

Earth Sciences Report 80-1

Hydrogeology of the Pelican-Algar Lake Area, Alberta

G. Ozoray and A.T. Lytviak

Alberta Research Council
1980

TABLE OF CONTENTS

	Page
Abstract	1
Introduction	1
Acknowledgments	2
Topography and drainage	2
Climate	2
Geology	2
Hydrogeology	3
Data used in map preparation	3
Scale of representation	3
Groundwater levels and flow systems	4
Aquifer lithology	4
Groundwater probability	4
Hydrogeological profiles	4
Hydrochemistry	4
Conclusions	6
References	7

TABLES

Table 1. Hydrochemical samples, represented on figure 1	5
---	---

FIGURES

Figure 1. Characteristic distribution of groundwater chemistries, Pelican-Algar Lake area, Alberta	5
Hydrogeological map, Pelican-Algar Lake, NTS 839-84A, Alberta	in pocket

ABSTRACT

This report describes the hydrogeology of the uppermost 300 m (1000 ft) of sediments in the Pelican-Algar Lake area. Maps and profiles were constructed from existing data and from data collected in a field survey. The 20-year safe yields are mostly over 0.4 L/s (5 igpm). Most bedrock aquifers, however, yield saline water unsuitable for human consumption. Water supplies must be based on shallow aquifers mainly in the drift and Upper Cretaceous Wapiti Formation.

INTRODUCTION

The Pelican (83P) and Algar Lake (84A) map areas are found in northern Alberta between longitudes 112° and 114° west. The Pelican map area, which is between 55° and 56° north latitudes, in Tps 69-81, Rs 13-27, W4 Mer, covers about 14 028 km² (5417 sq mi). The Algar Lake map area lies between latitudes 56° and 57° north, in Tps 81-92, Rs 13-26, W4 Mer and covers about 13 653 km² (5271 sq mi). Topographic maps on 1:50 000 scale are available only for the southwestern corner of the Pelican map area.

In 1974-75, two atlases of 1:63 360 scale (1 in:1 mi) Hydrogeological Information Maps were prepared covering the two NTS map areas. These maps included the very few hydrogeological data available in the Alberta Research Council files and in published literature. A field survey was carried out in 1975 by helicopter, on foot, and (on the southern fringe of the area) by car.

Hydrogeological maps and profiles of the map area were constructed during the winter of 1975-76. The legends of these maps follow the one for the Alberta Hydrogeological Reconnaissance Series (Badry, 1972) and are based on international usage (International Association of Scientific Hydrology, 1970).

In addition to the usual air photo interpretation, ERTS-1 satellite images were also studied and interpreted (Ozora, 1975).

Hydrodynamical and hydrochemical studies, which include the map area or are applicable to it, were

conducted by Hitchon (1963), Meyboom (1967), and van Everdingen (1968). Reeder *et al.* (1972) and Inland Waters Directorate (1976) published some data about surface waters. Carrigy (1965) published a detailed bibliography of the oil sands.

The southern half of the area has some roads: a paved highway (No. 63 to Fort McMurray) crosses the eastern part. Gravelled roads go to Calling Lake, Fawcett Lake, Wabasca and Sandy Lake; the southernmost fringe has some farm roads. Most of the area is without roads. Although there are some forestry airstrips, the greater part of the area can only be reached by helicopter or by a combination of canoe and foot trips.

The area is nearly unpopulated with only small populated places such as Wabasca, Calling Lake and Chipewyan Lake, some farms in the south, scattered forestry ranger stations, cabins, and lookout towers. The area includes the Wabasca and the Jean Baptiste Gambler Indian Reserves, Wabisca and Pelican Settlements, and the Calling Lake Provincial Park.

The vegetation of the area is mainly aspen poplar forest and sphagnum moss-black spruce treed muskeg; lodgepole pine-aspen, lodgepole pine-spruce or jackpine-white spruce forests occur in smaller areas (Government and University of Alberta, 1969).

There is minor farming and ranching in the southern fringe and in the Indian reservations. Lumbering is an important business. The map area contains producing natural gas wells and several undeveloped oil sands fields.

ACKNOWLEDGMENTS

The manuscript was critically read by E. I. Wallick and G. M. Gabert. F. Tuck edited the report.

TOPOGRAPHY AND DRAINAGE

The map area lies within the Alberta High Plains, which is part of the Interior Plains, and includes parts of the Birch Mountains, Pelican Mountain and Stony Mountain Uplands, the Eastern Alberta Plains, and the Algar Plain physiographic regions (Government and University of Alberta, 1969, p. 9).

The highest elevation of the area is more than 915 m (3000 ft) at Pelican Mountain. The lowest point, where the Athabasca River leaves the area, is less than 490 m (1600 ft). This corresponds to a difference in elevation within the area of about 425 m (1400 ft).

The topography is rolling hills and undulating plains. The entire area was covered by the Wisconsin ice-sheet. The landforms are mostly glacial: ground moraine, fluted surfaces, and eskers. There are also glaciofluvial and glaciolacustrine surfaces. Ice-disintegration features (Gravenor and Kupsch, 1959; Stalker, 1960) are widespread.

Some of the rivers have deep-cut valleys, most prominent of which is the Athabasca River with steep, landslide-prone slopes. The Willow River-Wabasca River inland delta separates the North and South Wabasca Lakes. The delta is similar to the Peace River-Athabasca River delta, but on a much smaller scale.

The entire area belongs to the Mackenzie River-Arctic Ocean drainage system and is divided between the Peace River (via the Wabasca River) and the Athabasca River basins. The watersheds of some important tributaries are also separated on the attached hydrogeological map.

The major lakes are the North and South Wabasca, Calling, and Fawcett Lakes, each of which exceeds 25 km² (10 sq mi).

Much of the area is covered by muskeg; the ribbed fen phenomenon is widespread. The activity of

beavers transforms many creeks into a chain of ponds. Signs of repeated slumping were seen on slopes below beaver ponds at the very margin of a plateau. The pond as a water-supplying agent possibly triggered the slumping.

CLIMATE

The entire area is in the "short, cool summer" (Dc) Koeppen zone (Longley, 1972, Fig. 53). About two-thirds of the area is within the climafrost zone (Lindsay and Odynsky, 1965), where the organic soils are only temporarily frozen, although they frequently remain frozen for more than a year.

Isohyets, modified from Longley (1972), are shown on the meteorological side map. Seven summer rain gauges measuring only from May to September were taken into account (Stashko, 1971). Precipitation for October to April was calculated by the same rate as was observed at the nearest meteorological station (Lac La Biche) as 58.4 percent of the May to September rainfall. Unfortunately, these rain-gauge observations are available only for the last few (5 to 8) years. Although these years appear to diverge from the long-term average, no adjustment for that factor to the usual 30-year period was made.

The wettest known point is May Lookout [668 mm (26.3 in)]; the driest one is Wabasca Ranger Station [411 mm (16.2 in)]. (Chipewyan Lake Lookout, with only three years of observations, was not considered.) The area is snowcovered from late October to late April (Potter, 1965, charts 2 and 5).

Near the map area, at Lac La Biche, the mean temperatures are: January, -17.9°C; July, 17.1°C; and 1.2°C annually (Canada Environment, Atmospheric Environment, n.d.). The potential evaporation, estimated from the maps of Bruce and Weisman (1967), exceeds precipitation as an annual mean and also during each month from May to October.

GEOLOGY

During construction of the geological side map and the profiles, data from boreholes, electric and

lithologs, and the available literature were considered. Surface geology or bedrock topography maps were unavailable. As for bedrock geology, the entire area is covered by the 1:1 267 000 scale geological map of Alberta (Green, 1972), the northern half of the area by the geological map of northern Alberta in 1:500 000 (Green *et al.*, 1970).

The oil sands were studied by Carrigy (1965) and Kramers (1974) and the deep-buried salt resources by Hamilton (1971).

Bedrock outcrops are limited to the deepest valleys, especially to that of the Athabasca River. Several Cretaceous units subcrop in the area: the Wapiti, Labiche, Pelican, Joli Fou, Grand Rapids, Clearwater, and McMurray Formations as shown on the geology side map (after Green, 1972). The subcrops are Lower Cretaceous, except for the Labiche Formation, which is Lower and Upper Cretaceous, and the Wapiti Formation, which is Upper Cretaceous in age.

The top of the Devonian, and the Lower Cretaceous McMurray-Wabiscaw, Grand Rapids, and Viking-Pelican Formations are shown on the geological side map by contour lines, mainly based on lithology interpreted from electric logs and the maps of Norris (1963, Fig. 3), Carrigy and Zamora (1960, Fig. 3), Martin and Jamin (1963, Fig. 2), Stewart (1963, Fig. 5), and Kramers (1974, Figs. 9 to 13).

The profiles show the geology down to 150 m (500 ft) above mean sea level. The distinguished bedrock geological units are characterized below.

Devonian strata of limestone, dolomite, shale, and evaporites underlie the entire area, but in the west and south they are too deep to be shown on the profiles. These strata do not outcrop or subcrop in the area. The buried Pre-Cretaceous erosion surface of the Devonian rocks exhibits an advanced state of karst development (Carrigy, 1959; Ozoray, 1977).

The McMurray Formation (Lower Cretaceous, mostly deltaic) and the Wabiscaw Member of the Clearwater Formation are shown together on the profiles and consist of sandstone and shales, mostly oil-saturated (Athabasca oil sands).

The Clearwater Formation contains marine shales and more sandstone than in the neighboring areas.

The Grand Rapids Formation consists of deltaic to marine sandstones and shales. In the Wabasca area, the Grand Rapids Formation includes some oil sands (Kramers, 1974).

The Joli Fou Formation is marine shale.

The Pelican Formation is mainly marine sandstone. The thickness of this formation varies, mainly about 10 to 15 m (30 to 50 ft), although at places it tapers off into a thin sandstone bed.

The Labiche Formation of marine shales is at places up to 300 m (1000 ft) thick. On the electric logs, the marker horizons of the Base of the Fish Scale beds, and the Second and the First White Specks horizons can be recognized. (The Lea Park Formation was undifferentiated from the Labiche Formation on the map and the profiles.)

The drift cover, of variable thickness, is about 60 m (200 ft) at the northern, and between 30 and 180 m (100 and 600 ft) thick at the eastern boundary of the area. Some boreholes seem to cross bedrock-channel fills. Most of the electric logs start deep within the bedrock, so there are not enough data to draw bedrock topography or a drift thickness map, even a sketchy one. The drift consists of a variety of materials such as sand, gravel, silt; these materials are not separated on the map or profiles because adequate data are lacking.

HYDROGEOLOGY

DATA USED IN MAP PREPARATION

The attached maps were constructed using 1719 data points comprised of 251 wells and springs, 585 water chemistry analyses (of both deep and shallow groundwater), 654 electric logs, and 229 Energy Resources Conservation Board stratigraphic logs without groundwater references. The distribution of data, which is unfortunately uneven, is shown on the data density side map.

SCALE OF REPRESENTATION

The scale of the side maps (1:1 000 000) and the vertical exaggeration of the profiles (about 40

times) are the same as usual for the Alberta Hydrogeological Reconnaissance Maps. The scale of the main (hydrogeological) map and the horizontal scale of the profiles are 1:500 000. The vertical scale of the profiles is 1:12 192. The scales selected are the most convenient to portray the available information.

GROUNDWATER LEVELS AND FLOW SYSTEMS

Groundwater level contours were not constructed because of the lack of data. The most characteristic and obvious flow lines are drawn on the profiles, extrapolated from chemical and pressure conditions, lithology of the aquifers, and topography. Groundwater chemistry was a sensitive tool to detect flow systems. The ascending deep groundwater (regional flow system?) can be well detected by its high common salt (NaCl) content, originating from the Middle Devonian evaporites.

A considerable part of the map area is overlain by muskeg, treed muskeg, or wet soil. In such places, the groundwater table is at the surface or very near it, although the water table is occasionally perched. The abundance of muskegs indicates the degeneration of flow systems of those areas, because of the extended periods of soil frost. In this case, most groundwater moves in the upper few metres of the soil (mostly organic deposits), parallel to the surface, in contrast to the more deeply penetrating normal groundwater flow of areas of shorter frost periods. On the surface, the elongated crescents of ribbed fens or other solifluctional phenomena are seen.

AQUIFER LITHOLOGY

The hydrogeological profiles generalize the lithology of each rock unit. The Devonian is shown as limestones; the McMurray, Clearwater, Grand Rapids, and Wapiti Formations as shale and sandstone; the Pelican Formation as sandstone; the Joli Fou and Labiche Formations as shale. The oil saturated beds ("oil sands") are separated on the profiles. Drift is usually represented by an undivided "sand, gravel and silt" lithology.

The main map shows the lithology of the main aquifer within the uppermost 300 m (1000 ft): the

Devonian rocks, the Grand Rapids Formation, or the drift, as the case may be.

GROUNDWATER PROBABILITY

The average available 20-year safe yield from the upper 300 m (1000 ft) of strata is shown on the main map by color-coded areas. The area around a well that was tested and some areas where adequate tests were conducted on the neighboring map areas are shown by firm colors. Elsewhere, yield estimates, based on lithology, electric logs, and topography, are shown by pale colors.

HYDROGEOLOGICAL PROFILES

Four hydrogeological profiles were constructed. The profiles show the 20-year safe yield of the important formations, ignoring the individual aquifers. The color-coded main map shows the sum of the yields of the formations in the upper 300 m (1000 ft). Because of the logarithmically chosen yield scale, the highest yielding formation dominates.

Topography, stratigraphy, generalized lithology of the formations, flow systems, groundwater chemistry, and important observation points (wells, testholes) are also shown on the profiles.

HYDROCHEMISTRY

To evaluate the groundwater chemistry, 540 water analyses were considered. Of these, 9 were from spring waters and 12 from surface waters. Bedrock and drift chemistry maps were constructed, but the areal distribution of the sampling points precluded the construction of total dissolved solids isolines. The bedrock analyses were separated into four groups according to formation tops. These four groups, plus drift waters, are compiled in Table 1. Included in the table are the number of samples considered, the total dissolved solids, and the dominant anions and cations. The total dissolved solids and dominant ions are tabled as percent fractions of total analyses falling within each of the categories in the left column. The unaccounted fractions in the dominant ion portion of the tables represent mixed waters; an ion was considered

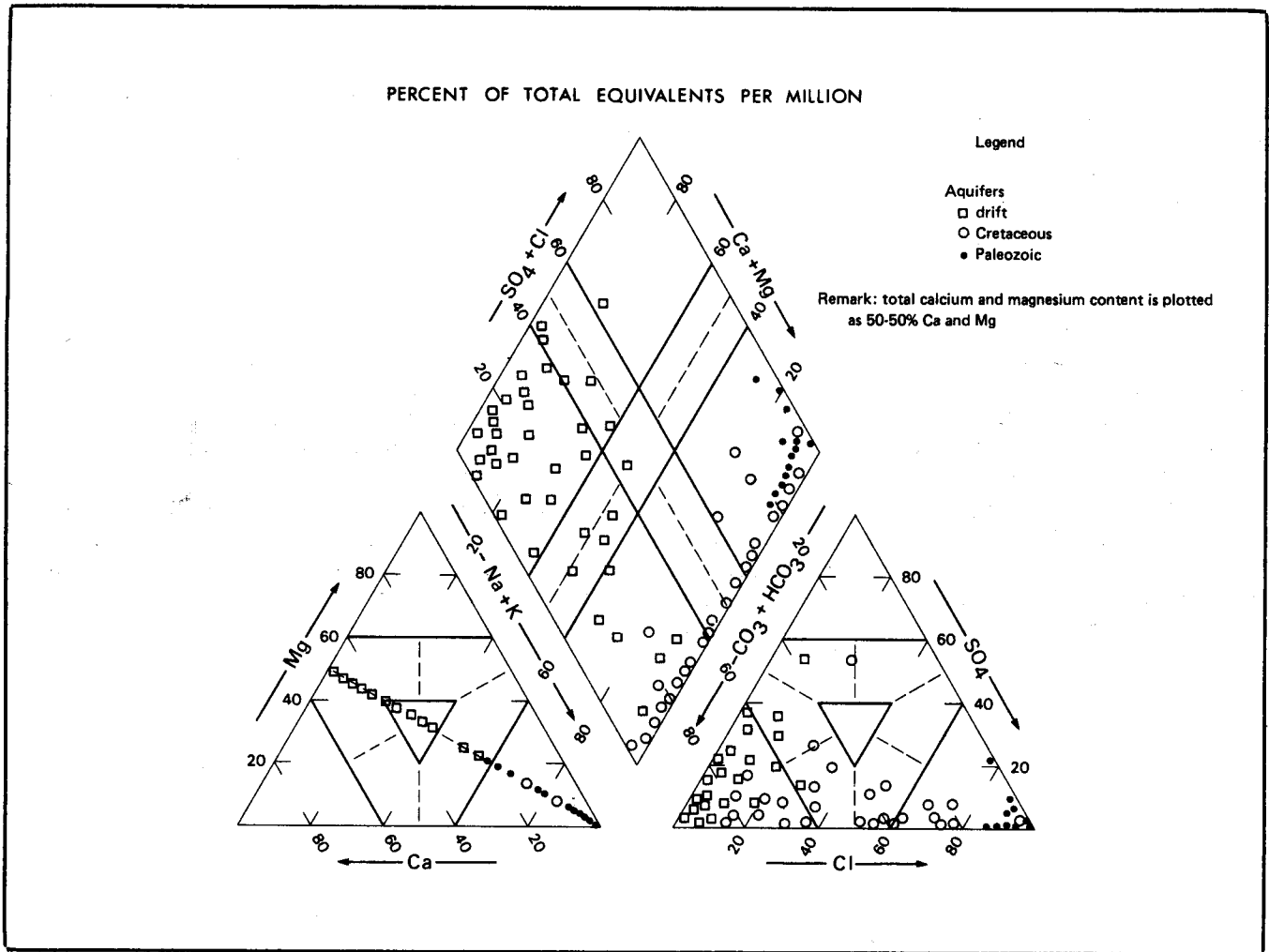


FIGURE 1: Characteristic distribution of groundwater chemistries, Pelican-Algar Lake area, Alberta

TABLE 1.
 Hydrochemical samples, represented on figure 1

	Drift	Pelican	Grand Rapids	McMurray	Paleozoic
No. of samples	136	35	53	112	182
TDS < 1000 mg/l	80%	0%	0%	1%	0%
TDS 1000-10000 mg/l	20%	80%	77%	62%	31%
TDS > 10000 mg/l	0%	20%	23%	37%	69%
Ca + Mg*	81%	0%	0%	0%	0%
Na + K*	12%	100%	100%	100%	100%
CO ₃ + HCO ₃ *	78%	26%	28%	22%	14%
SO ₄ *	5%	0%	0%	0%	0%
Cl*	0%	54%	53%	53%	78%

*being the predominant cation/anion

dominant when it constituted 60 percent or more of the total anions or cations.

In the drift waters, the dominant cations were calcium and magnesium and in bedrock, sodium and potassium. Drift anions were predominantly carbonate and bicarbonate, with the exception of an area around the Wabasca Lakes where sulfate was predominant. The dominant anion in the Pre-Cretaceous waters was chlorine, with the exception of a small area of mixed waters centered on Sandy Lake. The anions in the other three bedrock units exhibited patterns with chlorine dominant under the Pelican Mountain and Stoney Mountain Uplands. Surrounding these uplands, the bedrock waters were of mixed type, with carbonate and bicarbonate increasing northward, becoming dominant north of Tp 77. This change in character from chlorine waters to carbonate and bicarbonate corresponds to a decrease in depth and in total dissolved solids. The high chlorine waters general-

ly have a total dissolved solids content of 10 000 mg/L or greater. The drift waters have total dissolved solids of generally less than 1000 mg/L. The bedrock chemistry map was constructed to depict a characterization of Cretaceous waters.

Figure 1 (a Piper diagram) shows some characteristic distributions of chemistries.

CONCLUSIONS

Yields of more than 0.4 L/s (5 igpm) can be found nearly everywhere in the area and yields of 8 L/s (100 igpm) can be estimated for areas of thick drift. Groundwater from the drift is usually of acceptable quality. The bedrock aquifers, however, usually contain saline water that is unsuitable for human consumption. In the northeastern part of the area, where the yield classification is due to bedrock aquifers, the yield rank may pertain to saline groundwater.

REFERENCES

- Badry, A. (1972): A legend and guide for the preparation and use of the Alberta Hydrogeological Information and Reconnaissance map series; Alberta Research Council, Earth Sciences Report 72-12, 96 p.
- Bruce, J. P. and B. Weisman (1967): Provisional evaporation maps of Canada; Canada Department of Transport, Meteorological Branch, 21 p.
- Canada Environment, Atmospheric Environment (n.d.): Temperature and precipitation 1941-1970, Prairie Provinces; Downsview, Ontario, 159 p.
- Carrigy, M. A. (1959): Geology of the McMurray Formation: Part III. General geology of the McMurray area; Alberta Research Council, Memoir 1, 130 p.
- _____(1965): Athabasca Oil Sands bibliography (1789-1964); Alberta Research Council, Earth Sciences Report 65-3, 91 p.
- Carrigy, M. A. and M. J. Zamora (1960): The Athabasca Oil Sands; *in* Oil Fields of Alberta; Alberta Society of Petroleum Geologists, p. 38-49.
- Gravenor, C. P. and W. O. Kupsch (1959): Ice-disintegration features in Western Canada; *Journal of Geology*, Vol. 67, p. 48-64.
- Green, R. (1972): Geological Map of Alberta; Alberta Research Council, Map 35, scale 1:1 267 000.
- Green, R., M. A. Carrigy and G. B. Mellon (1970): Bedrock geology of northern Alberta (map with descriptive notes); Alberta Research Council Map, scale 1:500 000.
- Government and University of Alberta (1969): Atlas of Alberta; University of Alberta Press in association with University of Toronto Press.
- Hamilton, W. N. (1971): Salt in east-central Alberta; Alberta Research Council, Bulletin 29, 53 p.
- Hitchon, B. (1963): Composition and movement of formation fluids in strata above and below the pre-Cretaceous unconformity in relation to the Athabasca Oil Sands; *in* the K. A. Clark Volume, Alberta Research Council, Information Series 45, p. 63-74.
- Inland Waters Directorate (1976): Surface water data, Alberta, 1975; Environment Canada, Ottawa, Ontario, 218 p.
- International Association of Scientific Hydrology (1970): International legend for hydrogeological maps; Publication 98 (and UNESCO); Gentbrugge, Belgium, 101 p.
- Kramers, J. W. (1974): Geology of the Wabasca A oil sand deposit; Canadian Society of Petroleum Geologists, Memoir 3, p. 68-83.
- Lindsay, J. D. and W. Odynsky (1965): Permafrost in organic soils of northern Alberta; *Canadian Journal of Soil Science*, Vol. 45, p. 265-269.
- Longley, R. W. (1972): The climate of the prairie provinces; Environment Canada, Atmospheric Environment, Climatological Studies 13; Toronto, Ontario, 79 p.
- Martin, R. and F. G. S. Jamin (1963): Paleogeomorphology of the buried Devonian landscape in northeastern Alberta; *in* the K. A. Clark Volume, Alberta Research Council, Information Series 45, p. 31-42.
- Meyboom, P. (1967): Interior plains hydrogeological region; *in* Groundwater in Canada; Geological Survey of Canada Economic Geology Report 24, p. 131-158.
- Norris, A. W. (1963): Devonian stratigraphy of northeastern Alberta and northwestern Saskatchewan; Geological Survey of Canada, Memoir 313, 168 p.
- Ozoray, G. (1975): Lineament analysis using ERTS-1 images of Alberta; International Seminar and Exposition on Water Resources Instrumentation, Chicago, June 4-6, 1974, Proceedings, Volume 2, p. 456-466.

- _____(1977): The Athabasca carbonate and evaporite buried karst (Alberta, Canada); International Association of Hydrogeologists, Memoir 12, p. 85-98.
- Potter, J. G. (1965): Snow cover; Climatological Studies No. 3, Canada Department of Transport, Meteorological Branch, 69 p.
- Reeder, S. W., B. Hitchon and A. A. Levinson (1972): Hydrogeochemistry of the surface waters of the Mackenzie River drainage basin, Canada — 1. Factors controlling inorganic composition; *Geochimica et Cosmochimica Acta*, Vol. 36, p. 825-865.
- Stalker, A. Mac S. (1960): Ice-pressed drift forms and associated deposits in Alberta; Geological Survey of Canada, Bulletin 57, 38 p.
- Stashko, E. V. (1971): Precipitation means, Alberta forestry stations, May to September 1963-1970, 32 p.
- Stewart, G. A. (1963): Geological controls on the distribution of Athabasca oil sands reserves; *in* the K. A. Clark Volume; Alberta Research Council, Information Series 45, p. 15-26.
- van Everdingen, R. O. (1968): Studies of formation waters in Western Canada; *Geochemistry and hydrodynamics*; Canadian Journal of Earth Sciences, Vol. 5, p. 523-543.

ERRATA TO MAIN MAP LEGEND

At the centre of Profile C-C' (in line with Tp 78-79 on the main map), the letter symbol connected to two small, yellow colored areas is correctly Kg (not Km). The correct graphic symbol of the two relevant yellow colored areas are that of the "Oil impregnated sandstone and shale".

Main Map Legend, the symbol of the Pelican Formation should be correctly: Kpl (not Kp); also Kpl should be read (instead of Kp) on Profile A-A', top of right centre.

Main Map Legend, Groundwater Probability, the explanation of the yellow color symbol is correctly: "1 (<0.1)".



MAIN MAP LEGEND

Topography

Surface contours and elevation in feet (interval 500 feet)

Geology

Geological boundary

QUATERNARY

- Qd Unconsolidated deposits
- Qsg Sand and gravel or sand and silt and gravel
- Qs Sand

CRETACEOUS

- Kwl Wapiti Formation
- Klb Latiche Formation
- 1WS First White Specks Zone
- 2WS Second White Specks Zone
- Bfsc Base of the Fish Scale Zone
- Kp Pelican Formation
- Kj Joli Fou Formation
- Kg Grand Rapids Formation
- Kc Clearwater Formation
- Km McMurray Formation

DEVONIAN

- D Devonian Limestone

Lithology

- Sand and gravel
- Sand and silt and gravel
- Sand
- Sandstone
- Shale
- Shale and sandstone
- Oil impregnated sandstone and shale
- Carbonate

Hydrography

- Lake or slough, perennial
- Lake or slough, seasonal
- Marsh, meadow
- Stream, perennial
- Stream, intermittent
- Surface water divide

Groundwater Probability?

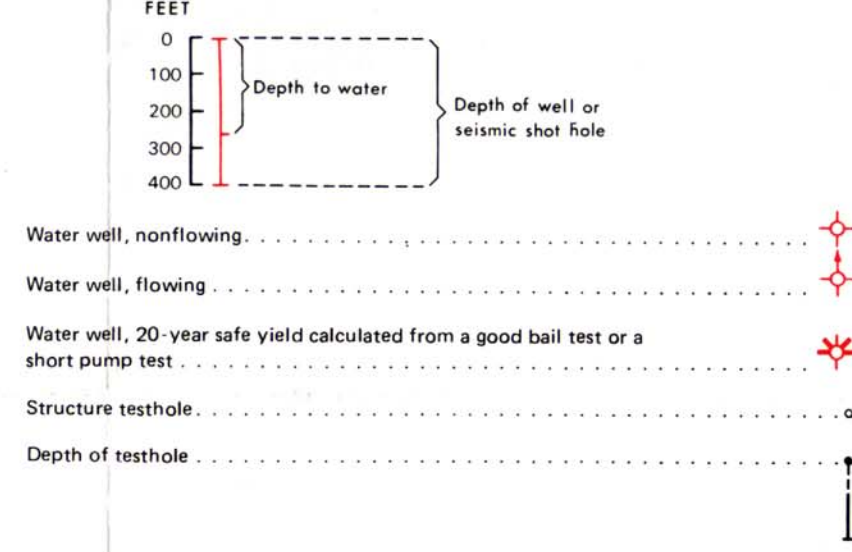
- Range of average expected yield of wells in imperial gallons per minute (L/sec)
- | | |
|--|--------------------|
| Probable, estimated from quantitative information (pump tests, bail tests, etc.) | 100 - 500 (8 - 38) |
| Possible, estimated from qualitative information (flow regime, lithology, etc.) | 25 - 100 (2 - 8) |
| | 5 - 25 (0.4 - 2) |
| | 1 - 5 (0.1 - 0.4) |
| | 1 (0.1) |

Boundary of yield area

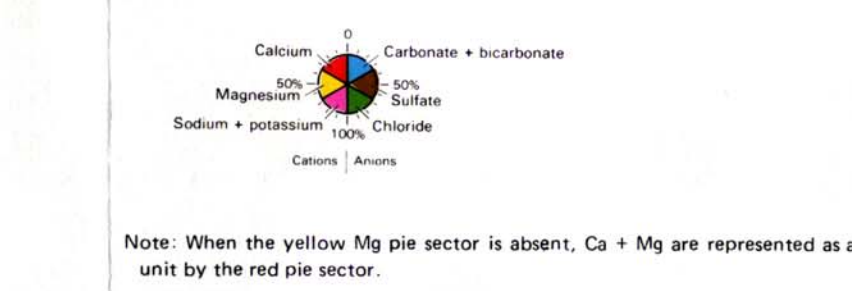
The indicated average expected yields to wells are predictions based on the best data available at the time of map compilation; due to data shortcomings and special conditions, local discrepancies between predicted and actual yields are inevitable. Multi-aquifer completion may be necessary to obtain the yield indicated.

Wells and Other Artificial Works

Depth scale

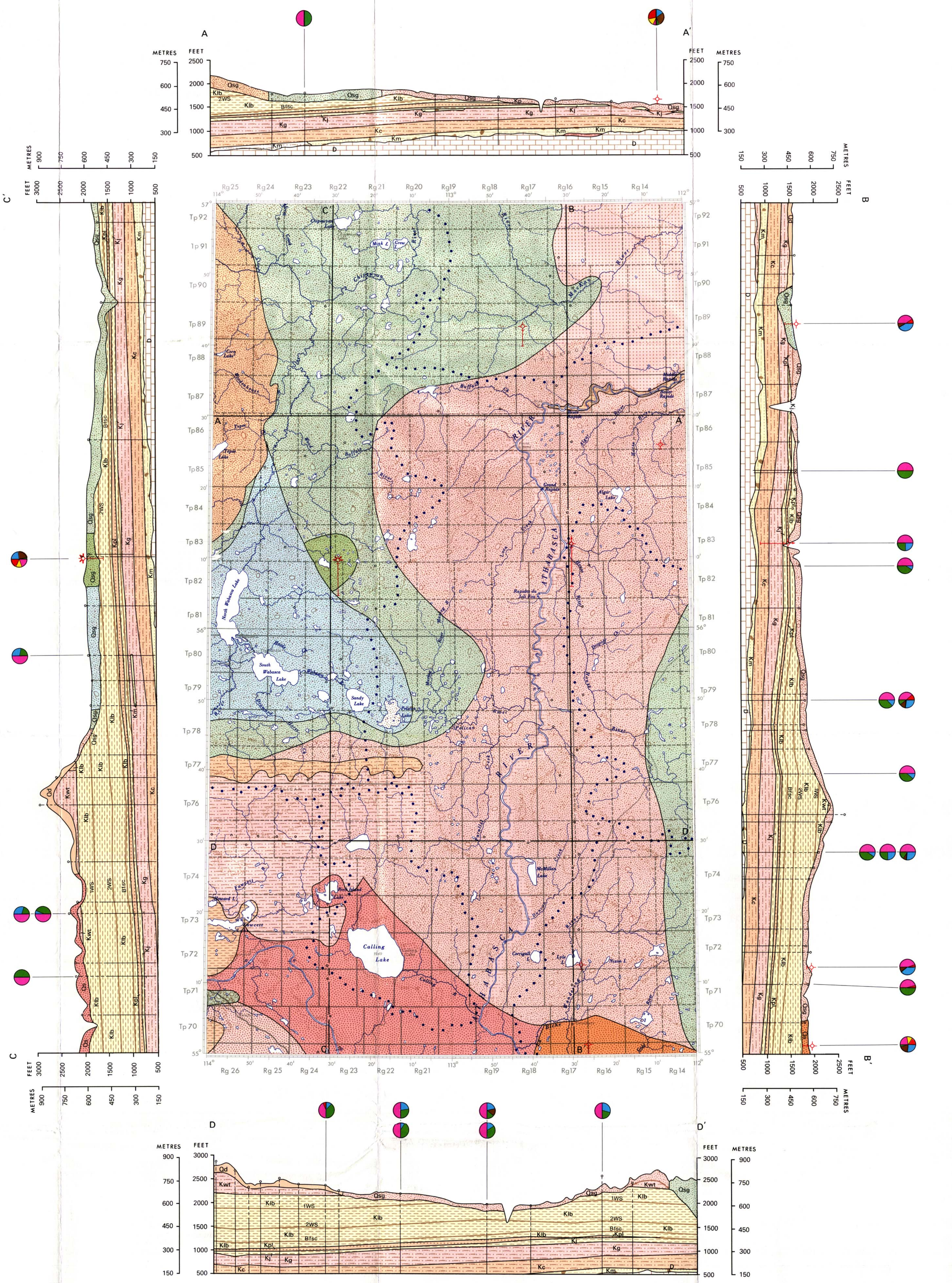
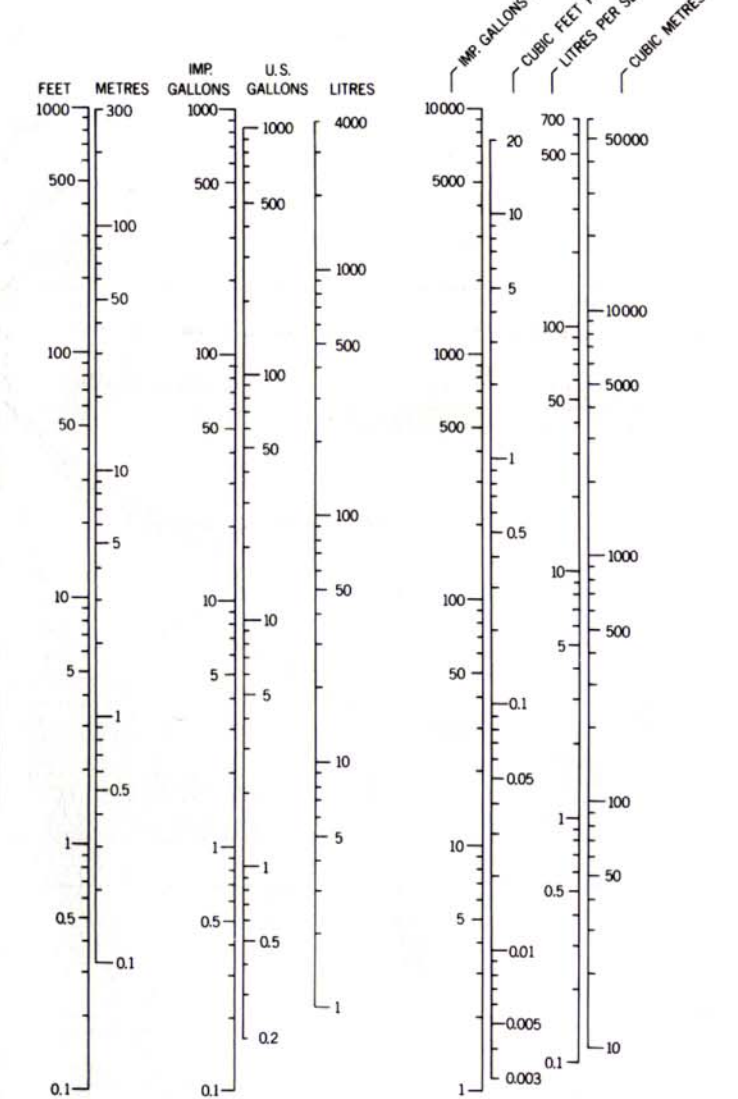


Hydrochemistry



CONVERSION TABLE

LOGARITHMIC SCALE



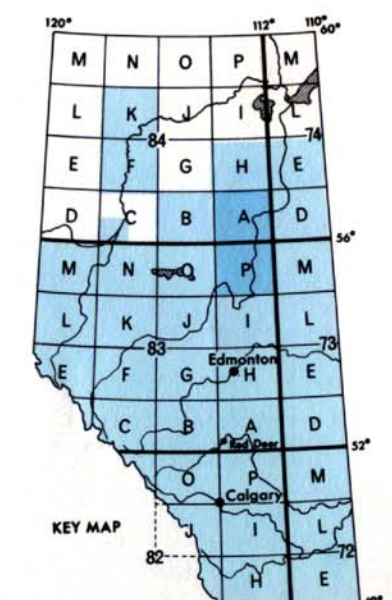
All elevations in feet and metres above mean sea level. Vertical exaggeration of the hydrogeological profiles is approximately 40X.

An expanded legend and explanatory notes (Earth Sciences Report 72-12) for use with this hydrogeological map series is available from Alberta Research Council, Edmonton, Canada.

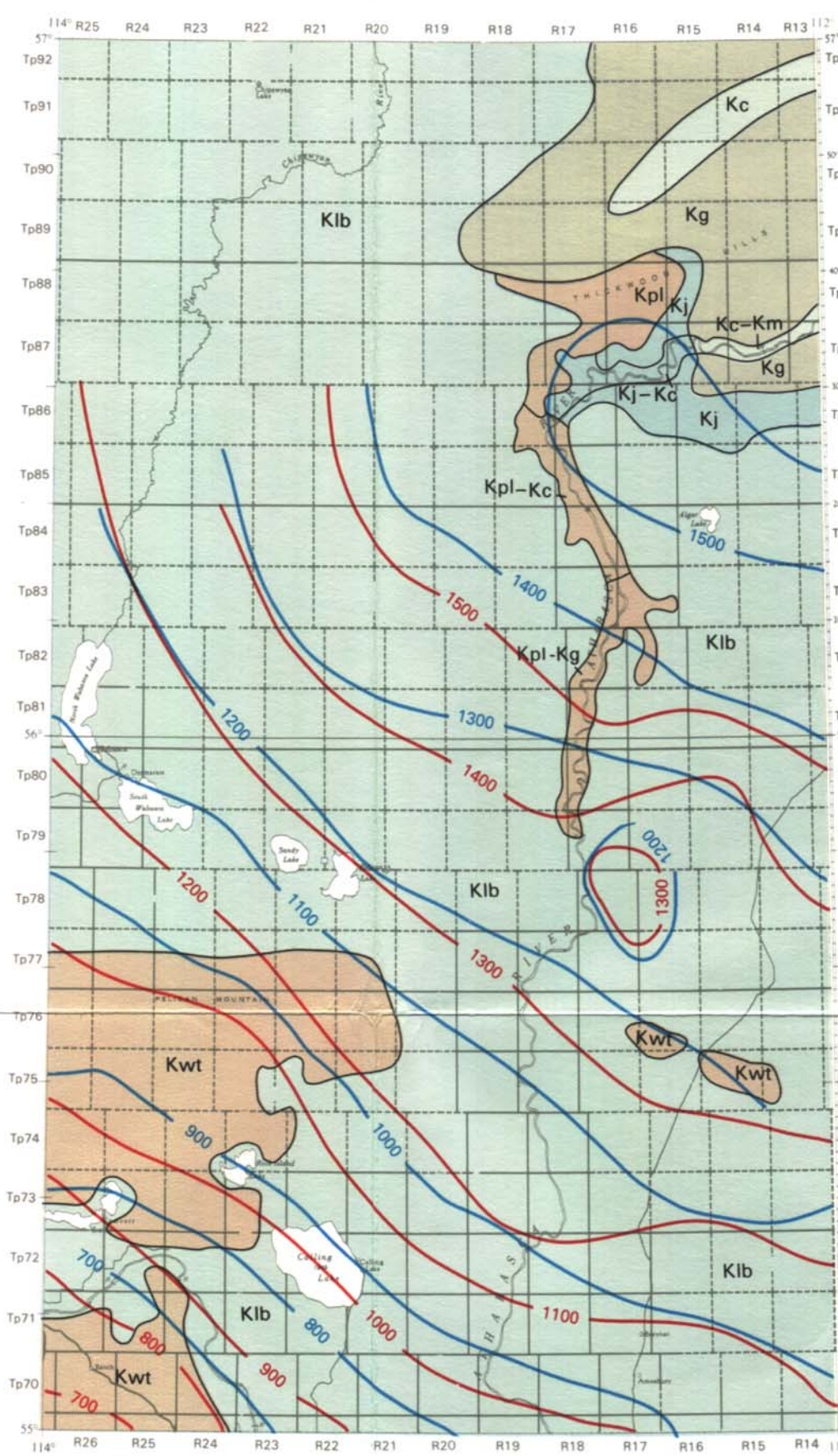
Map to accompany Earth Sciences Report 80-1. Hydrogeology by G. Orsary. Drafted by J.K. Mattheis.

**HYDROGEOLOGICAL MAP
PELICAN - ALGAR LAKE
ALBERTA**

NTS 83P-84A



GEOLOGY I

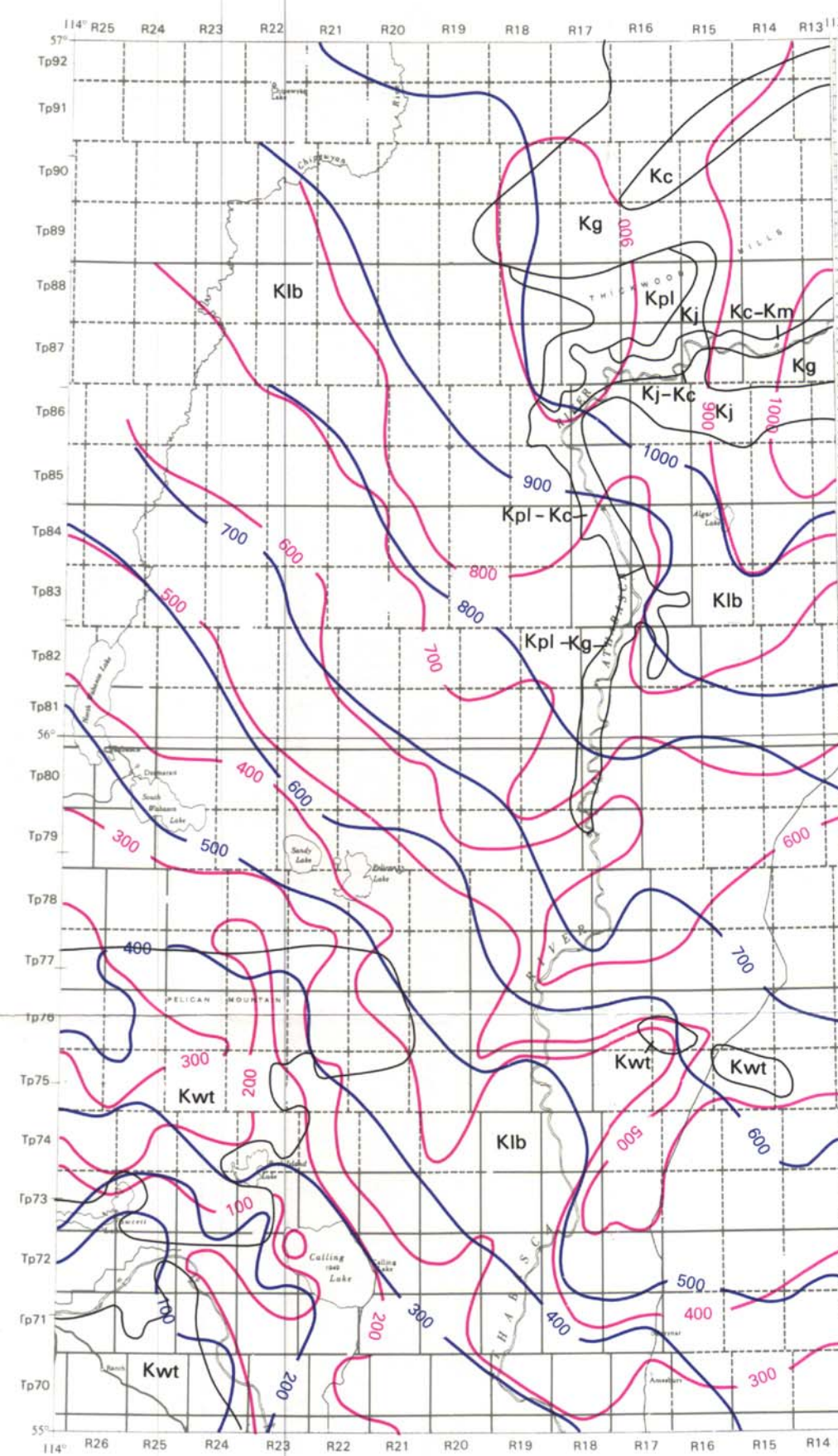


LEGEND

Kwt Wapiti Formation: grey feldspathic, clayey sandstone; grey bentonitic mudstone and bentonite; scattered coal beds; nonmarine.
Kib Labiche Formation: dark gray shale beds and silty shale; ironstone partings and concretions; silty fish scale bearing bed in lower part; marine.
Kpl Pelican Formation: fine-grained quartzose sandstone, silty and glauconitic in lower part; marine.
Kk Joli Fou Formation: dark grey fossiliferous shale, silty interbeds in upper part; marine.
Kg Grand Rapids Formation: fine-grained quartzose and feldspathic sandstone, laminated siltstone and silty shale; thin coal beds; shoreline complex.
Kc Clearwater Formation: dark grey fossiliferous, silty shale; laminated siltstone and fine-grained cherty sandstone; glauconitic sandstone (Wabiskaw Member) near base; marine.
Kkm McMurray Formation: thick-bedded quartzose sandstone and siltstone; oil-impregnated; grey silty shale interbeds in upper part; nonmarine to diatitic.

Rock unit boundary
 Structure contour on top of Viking-Pelican Sandstone (ft. amsl) 700
 Structure contour on top of Grand Rapids Formation (ft. amsl) 900

GEOLOGY II

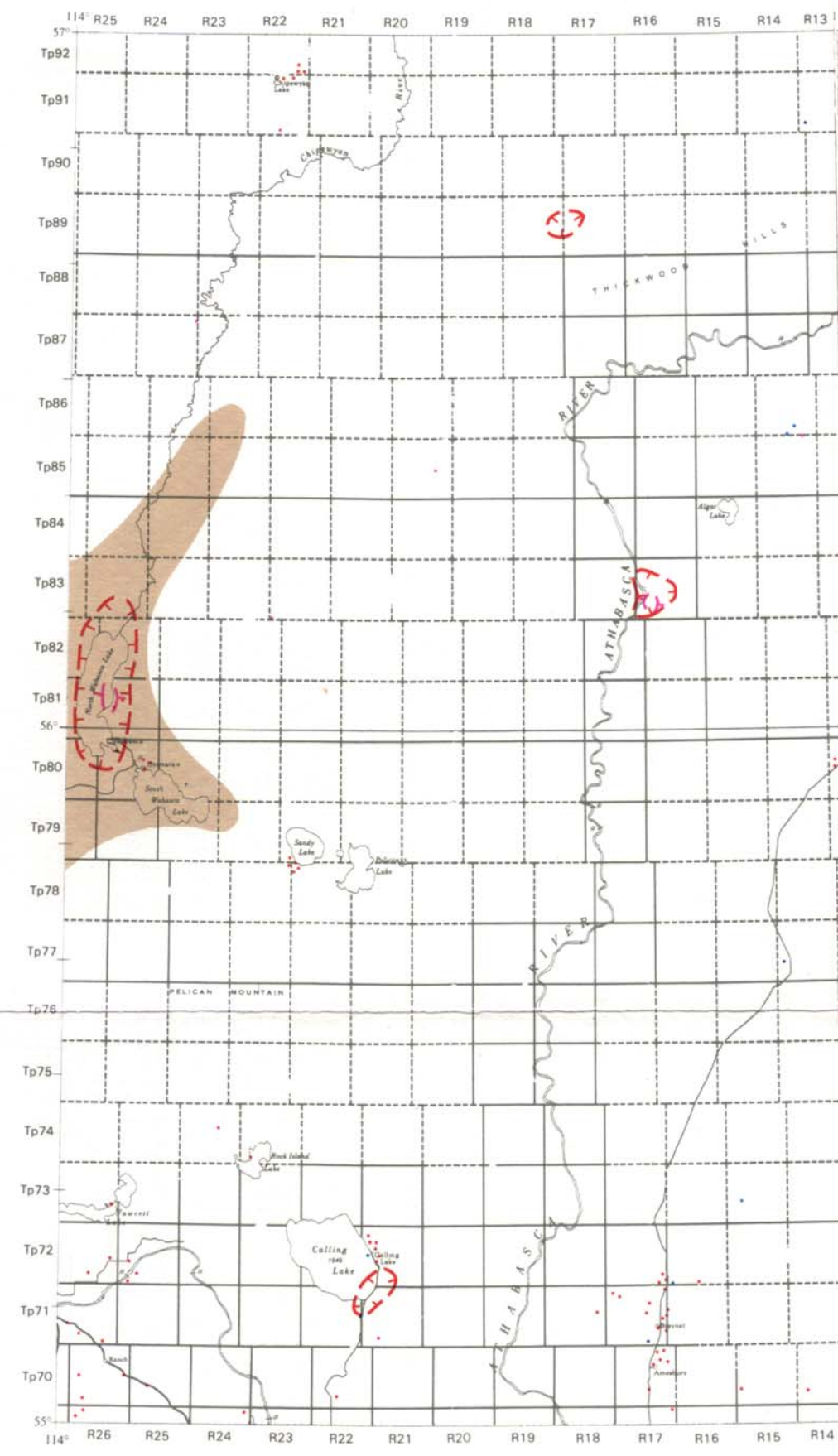


LEGEND

Kwt Wapiti Formation
Kib Labiche Formation
Kpl Pelican Formation
Kk Joli Fou Formation
Kg Grand Rapids Formation
Kc Clearwater Formation
Kkm McMurray Formation

Rock unit boundary
 Structure contour on top of the Devonian (ft. amsl) 400
 Structure contour on top of the McMurray-Wabaska Sandstone (ft. amsl) 800

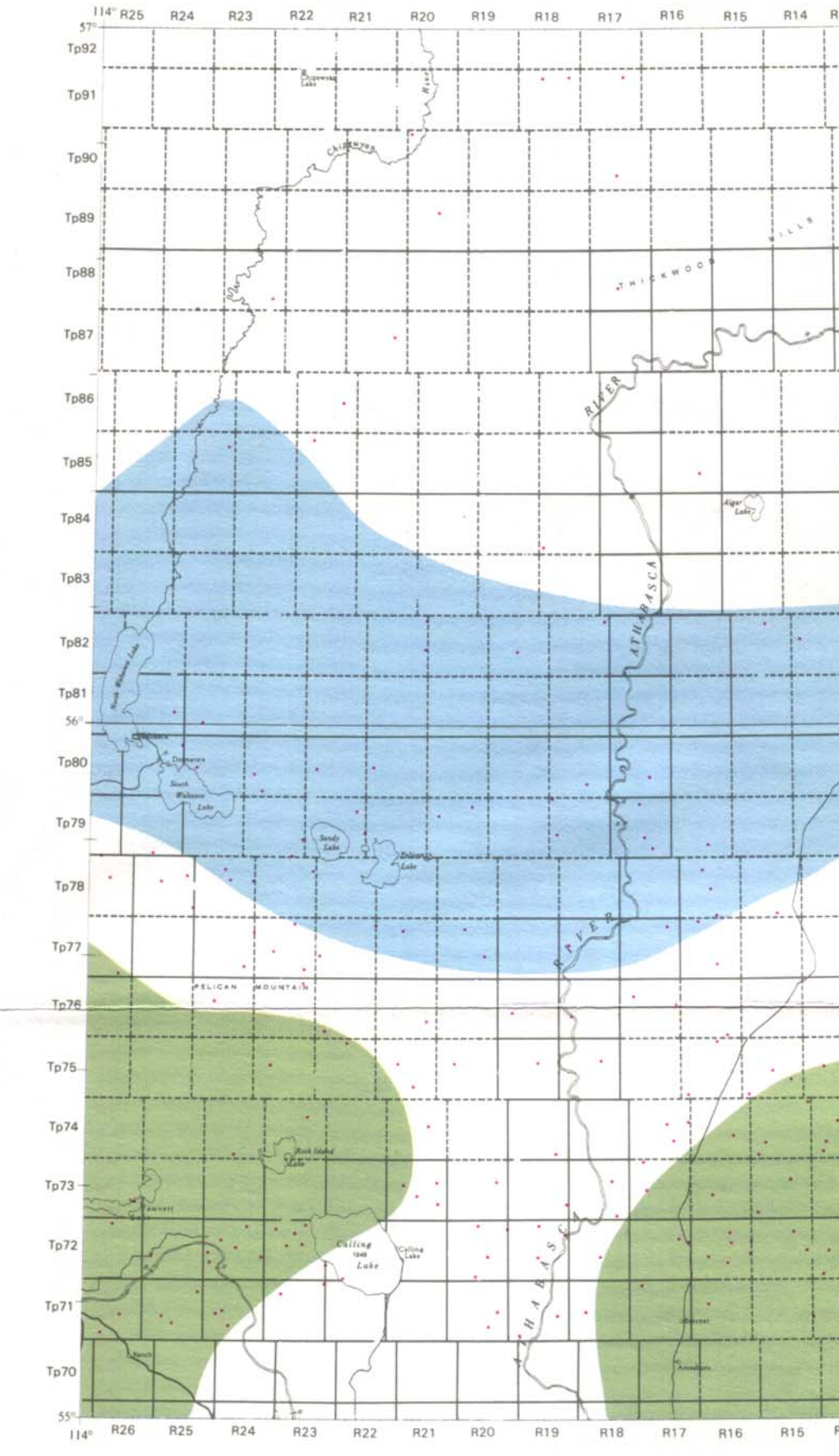
HYDROCHEMISTRY: DRIFT



LEGEND

Data control point marking the location of a water well
 Data control point marking the location of a surface feature
 Data control point marking the location of a spring
 Data control point marking the location of a structure testhole
 Sulfate constituting over 60 percent of total anions*
 Isogram along which calcium and magnesium constitute 60 percent of total cations*; teeth indicate direction of lesser calcium and magnesium content:
 approximate
 Isogram along which sodium and potassium constitute 60 percent of total cations*; teeth indicate direction of lesser sodium and potassium content:
 approximate
 *determine on equivalents per million basis.

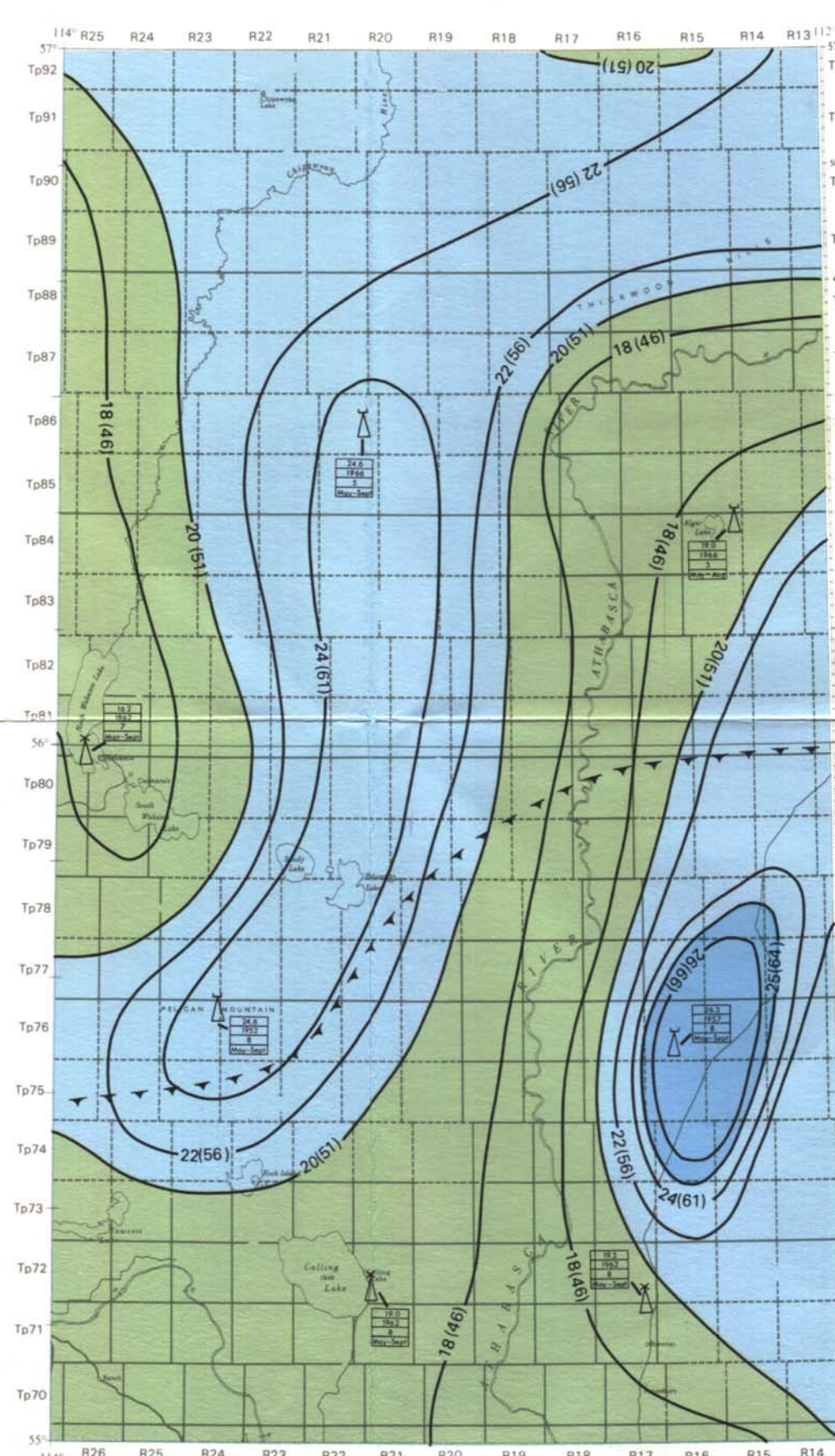
HYDROCHEMISTRY: BEDROCK



LEGEND

Data control point marking the location of a structure testhole
 Carbonate and bicarbonate constituting over 60 percent of total anions*
 Chloride constituting over 60 percent of total anions*
 *determined on equivalent per million basis.

METEOROLOGY



LEGEND

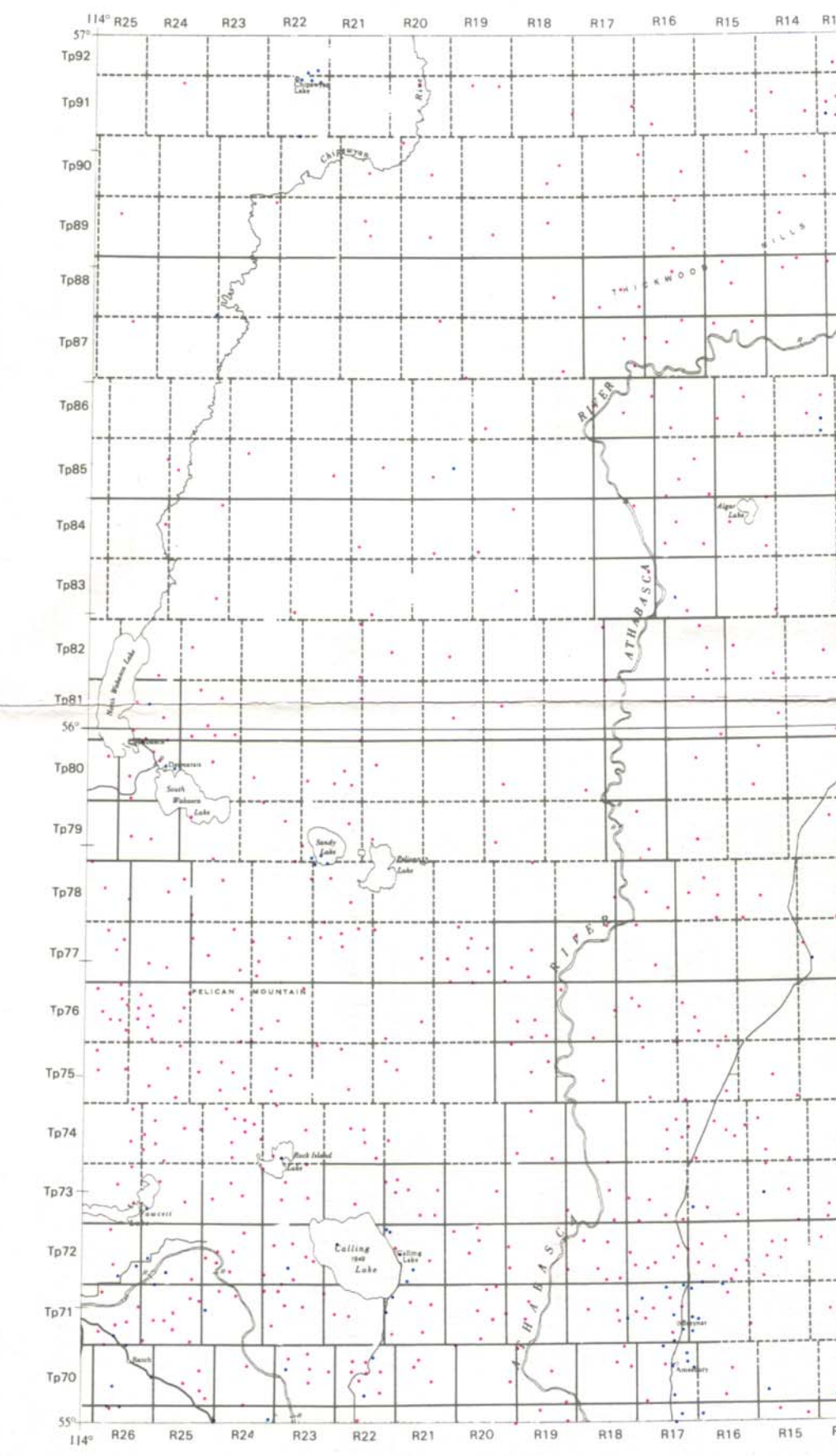
Isohyet, mean annual precipitation in inches (cm) 18(45)
 Mean annual precipitation in inches (cm):
 15 to 20 inches (38 to 51 cm)
 20 to 25 inches (51 to 64 cm)
 25 to 30 inches (63 to 76 cm)

Boundary of climofrost (teeth point toward frost-free area)
 Meteorological station
 Standard rain gauge
 Precipitation data:
 Mean annual precipitation estimated in inches
 Year of commencement of observations
 Number of years in average
 Months of record
 Source: The climate of the Prairie Provinces (R.W. Longley, 1972)
 Precipitation Means, Alberta Forestry Stations (Stankov, 1971)
 Permafrost in organic soils of Northern Alberta (Lindsay and Odynsky, 1966)

LEGEND

Data control point marking the location of a water well with no yield data
 Data control point marking the location of a well with yield data
 Data control point marking the location of a hydrologic surface feature
 Data control point marking the location of a structure testhole with lithology or E-log only
 Data control point marking the location of a water well with no yield data
 Data control point marking the location of a well with yield data
 Data control point marking the location of a hydrologic surface feature
 Data control point marking the location of a structure testhole with lithology or E-log only

DATA DENSITY



ALL MAPS
 SCALE 1:100,000
 Miles 0 10 20
 Kilometers 0 10 20 30

HYDROGEOLOGICAL MAP
 PELICAN-ALGAR LAKE
 ALBERTA
 NTS 83P-84A