2.3 Background Information

There are currently records for 3,201 water wells in the groundwater database for the Smoky Lake Region. Of the 3,201 water wells, 2,496 are located outside the Settlements and the Indian Reserves. Of the 3,201 water wells, 2,576 are for domestic/stock purposes. The remaining 625 water wells were completed for a variety of uses, including municipal, observation and industrial purposes. Based on a rural population of 2,782, not including the population from the Settlements and the I.R.s, there are 3.7 water wells per family of four. The domestic or stock water wells vary in depth from less than one metre to 152 metres below ground level. Lithologic details are available for 1,857 water wells.

Data for casing diameter are available for 1,403 water wells, with 481 indicated as having a diameter of more than 350 mm and 922 having a diameter of less than 350 mm. The casing diameters of less than 350 mm are for drilled water wells and water wells with a diameter of greater than 350 mm are mainly bored water wells.

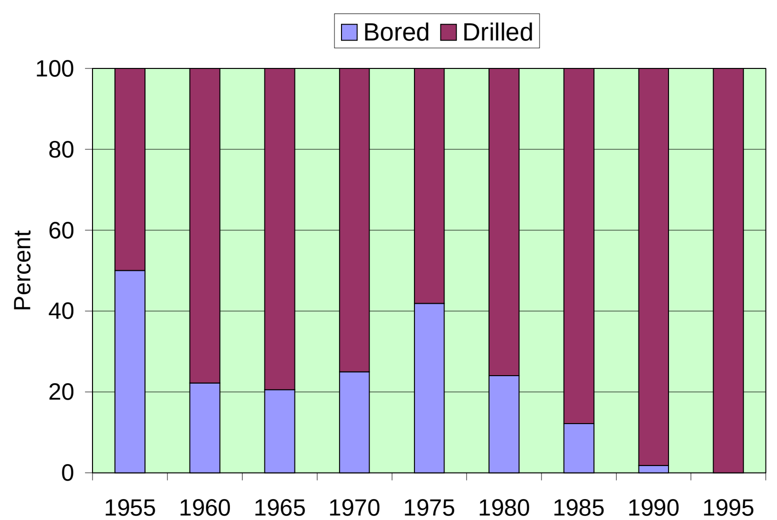

Figure 2. Relationship between Drilled and Bored Water Wells

There has been a gradual decline in the percentage of bored water wells completed within the Smoky Lake Region from the early 1950s to 1995. The only time when there was a rise in the percentage was during the 1970s. From 1970 to 1974, 50% of the bored water wells were drilled by one contractor; from 1975 to 1979, 30% were drilled by another contractor and 30% by a third contractor.

Steel, plastic and galvanized steel represent 90% of the materials that have been used for surface casing over the last 40 years in water wells completed in the Region. The most common material is steel. Steel casing was used in the 1950s and is still being used today. Approximately 37% of the water wells are reported as having steel surface casing. The next most common material is plastic. Plastic casing is used in 31% of the water wells. The first reported use of plastic casing in the Region was in June 1980. In the 1990s, nearly 90% of the water wells have been completed with plastic casing. Over the last 40 years, galvanized steel was used in 22% of the water wells. However, the last reported use of galvanized steel was in March 1994.

There are 1,511 water well records with sufficient information to identify the aquifer in which the water wells are completed. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the bedrock surface are water wells completed in surficial aquifers. The number of water wells completed in aquifers in the surficial deposits is 1,200. The adjacent map shows that these water wells are mainly in the southeastern part of the Region and in the two Settlements.

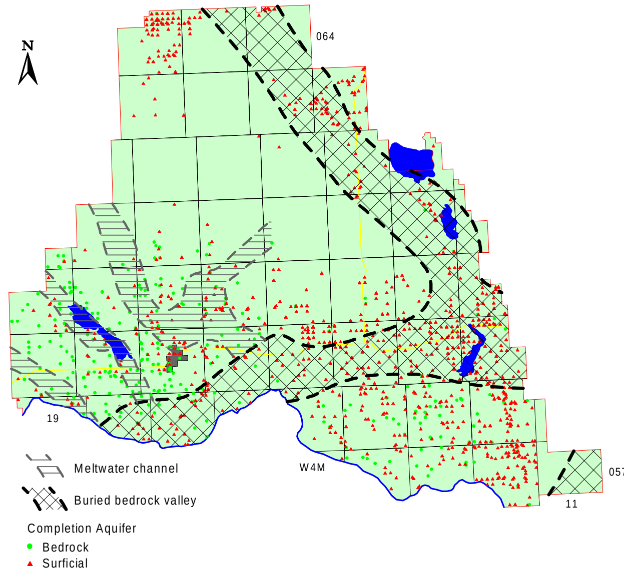

Figure 3. Location of Water Wells

The remaining 311 water wells have the top of their completion interval deeper than the depth to the bedrock surface. From the adjacent map, it can be seen that water wells completed in bedrock aquifers occur mainly in the southwestern part of the Region and do not tend to occur in the areas underlain by buried bedrock valleys or meltwater channels.

There are large areas of the Region where there are few, if any, water wells. For example, there are no records for water wells in Tp 062, R 17, and Tp 063, R 16, W4M and only one or two water wells in Tp 061, R 14 and 15, W4M, and Tp 062, R 15 and 16, W4M.

Water wells not used for domestic needs must be licensed. At the end of 1996, 29 groundwater diversions were licensed in the Region. The total maximum authorized diversion from these 29 water wells is 1,273 cubic metres per day (m^3/day); 59 percent of the authorized groundwater diversion is allotted for agricultural use. The largest licensed groundwater diversion within the Region is 669.4 m^3/day for the Town of Smoky Lake; this water well is completed in the Lower Sand and Gravel Aquifer.

At many locations within the Region, more than one water well is completed at one legal location. Digitally processing this information is difficult. To obtain a better understanding of the completed depths of water wells, a surface was prepared representing the minimum depth for water wells and a second surface was prepared for the maximum depth. Both of these surfaces are used in the groundwater query on the CD-ROM. When the maximum and minimum water well depths are similar, the impression is that only one aquifer is being used. The area where the greatest differences between the minimum and maximum depth occur most often is in areas where water wells completed in aquifers in the surficial deposits are most common.

The total dissolved solids in the groundwater in the Region are generally less than 2,000 milligrams per litre (mg/L). Groundwaters from the surficial deposits can be expected to be chemically hard with a high dissolved iron content. Groundwaters from the bedrock aquifers frequently are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. Very few chemical analyses indicate a fluoride concentration above 1.5 mg/L.

Alberta Environmental Protection (AEP) defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, the bedrock surface and the Base of Groundwater Protection, a depth to the Base of Groundwater Protection can be determined. This depth would be for the most part the maximum drilling depth for a water supply well. Over approximately 70% of the Region, the depth to the Base of Groundwater Protection is more than 100 metres. The area where the depth to the Base of Groundwater Protection is less than 20 metres is mainly in the northeastern part of the Region.

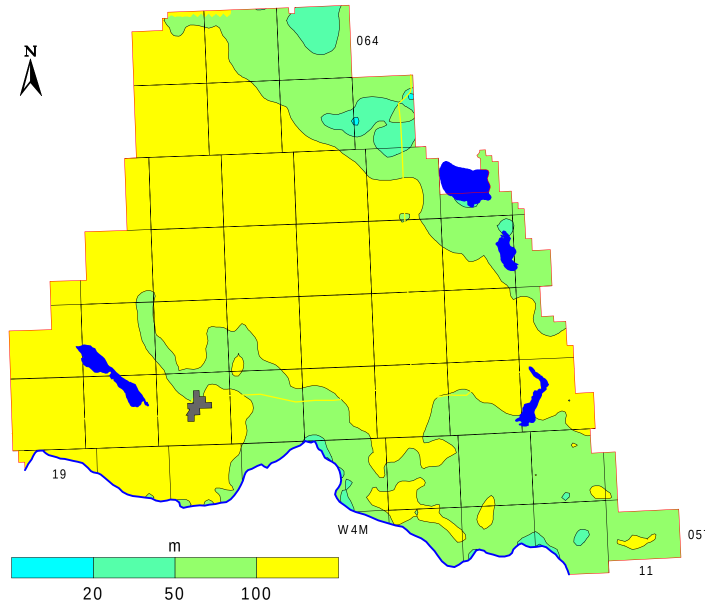

Figure 4. Depth to Base of Groundwater Protection

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are no data available from **Alberta Environmental Protection-**operated observation water wells within the Smoky Lake Region. Additional data can be obtained from some of the licensed groundwater diversions. In the past, these data have been difficult to obtain from AEP, in part because of the failure of the licensee to provide the data. **However, even with the available sources of data, the number of water-level data points relative to the size of the Region is too few to provide a reliable groundwater budget. The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis.**

3 TERMS

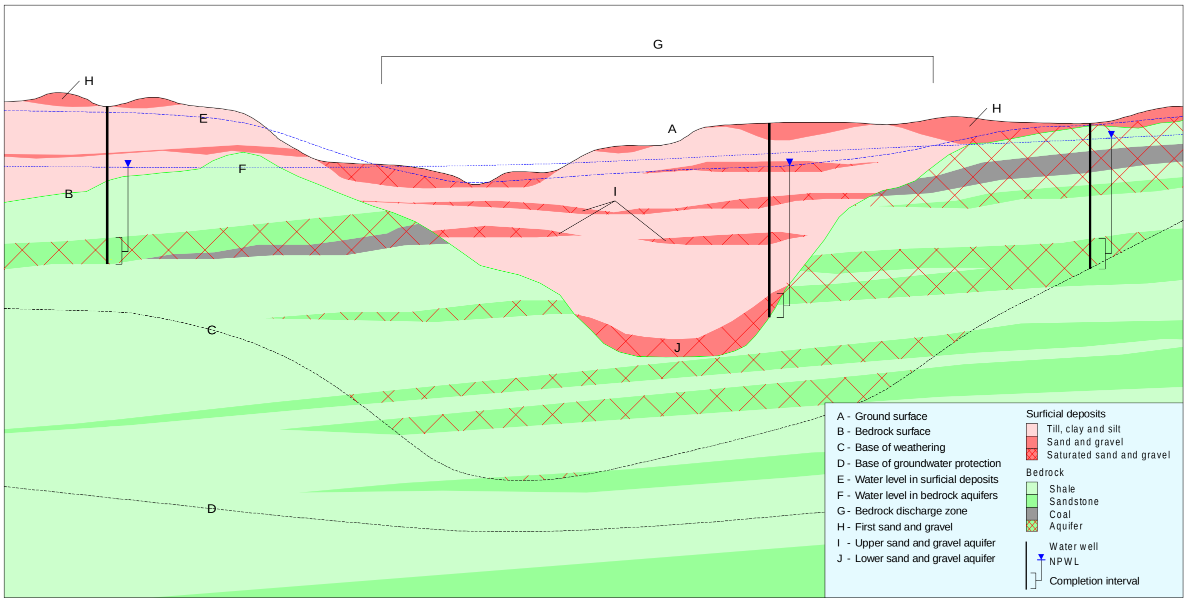

Figure 5. Generalized Cross-Section (for terminology only)

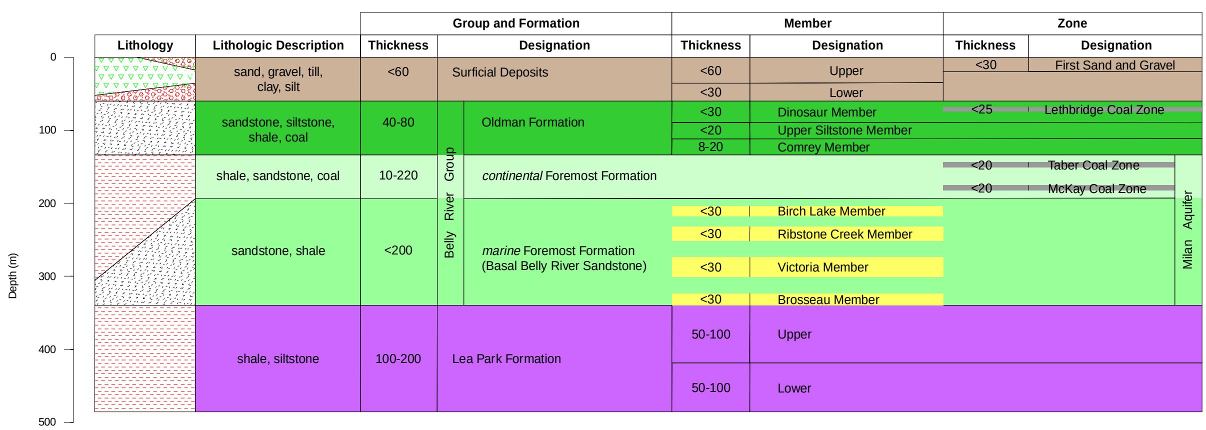

Figure 6. Geologic Column

4 METHODOLOGY

4.1 Data Collection and Synthesis

The AEP groundwater database is the main source of groundwater data. The database includes the following:

1) water well drilling reports;
2) aquifer test results from some water wells;
3) location of some springs;
4) water well locations determined during water well surveys;
5) chemical analyses for some groundwaters;
6) location of flowing shot holes;
7) location of structure test holes; and
8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the absence of quality control. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage to the database is the lack of adequate spatial information.

The AEP groundwater database uses a land-based system with only a limited number of records having a value for ground elevation. The locations for records usually include a quarter section description; a few records also have a land description that includes a Legal Subdivision (Lsd). For digital processing, a record location requires a horizontal coordinate system. In the absence of an actual location for a record, the record is given the coordinates for the centre of the land description.

The present project uses the 10-degree Transverse Mercator (10TM) coordinate system. This means that a record for the NW ¼ of section 28, township 059, range 17, W4M, would have a horizontal coordinate with an Easting of 163,689 metres and a Northing of 5,998,631 metres, the centre of the quarter section. Once the horizontal coordinates are determined, a ground elevation is obtained from the 1:20,000 Digital Elevation Model (DEM) from the Resource Data Division of AEP.

After assigning spatial control to the records in the groundwater database, the data are processed to determine values for hydrogeological parameters. As part of the processing, obvious keying errors in the database are corrected.

Where possible, determinations are made from individual records for the following:

1) depth to bedrock;
2) total thickness of sand and gravel;
3) thickness of first sand and gravel when present within one metre of ground surface;
4) total thickness of saturated sand and gravel; and
5) depth to the top and bottom of completion intervals.

Also, where sufficient information is available, values for apparent transmissivity[3] and apparent yield[4] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. The apparent transmissivity results are then used to estimate a value for hydraulic conductivity[5]. The conductivity values are obtained by dividing the apparent transmissivity by the completion interval. To obtain a value for regional transmissivity of the aquifer, the hydraulic conductivity is multiplied by the effective thickness of the aquifer based on nearby e-log information. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity.

The Alberta Energy and Utilities Board (EUB) well database includes records for all of the wells drilled by the oil and gas industry. The information from this source includes:

1) spatial control for each well site;
2) depth to the top of various geological units;
3) type and intervals for various down-hole geophysical logs; and
4) drill stem test (DST) summaries.

Unfortunately, the EUB database contains very little information from above the Base of Groundwater Protection. Because the main interest for a groundwater study comes from data above the Base of Groundwater Protection, the data from the EUB database have limited use.

Values for apparent transmissivity and hydraulic conductivity are calculated from the DST summaries.

Published and unpublished reports and maps provide the final source of information to be included in the new groundwater database. The reference section of this report lists the available reports. The only digital data from publications are from the Geological Atlas of the Western Canada Sedimentary Basin (Mossop and Shetsen, 1994). These data are used to verify the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

4.2 Spatial Distribution of Aquifers

Determination of the spatial distribution of the aquifers is based on:

1) lithologs provided by the water well drillers;
2) geophysical logs from structure test holes;
3) wells drilled by the oil and gas industry; and
4) data from existing cross-sections.

The identification of aquifers becomes a two-step process: first, mapping the tops and bottoms of individual geological units; and second, identifying the porous and permeable parts of each geological unit in which the aquifer is present.

After obtaining values for the elevation of the top and bottom of individual geological units at specific locations, the spatial distribution of the individual surfaces can be determined. Digitally, establishment of the distribution of a surface requires the preparation of a grid. The inconsistent quality of the data

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[3] For definitions of Transmissivity, see glossary
[4] For definitions of Yield, see glossary
[5] See glossary

necessitates creating a representative sample set obtained from the entire data set. If the data set is large enough, it can be treated as a normal population and the removal of extreme values can be done statistically. When data sets are small, the process of data reduction involves a more direct assessment of the quality of individual points. Because of the uneven distribution of the data, all data sets are gridded using the Kriging[6] method.

The final definition of the individual surfaces becomes an iterative process involving the plotting of the surfaces on cross-sections and the adjusting of control points to fit with the surrounding data.

The porous and permeable parts of the individual geological units have been mainly determined from geophysical logs.

4.3 Hydrogeological Parameters

Water well records that indicate the depths to the top and bottom of their completion interval are compared digitally to the spatial distribution of the various geological surfaces. This procedure allows for the determination of the aquifer in which an individual water well is completed. When the completion interval of a water well cannot be established unequivocally, the data from that water well are not used in determining the distribution of hydraulic parameters.

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), transmissivity and projected water well yield. The total dissolved solids, chloride and sulfate concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers.

Once values for the various parameters of the individual aquifers are established, the spatial distribution of the various parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid.

4.3.1 Risk Criteria

The main source of groundwater contamination involves activities on or near the land surface. The risk is high when the near-surface materials are porous and permeable and low when the materials are less porous and less permeable. The two sources of data for the risk analysis include (a) a determination of when sand and gravel is or is not present within one metre of the ground surface, and (b) the surficial geology map. The presence or absence of sand and gravel within one metre of the land surface is based on a geological surface prepared from the data supplied on the water well drilling reports. The information available on the surficial geology map is categorized based on relative permeability. The information from these two sources is combined to form the risk assessment map. The criteria used in the classification of risk are given in the table above.

Surface Permeability	Sand or Gravel Present To Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 1. Risk of Groundwater Contamination Criteria

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6 See glossary