

2015 Geophysics Field School

Virден Project: Data Analysis and Report

1. Goals

Since this project is a (simulated) consulting project, we expect typed project reports in a style appropriate for delivery to a client. The report should contain descriptions of: the project aim, site information, site history, a summary of surveys performed, results, analysis, and interpretation. The two days allocated for data analysis and write-up should be divided approximately into 2/3 analysis and 1/3 preparation of project report. All material is to be submitted by **10 PM Saturday, May 9th 2014**.

As noted in the original handout, more specific questions to be answered include:

1. Is there an electrical response associated with a previous facility at the site?
2. What is the aerial and depth distribution of high salinity?
3. What remaining subsurface infrastructure is present?
4. What are optimal, and other possible, instruments for investigation of the salinity?
5. What is appropriate compensation to the landowner for the presently impacted ground?

2. Steps

There are four key steps in assembling and interpreting the data:

a) Data entry: This is a *communal* activity, in the interest of saving time and minimizing the most tedious part of the work. Everyone should cooperate to produce digital files of all of the data collected, which will then be made available to all participants. This includes README files containing information such as the locations of the seismic, GPR and dipole-dipole lines! All data should be archived on the website (via email to Andrew) if you find data that isn't included, please send it in.

b) Producing maps: The most essential data analysis to be done is the generation of contour maps of the EM31, EM34 and EMP400 data, elevation, magnetic data, VLF, and the site layout. Generating these maps requires editing out bad points and selecting interpolation/contouring parameters. Mapping will be done *in the data acquisition groups* to allow for some division of labor; include maps of unedited and edited data in each report.

c) Further analysis: In addition to maps, you have collected a variety of other data sets: hammer seismic lines, DC resistivity soundings, TEM soundings, and GPR profiles etc. Each report should include raw plots of all data collected, with location and instrumental information; perform as much further analysis as time allows, prioritized based on how much you think they will contribute to the overall interpretation. Analyses may include EM modelling, seismic refraction analysis, DC resistivity inversion, magnetic modeling, etc.; include results in your report (layered models, etc.) It is not necessary to include details of all calculations, though you should indicate what basic methods you used. All of this analysis is to be performed *in pairs*.

d) Report writing: Reports for this project are *individual*; the report should include a summary, an introduction, a description of the survey site (including soils, bedrock geology, topography, land-use) and site history, a description of the surveys performed, analysis results, interpretation, conclusions,

and references. The interpretation, conclusions, and summary for the report should reflect the primary questions being addressed in the survey. References including topographical, geological, and soils maps of the area, previous EM studies, and geophysical texts will be provided. You do not need to submit tables of the data already on the website, but tables of *processed* data may be submitted electronically. When writing the report, keep in mind that the client should be able to access the main information without having to read through excess material – so use Appendices appropriately.

3. Schedule

You have two complete days in which to analyze the data and complete the report. We recommend leaving at least one afternoon free for writing up the report, as it can take longer than expected. Here is a possible schedule to consider:

- Friday AM: Reduction and preliminary analysis of EM, magnetic and elevation results
- Friday PM/Evening: Reduction and preliminary analysis of other geophysics
- Saturday AM: Geological/environmental interpretation and start report
- Saturday PM: Any remaining interpretation, work on report
- Saturday Evening: Finish report writing, submit at 10 PM

4. Groups

	Group 1		Group 2		Group 3
1a	Neil Clark	2a	Easton Sato	3a	Shehryar Gill
1a	Steve Kachappilly	2a	Harsimran Mann	3a	Kevin Ramlakhan
1b	Tony Ulom	2a	Gafaar Ibikunle	3b	Amandeep Dhatt
1b	Qaisar Naseem	2b	Yana Tyomkin	3b	Jason Cornick
		2b	Sodiq Ishola		

4. Specific suggestions regarding data analysis

Apart from points A and B below (which are essential for everyone), these are to be done to the extent that they can make a useful contribution to your interpretation. you have some discretion to prioritize given the limited time you have available.

A. ELEVATION AND GENERAL SURVEY

1. A general site map should be prepared (e.g., with **GRAPHER** or **SURFER**) showing the location of all surveys, the areas of stressed or damaged vegetation, significant points such as marker posts left in the ground, and cultural features such as roads and pipes
2. Elevation data should be contoured and described
3. Relevant GPS coordinates may be used to tie the grid to an absolute coordinate system. Include a table of UTM locations for important points.

B. BASIC EM ANALYSIS

1. Produce contour maps of the unedited vertical and horizontal data for the different EM instruments/modes

2. Data should be edited to remove obviously spurious data points (e.g., using the site map or magnetic information)
3. Produce contour maps of the edited data for both modes.
4. Interpret the spatial variations in conductivity
5. Examine and interpret the correlation between the conductivity and elevation across the site. This may be done qualitatively, using a scatter plot in **GRAPHER**, or better, by plotting the contoured EM response over a 3-D wireframe of the elevation.
6. Plot pseudosections of the EM responses along selected profiles by gridding and contouring each EM response plotted at its position along the profile and a depth corresponding to 50% of the exploration depth (the depth above and below which material contributed 50% of the response). This depth is equal to 0.375 times the coil spacing for the horizontal dipole mode and 0.866 times the coil spacing for the vertical dipole mode.

C. MORE ADVANCED EM ANALYSIS

1. Using EM forward modelling and inversion software, generate layered models from available FEM data at points of particular interest
2. Examine the higher frequencies recorded by the GSSI Profiler, as well as the in-phase values. The higher frequencies are sensitive to shallower structure; the in-phase values are sensitive to magnetic susceptibility in the subsurface.
3. Plot pseudosections of the EM responses along selected profiles by gridding and contouring each EM response plotted at its position along the profile and a depth corresponding to 50% of the exploration depth (the depth above and below which material contributed 50% of the response). This depth is equal to 0.375 times the coil spacing for the horizontal dipole mode and 0.866 times the coil spacing for the vertical dipole mode.

D. DC-RESISTIVITY ANALYSIS

1. Plot Wenner results and provide qualitative interpretation
2. Model using unconstrained and constrained inversions
3. Plot dipole-dipole data as pseudosections
4. If time permits work with an instructor to invert the data using **RES2DINV**
5. Compare and integrate with layered structure from EM31 and seismic analyses

E. SEISMIC REFRACTION ANALYSIS

1. Plot forward and reversed arrivals
2. Fit with layered models examining evidence for dip and calculating dips if appropriate
3. Interpret seismic structure in terms of geology.

F. MAGNETIC DATA

1. Plot total field and gradient data as profiles or contour maps. Shaded relief maps may also be useful for the magnetic plots.
2. Perform qualitative interpretation.
3. If clear signals due to pipes, etc., are present, complete quantitative interpretation e.g. to define the depth.

G. GPR

1. With the assistance of an instructor construct plots of the GPR profiles.
2. Interpret GPR structure in terms of geology or absorption by conductive zones.

H. SYNTHESIS

1. If possible and time allows, synthesize a single layered structure that is compatible with all of the magnetic, seismic, DC-resistivity, and EM data. This process is sometimes difficult and not always successful as seismic and EM (and even galvanic electrical and inductive EM measurements) response to different subsurface properties.
2. If possible and time allows, synthesize a map showing the location of subsurface cultural features as indicated by the different methods (magnetic, magnetic gradient, in-phase-EM, and low induction number EM).
3. Examine the spatial correlation of the level of the shallow EM responses with visible signs of salinity (e.g. dead or stressed vegetation).
4. Calculate the area of impacted vegetation and the corresponding compensation required.

5. Resources

Large-scale geological setting

The large-scale geological setting is shown in Figure 1 and 2. Additional data can be found at the Manitoba Geological Survey Williston Basin TGI web pages and other web pages <http://www.manitoba.ca/iem/mrd/geo/willistontgi/index.html>

Smaller-scale geological setting including surficial geology

Figure 3 shows the bedrock geology in the Virden area. Figure 4 shows the thickness of the surficial deposits (drift thickness) and Figure 5 shows the divisions of the surficial geology. Figure 6 shows the water quality in the Virden area. Relatively high values of TDS are noted in both the surficial and shale aquifers. Additional information is available in Betcher (1983).

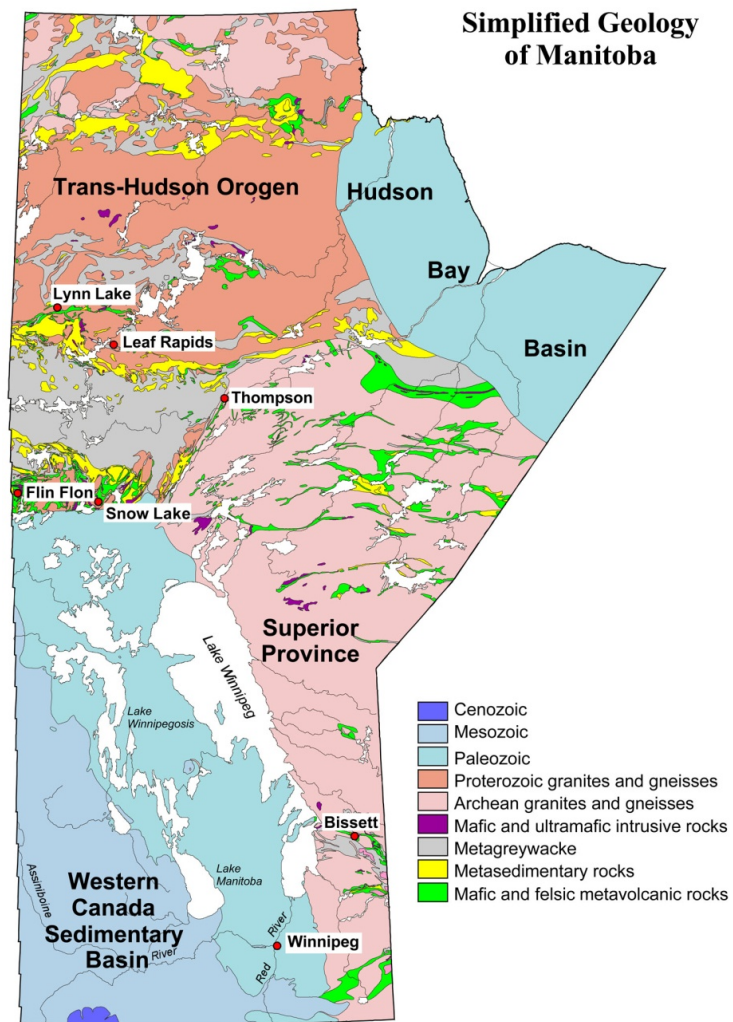


Figure 1. Bedrock geology of Manitoba (Manitoba Geological Survey <http://www.manitoba.ca/iem/mrd/geo/exp-sup/files/fig1.pdf> accessed 03 May 2014). The Virden area is characterized by Mesozoic (Cretaceous) rocks.

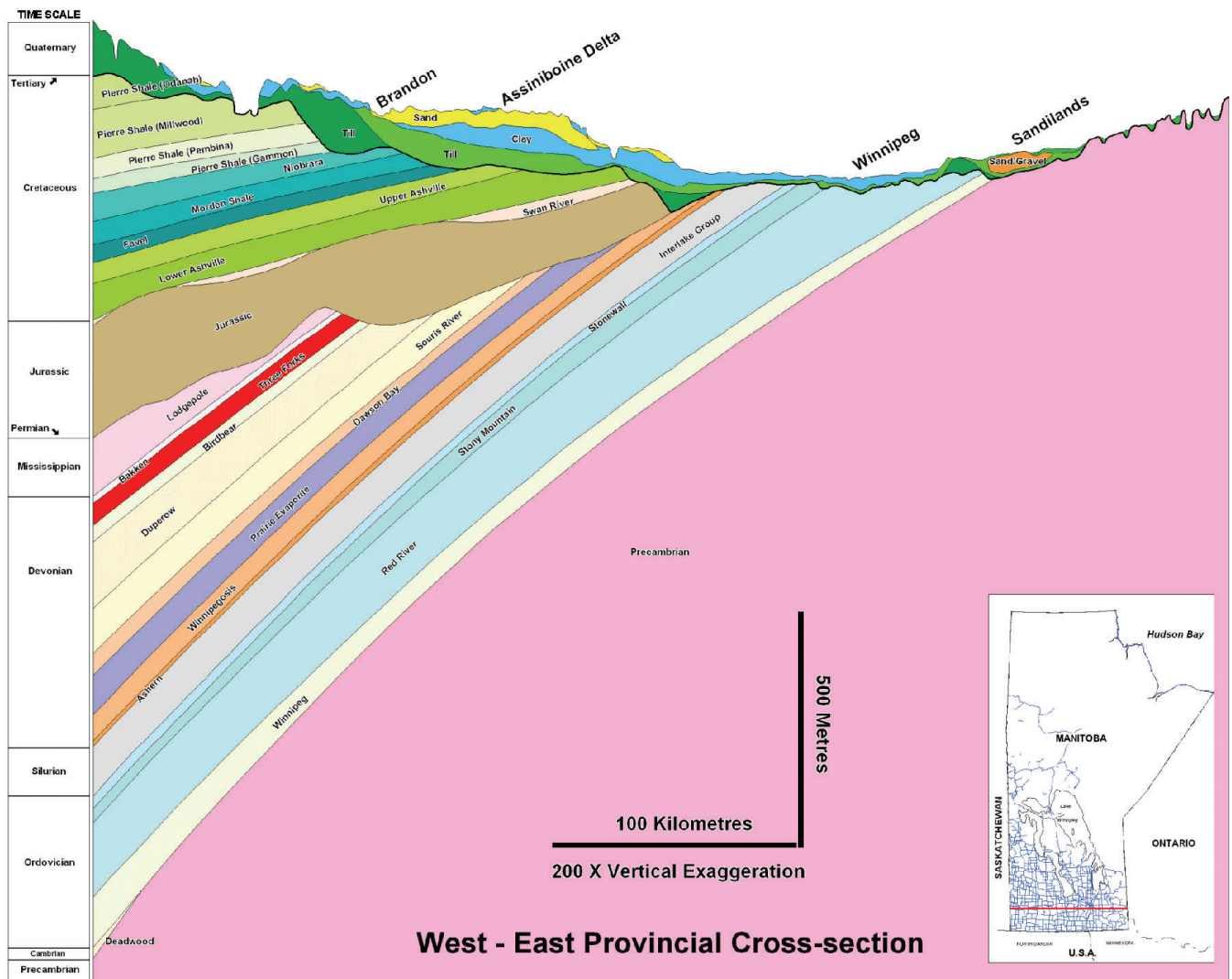
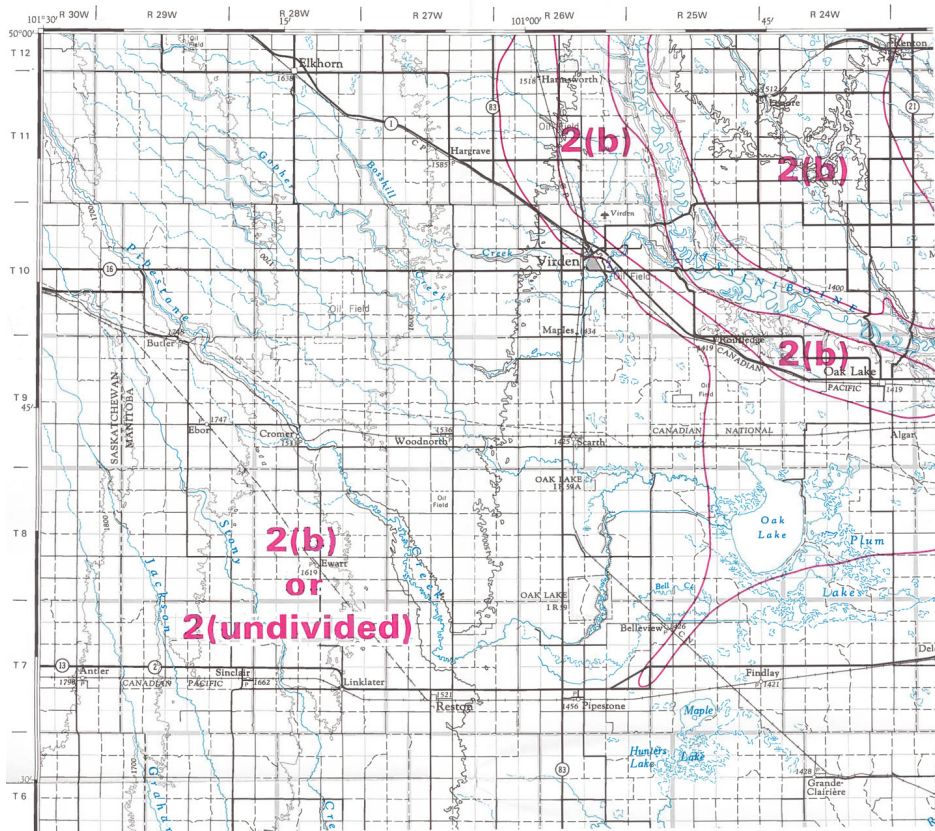


Figure 2. Geological cross-section for Manitoba (Manitoba Geological Survey http://www.manitoba.ca/iem/mrd/geo/3dmodel/cross_section_large.html accessed 03 May 2014). The Virden area is characterized by subcropping Odanah shale.



BEDROCK GEOLOGY

TERTIARY

4 TURTLE MOUNTAIN FORMATION: grey, brown and yellow sand, silt, silty clay and clay; minor lignite.

CRETACEOUS

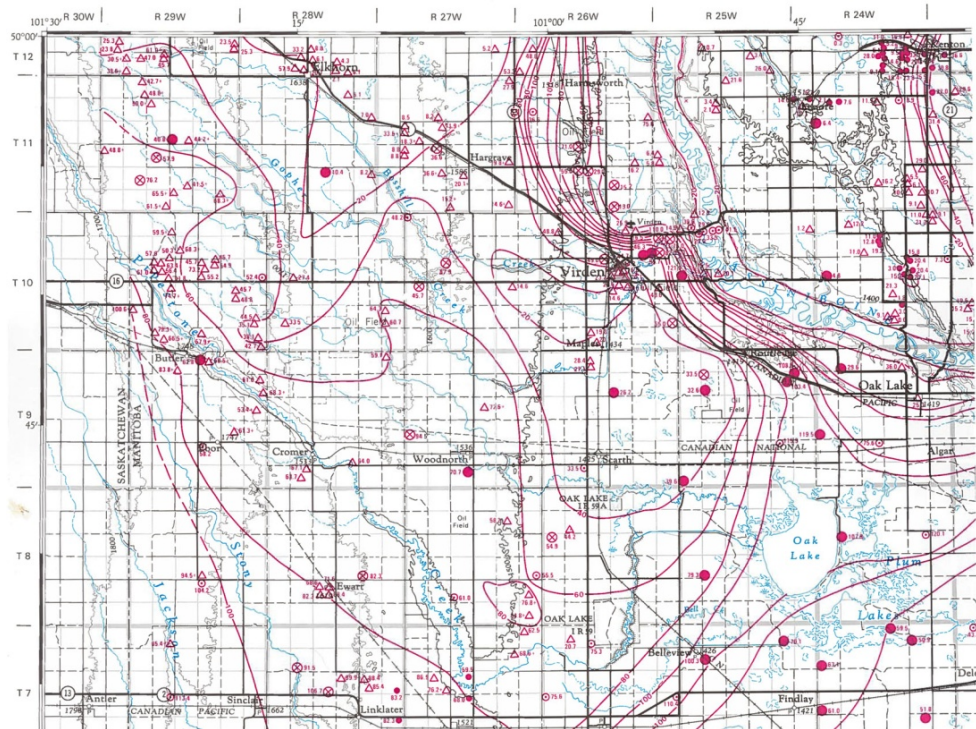
3 BOISSEVAIN FORMATION: grey, brown, green sandstone; minor siltstone and shale.

2 RIDING MOUNTAIN FORMATION:
 (a) Coulter Member: light grey to buff clayey siltstone and shale.
 (b) Odanah Member: hard grey siliceous shale.
 (c) Millwood Member: soft greenish brown bentonitic silty shale.

1 VERMILLION RIVER FORMATION: black, soft, calcareous or non-calcareous shale.

CONTACT BETWEEN BEDROCK FORMATIONS

Figure 3. Bedrock geology of the Virden area (modified from Betcher 1983).



DRIFT THICKNESS

LEGEND

- W.R.B. GROUNDWATER AVAILABILITY BOREHOLE ●
- W.R.B./W.S.B. WATER SUPPLY INVESTIGATION BOREHOLE ●
- W.R.B. BOREHOLE, OTHER ○
- G.S.C. OR MANITOBA MINES BRANCH BOREHOLE ○
- UNIVERSITY OF MANITOBA BOREHOLE ○
- OIL EXPLORATION BOREHOLE ○
- WATER WELL ○
- BOREHOLE, OTHER ○
- DEPTH OF BEDROCK IN METRES ○
- CONTOUR LINE OF EQUAL DRIFT THICKNESS —
- (Contour Interval 20 Metres)
- BEDROCK OUTCROP x

W.R.B. = Manitoba Water Resources Branch
 W.S.B. = Manitoba Water Services Board
 G.S.C. = Geological Survey of Canada

Figure 4. Drift thickness in the Virden area (modified from Betcher 1983).

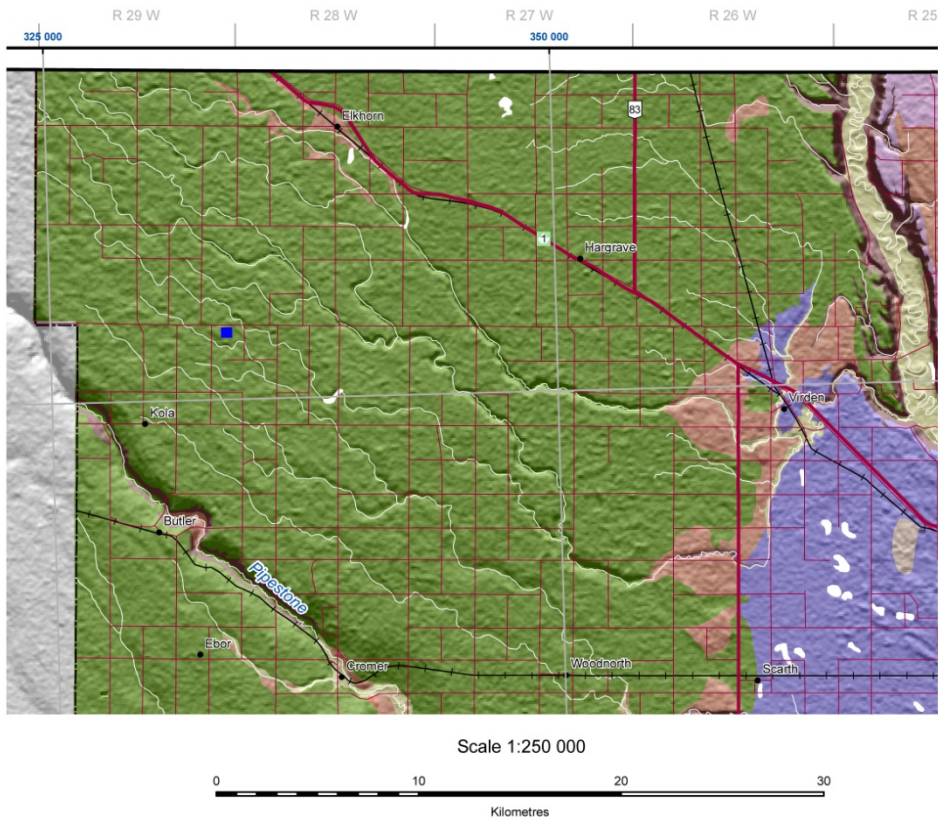


Figure 5. Surficial geological units in the Virden area. Modified from Matile & Keller (2004) after Blais-Stevens et al. (1999).

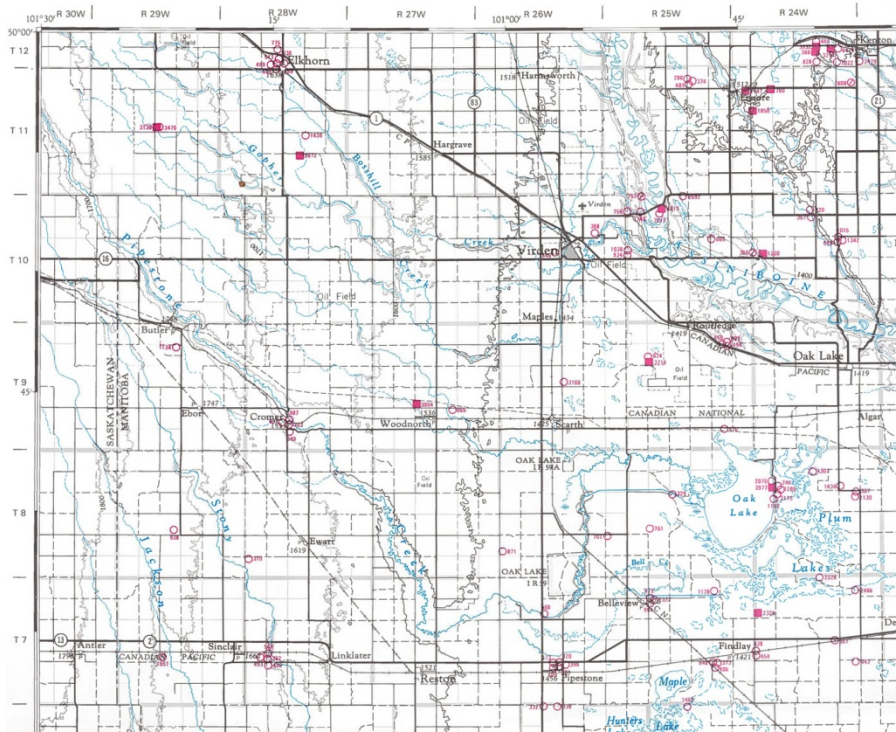


Figure 6. Water quality in the Virden area (modified from Betcher 1983).

References

- Betcher, R.N., 1983. Groundwater availability, Virden area (62F); Manitoba Department of Natural Resources; Water Resources, Groundwater Availability Map Series, Map 62F, scale 1:250 000.
- Blais-Stevens A., Sun C., & Fulton R.J., 1999. Surficial geology, Virden, Manitoba-Saskatchewan; Geological Survey of Canada, "A" series Map, Map 1922A, scale 1:125 000.
- Matile, G...D. & Keller, G.R., 2004. Surficial geology of the Virden map sheet (NTS 62F) Manitoba. Published by Manitoba Economic Development and Mines, Manitoba Geological Survey.