



Saskatchewan Research Council
15 Innovation Boulevard
Saskatoon, SK Canada S7N 2X8
Ph: 306-933-5400 Fax: 306-933-7446
Internet: <http://www.src.sk.ca>

June 21, 2004

Mr. Gene Kimbley
Prince Albert Model Forest
Suite 1, 1304 Central Avenue
Prince Albert, SK, S6V 4W3

Attention: Mr. Gene Kimbley

Re: 2004 Progress Report
Assessment of Ground and Surface Water Conditions in the
Prince Albert Model Forest Area
SRC Publication No. 11618-1E04

Dear Mr. Kimbley:

This is a progress report for the project entitled, “*Assessment of Ground and Surface Water Conditions in the Prince Albert Model Forest Area*”. This project is being conducted jointly by Saskatchewan Research Council (SRC) and the National Water Research Institute (NWRI) on behalf of the Prince Albert Model Forest. The approximate area of interest for this investigation is shown on Figure 1.

The activities conducted this year are discussed below in terms of the following major headings:

- Study Area
- Hydrostratigraphic Framework
- Groundwater Availability and Sensitivity
- Surface Water Sensitivity

STUDY AREA

Figure 1 includes the approximate outline the study area. In the initial proposal, we provided a study area outline. During the course of this year, we have refined this outline. This outline was refined for a number of reasons:

- Better fit of the study area boundary with the new subwatershed boundaries that were recently developed by Prairie Farm Rehabilitation Administration (PFRA)
- Ensuring coverage of the Prince Albert Model Forest (PAMF) area and surrounding background area
- Ensuring that the area includes the boreal forest to prairie agricultural land use transition zone
- Concentrating the research activities on areas where there is existing data, and
- Concentrating the research activities on areas where there is access

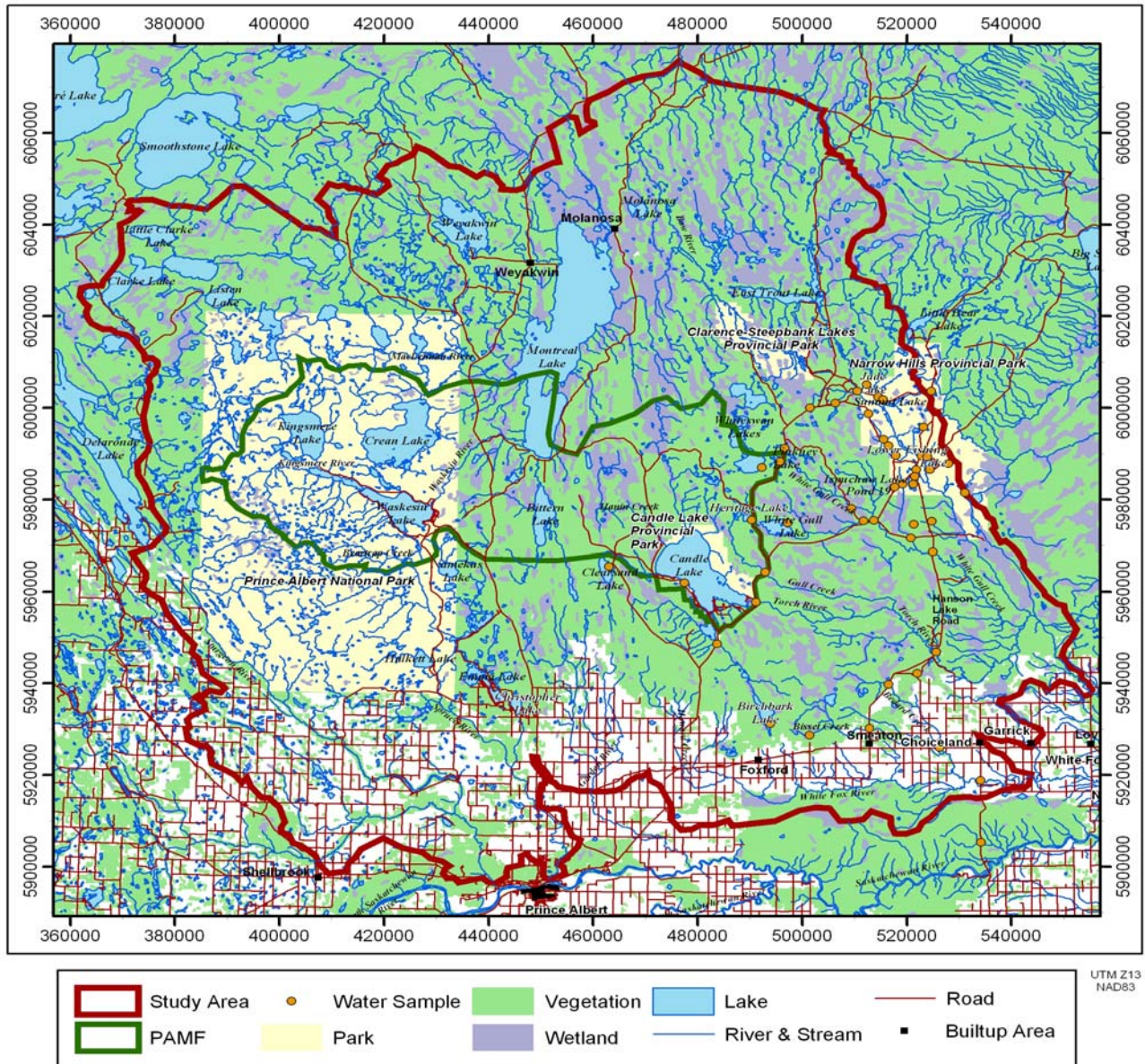


Figure 1: Study Area with Revised Study Boundary

Work is continuing on the construction of the geographic information system (GIS). This work included building more information or layers into this system. A digital elevation model was generated from the merged topographic information. Figure 2 uses the radar satellite elevation data and a “shadowed” presentation of this data. This topography data and the “shadowed” presentation technique highlight slight changes in elevation allowing for improved analyses of the landforms in the area. For example, Figure 2 shows that in the area of Narrow Hills Provincial Park there is low valley through a hill. This valley contains two rivers: one river flows north (Bow River) while the other flows south (Caribou Creek). This valley has been interpreted to have been formed as an incipient tunnel channel (Dr. Darren Sjogren, pers. comm. 2003). Incipient tunnel channels have been described by Sjogren and others (2002)¹ as channels that have hummocks and transverse ridges separating depressions along their floor. These tunnels are erosional features that were cut by pressurized sub-glacial waters.

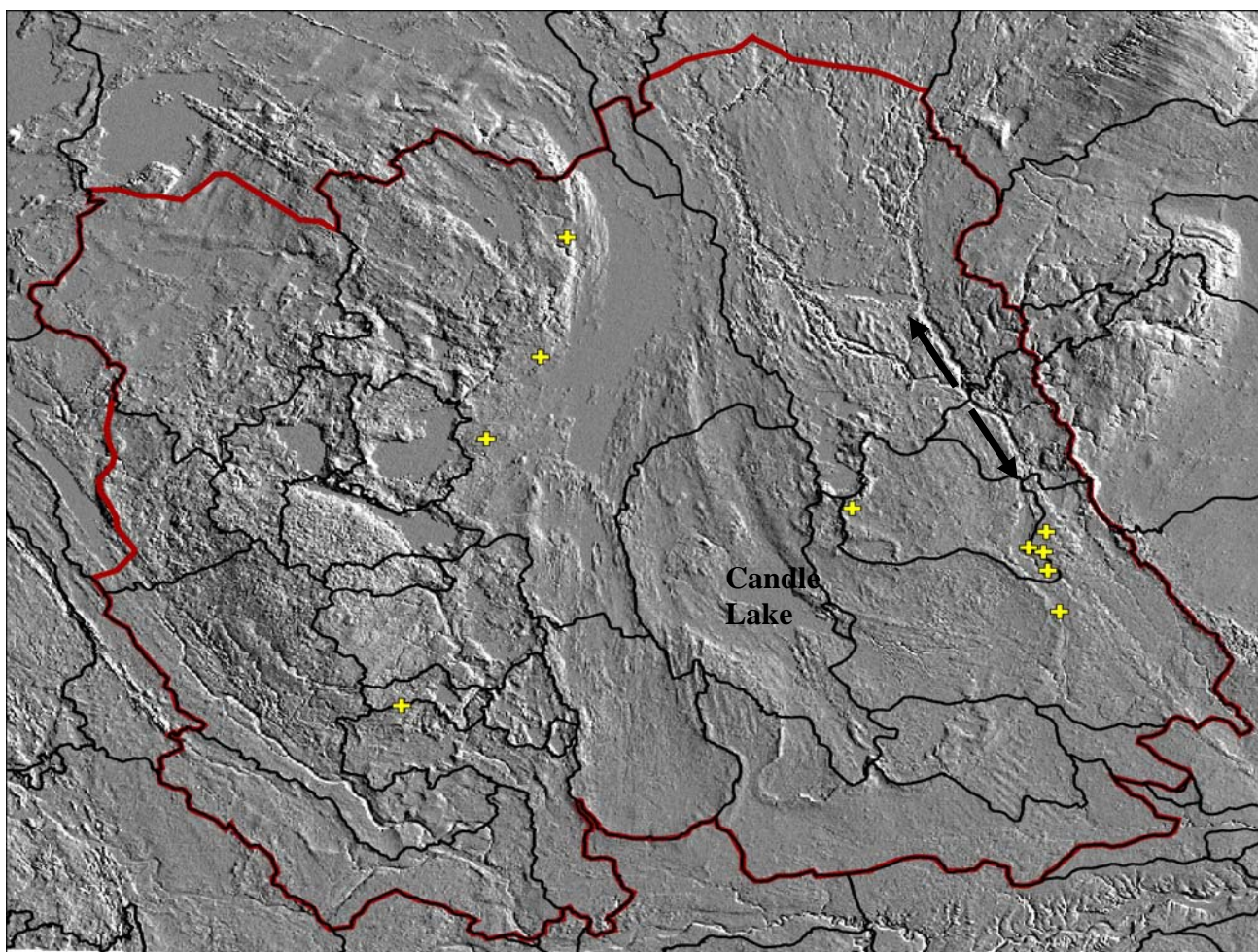


Figure 2: Shadowed Presentation of the Digital Elevation Model (DEM)

Another interesting feature shown on Figure 2 is the slight hill that is located immediately southwest of Candle Lake. You can see lines or ridges that appear to flow around this small hill

¹ Sjogren, D.B., T.G. Fisher, L.D. Taylor, H. M. Jol and M. J. Munro-Stasiuk, 2002, Incipient tunnel channels, *Quaternary International*, 90 (120), 41-56

or knob. These slight ridges suggest that the last gasp of the glaciers in this area flow around this hill and deposited an end moraine just south of this hill.

The interpretation and understanding of this topographic information allows us to develop a better understanding of the glacial processes that helped shape both the topography and the shallow subsurface in this area.

HYDROSTRATIGRAPHIC FRAMEWORK

The hydrostratigraphic framework describes the geological control on the movement and storage of groundwater in the subsurface. The activities conducted this year on this aspect of the project can be discussed in terms of surface geology and subsurface geological/hydrogeological mapping.

Figure 3 shows the 1:1,000,000 surficial geological map (Saskatchewan Geological Survey, 2004 obtained from http://142.165.150.133/website/sir_geological_atlas/viewer.htm). This information was built into the GIS. In addition, the four 1:250,000 surficial geology maps that cover the area have been digitized and edited, and we are presently incorporating this more detailed information into the GIS database.

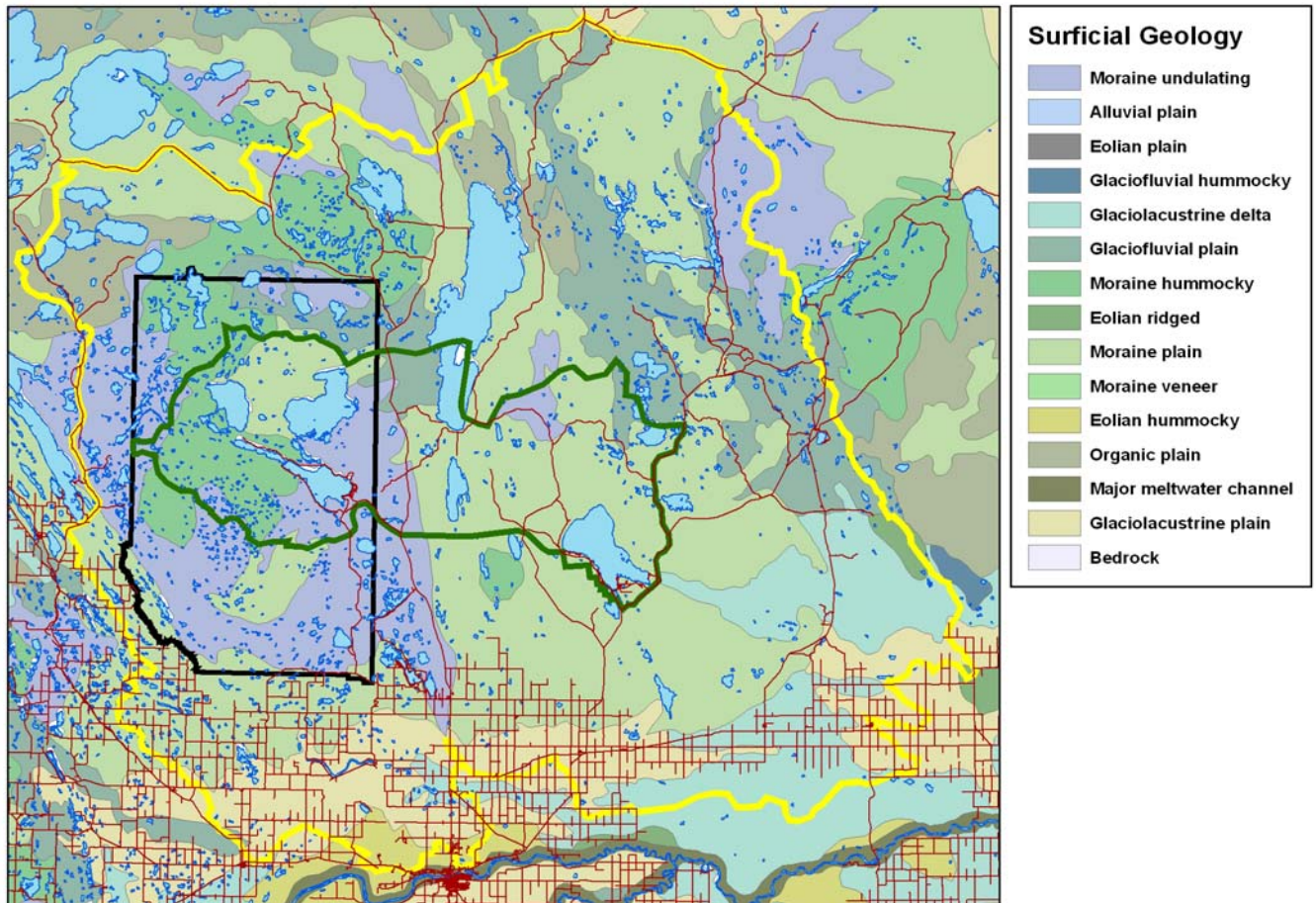


Figure 3: Surficial Geology of the Study Area

The 1:1,000,000 surficial geology information was combined with the road and surface water features to suggest sampling locations during the drought sampling that occurred in 2003. This information also helped in the interpretation of the water chemistry and surface water flows that were collected (discussed below).

Last year borehole records with geophysical logs for the area bounded by 51-15-W2 to 68-10-W3 were collected from Saskatchewan Watershed Authority (SWA) and SRC files. A total of 590 well records were obtained. The locations of these wells are shown on Figure 4. Figure 4 shows that most of these wells are concentrated along the southern edge of the study area and around Candle and Emma Lakes. As expected, information in the middle and northern portions of the study area is scarce.

Well data was also obtained from Saskatchewan Industry and Resources (SIR). SIR provided the stratigraphy picks on the deeper bedrock units from the oil, gas and mineral exploration boreholes that have been completed in the study area. Information from 129 boreholes was obtained. These are also shown on Figure 4.

These data were augmented this year with data from First Nations and Saskatchewan Parks in the area and SWA borehole records without e-logs. The information from the First Nations and Saskatchewan Parks was added to the SRC database. Borehole records without e-logs for the same area were collected this year from SWA. The distributions of the SWA borehole records without e-logs are also shown on Figure 4. Continuing efforts are currently underway to analyze these data, identify useable data and identify data gaps.

Figures 5 and 6 are two preliminary cross sections through the study area. The locations of these cross sections are shown on Figure 4. These cross sections show that the sands of the Mannville Group are the upper-most bedrock unit beneath most of the study area. Beneath the southern edge of the study area the silts and clays of the Lower Colorado Group over lay the Mannville Group sands. Figures 5 and 6 also show that the aquifers within the tills of both the Saskatoon and Sutherland Groups are very variable on a regional scale. Some of the aquifers from the Saskatoon Group (the upper till group) can also be seen to be near-surface or possibly hydraulically connected to surface water features (e.g. Figure 5 at well locations 19711 and 1930).

The analyses of the historical groundwater quality are continuing. The source of historical groundwater quality data and the limitation of these data were discussed in the 2003 progress report. We are continuing to identify sources of data and are augmenting these data with analysis conducted as part of this investigation.

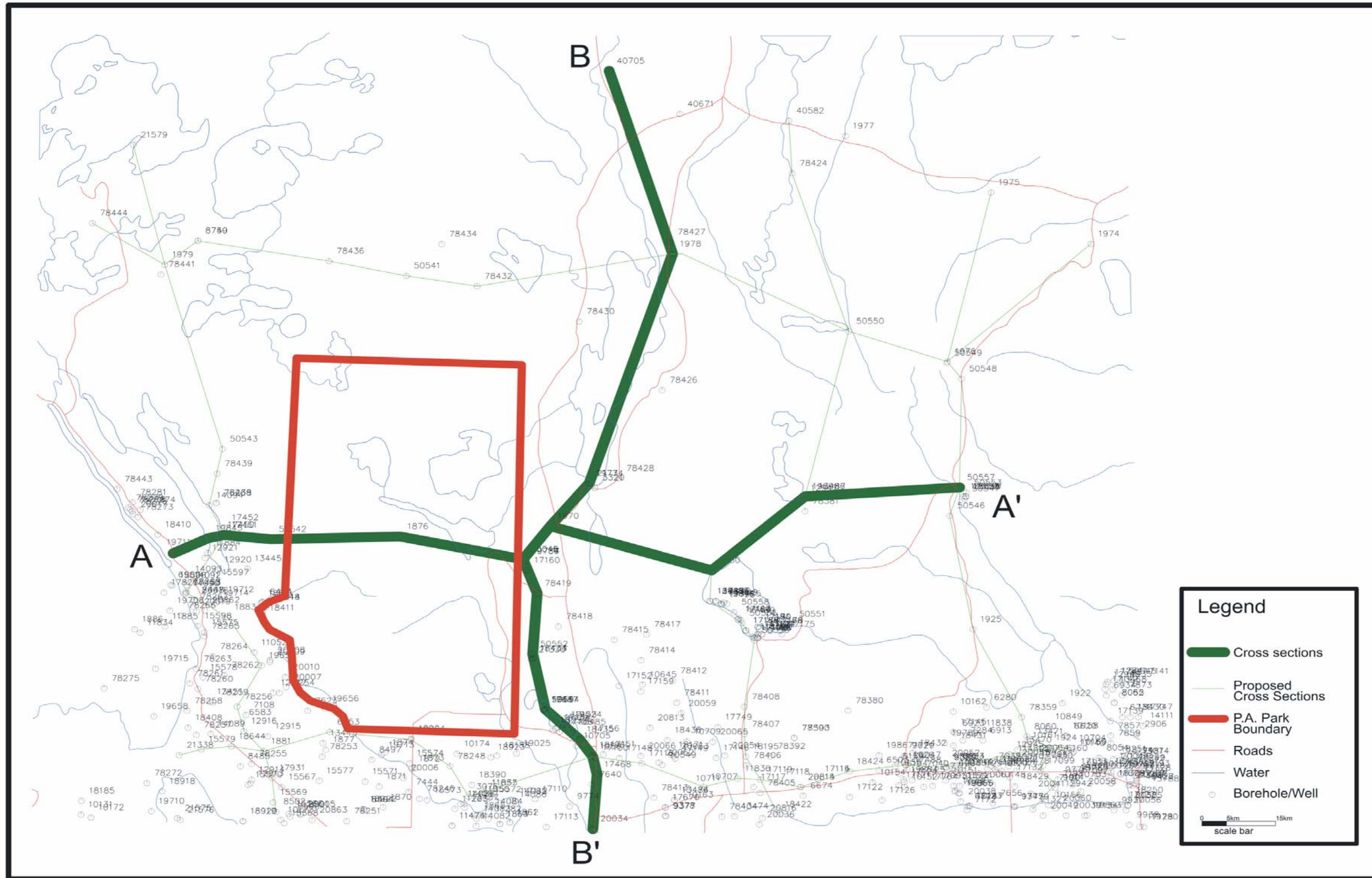


Figure 4: Locations of Water Wells and Cross Sections

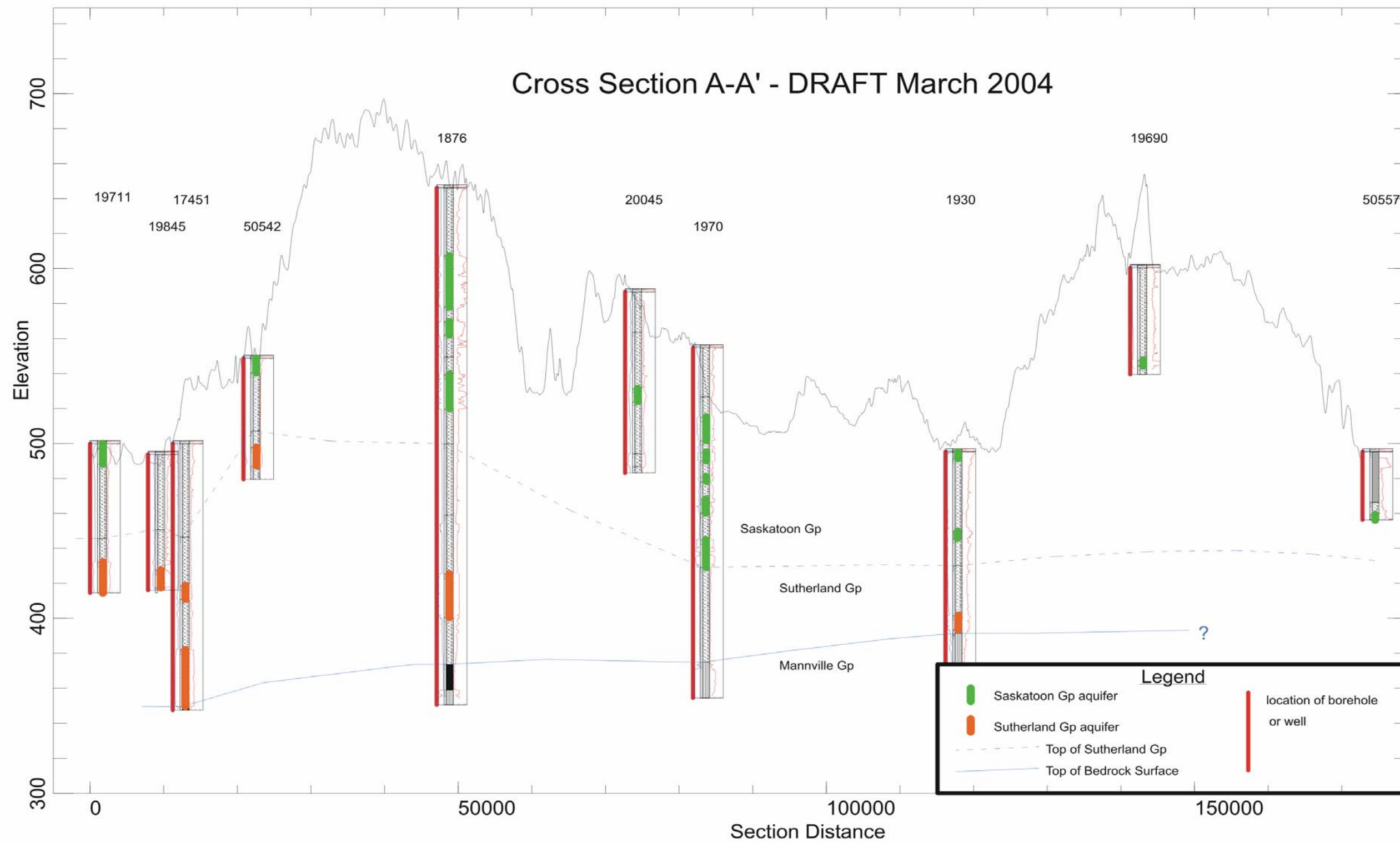


Figure 5: Hydrogeological and Geological Cross Section A – A'

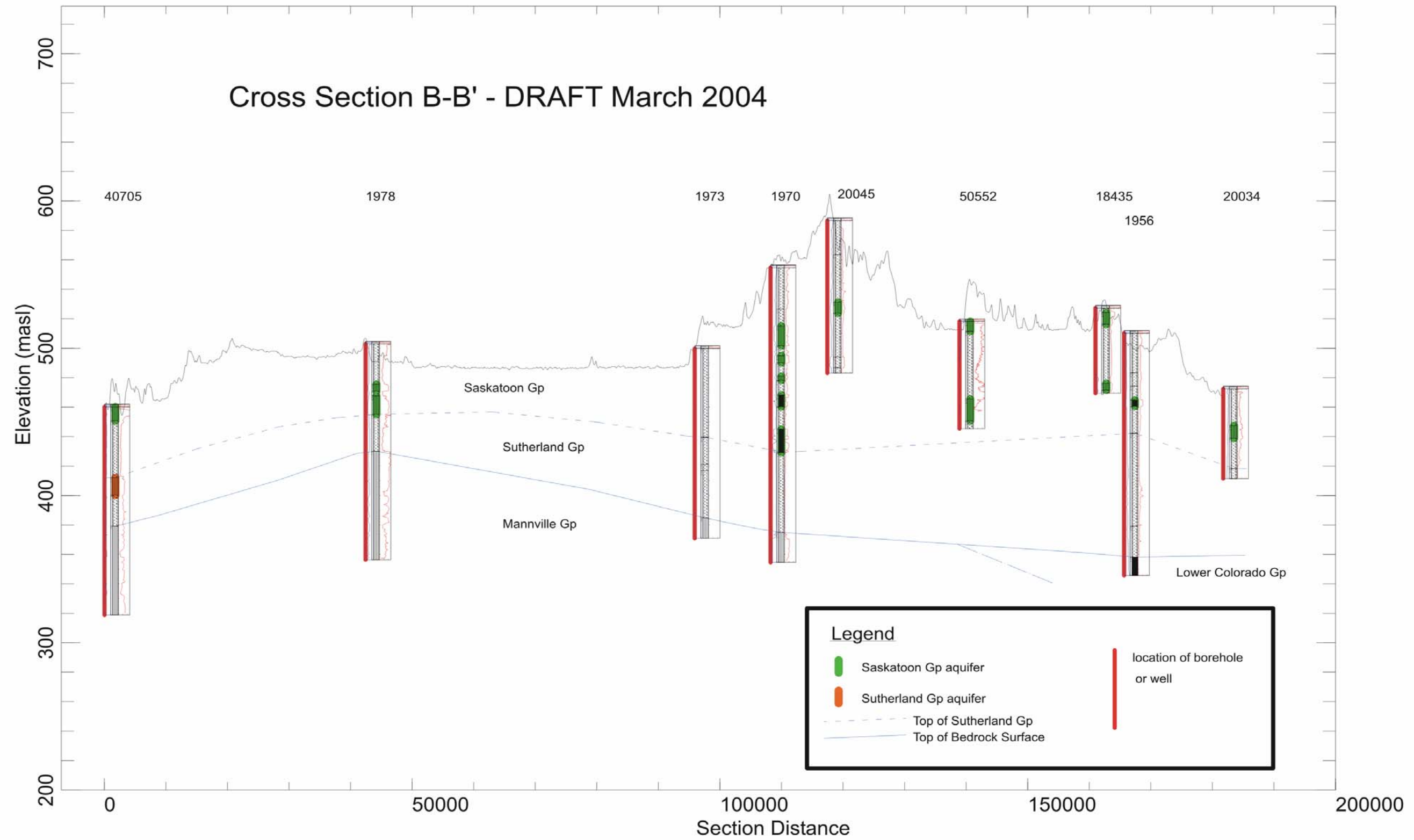


Figure 6: Hydrogeological and Geological Cross Section B – B'

GROUNDWATER AVAILABILITY AND SENSITIVITY

As indicated in the 2003 progress report, aquifer testing data has been obtained from a number of sources. This testing data provides information on transmissivity (T) and in some cases permeability (K). Information on about 40 locations has been obtained. This information will be used in conjunction with the hydrostratigraphic framework analyses to examine groundwater availability in the area.

Recent Climatic Conditions

The study area is undergoing a drought which has a large affect on our project. This drought may be the most severe drought in this area in the last 100 years. This drought is illustrated on Figure 7, which show the annual precipitation from the Prince Albert Airport Meteorological Station.

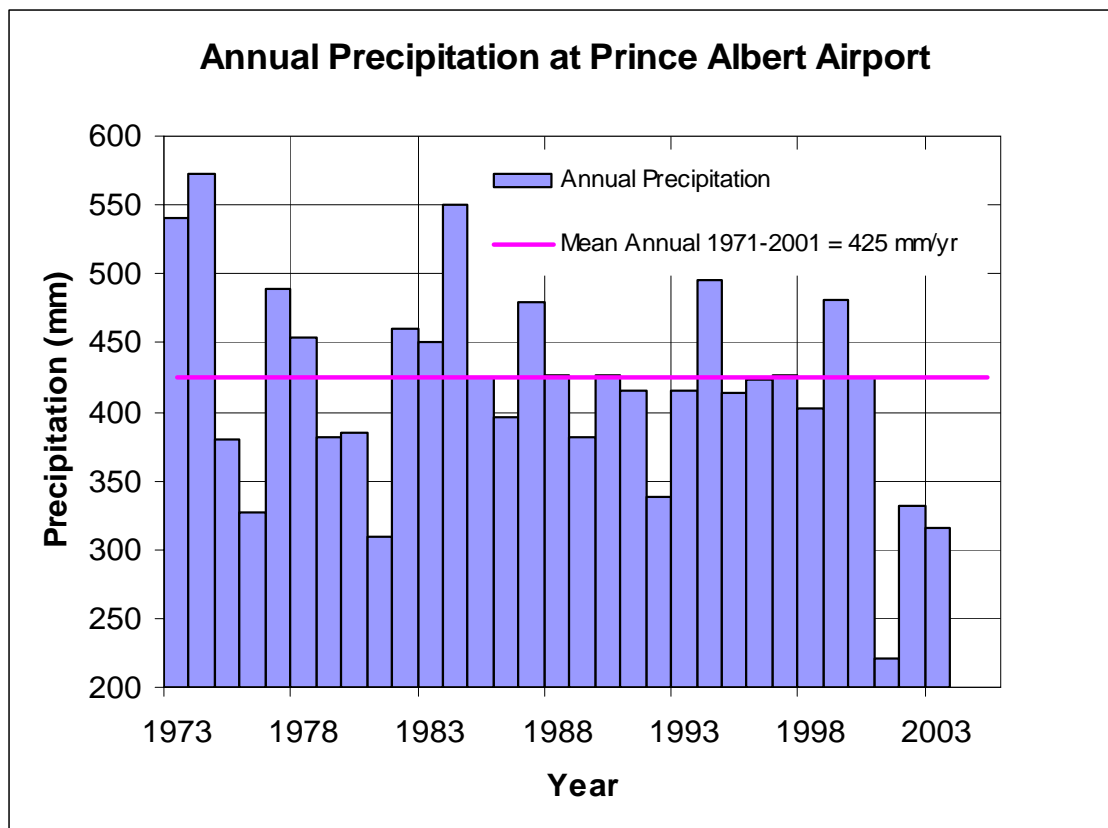


Figure 7: Annual Precipitation at the Prince Albert Airport Meteorological Station

Figure 7 shows that the precipitation in 2002 and 2003 were much less than the 30-year normal for the period 1971-2001. The normal annual precipitation from 1971 – 2000 was 425 mm/year whereas in 2002 and 2003 the total precipitation was 332 mm/year and 315 mm/year, respectively. The 2002 annual precipitation would have been even less if it had not been for the fall (late August and September) rains.

The Water Survey of Canada (WSC) was forced to close down most of the stream flow gauging stations in the mid-1990s. The WSC is still operating a station on White Gull Creek at Highway 106 and the period of record is from 1994 to present (Figure 8). Figure 8 shows the annual runoff from the 629 square kilometer area of the White Gull drainage basin above the Highway 106 monitoring station. Figure 8 shows the effect of the reduced precipitation on the total annual flows in the White Gull Creek in 2002 (2003 data is not yet available), the annual flow in 2002, which is 71 mm, is about 60% less than the average annual flow for the period of record.

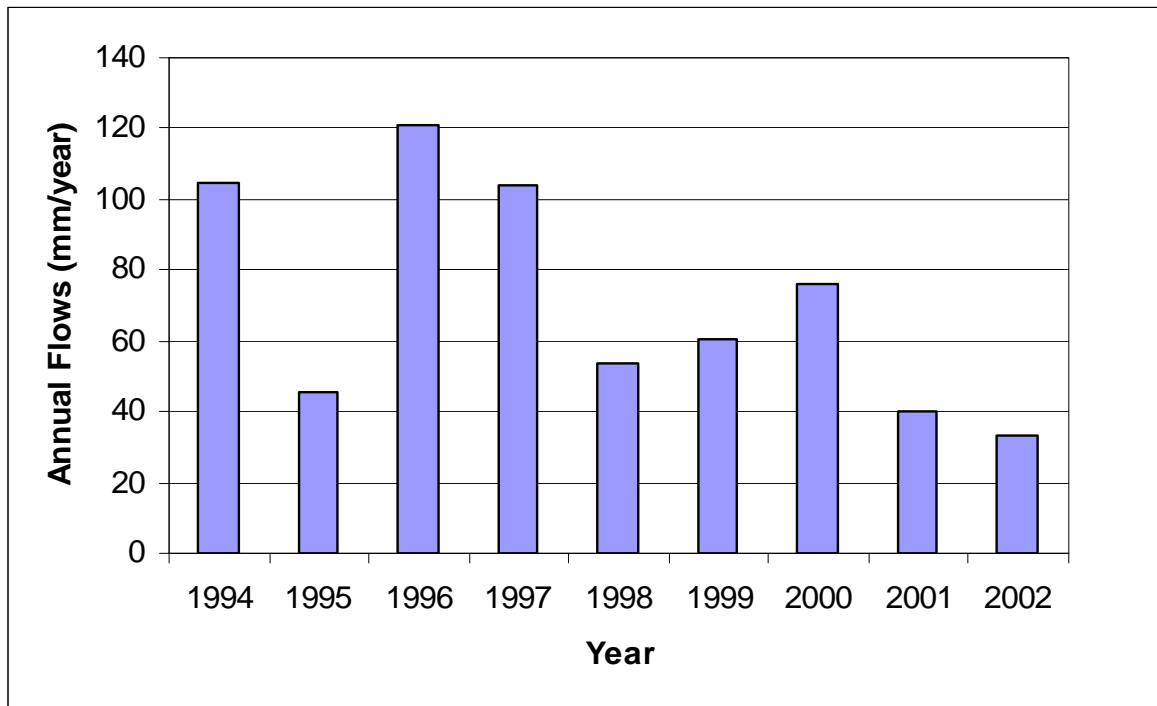


Figure 8: White Gull Creek Annual Flows, at Highway 106, expressed in mm/yr

Figure 9 shows the effect of the recent drought conditions on the lake levels in the area. Figure 9 is for Candle Lake and Waskesiu Lake. Records collected by WSC and Saskatchewan Watershed Authority to produce the records that are shown. Figure 9 shows that Waskesiu Lake has been affected more than Candle Lake. The drop in the water levels in Waskesiu Lake is approximately 0.5 metres, between 2000 and 2003, whereas Candle Lake has dropped about 0.2 metres in the same period.

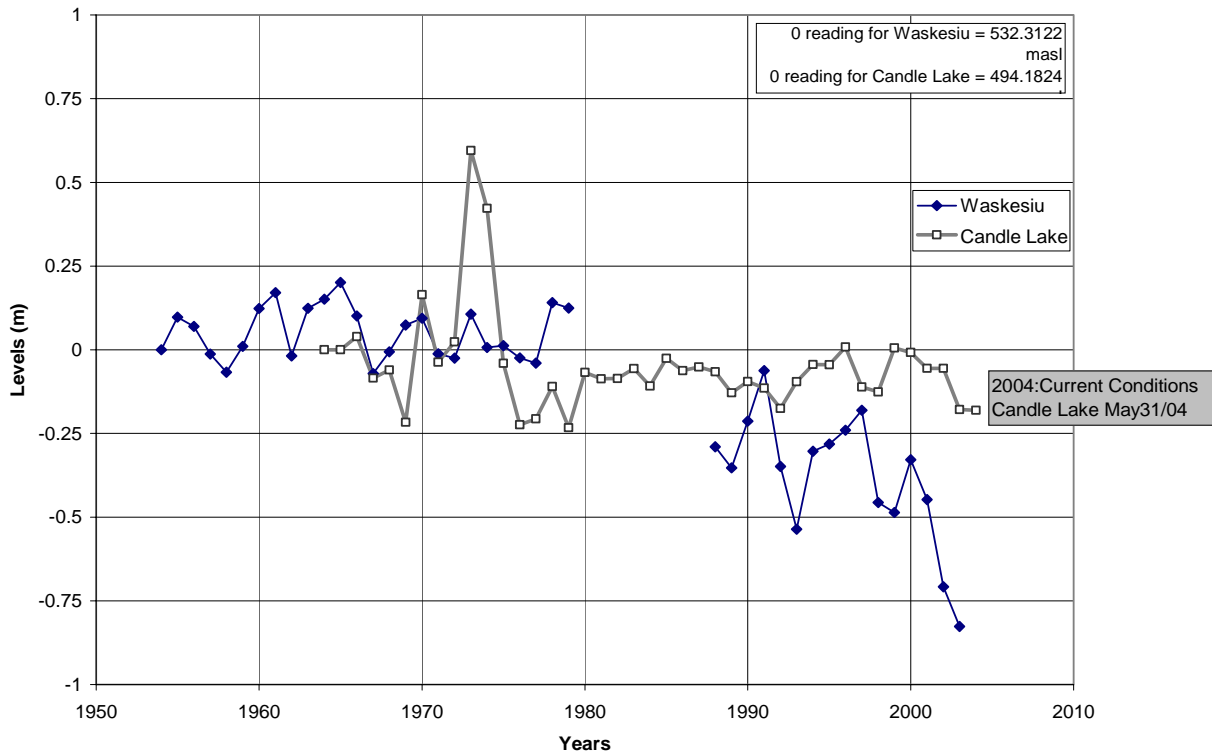


Figure 9: Relative Water Levels at Candle and Waskesiu Lakes

The project team has also monitored the water levels in isolated lakes in the study area in November 2003 and March 2004. These measurements are being collected in order to estimate the amount of groundwater recharge into these lakes over the winter. These data are presently being analyzed.

There are three BERMS monitoring wells in located within the study area are; Old Aspen (OA), Old Jack Pine (OJP) and Old Black Spruce (OBS), these are shown on Figure 4. The water levels at the OA monitoring well, located in the southern part of Prince Albert National Park, have dropped by almost one metre in the last four years, whereas water levels at the OJP site, located south of the Narrow Hills Provincial Park, have dropped by about 0.2 metres in the last year (the only available period of record).

These data from the monitoring wells within the study area are confirmed by the long-term water level record from the shallow groundwater observation wells in the general vicinity. Figure 10 shows the observations from the shallow SRC Duck Lake observation well, which is located south of the study area. Figure 10 indicates that in the last three years there has been a drop of approximately 0.7 m in the shallow groundwater levels at this location. Other shallow groundwater observation wells from west and south-east of the study also show a decline in the groundwater levels over this period.

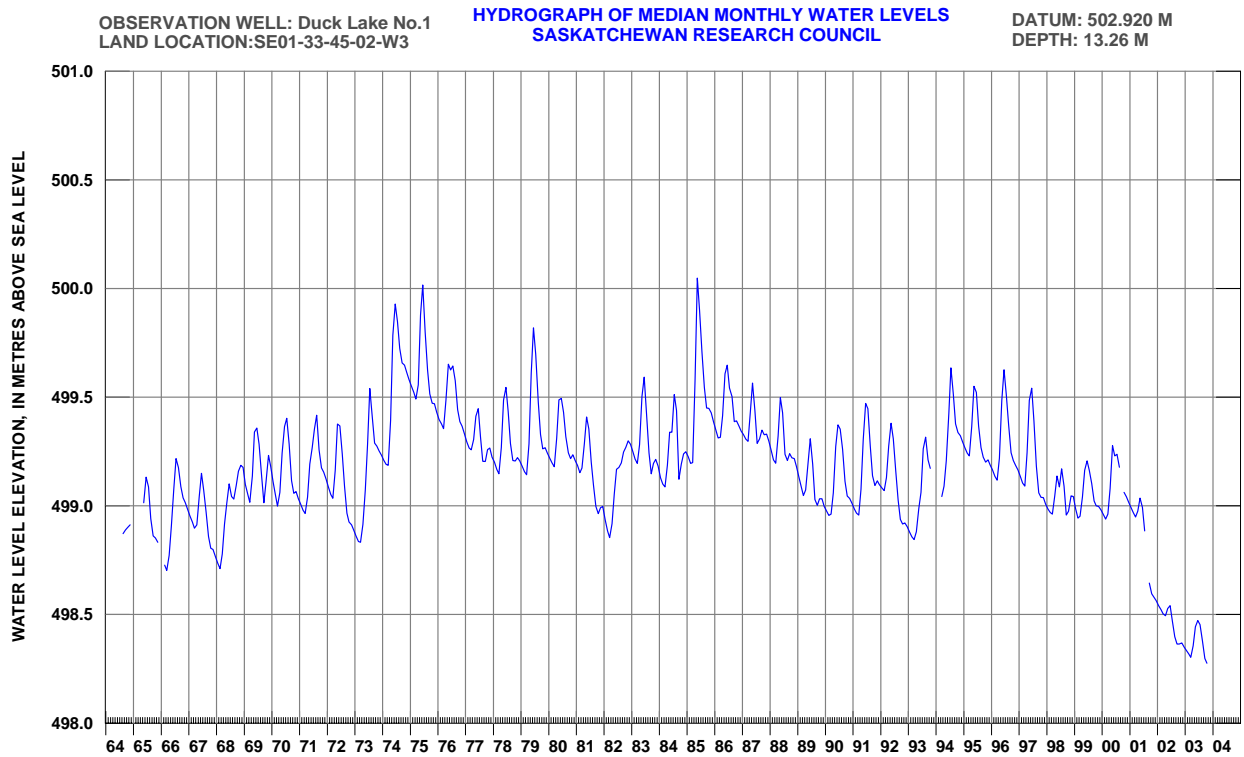


Figure 10: Median Monthly Water Levels from the Shallow Groundwater Observation Well at Duck Lake

Groundwater and Surface Water Sampling

To investigate these drought conditions, surface water sampling was conducted in the fall of both 2002 and 2003. In the fall of 2003, flow and water level observations were also conducted. Figure 11 shows the isotope results from the 2002 sampling program (2003 results are not yet complete), together with the Saskatoon meteoric water line (Saskatoon MWL) on which precipitation for the area falls. The data show large contrasts in isotopes, with most small streams being located near the lower-left portion of the MWL, while most lakes and ponds are located to the right and beneath the MWL, indicating the effects of evaporation.

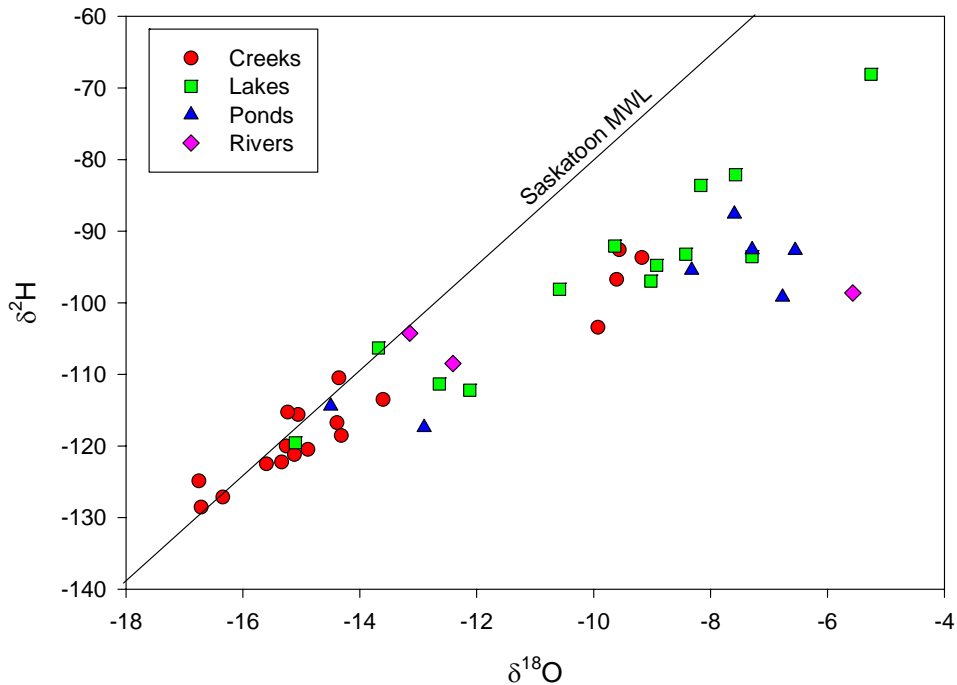


Figure 11: Water Isotope Results from the eastern part of the study area (sampling conducted by NWRI in October 2002)

Figure 12 shows the results from the flow analyses conducted on a small subwatershed (White Gull Creek) in the fall of 2003. Figure 12 shows that there is a large variation in the contribution to the baseflow in White Gull Creek from the various portions of the subwatershed. The western part of the watershed contributes very little to the flows. Figure 12 illustrates observations made during field inspections and sampling in the fall of 2003 when it was noted that there was strong baseflow in some of the streams in and around the southern part of Narrow Hills Park. This persistent flow is likely due to groundwater seepage coming out of the thick surficial sands in the area. These observations suggest that further study is likely to show correlation between surficial geology and the surface water flow regime and chemistry of small streams. Small ponds and lakes may show similar relationships, depending on how they gain and lose water.

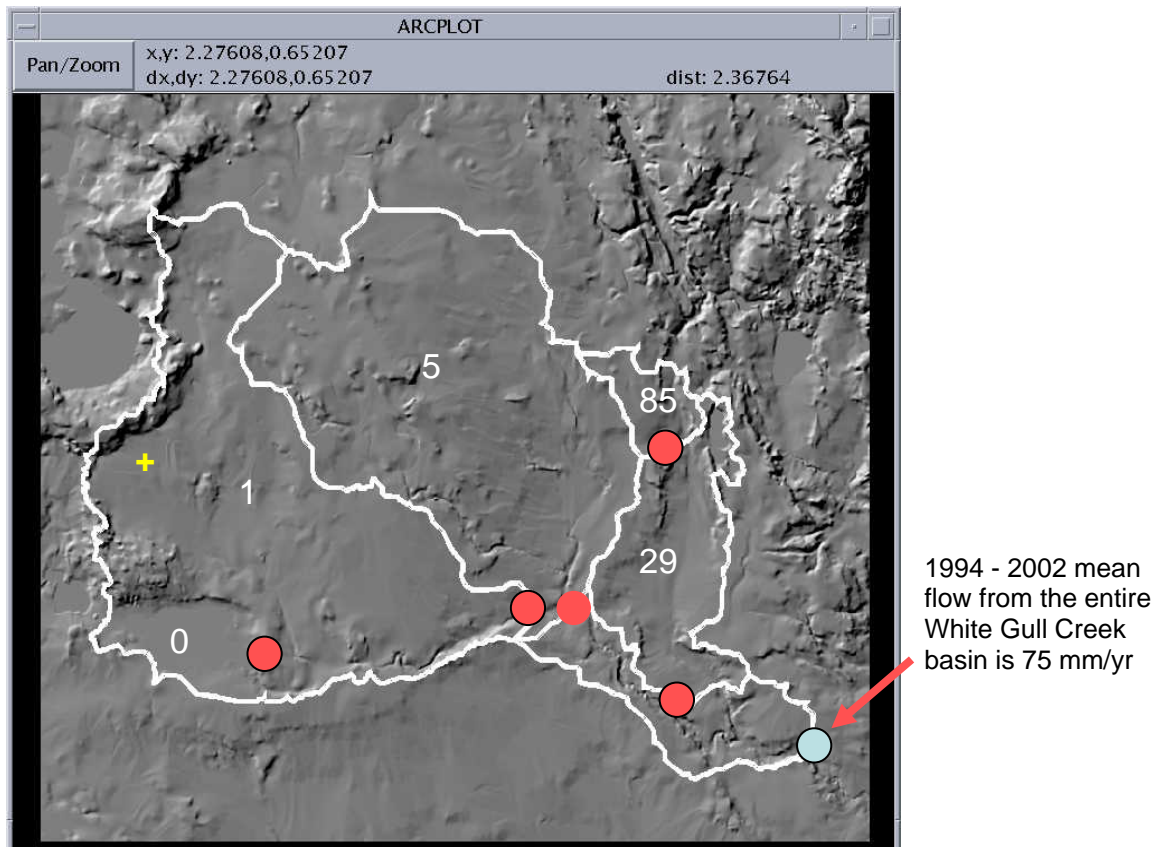


Figure 12: Low (Base) flows in White Gull Creek Drainage Basin at Highway 106 in the fall of 2003 (expressed in millimeters per year [mm/yr] for comparison with the mean annual flows)

In addition, observations were conducted from selected surface water bodies in the summer of 2003. These observations were used to help explain the variation in chemical signatures and corroborate the hydraulic association with the larger systems. Continued observations of these surface water bodies are contingent on receiving continuing funding from the PAMF.

SURFACE WATER METASYSTEM RELATIONSHIPS

The large scale relationships between the surface waters and the hydrogeological flow regime are under review. From a surface water perspective, in a land-use context, the analytical and presentation needs and the data requirements are being defined. Potential sources of this information are being inventoried, collected and tabulated. These data will be reviewed in conjunction with the hydrogeological data to identify the data gaps.

The work initially focuses on horizontal surface flows at the landscape level, including the relative influence of groundwater on hydraulic indices such as discharge from watersheds. Major tasks this year have been initial steps in the construction of an empirical benchmark model to predict flows based on natural features such as precipitation, surficial geology, landform types,

and topography. Areal precipitation values for selected years have been received and we expect the remainder by late spring 2004. Surficial geology indices will be calculated once we have a chance to review the 1:250,000 mapping data. We began to define the landform and topographic indices in late February.

Potential data sources with respect to model validation and the determination of model sensitivity are currently under review. Validation will be carried out through the examination of data subsets while sensitivity will be investigated by way of the variation in regression parameters. Most of the fieldwork in summer 2003 concentrated on confirming subwatershed boundaries in this context, especially for selected no-flow threshold determinations. The requirement for boundary confirmation developed through the 2003 season, since it became apparent that knowledge of many boundaries was erroneous, poorly represented or missing. This is particularly problematic where the information is based on previous work, including the DEM produced in the first phase of the PAMF. The summer fieldwork was also required for planning the sampling in autumn 2003.

The landscape-flow model will be compared with a parallel empirical chemical-constituents model, based on major ions and stable isotopes as dependent variables, or indicators of metasystem connectivity. The first dataset will be complete when all the 2003 water samples have been analyzed chemically.

Lakes as metasystem storage components are under investigation by way of changes in water levels in relation to landscape variables in the basic benchmark model. A preliminary assessment of historical water level data for selected lakes has been undertaken. Historical water level data for additional lakes have been requested. Autumn water level measurements were made of several lakes in the area to determine water level changes over the winter of 2003-2004; these will help determine the sensitivity of numerical storage relationships.

SURFACE WATER SENSITIVITY

These aspects are an expansion of the benchmark models reported on above. Currently, we are formulating criteria in four areas which can affect and be affected by water relationships: forestry and fire management, afforestation and deforestation, wildlife habitat vulnerability, and water management. Considerations with respect to the first three are more areal in nature, while the last-mentioned incorporates aspects that are more linear. Initial inquiries have suggested existing data which may be sufficient for defining variables in the first three areas. Data which may be of use with respect to water management practices have just been received, but an assessment of the potential usefulness of the data won't start until late spring 2004.

PRESENTATIONS

A total of three presentations on the results or about this project have been made. The first presentation was the introduction to our project given Guy Melville at the national model forest workshop in Edmonton February 3 and 4, 2003 at the invitation of the Canadian Forest Service.

We have also made a presentation of some of the results from this project at the Canadian Society of Civil Engineers conference on June 3, 2004 in Saskatoon. The talk was entitled “Surface – Ground Water Interaction in the Prince Albert Model Forest Area”. The PAMF was recognized as the funding source for the work.

Garth van der Kamp also presented some of the data from this project in a talk entitled; “Integrating Hydrology with Fluxnet studies in Canada” that was made to the Fluxnet Canada Annual Meeting in Banff Alberta Feb. 26-29, 2004. The PAMF was recognized as the funding source for the work.

CONCLUSIONS AND RECOMMENDATIONS

Progress has been made on developing the baseline surface and groundwater conditions at the ecosystem level in the PAMF area, and discussing these conditions with respect to the interests of the PAMF partners.

This concludes the second phase of this multi-year project. To complete the activities outlined in our original proposal for the coming fiscal year (2004/2005) additional funding will be required. At this time we anticipate to complete the tasks outlined in this proposal for the fiscal year 2004-2005 an additional \$50,000 (plus GST) will be required from PAMF. The previously proposed budget for fiscal year 2004/2005 was as follows:

| | |
|---|------------------|
| Prince Albert Model Forest Contribution | \$ 50,000 |
| SRC and Others Contribution | \$ 24,500 |
| NWRI/Environment Canada Contribution | \$ 16,800 |
| PFRA Contribution | <u>\$ 5,000</u> |
| Total Proposed FY 2004-2005 Budget | \$ 96,300 |

The proposed tasks to be completed in fiscal year 2004-2005 are:

- Completion of the digitizing of the surficial geology at 1:250,000 scale
- Further development of geological cross sections through the PAMF area
- Aquifer mapping and boundary identification
- Further sampling and instrumentation of both the ground and surface water flow regimes
- Seepage survey to assess groundwater – surface water interaction
- Surface water sensitivity consideration assessment

As previously indicated, the study area was until recently undergoing a severe drought which has a large affect on our project. This drought may be the most severe drought in this area in the last

100 years. During this year's activities, the project team performed additional monitoring of this extreme event by conducting additional stream and river sampling in the fall when surface flows are at their lowest. This sampling event included both water quality sampling and flow measurements throughout the study area. The preliminary results from this event suggest that the surficial geology has an important role in controlling the amount of base flow in stream and river

The proposed increase in the FY 2004-2005 PAMF portion of the budget is \$5,000. This increase will help the study team to finish this sampling program next fall and to include lake samples and also to take measurements to estimate the amount of groundwater recharge into selected lakes over the winter. This increase would also allow the team to continue the sampling of selected streams and rivers during the same period and possibly increase the sampling program. These samples will help monitor the recovery from this extreme drought of 2003.

We understand that the Prince Albert Model Forest will not be making any decision at this time with regard to FY 2004-2005 budget and that the above information was required for planning purposes. As indicated earlier, we will be proposing in March 2004 that the budget for this project be set at \$55,500 (plus GST) for FY 2004-2005, to enable the team to continue to monitor the local water levels and chemistry and the recovery from this extreme drought.

Thank you very much for the opportunity to work on this interesting project. If you have any questions or concerns please contact the undersigned at (306) 933-6711.

Respectively Submitted,

Ian Judd-Henrey
SRC

Guy Melville
SRC

Garth van der Kamp
NWRI