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Some Observations on the Groundwater Geology in the Lloydminster Area

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by

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Alberta
RESEARCH COUNCIL

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Introduction

General statement

The purpose of the survey had a very limited and immediate objective. This was to locate if possible, or to determine the prospects of finding a suitable and large supply of water within a reasonable distance of the City of Lloydminster.

The aids used in looking into this problem were aerial photographs, geologic reports, geologic maps, lithologic logs from drillers and electric logs supplied by the oil companies. This was followed by geophysical prospecting consisting of seismic and resistivity profiles to gain information about the bedrock topography and the location of buried sand and gravel. Later, on the basis of the information collected three test holes were drilled.

In addition to the above a survey was made of many farm wells. The chief value of this lay in collecting data on the depth of the well, the depth to the water level, and whether or not it was considered to be a poor, good, or excellent domestic and/or stock well. Also samples of water were taken to supply information on the chemical characteristics.

At present most of the population of 5,800 is on the city's water supply system but none of the city's major industries use it. The water supply from three pumping wells is barely adequate to supply the system. The growing demand for water and the likely future growth of Lloydminster show increased supplies are necessary to allow for expansion of the city's amenities.

Local Geology

The geology of an area and the character of the subsurface material exert the controlling influence on the availability of groundwater supplies. Both surficial deposits and bedrock geology are relevant.

Glacial or Surficial Deposits

Apart from an occasional exposure of bedrock, glacial drift forms a continuous cover over the whole area. The City of Lloydminster is situated almost in the centre of an area of ground moraine lying between Big Gully Creek and Blackfoot Creek. This moraine varies in thickness from 40 feet to 173 feet and averages 92 feet thick.

Ground moraine consists chiefly of till which is an unsorted and unstratified deposit of sand, silt and clay with broken rock fragments varying in size from small pebbles to large boulders. Locally it may contain isolated pockets of sand and gravel.

The northeast and southwest margins of this moraine are flanked by outwash, which is sorted silt, sand and gravel. This is found in the former glacial drainage channels of Blackfoot Creek to the southwest of Lloydminster, and in the channel from Pasatchaw Lake to Sandy Beach Lake and in the lower portion of Big Gully Creek to the northeast of Lloydminster.

To the west of Blackfoot Creek the topography is more rugged and has a characteristic knob and kettle appearance. This is an area of "dead-ice" moraine which is composed primarily of till, but which was deposited from stagnant, melting ice during the final stages of deglaciation.

Other significant glacial features are crevasse fillings, spillways and stream trenches.

Crevasse fillings consisting of till, sand and gravel are low, narrow ridges often one mile long. These are quite distinctive and numerous to the southwest of Lloydminster and are superimposed on the ground moraine.

Spillways are steep sided valleys cut by the scouring action of glacial melt water which at the present day may contain undersized or misfit streams. The upper portion of Big Gully Creek from St. Ives Lake to the Alberta-Saskatchewan border is such a feature.

Stream trenches which may contain sorted sand and gravel were formed by the activity of glacial meltwater flowing through valleys the sides of which were sometimes supported by ice. The courses of streams flowing between ice walls later became obscured by till slumping into them with the collapse of the ice walls.

The only important sources of groundwater supply from the Pleistocene cover for public and industrial purposes are the outwash sands of the stream trench systems of Blackfoot Creek and Big Gully Creek.

Bedrock Geology

Several reports have been written which include general or specific reference to the area, but the nomenclature and work of Shaw and Harding is preferred in considering the bedrock geology. Their subdivision of part of the Upper Cretaceous System is presented below. In east-central Alberta it is particularly applicable from Townships 40 to 50 and Ranges 1 to 10, West of the 4th Meridian.

SYSTEM	GROUP	FORMATION	MEMBERS
CRETACEOUS	MONTANA	BELLY RIVER	OLDMAN
			UPPER BIRCH LAKE SS
			MULGA SHALE
			LOWER BIRCH LAKE SS
			GRIZZLY BEAR SHALE
			RIBSTONE CREEK SS
			VANESTI SHALE
			VICTORIA SS
			SHANDRO SHALE
			BROSSEAU SS
		LEA PARK SHALE	

At Viking and to the west the Belly River is not divisible into the above members where continental beds mostly occur. Towards the east in the Vermilion-Lloydminster area the accompanying table portrays a marked series of changes from continental to marine conditions of deposition. Although the above major members can be recognized in east-central Alberta, there is apparently no marked uniformity in lithology within each member.

It is considered that successive subsidences of the area brought about rapid trangression of the sea permitting the deposit of marine shale tongues. These were followed by a gradual filling of the area and an accompanying change

to continental deposits. This is reflected by the sharp change from shale to sand, and by a gradual transition from sands to shales shown in logs and found in drilling. Towards the eastern margins of the continental beds minor fluctuations of sea-level interrupted continuous continental conditions. Consequently these beds have sandy shales and shales in the section.

It is important to remember the above comments in the search for groundwater supplies. For the specific interest of this report the only significant aquifer in the area is the Ribstone Creek, but isolated cases are known of water being obtained from a sand in the "Lea Park Shale". This sand, about 110 ft. below the Ribstone Creek, is the Victoria Sandstone and can be picked out on some E-logs - Excelsior Lloydminster #11-A-10-50-2 and Excelsion Devonia Lloydminster #1-C-24 and #14-B-18.

Structure

Though the general regional dip of the strata is to the southwest at 8 ft. per mile, the structure at Lloydminster reveals a flattening of the beds beneath the city to 2 ft. per mile. As the regional dip is very gentle, the structure exerts little or no influence upon hydrostatic pressure in the water wells.

The geologic map shows outliers of Birth Lake sandstone, one west of the city trending from northwest to southeast. Below and surrounding this sandstone is the Grizzly Bear Shale which also occurs within the western limits of the city. Where present this shale should have formed a protective covering for the Ribstone Creek against erosion and consequently preserved the section. The highest points

of the Ribstone Creek occur in a northwest to southeast line along the eastern edge of the Birch Lake outlier. Elsewhere, like the overlying beds, the Ribstone Creek has been partly or completely eroded away.

The Ribstone Creek Sandstone

The thickness of the Ribstone Creek varies considerably to the east and west of the city. To the northeast the log for the Lloydminster Gas Well No. 2 records a thickness of 20 ft. The Research Council test holes, No. 3 to the northwest, recorded hard sandstone at 116 ft. with a return to shale at 215 ft., a thickness of 99 ft. and No. 2 to the southwest recorded silty sand and shale from 140 ft. to 260 ft., a thickness of 120 ft.

Many E-logs for the area record a thickness of 100 ft. with the Ribstone Creek occurring at depths of 100 ft. to 150 ft., but one such log recorded it from 100 ft. to 250 ft. (S.E. Lsd. 4-32-Tp. 50, R. 1, W. 4).

Samples believed representative of the Ribstone Creek were obtained in Research Council test holes 2 and 3 and are described below.

(1) Grey, brown or greenish hard sandstone chips were composed of 60% to 80% quartz and 20% to 40% chert tightly cemented with calcite and showing very little porosity.

(2) Soft brown sandstone 60% quartz and 40% chert cemented with calcite but having greater porosity.

(3) Silty sand with roughly equal amounts of quartz and chert, and a silt matrix with little porosity.

The results of the geophysical work

The use of seismic surveys was restricted to the Alberta side of the border and was further limited by the presence of power lines and pipe lines. The power lines cause interference with readings. Because of this it was possible to run only a partial seismic profile from SW. Sec. 14, T. 50, R. 2, W. 4 to S. E. Sec. 8, Tp. 50, R. 1, W. 4 and this did not show any indications of a buried channel.

Analysis of resistivity results from stations around Lloydminster did not produce evidence of any major breaks in readings in the ground moraine. A few minor anomalies were apparent and these correlated to some extent with the presence of sands to the northeast of the city.

In general, apparent resistivity readings to depths of 90 ft. to 120 ft. were between 1,000 and 2,000 ohms /cm^2 and below 120 ft. were less than 1,000 ohms /cm^2. Plotting the results, apparent resistivity versus electrode spacing produced fairly straight lines characteristic of till.

The lithologic log for Lloydminster Gas Well #2 recording sands to 150 ft. correlates somewhat with resistivity showing higher readings around 50 ft., 90 ft., and 130 ft. of 2,000 ohms/cm^2 and over.

Due north of the city readings of 1700 to 2000 ohms/cm^2 from 70 ft. to 120 ft. at a few stations correlate with International Water Supply logs recording sandy clay, silty sand, fine sand and sandstone layers.

However there was no correlation between resistivity around NE 1/4 Sec. 11, Tp. 50, R. 28, W. 3 with International Water Supply test hole #15 on this quarter and which was considered worth pump testing.

Partly for the purpose of ascertaining the value of the above results the Research Council test holes were drilled at the sites of the poorest and slightly better than average results obtained on the Alberta side of the border.

This policy of foldowing resistivity turned out to be successful for as expected to the southwest of the city the log showed very little porous material, and to the northwest drilling encountered a water-bearing sand which appeared to be good. The city's test hole at the latter location showed that a water well with a capacity of 75 to 100 gallons per minute might be expected at this site.

Other profiles were run along a 2 mile line west and south of Sandy Beach Lake and at certain selected points across Big Gully Creek and Blackfoot Creet. It was in these drainage channels where the most encouraging results were obtained from resistivity. A summary of the inferred interpretation is presented below:

Blackfoot Creek

Location in relation to Lloydminster	Results indicate
1. 7 miles west, 2 miles south	Gravel - 20 ft., sand - 30 ft.
2. 6 1/2 miles west, 4 1/4 miles south	Sand and gravel - 20 ft.
3. 6 miles west, 6 miles south	Gravel - 30 ft., sand - 100 ft. (200 ft. at 2 points)
4. 6 miles west, 8 miles south	Sand and gravel - 100 ft.

The log for a dug well in the vicinity of locations 3 and 4 shows:

Sand and gravel to 12 ft.
Clay with shale at base 17 ft.
Sand and gravel 17 ft.+

While there is some evidence to indicate the value of the resistivity results, test drilling is essential to confirm the above interpretation. Water is present at 5 ft. or more below the surface sand and gravel at location #3 which would appear to be the most favorable for large supplies of water.

Big Gully Creek

Location in relation to Lloydminster	Results indicate
1. 6 miles north, 5 miles east	
west side of gully	Sand to 150 ft.
east side of gully	Sand - 10 ft.
2. 9 miles north, 2 miles east	Sand to 120 ft.
3. 10 miles north, 2 miles east	Sand - 100 ft.
4. 12 miles north, 1 mile east	Sand - 90 ft. to 150 ft.
5. 12 1/2 miles north (south of Sandy Beach)	Sand to 110 ft. and 130 ft.
6. A line from	
12 1/2 miles north and 1/4 mile east to	Sand and gravel increasing
14 miles north and 3/4 mile west	in thickness to the north from
	130 ft. to 200 ft.

For comparison with the above resistivity results the following lithologic logs are recorded:

I.W.S. Test Hole #31 South of Sandy Beach

0' - 4'	Sand
4' - 7'	Grey clay
7' - 45'	Coarse and fine sand
45' - 108'	Silty sand
108' - 135'	Fine sand and pieces of coal
135' - 140'	Coal

Correlates with location #5

14 miles north & 1 mile west

0 - 20' gravel
20' - 35' Sand
35' - 180' Blue clay

R.C.A. test hole #1 does not correlate with location #6 This hole was drilled into the gravel terrace and not in the sand filled channel

A little more detailed correlation between the log at Sandy Beach with the resistivity results seems justified at this point. A "break" in resistivity is recorded from 40 ft. to 50 ft. where the change from sand to silty sand is shown. Similarly, coal which gives low resistivity readings is recorded in the log at 135 ft. Interpretation for readings to the northwest shows a break at 70 ft. for a possible change to silty sand, and low readings at 150 ft. to 160 ft. for a possible change to coal. Still further northwest the silty sand may occur at 80 ft. and coal at 190 ft.

On the basis of the above interpretation the sedimentary deposits filling this channel are thickening to the northwest with both the coal and silty sand being recorded at greater depths.

The logs indicate resistivity may be a useful guide but test drilling is necessary to confirm interpretation of the results.

Groundwater Hydrology

Groundwater in the Glacial Drift

Drilling logs show this morsine to consist chiefly of soft or hard stony grey clay, sandy clay and stony brown clay. The rate of movement of water through this material is extremely slow. Locally there are pockets of water-bearing sand and gravel from 20 ft. to 50 ft. below ground surface, but domestic wells located in these pockets can often be pumped dry. Some of these wells yield a fair quantity of water, others are poor and take a long time to recover, and only one excellent shallow well was reported. The rate of percolation then varies from low to high. Though the water table may be continuous in the ground moraine wells finished in this material cannot be expected to yield more than domestic supplies of water.

All the evidence indicates it is not worthwhile prospecting for large groundwater supplies in drift aquifers in the area of ground moraine between Blackfoot Creek and Big Gully Creek.

Groundwater prospects of the Pasatchaw Lake to Sandy Beach Lake System

This part of a pre-glacial or interglacial channel appears to be the best of the marginal drainage channels in the area. This channel which may be regarded as a large 'natural reservoir' is a broad depression trending northwest to southeast, extending from the north end of Pasatchaw Lake to the south end of Sandy Beach Lake.

The lithology of the deposits filling this channel may be represented by the log of International Water Supply test hole #13 showing:-

0 - 4'	Sand
4' - 7'	Grey clay
7' - 45'	Coarse and fine sand
45' - 108'	Silty sand
108' - 135'	Fine sand and pieces of coal
135' - 140'	Coal

The form of the water table is continuous and where it interseets the surface the lakes occur. According to local knowledge when the water level of the lakes to the northwest fluctuates, the levels of those to the southeast later fluctuate in like manner. So there is a general movement of water through this channel. The average depth of the water table will be assumed as 10 ft. This figure is chosen for the water is near the surface at many points and at the well south of Sandy Beach Lake was measured as 9 ft. down.

The volume of the 'reservoir'

The volume of the water is dependent upon the following conditions:

(i) the areal extent of the porous sediments
(ii) the porosity of these sediments
(iii) the thickness of the saturated column of the porous sediments.

The porosity of sands and gravels may vary from 25% to 45% by volume. As the amount of sorting may vary also the lower figure of 25% will be used for the purposes of this report.

The thickness of sand and sandy material is known at one point to be 135 ft. Using the assumed average depth of the water table as 10 ft., the thickness of water saturated sediment is 125 ft. However, as the depth of coarser sand is shown as 45 ft. and using this figure as the limit for large capacity wells, only a depth of 35 ft. of saturated sands will be considered for the purposes of calculation.

The areal extent of the reservoir has been arbitrarily divided by the dotted line to separate the lake systems to the east and west of the till ridge at Sandy Beach Lake. This again is entirely for calculation purposes. The intention is to consider all the water to the west of the line flows to Sandy Beach and that most of the water to the east flows into the lakes to the east of the till ridge.

The relevant figures for calculating the volume of water in the west lake system are length 9 miles, average width 1/2 mile, saturated depth of coarse grained sediments 35 ft., average porosity 25%. This should give the minimum possible volume of water available to large capacity wells. Through these may be considered unacceptable figures, some idea can be gained of the length of time that this reservoir could be expected to supply the City of Lloydminster. This theoretical consideration excludes recharge by precipitation and loss of water to the south of Sandy Beach Lake into the lower portion of Big Gully Creek.

Calculations

(a) To the west of the dotted line

Length 9 miles, average width 1/2 mile, depth 35 ft., porosity 25%

Volume of the reservoir 47,520' x 2,640' x 35' = 4,390,848,000 cu. ft.

Assuming 25% porosity, the volume of water is 1,097,712,000 cu. ft.

As 1 cu. ft. holds 6.232 Imperial Gallons the number of gallons of water in the reservoir is 6,835,000,000 (slide rule). At a rate of future use of 1,000,000 gallons per day there is a supply available for 19 years (18.7 yrs.)

(b) To the east of the dotted line

Length 9 miles, average width 1 mile, depth 35 ft., porosity 25%

To the east there is twice the volume of water available for 38 years (37.4).

In reality water can probably be obtained without difficulty to twice the depth in each case, porosity may be nearer 35%, and the volume of water in the lakes has not been calculated. So it can readily be seen that an ample supply of water for far greater daily demands is present in the reservoir for very many years.

Groundwater prospects of the Ribstone Creek Sandstone

The Ribstone Creek has a thickness of 20 ft. to 150 ft. but a vertical section at any particular location records a sequence of alternating soft and hard sandstone layers, sandy shale, silty sand and shale. This can be seen in lithologic logs and can be determined from E-logs. Lateral continuity of any one layer is generally absent and this may be reflected by considerable variation in the elevation of water wells over short distances.

Considerable prospecting for water supplies which has been carried on has revealed that large capacity wells of over 50 gallons per minute can be obtained only where the sands become clean, coarse and porous. On the Alberta side of the border the depth of most domestic wells is 100 ft. to 170 ft. or 1960 ft. to 2060 ft. above sea level. Similar figures for industrial and municipal wells give a depth of 170 ft. to 260 ft., or 1900 ft. to 1960 ft. above sea-level.

From the above figures it would appear that the larger producing water sands occur near the base of the Ribstone Creek, but domestic wells have not been tested for capacity and figures for production are not available. Further, deep test holes on the Saskatchewan side of the border have not recorded any deep high yield sands.

However, to the northeast of Lloydminster sorted sands up to 50 ft. thick are found at depths of 60 ft. to 120 ft. below the surface. These sands at an elevation of 1970 ft. to 2030 ft. had previously been placed in the glacial drift, but the writer believes them to have been misplaced and to belong to the bedrock sands of the Ribstone Creek. Data from pump tests show them to be a fair to moderately good aquifer. These sands (described as pepper and salt, a term widely applied to Cretaceous sands throughout the province) are recorded in Lloydminster Gas Well #2.

In view of the variation in elevation of water-bearing zones and rapid lateral change in the bedrock, test drilling might go as deep as 260 ft. to 300 ft. This suggested to avoid terminating drilling at a shale zone higher in the Ribstone Creek and so possibly missing a lower sub-division of the aquifer.

Water Well Depths

The most comprehensive data available for the area on water wells is in the Geological Survey Water Supply Papers Nos. 253 and 258 for theRural Municipalities of Wilton and Britannia, Saskatchewan. Close examination of these records shows general concentrations of domestic wells in particular zones for certain areas. The writer's own data on water wells for the Alberta side of the border is much more localized and consequently areal coverage does not permit as detailed and clear an analysis.

On the basis of elevation above sea-level there are three major groupings of water well depths. Those drawing water above 2000 ft. are found to the west of a line running from NE Sec. 31, Tp. 50, R. 1, W. 4 through NE Sec. 13, Tp. 49, R. 1, W 4 to S.W. 12, Tp. 48, R. 27, W. 3. Wells in aquifers from 1900 ft. to 2000 ft. lie mostly between this line and one from NE Sec. 35, Tp. 50, R. 1, W. 4 to SE Sec. 1, Tp. 49, R 27, W. 3. To the east of the latter line are wells in aquifers below 1900 ft. above sea-level. Whilst the above picture is not a rigid division and water-bearing zones occur throughout the Ribstone Creek, it is very apparent that water is drawn from successively lower elevations in an easterly direction. This correlates with the progressive thinning and erosion of the Ribstone Creek to the northeast.

The Piezometric Surface

The piezometric surface is the pressure surface formed by the height to which water will rise in wells tapping aquifers under confined or artesian conditions.

The shape and slope of this surface as shown in Fig. 1 follows the general topography of the area. This indicates that recharge to the Ribstone Creek is by local precipitation.

Though a radial movement of water takes place from three high centres trending west-northwest to east-southeast, the major movement of water is at right angles to this. The slope of the piezometric surface to the northeast ranges from 25 ft. to 40 ft. per mile and to the southwest is about 10 ft. per mile. Due to lack of data these figures give only a general impression of the slope of the piezometric surface and the direction of movement of the water.

Pump Test Results

The data from pump testing the better water sands show wide variation in their yields.

Location SE Sec. 14, Tp. 50, R. 1, W. 4. International Water Supply's pump test near the site of the Research Council test hole provided two comparable sets of data at different pumping rates of 5 g.p.m. and 10 g.p.m. For the former test specific capacity was 2.27 g.p.m. per foot of drawdown, and for the latter specific capacity was 2.17 g.p.m. per foot of drawdown. As the maximum possible drawdown to the top of the aquifer is 81 ft. a simplified calculation of the yield of the well at each pumping rate gives an output of 184 g.p.m. to 176 g.p.m. respectively. However, as the yield declines by 0.10 g.p.m. per foot of drawdown at the increased pumping rate, an allowance for this gives a yield of 111 g.p.m. However the safe yield would probably be about 102 g.p.m.

During the second test the pumping rate fell off to 8 g.p.m. and much fine grained green sand was pumped out. At this point the specific capacity is higher. Thus it could be expected that as porosity increased around the hole with well development, the yield from such a test hole may be much higher.

Other interesting tests conducted by International Water Supply were made on S.W. Sec. 14, Tp. 50, R. 28, W. 3 on holes 850 ft. apart.

Test hole #21 was drilled to a depth of 92 ft. and terminates in sandstone. A pumping test was run on a 2 ft. sand aquifer at 74 ft. The yield was 3 g.p.m. per foot of drawdown, but as the maximum available drawdown is 16 ft. such a well would produce only 48 g.p.m. A safe yield of not more than 35 g.p.m. should be expected.

Test hole #22 immediately to the north terminates in shale at 120 ft. and pumping was from an aquifer at 104 ft. to 110 ft. Results here show an output of 2.9 g.p.m. per foot of drawdown giving a maximum yield of 104 g.p.m. for 36 ft. of drawdown. A safe yield of not more than 78 g.p.m. should be expected.

There is a possibility that the above aquifers may not be the same, two wells on SW 14, Tp. 50, R. 28, W. 3 may provide over 100 g.p.m. of water.

Thus, at locations about 1 1/2 miles apart (SE Sec. 14, Tp. 50, R. 1, W. 4 and SW Sec. 14, Tp. 50, R. 28, W. 3) on the east-west road 2 miles north of Lloydminster there is a potential supply of groundwater of about 200 g.p.m.

The test which was made on the Golf Course and came within the radius of interference of the C. P. R. Well shows a maximum yield of only 29 g.p.m.

Town Well #3 is reported to be a poor producer and to yield only 25 to 30 g.p.m. A short test gave a yield of 3 g.p.m. per foot of drawdown and if the aquifer is at 130 ft. then a maximum capacity of 84 g.p.m. is indicated. The safe yield should be about 60 g.p.m.

Figures submitted by a local driller for domestic wells on Sec. 36, Tp. 49, R. 1, W. 4 show 1 3/4 g.p.m. per foot of drawdown for a well 130 ft. deep on the N.E. quarter, and 1 1/2 g.p.m. per foot of drawdown for a well 167 ft. deep on the N.W. quarter. The respective maximum yields would be 70 g.p.m. and 67 g.p.m. from these sands.

From the pump test data available large producing wells of over 50 g.p.m. are found to the west and to the north of the city. On this basis prospecting in a northwesterly direction seems reasonable.

Water Level Fluctuations

A permanent water well recorder has been placed on abandoned well in the Husky Oil Refinery with the permission of the company. This is intended to record the effects of several closely spaced large capacity wells on the aquifer. Reliable readings show the water level to fluctuate between 103.68 ft. and 118.17 ft.

Monthly readings are taken on other observation wells in the area.

These measurements were begun late in 1957 and in the summer of 1958.

Quality of Groundwater

Bedrock

The groundwater in the Ribstone Creek in the immediate vicinity of Lloydminster is very hard. The hardening agents are bicarbonates of lime and magnesium. In parts per million the hardness ranges from 415 to 470. Samples over a wider area show a drop to 250 ppm. and one well near Blackfoot had soft water of 60 ppm.

The chloride content has a range from 13 to 78 ppm.

Iron ranges from zero to 1.8 ppm.

The sulphate content has a wide range from 14 to 496 ppm.

The soda content is expressed in grains per gallon and ranges from 6.3 to 49.0. Though below the harmful limit for human consumption and livestock, it will usually corrode aluminum and harm plants.

Glacial Drift

(a) Ground moraine

For shallow wells to 50 ft. in sand or gravel pockets reports varied as to their suitability. Some had a high alkalinity and sulphate content giving undesirable laxative effects.

The hardness of water in these wells is often up to and over 1,000 ppm.

Deeper wells in the drift cover (70 to 100 ft. deep) had hard water to 1000 ppm, an iron content of 1.0 ppm, but fewer reported an "alkali problem"

The hardness of water in Blackfoot Creek and Sandy Beach Lake area ranges from 160 to 450 ppm, iron is up to 0.5 ppm, and alkalinity from 145 to 330 ppm. The sulphates range from 0 to 76 ppm.

Conclusions

The best aquifers in the area occur to the north and west of the City on the Alberta side of the border. The City, Husky and Excelsior Oil Refineries all have large capacity wells in this area, and the best test hole was located here too.

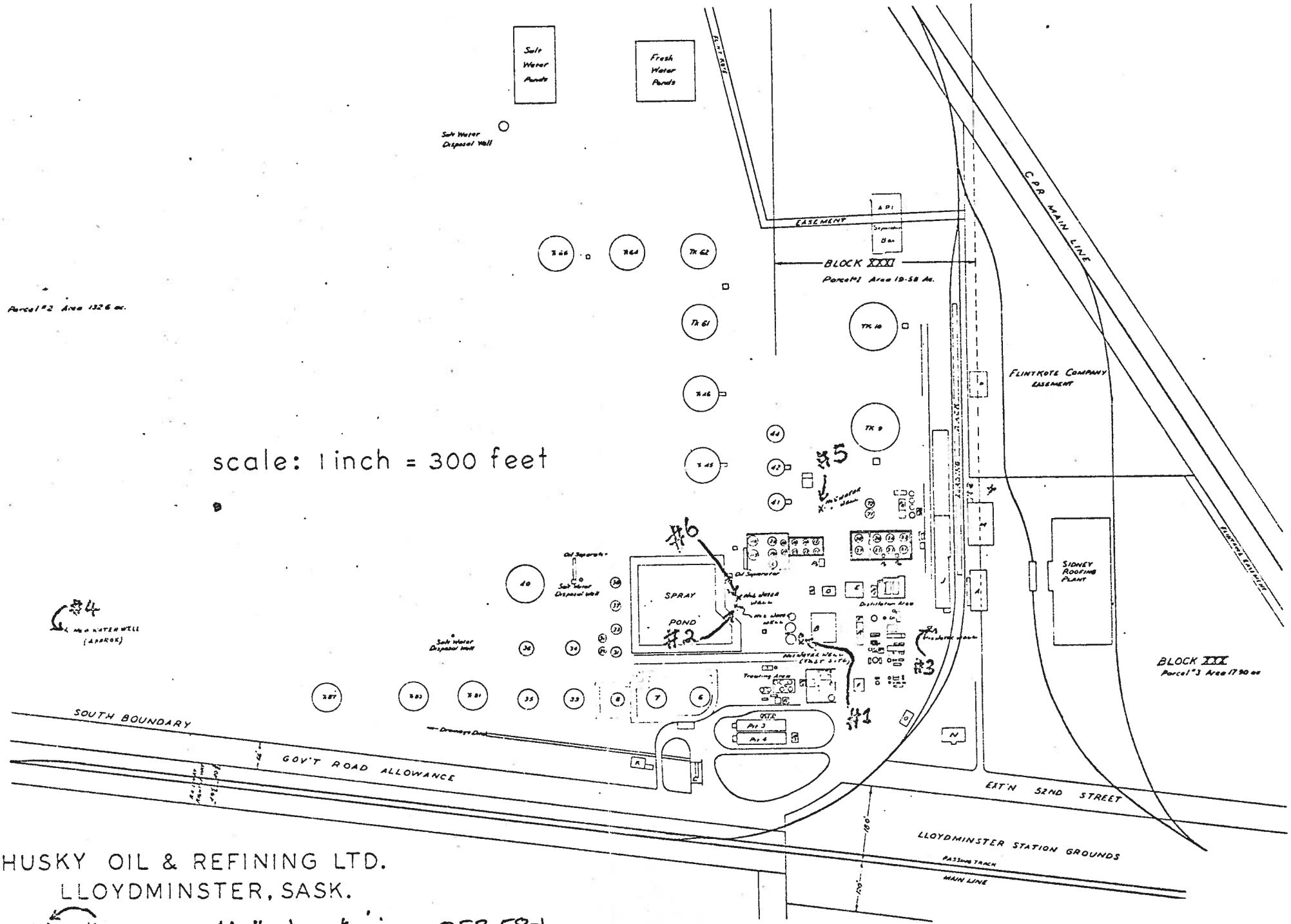
Following this come the sands on the Saskatchewan side of the border north of Lloydminster, encountered in I. W. S. test holes #21 and #22. It may be possible to find both aquifers in one well and this should be one aim of any additional prospecting near these test holes.

In all cases it is reasonable to drill to 260 ft. to be sure of penetrating the Ribstone Creek section. As the topography roughly coincides with the surface of the Ribstone Creek at most points allowance for elevation is not particularly important.

If additional prospecting proved successful then well development is very important. All large capacity wells in the area have a sand problem. This requires screening and gravel packing. Because of this production can be expected to fall off and periodic servicing will be essential.

Should additional prospecting fail to locate adequate bedrock supplies of water, then 12 miles north of the City at Sandy Beach Lake there is an adequate supply available.

December 11, 1958.



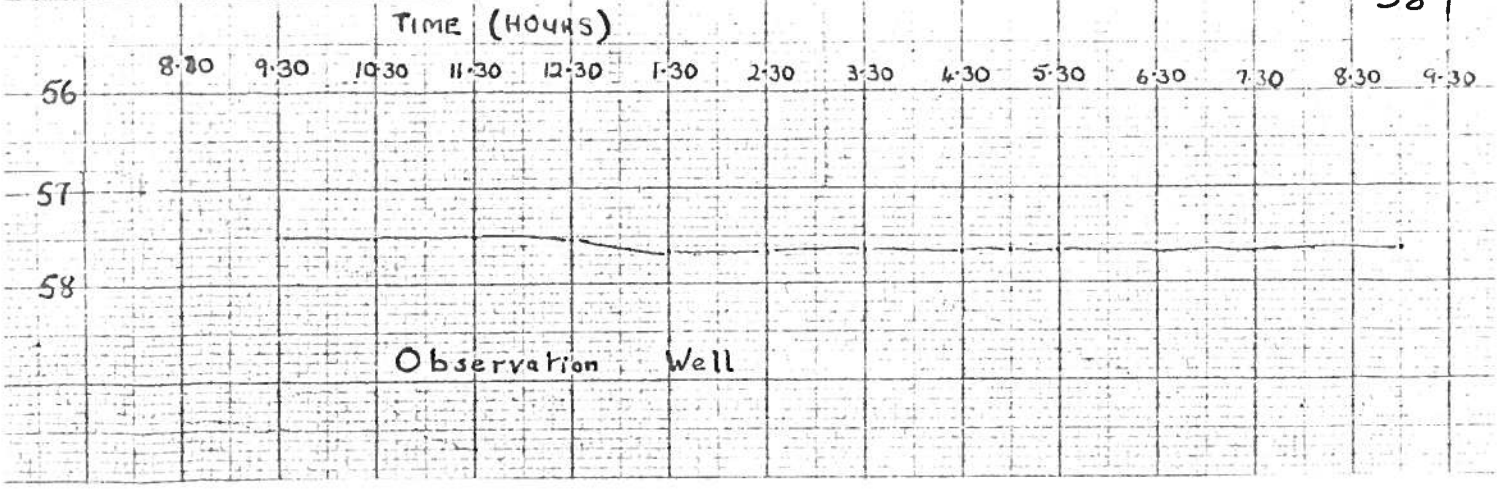
HUSKY OIL & REFINING LTD.
LLOYDMINSTER, SASK.

X #4 ---- Well location OFR 58-1

LLOYDMINSTER AREA INTERNATIONAL WATER SUPPLY PUMP TEST

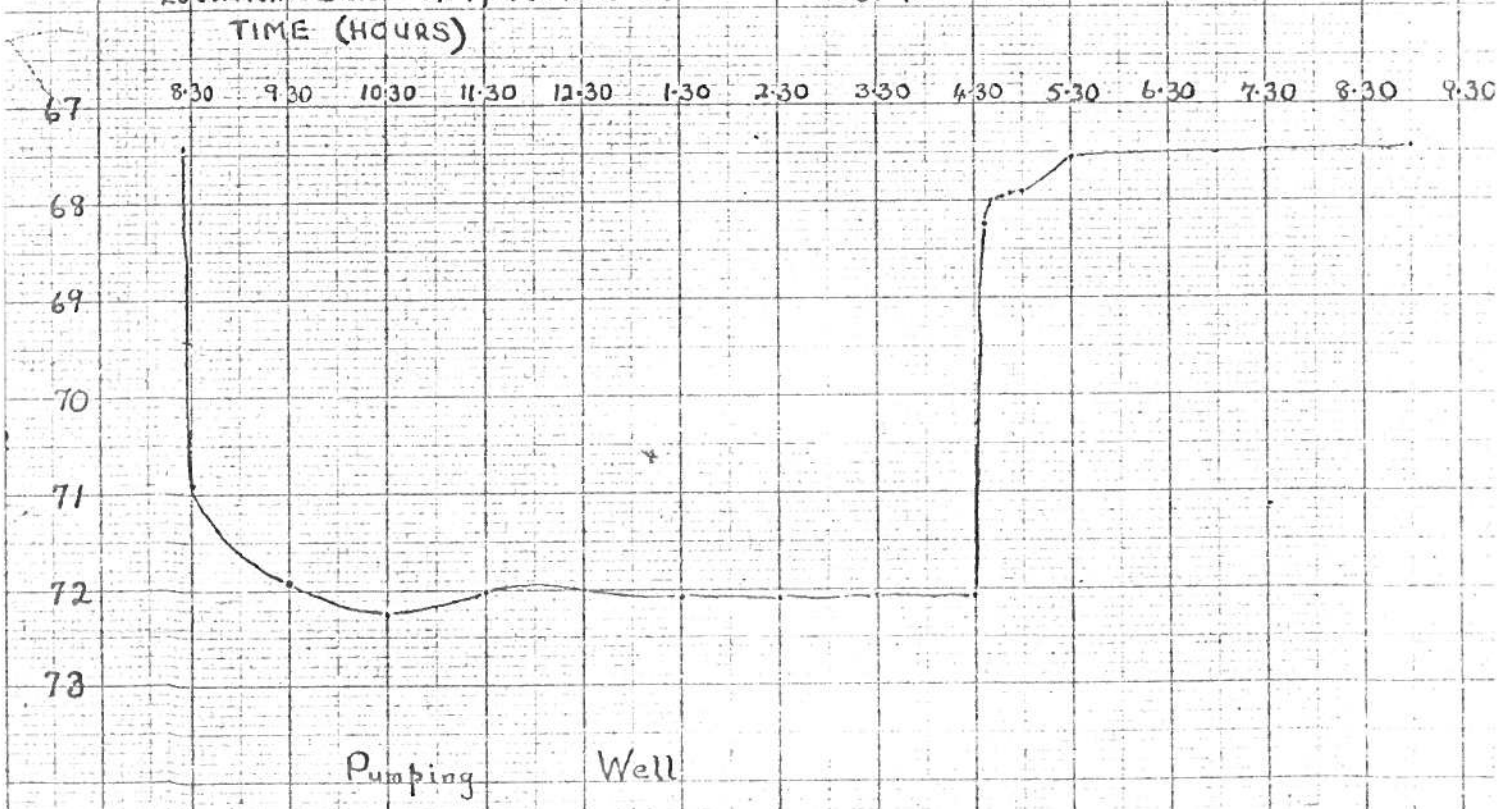
LOCATION:- SW Sec 14 . Tp50. R28. W3 HOLE #22 A

OFR 58-1



LLOYDMINSTER AREA INTERNATIONAL WATER SUPPLY PUMP TEST

LOCATION:- SW Sec 14 Tp 50. R28. W3 TEST HOLE #22

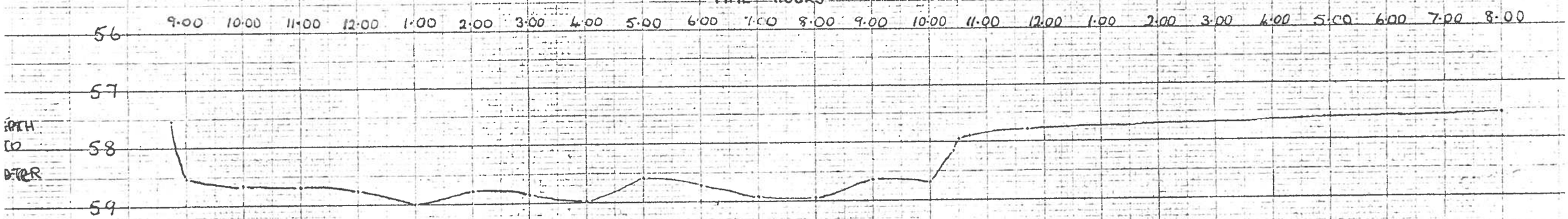


AQUIFER	From 104' – 110'
Pumping Rate	114 g.p.m
Drawdown	4·8 ft
Specific Capacity	2·9 g.p.m/ft d.d.
Maximum Drawdown	36 ft
Maximum Yield	104 g.p.m
Safe Yield (75% of Max)	78 g.p.m

Depth of Well below Pump Base – 114 ft 0 ins

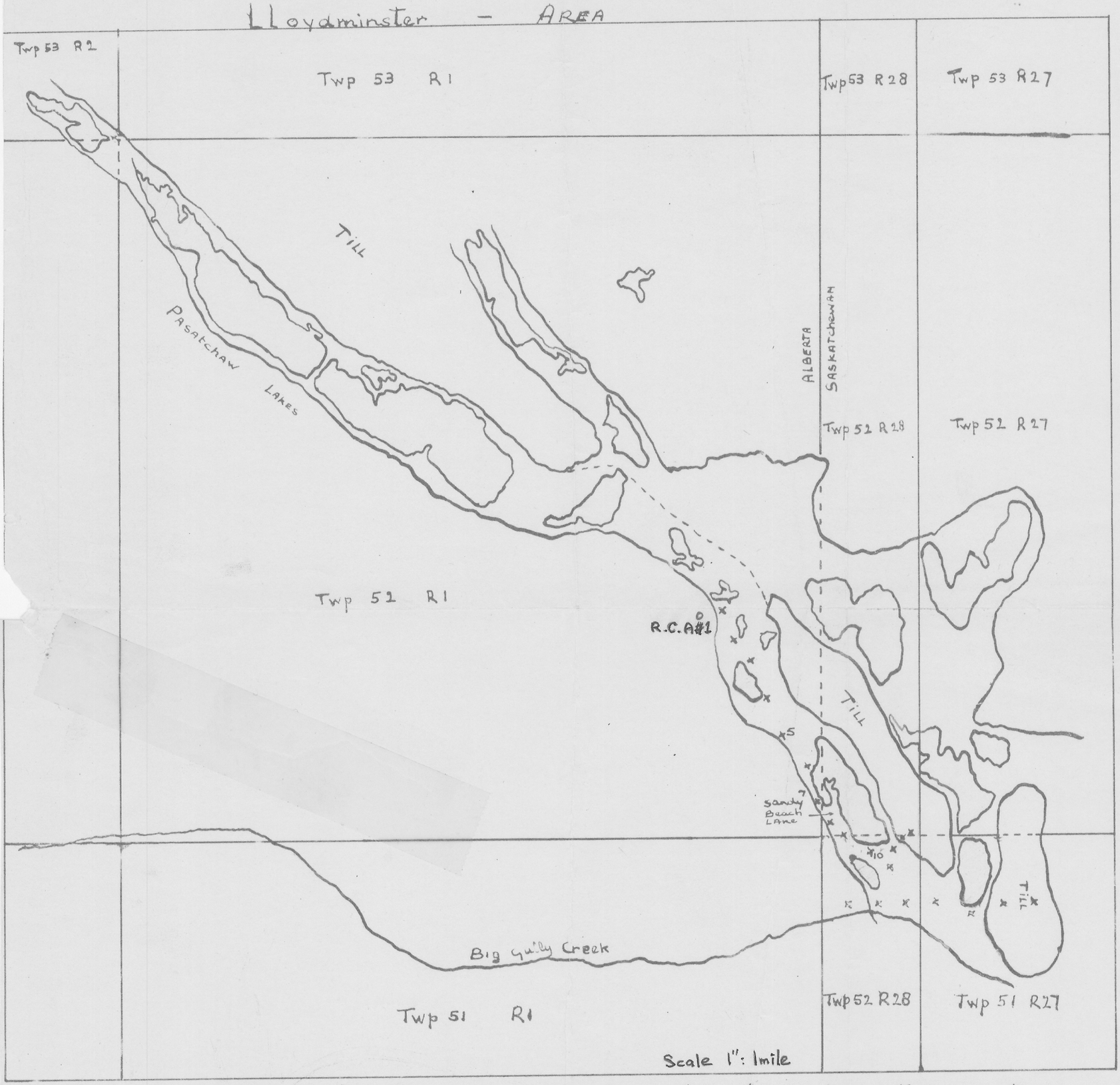
LLOYDMINSTER AREA INTERNATIONAL WATER SUPPLY PUMP TEST OFR 58-1

LOCATION SW Sec 14 Tp 50 R28 W3 TEST HOLE #21



AQUIFER from 74 ft to 76 ft

Pumping Rate	4½ g.p.m.
Drawdown	1½ ft
Specific Capacity	3 g.p.m/ft d.d
Maximum Drawdown	16 ft
Maximum Yield	48 g.p.m.
Safe Yield (75% of Max.)	35 g.p.m.
Depth of Well below Pump Base	84 ft Diss
Top of Screen below Pump Base	74 ft Diss



MAP Showing:

1. AREAL extent of Outwash Sand in Pasatchaw Lake - Sandy Beach Lake stream trench system
2. Upper portion of Big Gully Creek, a Spillway
3. Resistivity Stations marked ××××
4. Research Council testhole # 1 marked ○

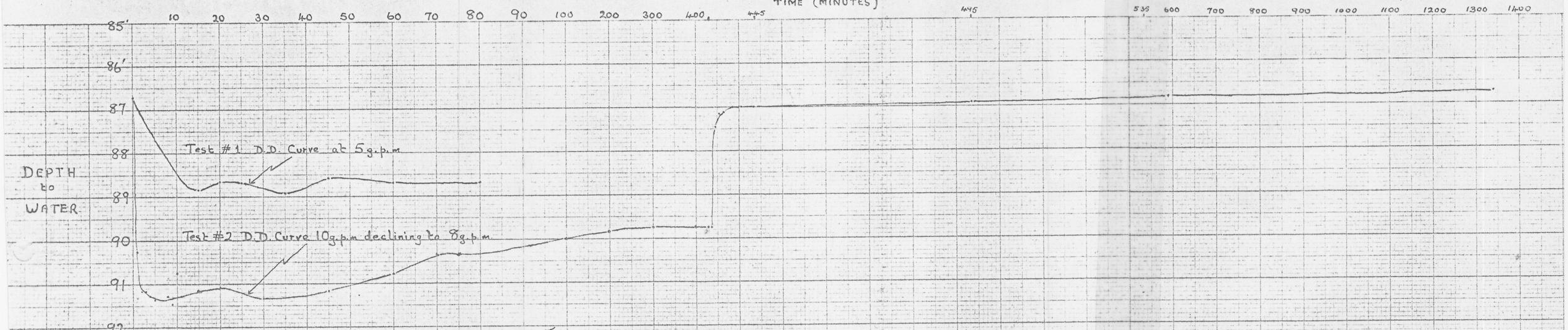
OFR 58-1

LLOYDMINSTER AREA

INTERNATIONAL WATER SUPPLY PUMP TESTS

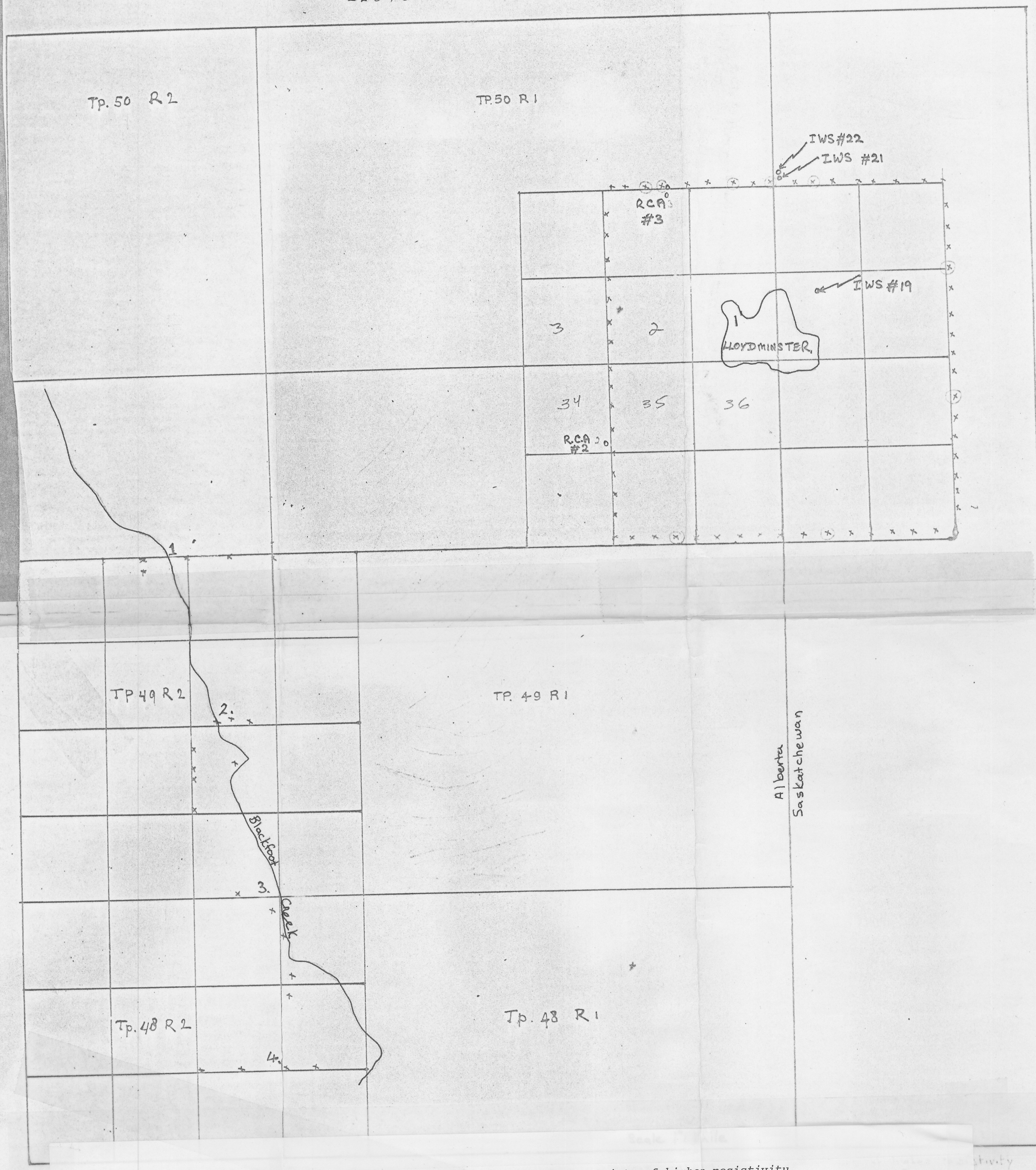
OFR 58-1

LOCATION:- SE Sec. 14 Tp 50 R1 W4



	Test #1	Test #2
AQUIFER from 168'-171'		
Pumping Rate	5 g.p.m	10 g.p.m.
Drawdown	2·2 ft	4·6 ft
Specific Capacity (g.p.m/ft d.d)	2·27	2·17
Maximum Drawdown	81 ft	81 ft
Maximum Yield	184 g.p.m	176 g.p.m.
Safe Yield (75% of Max.)	138 g.p.m	132 g.p.m.
Safe Yield (allowing for declining Spec. Cap.)	95 g.p.m	

LLOYDMINSTER AREA

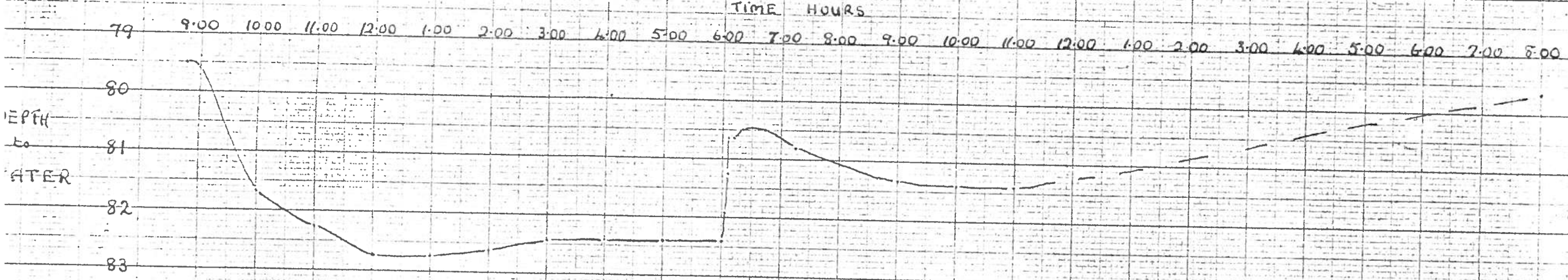


(l) Resistivity stations around Lloydminster. Stations marked x denote points of higher resistivity.
(ll) Resistivity stations in relation to Blackfoot Creek
(lll) Some crevasse-fillings south-west of Lloydminster.
(lv) RCAo2&3 ... Sites of Research Council Test Holes # 2 & #3.

OFR 58-1

LLOYDMINSTER AREA INTERNATIONAL WATER SUPPLY PUMP TEST OFR 58-1

LOCATION NW Sec 2 Tp 50 R 28 W3 TEST HOLE # 19 On Golf Course



AQUIFER from 104 ft

Pumping Rate	4 g.p.m
Drawdown	3 ½ ft
Specific Capacity	1 g.p.m / ft d.d
Maximum Drawdown	29 ft.
Maximum Yield	29 g.p.m
Safe Yield (75% of Max.)	21 g.p.m

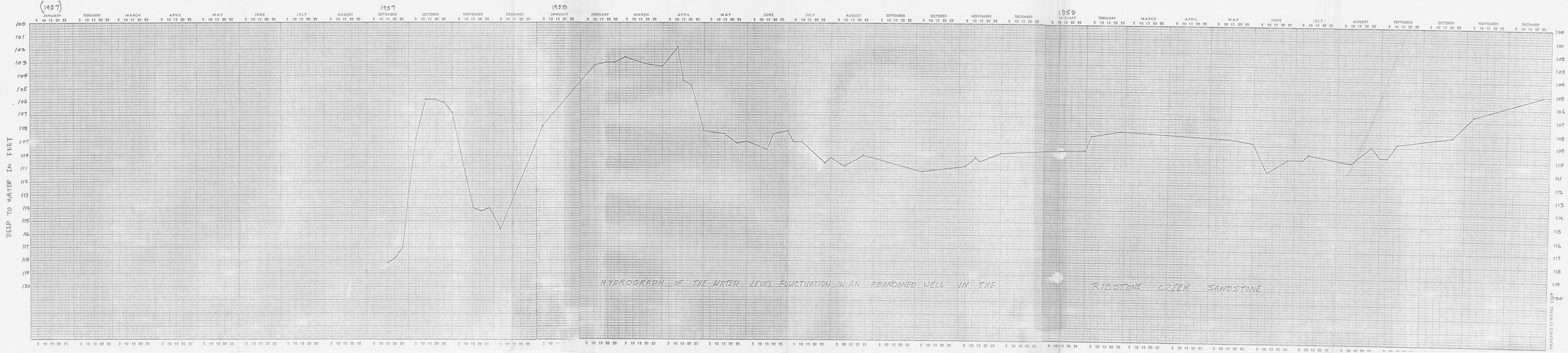
Depth of Well below Pump Base 119'0"

Top of Screen below Pump Base 104'0"

LLOYDMINSTER AREA

OFR58-1

(1957)



LLOYDMINSTER AREA

OFR58-1