b) Surficial Aquifers

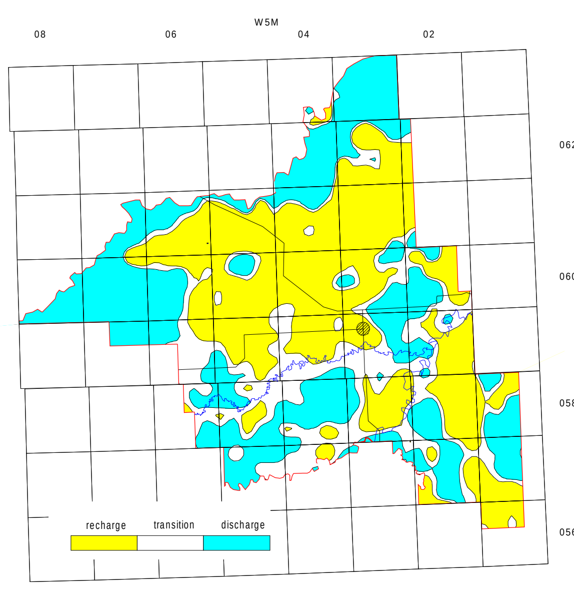
Within the County, there are 113 control points for the NPWL in the unconsolidated sediments, with most townships having less than 5 control points. This number of control points for the entire County is too few to prepare a meaningful regional NPWL map for the unconsolidated sediments. A digital water-level surface has been prepared for reference purposes. To prepare the NPWL surface, seeded points were added to the 113 data points in the control set. The seeded values were added along the Athabasca, Pembina and Paddle Rivers; the seeded points coincide with the elevation of the surface water.

iv) Saturated Thickness of Surficial Deposits

The saturated thickness of the surficial deposits is the difference between the NPWL surface prepared for unconsolidated sediments and the elevation of the bedrock surface. The saturated thickness is greatest in association with the High Prairie Valley and the linear bedrock low along the Paddle River. Even though the map has been prepared for the entire County, a paucity of data leaves many parts of the study area with no true indication of the saturated thickness.

v) Recharge and Discharge Areas

Recharge areas by definition are areas where the hydraulic gradient is away from the land surface; the discharge areas are where the hydraulic gradient is toward the land surface. In the County of Barrhead, the unconsolidated sediments are considered to be one aquifer and the bedrock is a second. Even though there can be variation in the water levels for water wells of differing depths at the same location, it is not possible to identify regional aquifers within the bedrock.



Recharge - Discharge Areas

Based on the two aquifers being the unconsolidated sediments and the bedrock, areas of recharge and discharge have been determined from the hydraulic head in the two different sediments. In areas where there is neither recharge nor discharge, the hydraulic gradient is parallel to the land surface and the area is considered to be one of transition; the transition areas are the ones where the difference between the hydraulic head in the unconsolidated sediments is within 3 metres of the hydraulic head of the bedrock aquifers.

On a regional basis, the areas of recharge, discharge and transitional flow are determined by comparing the non-pumping water-level surfaces prepared for each of the two types of sediments. Because there are so few data control points for the water-level surface associated with the unconsolidated sediments, the results of the analysis are not as accurate as they might otherwise be.

Also, the elevation control on which the water-level surfaces are based can have errors that exceed the 6 metres leeway in the different areas. In spite of the limitations, the recharge/discharge/transition flow map does indicate a large recharge area between the Athabasca and Paddle Rivers, and some smaller recharge areas in the southeast part of the County. Discharge areas occur along the Athabasca River Valley. In the southern part of the County near the Paddle and Pembina River Valleys, the discharge areas do not appear to be associated with the present-day rivers. This shift in discharge areas may be a reflection of the limited control for the non-pumping water-level surface associated with the unconsolidated sediments.

vi) Apparent Transmissivity

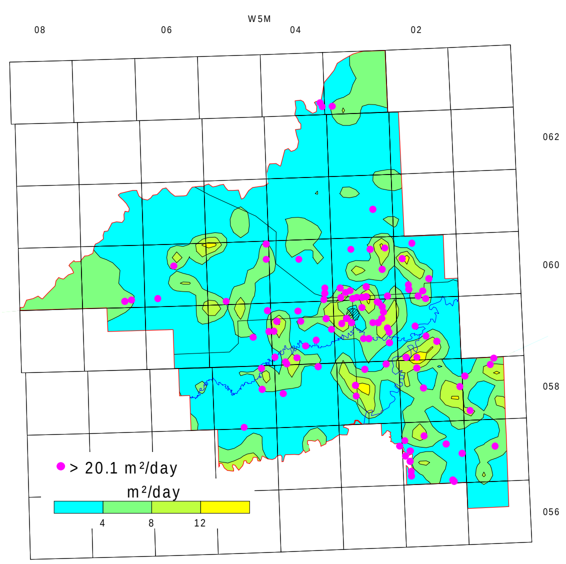
a) Bedrock

Sufficient data exist in the groundwater database for the calculation of apparent transmissivity (Ta) values for 1052 water wells that are completed in bedrock aquifers. The apparent transmissivity is calculated by the iterative solution of two equations. To calculate the apparent transmissivity, a value is required for discharge rate, discharge time, casing diameter and drawdown at the end of the discharge interval. The equations used in the solution are:

$$u = \frac{r^2 S}{4tT}$$

$$T = \frac{Q\left(-0.5772 - \ln u + u - \frac{u^2}{4} + \frac{u^3}{18}\right)}{4\pi\Delta h}$$

u - well function
r - radius of casing (mm)
S - Storativity
T - Transmissivity (m²/day)
Q - pumping rate (m³/day)
Δh - drawdown per log cycle (m)
t - time (min)

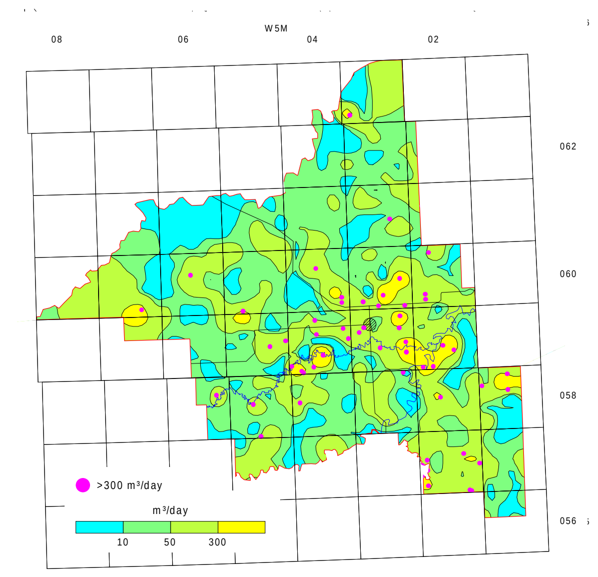


Apparent Transmissivity for Bedrock Aquifers

The values for apparent transmissivity vary from a low of 0.1 to a high of 213 m²/day, with 90% being less than 20.1 m²/day. Because of the large number of values of less than 20.1 m²/day, the map showing the distribution of various transmissivity values was prepared using only the values of less than 20.1 m²/day. The 107 values that are 20.1 m²/day and larger have been posted to the map. From the map, it can be seen that the apparent transmissivity values for the majority of the County are less than 4 m²/day. The transmissivity values in the 4 to 16 m²/day range occur in a northwest-southeast swath through the County. The posted values, which include apparent transmissivity values of greater than 20.1 m²/day, for the most part also occur in this swath.

b) Surficial

There are 18 values available for apparent transmissivity for surficial aquifers, eight of which are for the sand and/or gravel deposits in the area where the Barrhead and Dapp Valleys are present. The values of transmissivity vary from 0.1 to 34.9 m^2/day, with the average being 7.5 m^2/day. The remaining 10 values for apparent transmissivity are from throughout the County.



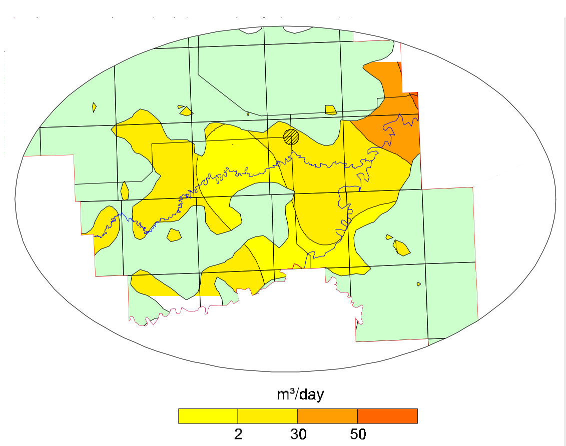
Apparent Safe Yield in Bedrock Aquifers

vii) Apparent Safe Yield

Values of apparent safe yield (Q20a) have been calculated using the apparent transmissivity values. The calculation has been generic using the form:

$$T \times H \times 0.7 \times 1.44 / (0.264 \times 7)$$

where transmissivity (T) is in m^2/day, available drawdown (H) is in metres and the apparent safe yield (Q20a) is in m^3/day.



Apparent Safe Yield in the Barrhead and Dapp Valleys

The apparent safe yield for the bedrock aquifers varies from less than 1 to over 1500 m^3/day. All of the values were used to prepare the contour grid for the map. However, on the map there was no breakdown of values above 300 m^3/day. In addition to the contours, the locations of the water wells with projected long-term yields of more than 300 m^3/day have been posted.

From the apparent safe yield map, it is evident that, in most of the area, water wells with yields of in the order of 10 to 300 m^3/day can be expected.

A map has been prepared for the apparent safe yield for the sand and/or gravel aquifers associated with the Dapp and Barrhead Valleys. The limited data show water well yields vary from less than 2 to more than 30 m^3/day.

viii) Chemical Quality

A total of 932 chemical analysis results are available from the County of Barrhead water wells. Of the 932 analyses, 818 are from water wells completed in bedrock aquifers and 122 are from water wells completed in sand and/or gravel aquifers; two chemical analysis results have not been assigned to either a bedrock or surficial aquifer. For the present review, groundwaters are being assessed relative to the recommended maximum concentration of constituents for drinking water. The maximum concentrations for either aesthetic or health concerns are outlined in the adjacent table.

Chemical Constituent	Recommended Maximum Concentration mg/L GCDWQ	CCME	LRHA
Calcium*	-	-	75
Magnesium*	-	-	500
Sodium*	200	-	200
Potassium*	-	-	-
Sulfate*	500	500	500
Chloride*	250	250	250
Bicarbonate*	-	-	1000
Nitrate+Nitrite as N	-	10	10
Fluoride	1.5	1.5	1.5
Total Alkalinity*	-	-	500
Hardness*	200	-	200
Total Dissolved Solids*	500	500	500
Iron*	0.3	-	0.3

* Aesthetic Limits

GCDWQ: Guidelines for Canadian Drinking Water Quality Health and Welfare Canada (1993) 5th Edition

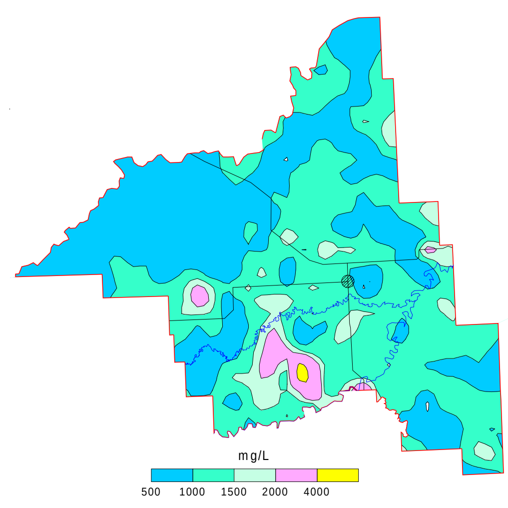
CCME: Canadian Council of Ministers of the Environment Interim Criteria using the Best-Fit Option - Assessment Criteria

LRHA: Lakeland Regional Health Authority (1996)

The chemical analyses used for the present program include results from water wells that are less than 150 metres deep, have an anion-cation balance within 10%, and whose sodium, calcium and sulfate concentrations are not null.

a) Total Dissolved Solids

There are 814 total dissolved solids (TDS) values available for bedrock groundwaters in the County of Barrhead. Of the 814 values, 3.8% are less than 500 mg/L and 14.7% are more than 1500 mg/L. A map of the distribution of total dissolved solids shows that areas where TDS values are above 1500 mg/L can be found at several locations. The largest area with high TDS values occurs in Tp 058, R 04, W5M. The main areas where TDS values are less than 1000 mg/L are the northern and western parts of the County.



Total Dissolved Solids - Bedrock

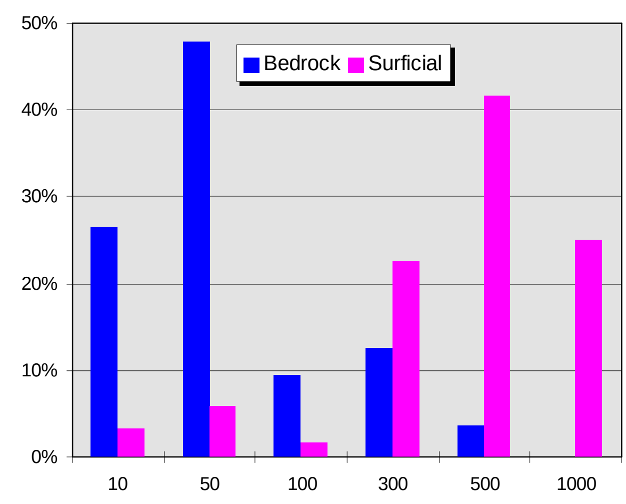
The total dissolved solids in the groundwaters from the surficial deposits are significantly less than the TDS in the groundwater from the bedrock. A comparison of the percentages in each category is as follows:

TDS Concentration mg/L	Groundwaters From Bedrock	Surficial
<200	0.5%	0.0%
<500	3.8%	21.7%
<1000	44.8%	73.3%
<1500	85.3%	94.2%
<2000	93.9%	99.2%
<4000	99.1%	100.0%

The groundwaters from the surficial deposits do not contain more than 2000 mg/L and only 0.8% have more than 1500 mg/L. Also, 21.7% of the groundwaters from the surficial deposits have total dissolved solids of less than 500 mg/L.

b) Total Hardness

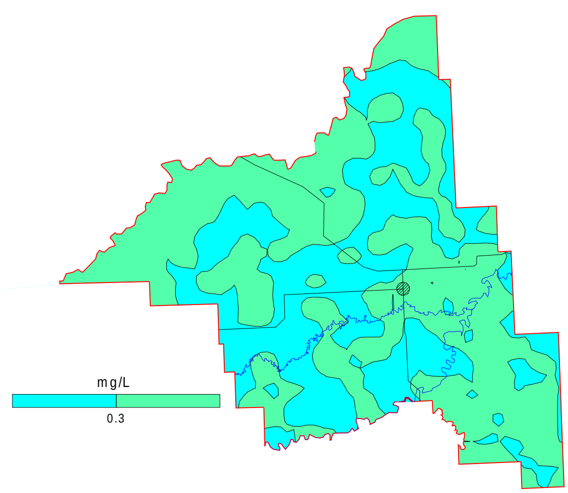
In general terms, the groundwater from the bedrock aquifers will be chemically soft and groundwater from the sand and/or gravel aquifers in the surficial deposits will be chemically hard. In the County of Barrhead, a predominance of bedrock groundwaters have a chemical hardness of less than 50 mg/L, while the groundwaters from the surficial deposits mainly have a chemical hardness of more than 100 mg/L, with the largest group having a chemical hardness of between 300 and 500 mg/L. The anomalies may be a result of the groundwater source not being properly categorized, or the water well having been completed in both a bedrock and a surficial aquifer, or an unexpected variation in the local hydrogeology.



Chemical Hardness

c) Iron

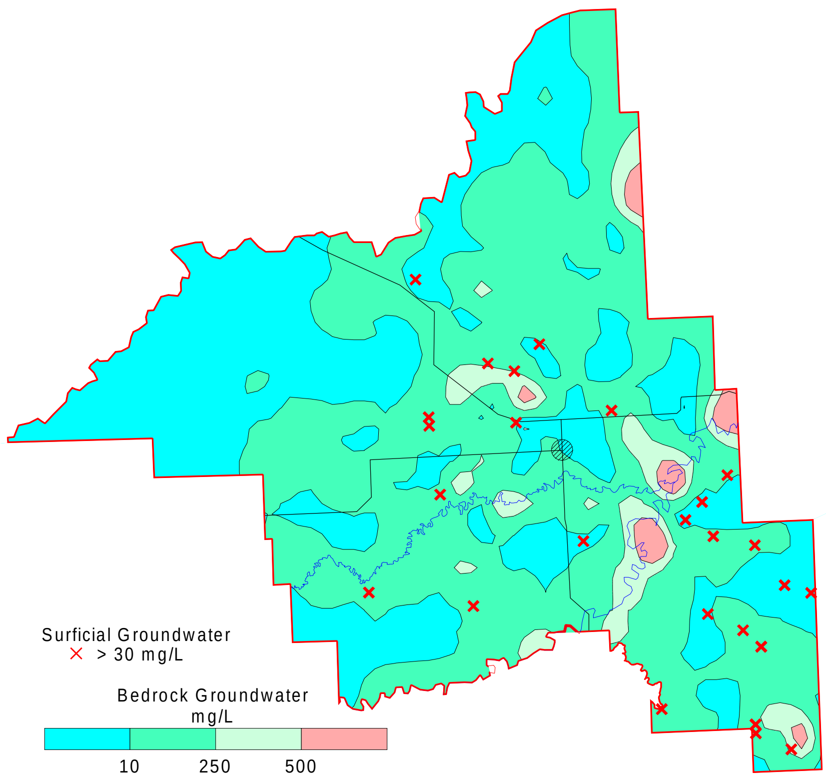
In general terms, the groundwater from the bedrock aquifers will contain less than 0.3 mg/L of dissolved iron and groundwater from the sand and/or gravel aquifers in the surficial deposits will contain more than 0.3 mg/L, with concentrations reaching several mg/L in some cases. A frequency distribution shows that for bedrock groundwaters in the County of Barrhead, 65% have a dissolved iron concentration of 0.3 mg/L or less. However, when the areal distribution is considered, the area where dissolved iron is less than 0.3 mg/L is only approximately 50% of the County. Often when groundwater is obtained from a coal aquifer in the bedrock, the dissolved iron will be higher than when the aquifer is a sandstone or fractured shale unit.



Iron Concentration - Bedrock Groundwater

Slightly less than 50% of the groundwaters from the sand and/or gravel deposits have dissolved iron of 0.3 mg/L or less. The large number of groundwater samples from the surficial deposits with 0.3 mg/L or less may indicate that water samples are being taken downstream from a water treatment facility, or the groundwater source has not been properly categorized, or the local hydrogeology is unusual. When sampling for dissolved iron, the sample should be obtained as close to the source as possible and if possible the sample should be preserved at the time of sampling.

d) Chloride



Chloride Concentration

The concentration of the chloride ion in bedrock groundwaters varies from less than 1 mg/L to 2808 mg/L. Of the 869 values for chloride, 49% have 10 mg/L or less and 8% have more than 250 mg/L, the recommended maximum for drinking water. None of the groundwaters with 250 mg/L or more of chloride have an elevated NO_2+NO_3 concentration that would suggest contamination of the groundwater.

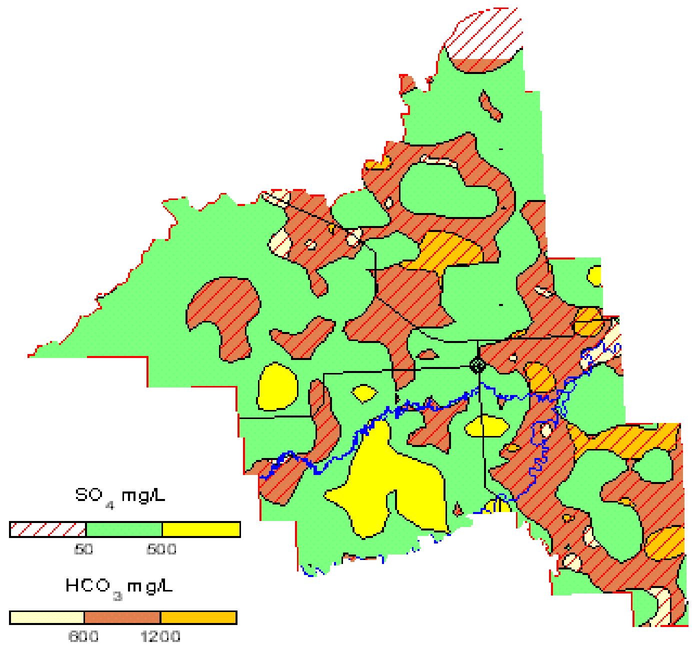
The chloride ion concentration in groundwater is above 250 mg/L in several areas of the County. The main areas include parts of Tp 058 and 059, R 02 and 03, W5M, southeast of Barrhead.

In the unconsolidated sediments, the chloride concentrations are significantly lower than in the bedrock groundwaters. The range of chloride concentration is from 1 to 225 mg/L. There are 37 chloride concentrations from surficial aquifers that are over 30 mg/L. Of the 37 samples, NO_2+NO_3 concentrations are also given for 22 of the chemical analysis results. The NO_2+NO_3 values vary from <0.004 to 1.7 mg/L. These concentrations of NO_2+NO_3 are not a health hazard, but of the 22 values provided, at least 13 are considered elevated and may be indicative of the groundwater being contaminated. Of the 13 water wells from which the samples were obtained, 10 are less than 20 metres deep. The 37 locations where chloride concentration exceeds 30 mg/L in the surficial deposits are shown on the chloride map. Very few of the 37 locations are close to the areas where the chloride ion concentration in the bedrock is above 250 mg/L, and several are in areas where the chloride concentration in the bedrock is less than 10 mg/L.

e) Sulfate

The total number of sulfate concentration values for the bedrock groundwaters is 818. Of these 818 values, 579 are less than 100 mg/L and 139 are greater than 500 mg/L. The areas where the sulfate concentration is the highest are in the southwest part of the County.

A total of 488 values for SO_4 concentration are less than 50 mg/L. Of these 488 samples, the bicarbonate concentration of 86% of the samples is greater than 600 mg/L, with some values as high as 3066 mg/L. The presence of elevated bicarbonate values with low sulfate concentrations suggests that sulfate reduction is taking place, with H_2S gas being a by-product. In almost all of the areas on the map where the SO_4 concentration is less than 50 mg/L, the bicarbonate concentration is greater than 600 mg/L.

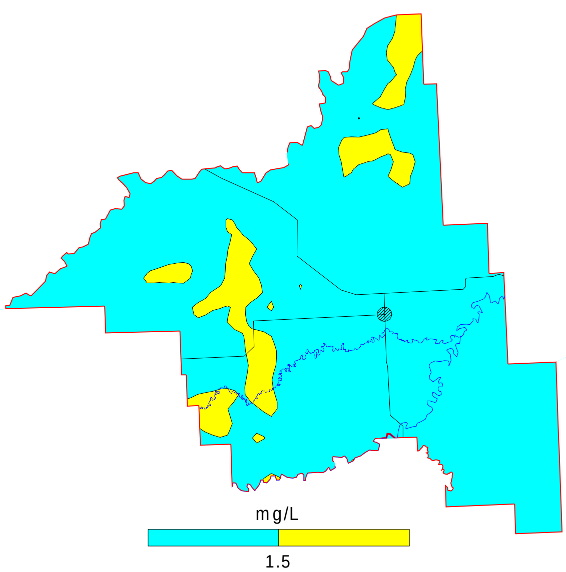


Sulfate and Bicarbonate Concentration

f) Fluoride

The fluoride concentrations in bedrock groundwaters range from 0.05 to 4 mg/L, with 18.9% exceeding the maximum recommended limit of 1.5 mg/L for drinking water. Areally, the high fluoride groundwaters are mainly in R 05 and in the most northerly part of the County.

Because the solubility of fluoride is higher in chemically soft waters, the fluoride concentration in the groundwater from surficial aquifers is low.

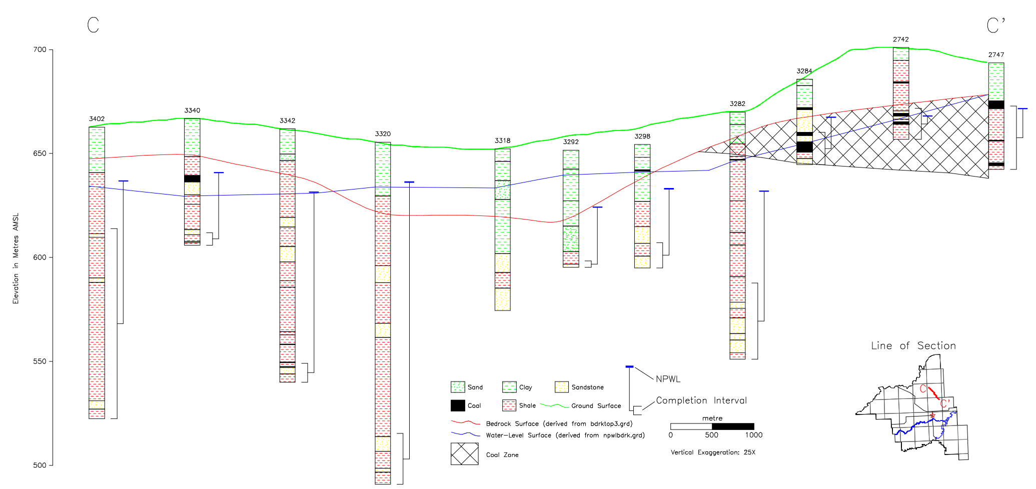


Fluoride Concentration

ix) Cross-Sections

Four cross-sections have been prepared from the water well records in the groundwater database. In addition to the lithological and completion details for individual water wells, traces of the gridded surfaces from various maps have also been included on the cross-sections. The surfaces include the ground surface, the bedrock surface and the non-pumping water-level surface for bedrock water wells. In addition to these surfaces, the top of the Lea Park Formation was mapped for the area and used as a guide for regional structure.

Correlation of individual lithologic units along any given cross-section is difficult to accomplish over any significant distance. The one feature that is apparent from the cross-sections is the occurrence of coal zones. Even though individual coal layers do not appear to be continuous, there is an interval that can be identified within which most of the significant coal layers occur. The base of the interval is approximately 340 metres above the top of the Lea Park Formation and the interval is approximately 100 metres thick. This interval has been included on each cross-section as a hatched area. Along cross-section C-C', only the lower part of the coal zone is present and it is only along the southeast end



Cross-Section C-C'

(C") where the base of the interval is below the bedrock surface. On the northwest end of the cross-section (C), there is a noticeable coal layer which is approximately 10 metres below the base of the coal zone.

The regional trend surfaces do provide a means of attempting to correlate different lithologies between adjacent water wells. However, extrapolation of the results over any horizontal distance is difficult.

The bedrock surface trace has been created from the bedrock topography map. In many places, the bedrock surface does not agree with the bedrock pick for an individual water well. The discrepancy is in part a result of not being able to unequivocally identify the bedrock surface due to the interchange of terminology by the water well drillers and in part by the limited spatial control.