friable porous sandy zone.

290 - 314 Dense sand and gravel, amount of silt not known, but electric log shows low potential values and high resistivity values between 290 and 300 feet, which is the end of the electric log record. Between 290 and 294 feet the driller's log shows a sudden drop in the drilling mud viscosity, indicating a more permeable water-bearing zone. The drilling rate is less than 2 minutes per foot for the entire sections.

314 - 326 Compact siltstone and sandstone containing many poorly sorted granule sized grains and rock chips. Uniform drilling rates to 11 minutes per foot.

326 End of hole.

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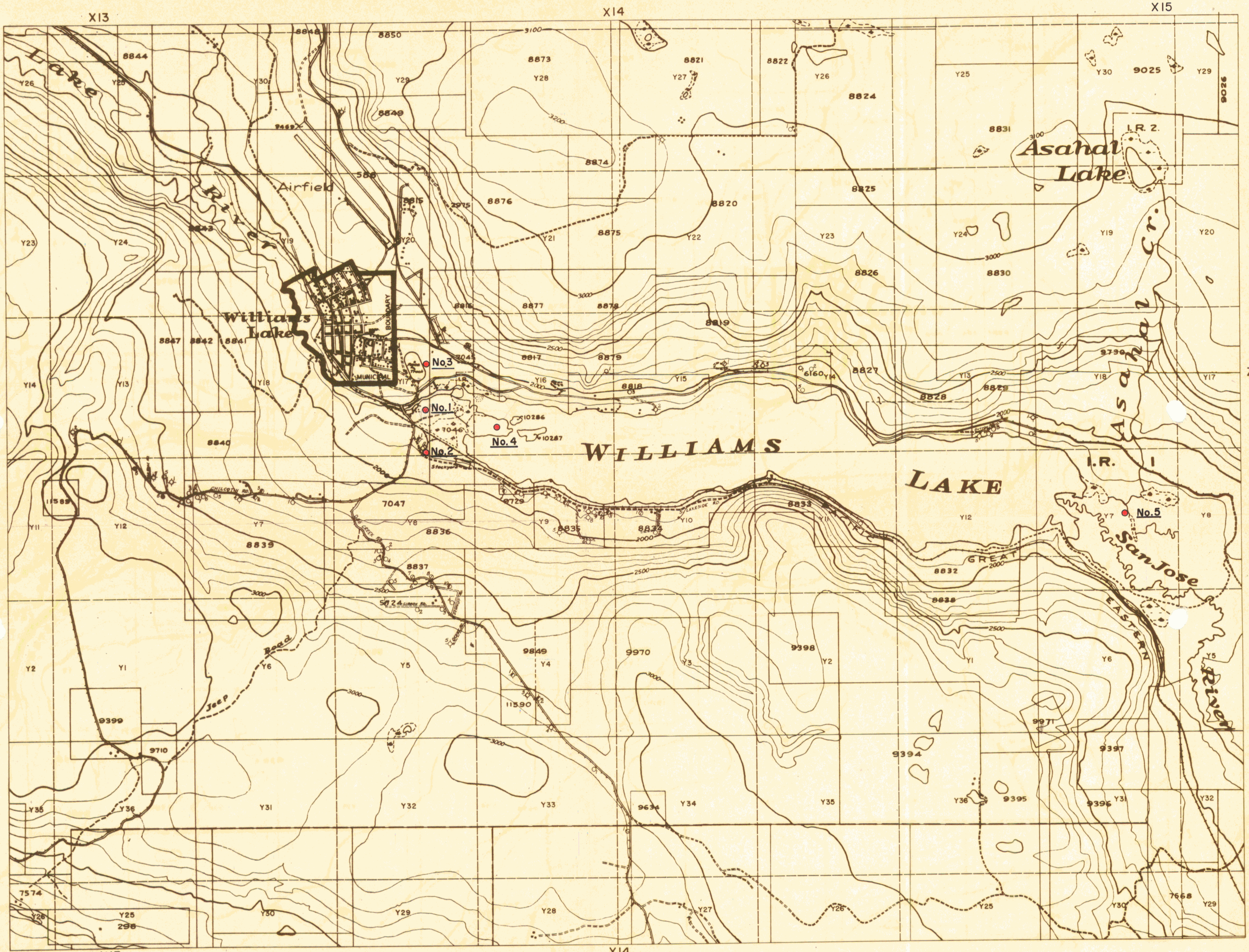

◇ DRILLED WELL	ARTESIAN (FLOWING)
◆ DRILLED WELL (DRY)	ARTESIAN (NON FLOWING)
○ DUG WELL	SPRING
● DUG WELL (DRY)	⊘ WATER QUALITY INADEQUATE
WATER QUANTITY INADEQUATE	

FIGURE 3

Plan showing location of Rotary Test Holes at Williams Lake (see memo on file 0239014A Feb.16, 1968 by J. Foweraker.

CARIBOO DISTRICT 45
SHEET NO. 1
SCALE: 1" = 2640'

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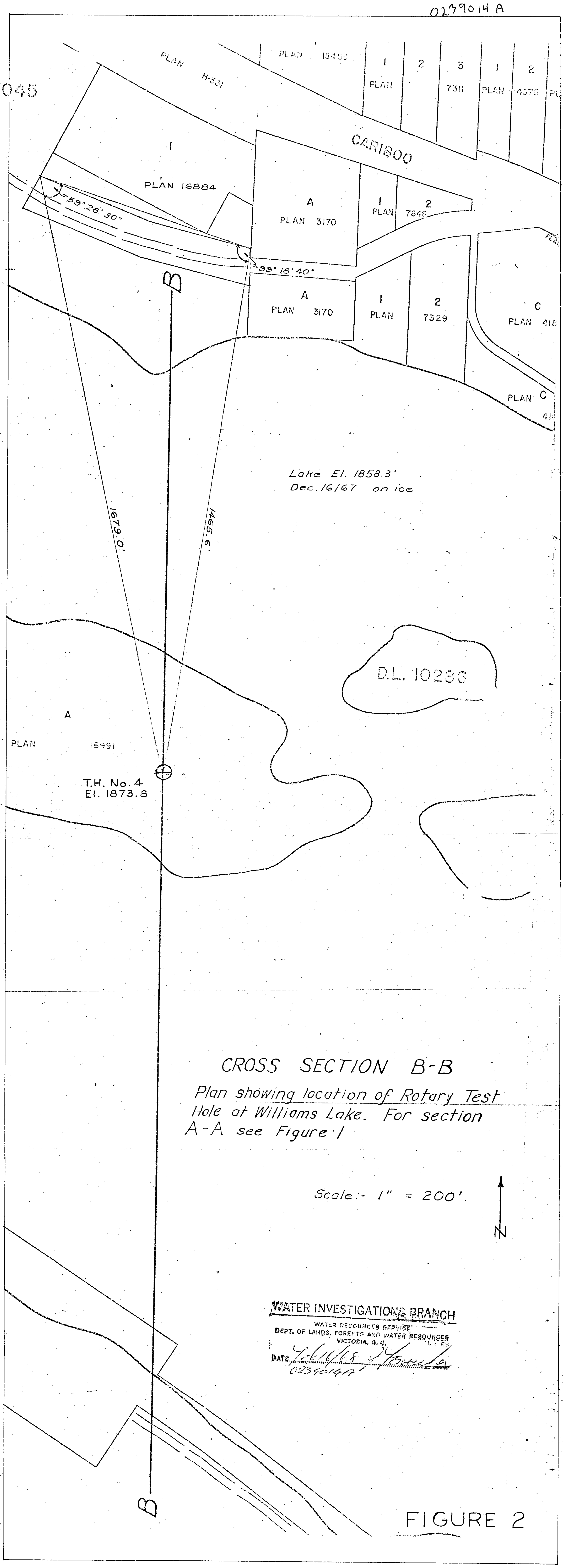

CROSS SECTION B-B

Plan showing location of Rotary Test Hole at Williams Lake. For section A-A see Figure 1

Scale:- 1" = 200'.

FIGURE 2

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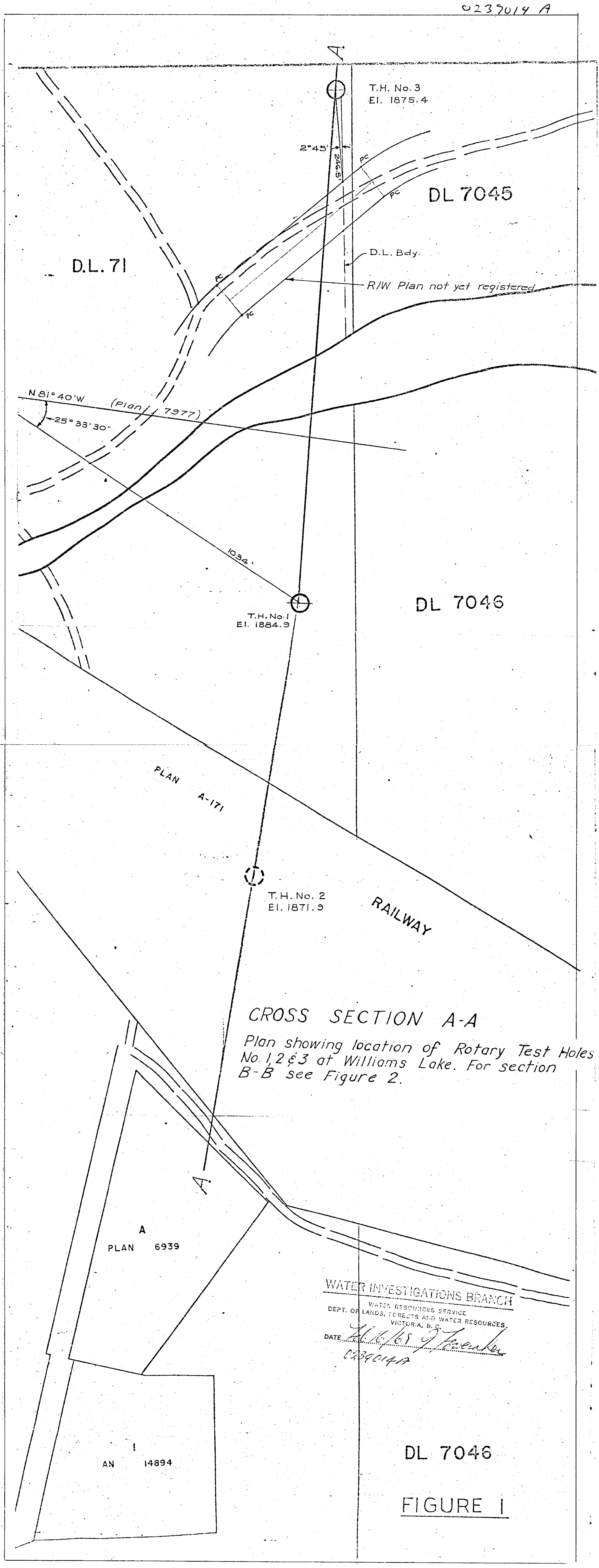

CROSS SECTION A-A

Plan showing location of Rotary Test Holes No. 1, 2 & 3 at Williams Lake. For section B-B see Figure 2.

FIGURE 1

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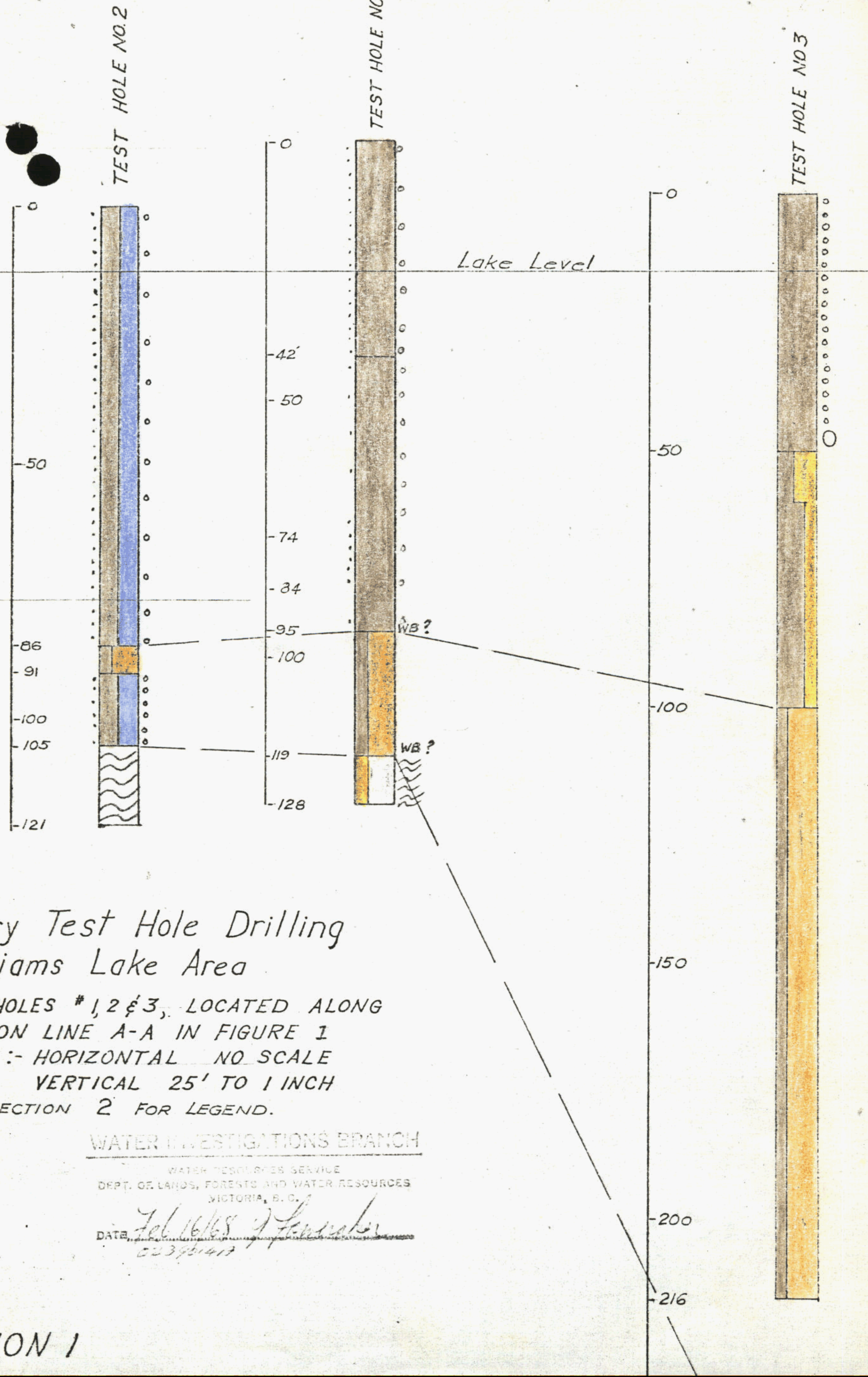

Rotary Test Hole Drilling
Williams Lake Area

TEST HOLES # 1, 2 & 3, LOCATED ALONG
SECTION LINE A-A IN FIGURE 1
SCALE :- HORIZONTAL NO SCALE
VERTICAL 25' TO 1 INCH
SEE SECTION 2 FOR LEGEND.

SECTION 1

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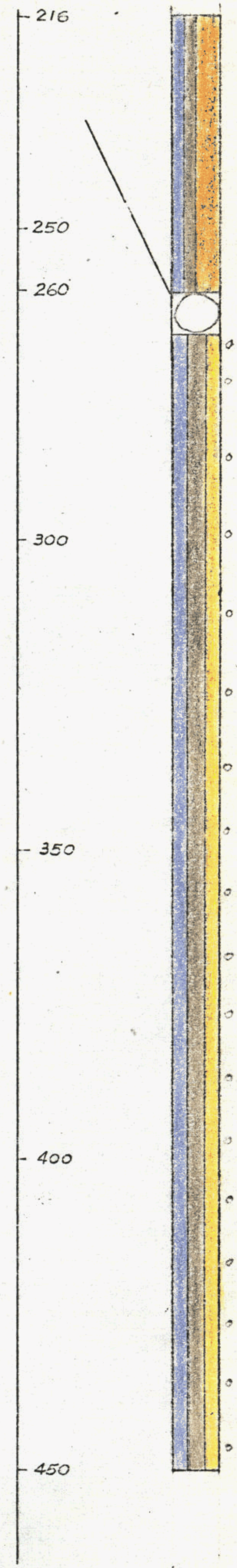
#3(Cont'd)



SECTION I (CONTINUED)

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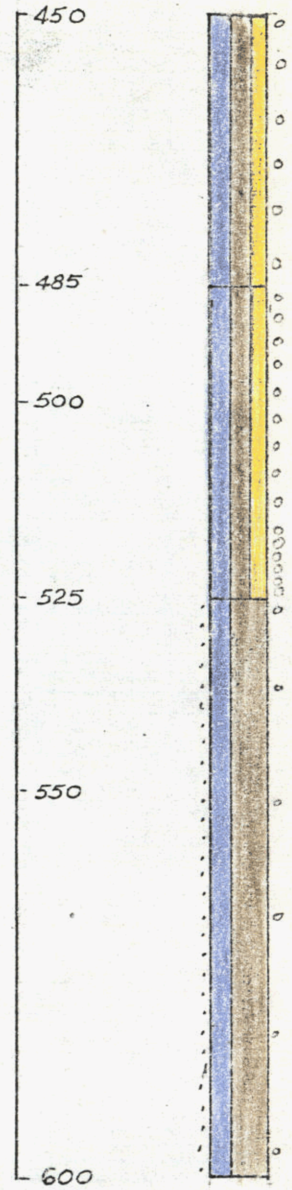
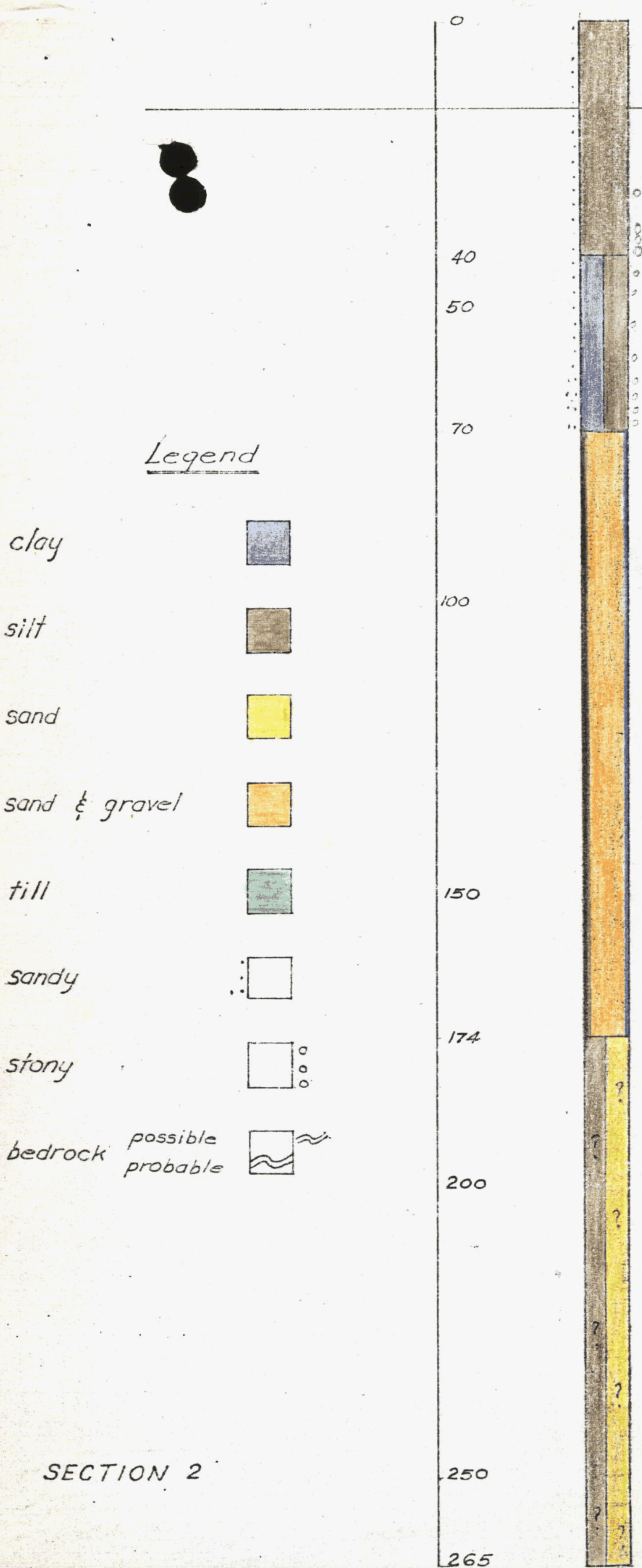
#3 (completed)



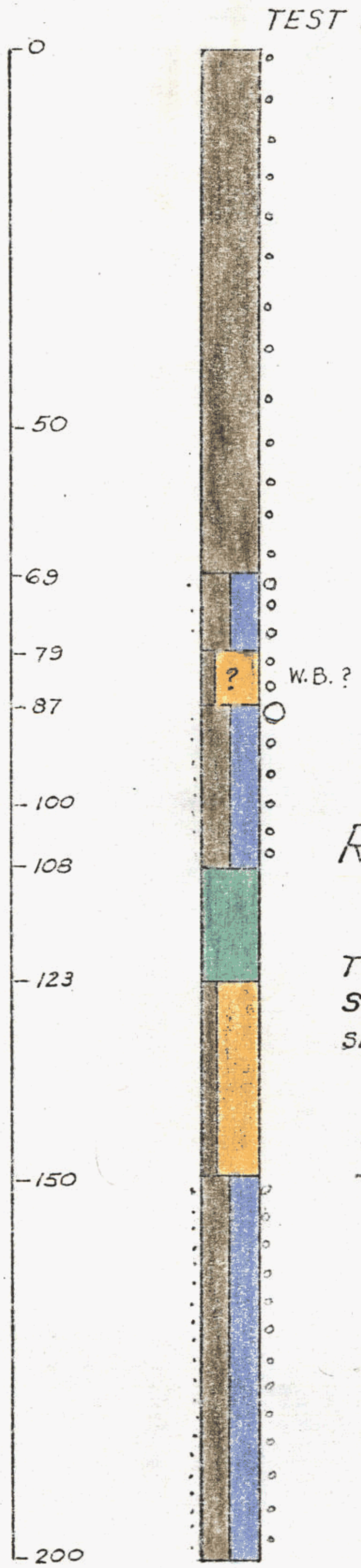
SECTION I (CONTINUED)



Lake Level

Rotary Test Hole Drilling
Williams Lake Area

TEST HOLE NO. 4 (SEE FIG. 1)
SCALE :- VERTICAL 25' TO 1 INCH



Rotary Test Hole Drilling
Williams Lake Area

TEST HOLE NO. 5
SCALE :- VERTICAL 25' TO 1 INCH
SEE SECTION 2 FOR LEGEND

SECTION 3

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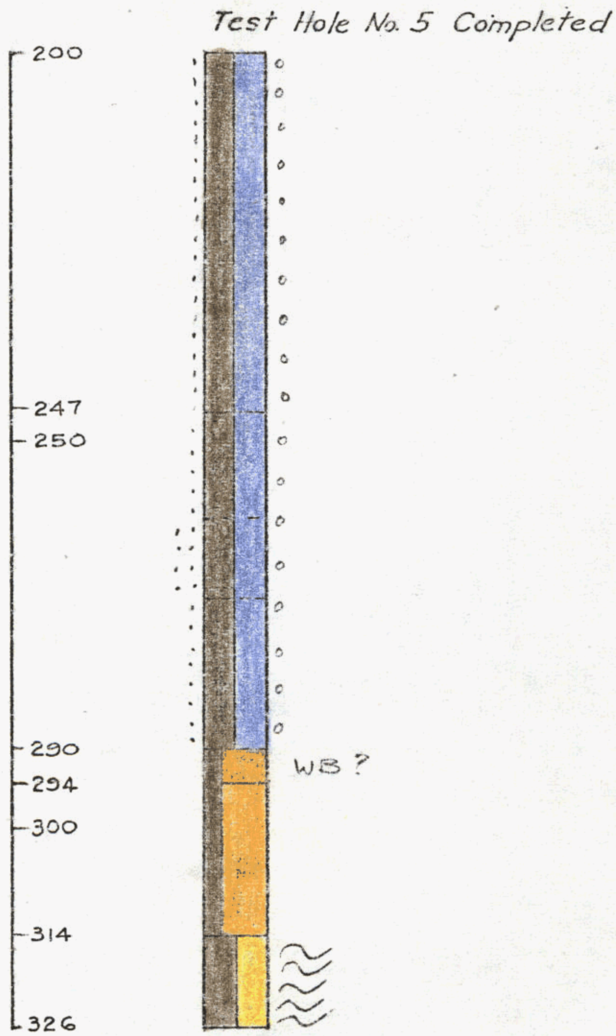

SECTION 3 COMPLETED