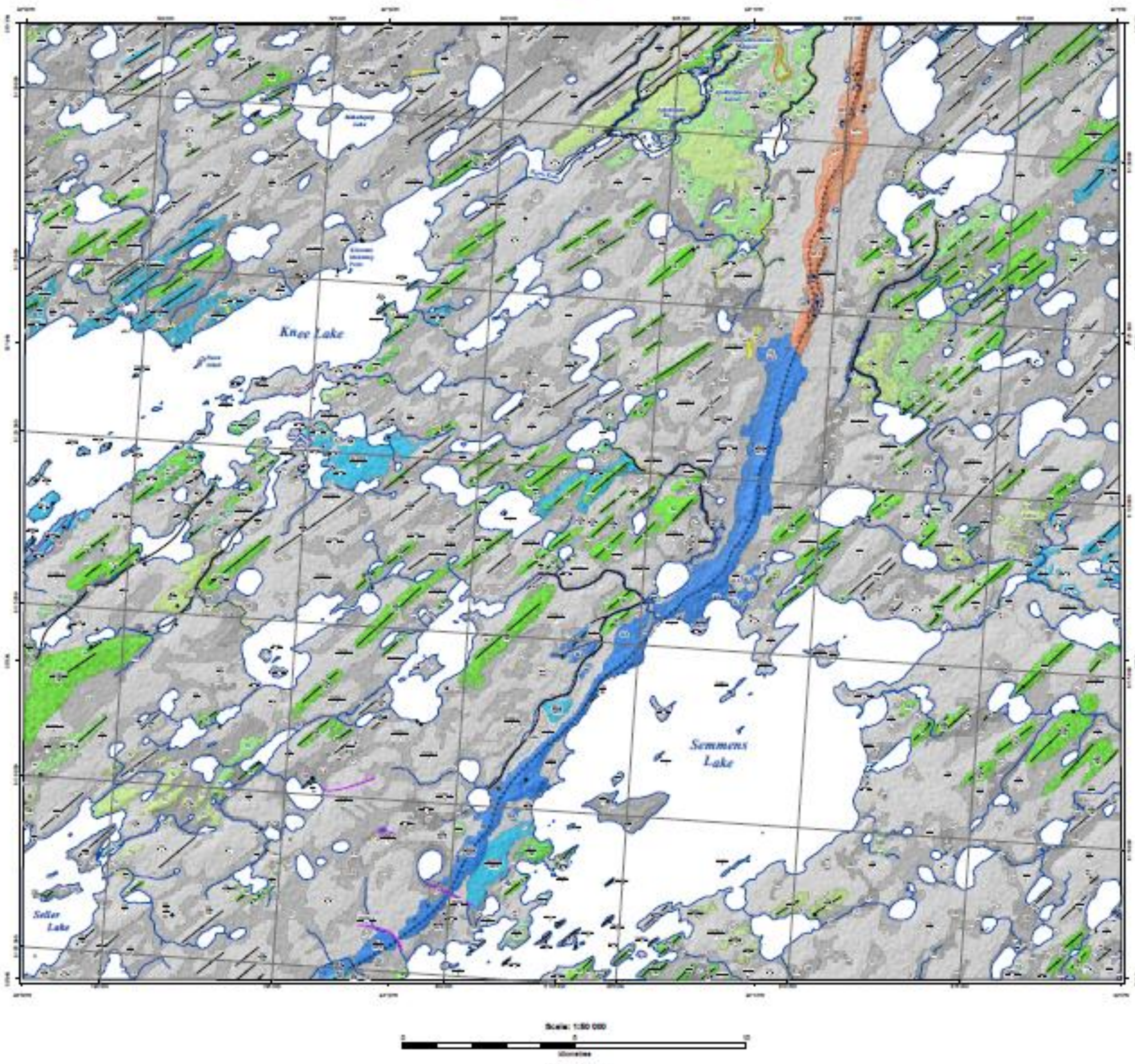
How to create, and understand, surficial geology maps

Manitoba Geological Survey, 2014



•Surficial maps describe the distribution and characteristics of sediments at the surface. This can include unconsolidated sediment and consolidated rock.

QUATERNARY
SURFICIAL DEPOSITS
QUATERNARY
HOLOCENE

NONGLACIAL ENVIRONMENTS

ALLUVIAL DEPOSITS: Sorted sand, silt and clay with minor gravel and organic detritus; commonly stratified; deposited along and/or within all modern rivers and streams.

Ap — **Floodplain deposits:** sorted sand, silt, clay, minor gravel and organic detritus greater than 1 m thick; forming active floodplains close to river and stream level; includes terraces too small to show at this map scale.

At — **Fluvial terraces:** inactive terraces above modern floodplain; greater than 2 m thick; consisting of gravel, sand, and overbank silts and organic detritus on the North Knife River. Annual spring ice-push continues to build up sediment along the side of these terraces.

O — **ORGANIC DEPOSITS:** Undifferentiated peat and muck; 1 to greater than 5 m thick; formed by the accumulation of plant material in various stages of decomposition; generally occurs as flat, wet terrain (swamps and bogs) over poorly drained substrates. Fibric fens are present along some water channels. Permafrost is commonly present underlying/within thick organics, as seen by the prevalent raised bogs with ice wedge polygons. Small, unmapped deposits commonly occur in most terrain units. Peat mantles most geologic units.

Ov — **Organic veneer:** thin, discontinuous peat, less than 1 m thick, which drapes the existing topography.

Ob — **Organic blanket:** continuous peat between 1 and 2 m thick, which drapes the existing topography.

Op — **Organic plain:** flat to gently undulating plain of peat greater than 2 m thick, that contains numerous small thermokarst ponds and depressions.

COLLUVIAL DEPOSITS: Mass-wasting debris up to 5 m thick along the North Knife River; nonsorted to poorly-sorted, massive to stratified debris deposited by direct, gravity-induced movement; composition depends on source material.

Ch — **Mass-wasting debris:** glacial sediment moved down-slope by active and inactive mass-movement processes; hummocky topography.

Cf — **Landslide and slump debris, toe:** fan-shaped base where sediment derived from mass-movement processes upslope has come to rest.

Cv — **Colluvial veneer:** thin and discontinuous cover of slumped and/or solifluctred material greater than 1 m thick.

EOLIAN DEPOSITS: wind-deposited medium to fine sand; derived from deltaic, esker or glaciolacustrine deposits; in some areas eolian sediments are thin or absent between dunes.

Ev — **Eolian veneer:** discontinuous veneer of eolian sediments; less than 1 m thick.

Er — **Ridged eolian deposits:** forming dunes; generally greater than 2 m thick.

L — **LACUSTRINE DEPOSITS:** Undifferentiated deposits; massive to stratified, sorted sand, silt, clay and minor organic detritus deposited adjacent and/or within modern ponds and lakes

MARINE SEDIMENTS: Poor to well-sorted sand and silt with 0-20% pebbles, cobbles and occasional boulders (ice rafted and lags), deposited in the postglacial Tyrrell Sea. Clasts are typically subrounded to subangular, occasionally striated and/or faceted/bullet-shaped, derived from the reworking of till. The marine limit is between 165-180m a.s.l., defined by washing limits on eskers and till plains and by the elevations of sand blankets and beaches. The exact elevation is uncertain, owing to the likelihood that glacial Lake Agassiz was coeval to the Tyrrell Sea during deglaciation. Near the marine limit, glaciomarine sediment also occurs. These sands and silts locally include pockets of debris-flow sediments, till and/or minor dropstones, deposited from suspension and iceberg rafting.

Mv — **Marine veneer:** thin, discontinuous sands less than 1 m thick that drape the existing topography; overlies wave-washed till between 170 and 140 m a.s.l.; below 140 m a.s.l. present as sandy patches overlying bedrock outcrops where all till has been removed. Predominately derived from reworking of till and/or glaciofluvial deposits.

Mn — **Nearshore sediments:** poor to well-sorted, sand, silt and clay; occurs as veneers and blankets of sediment overlying till and/or bedrock; commonly between 1 and 2 m thick, but can be up to 5 m along the North Knife River valley.

Mb — **Offshore sediment blanket:** flat to gently undulating plain of fine sand, silt and clay greater than 2 m thick; often overlain by a layer of organic material (less than 1 m thick); sparsely fossiliferous; offshore sediment.

Mr — **Littoral sediments:** poor to well-sorted, stratified sand with 5-20% pebbles and cobbles; typically 1-2 m thick. Beach ridges, consisting of sand and cobbles derived from the underlying till, are present at elevations of 155-170 m a.s.l. More common are linear patches of pebbly sand with occasional spits, derived from esker and crevasse ridges. The latter typically contain a higher percentage of exotic lithologies. Where esker and crevasse ridges occur below marine limit, wave-washing has commonly reduced the ridges down to a common height of 0.25-1 m and re-distributed the sand — creating veneers and blankets of light orange, granitic pebbly sand. Low-lying regions or depressions often have an organic veneer overlying the sand and silt.

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- Each map has a legend, with common classes that may have been modified to provide information for a specific area.

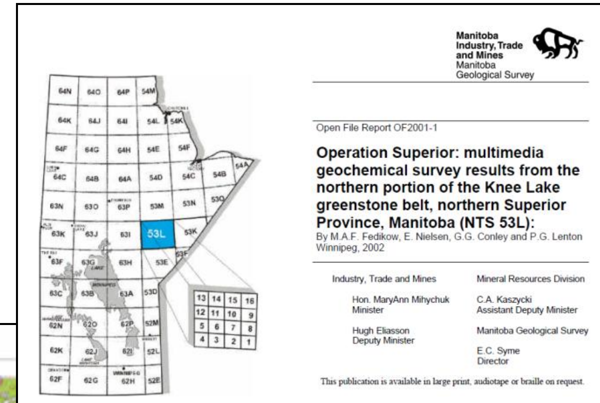
Symbols

Rogen moraine (pristine)	Limit of mapping	Mass movement
Trimline (Scarp)	Major moraine	Outcrop
Streamlined bedrock	Meltwater channel	Radiocarbon
Beach ridge	Meltwater channel corridor	Delta
Crag-and-tail landform	Minor moraine undifferentiated	Field site with sample
Crevasse ridge	Scarp	Field site without sample
De Geer moraine	Esker, direction known	Striae - known well
Drumlin	Esker, direction unknown	Striae - known poor
Drumlinoid ridge or fluting	Esker, washed known	Striae - unknown well
Dune	Esker, washed unknown	Striae - unknown poor
Iceberg scour		

•The production of a surficial geology map involves a combination of air photo interpretation and field work.

Pre-fieldwork

- Mappers start by gathering pre-existing data:
  - Surficial, terrain, soil or aggregate maps,
  - mineral deposits, and/or
  - historical data.


Manitoba Industry, Trade and Mines
Manitoba Geological Survey

Open File Report OF2001-1

Operation Superior: multimedia geochemical survey results from the northern portion of the Knee Lake greenstone belt, northern Superior Province, Manitoba (NTS 53L):

By M.A.F. Fedikow, E. Nielsen, G.G. Conley and P.G. Lenton
Winnipeg, 2002

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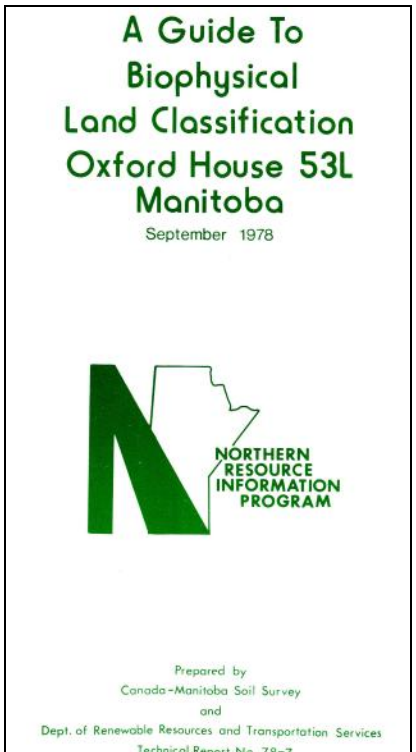
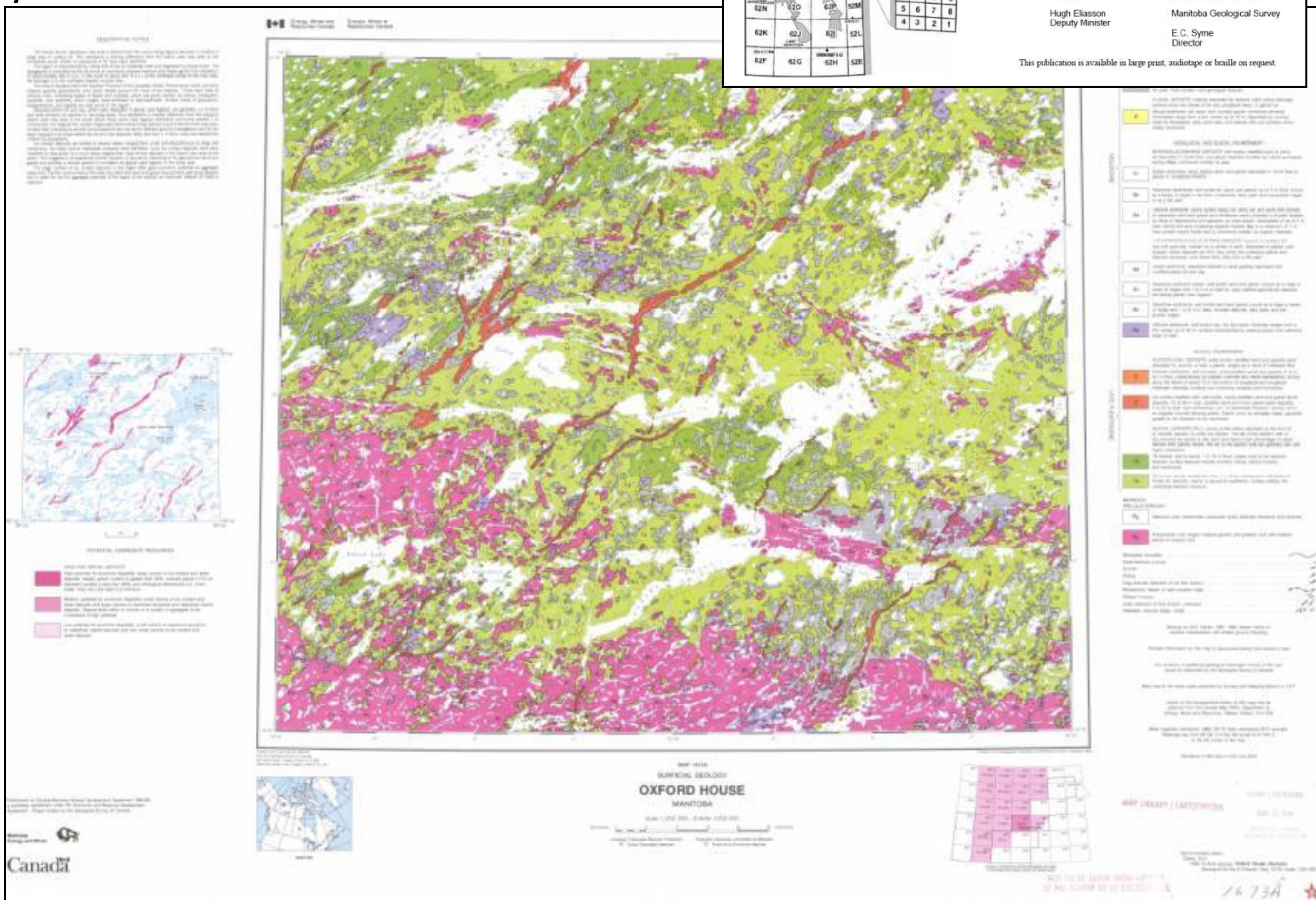
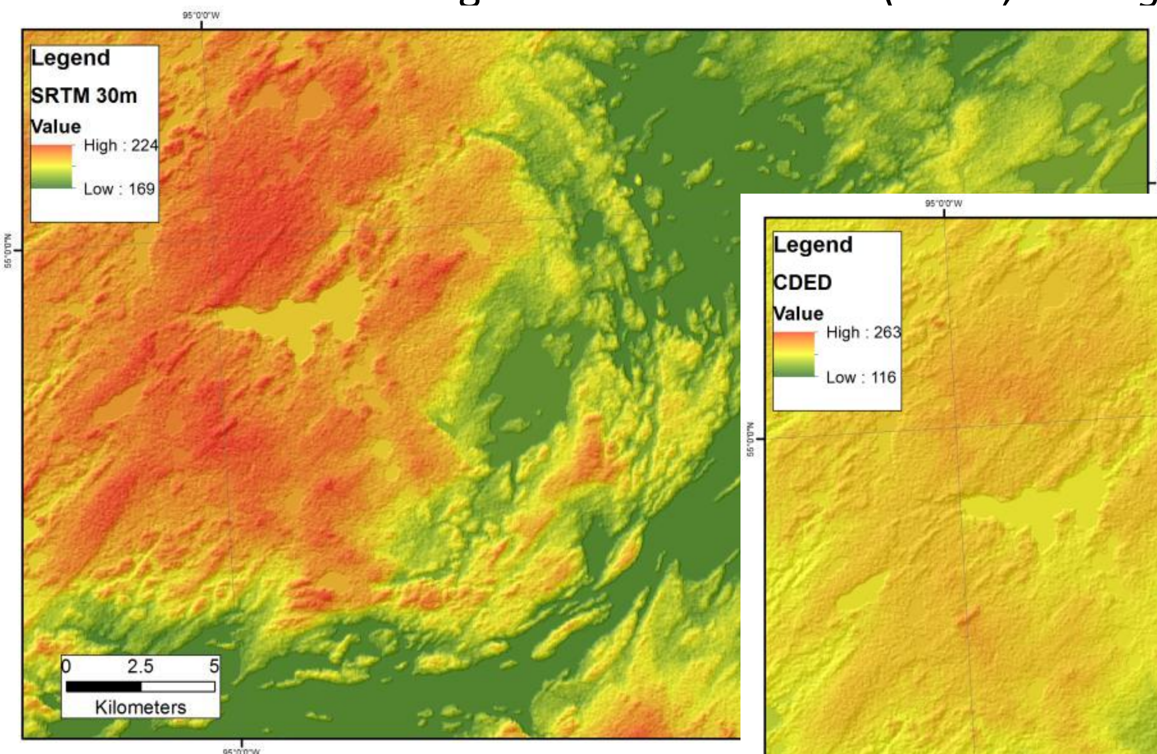

A Guide To
Biophysical
Land Classification
Oxford House 53L
Manitoba
September 1978

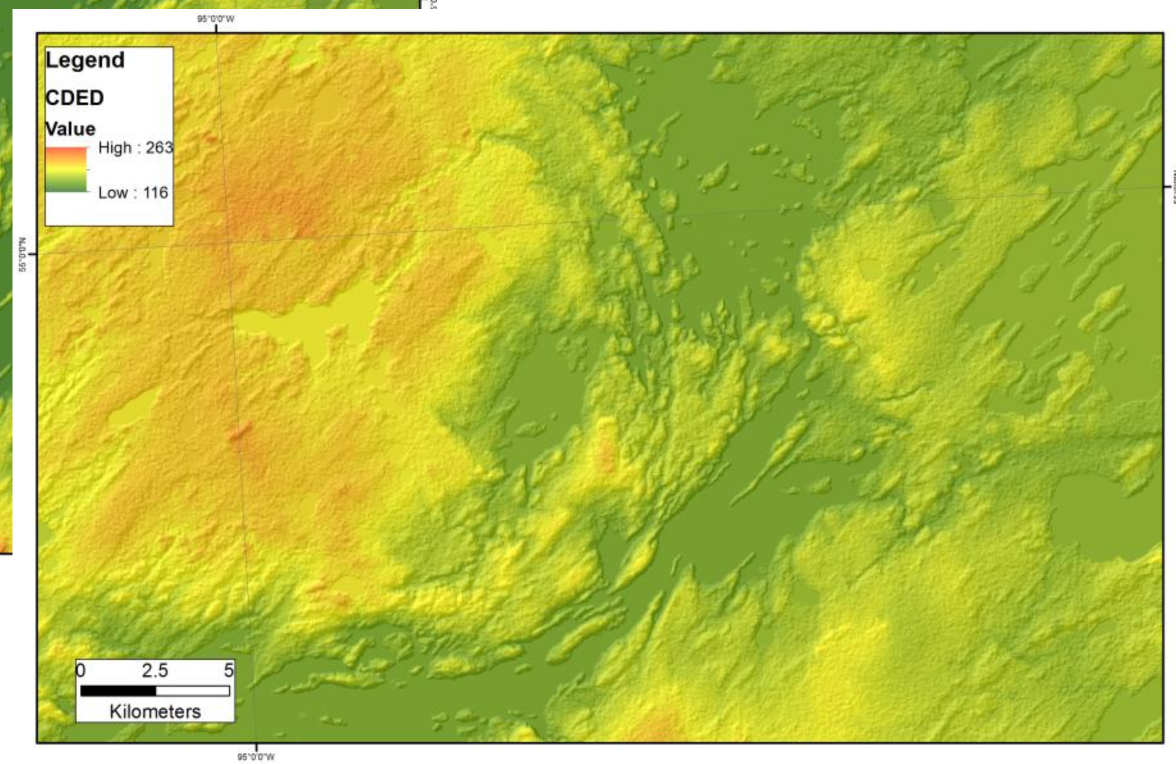
Prepared by
Canada-Manitoba Soil Survey
and
Dept. of Renewable Resources and Transportation Services
Technical Report No. 78-7



Pre-fieldwork

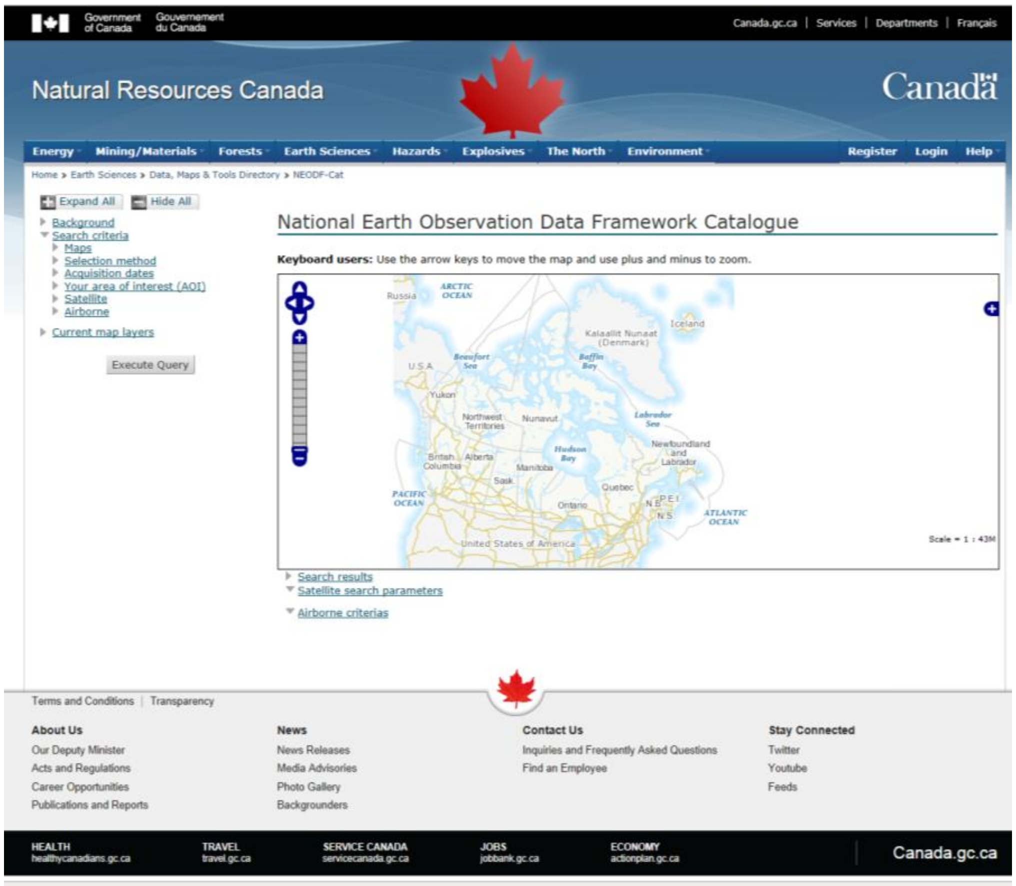
- Mappers also gather topographic data:
  - Shuttle Radar Topography Mission (SRTM; *http://dds.cr.usgs.gov/srtm*),
  - Canadian Digital Elevation Model (CDED, *www.geobase.ca*).

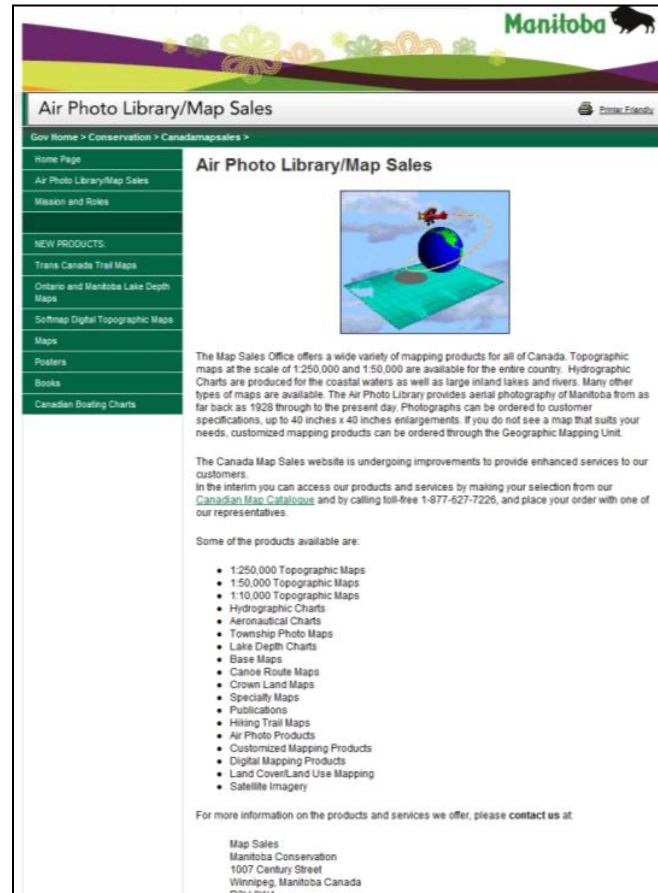




Pre-fieldwork

- Mappers then order aerial photographs.
  - In general, air photos should be at a scale slightly larger than that of the finished map. Air photos with a smaller scale than the finished map should not be used unless photos of a suitable scale are not available.





https://www.gov.mb.ca/conservation/canadamapsales/

Fieldwork

•Fieldwork involves identifying and characterizing different surficial materials and landforms.

•Geologists go into the ‘field’ (the outdoors), set up a camp, and get ready to explore and document what they find.

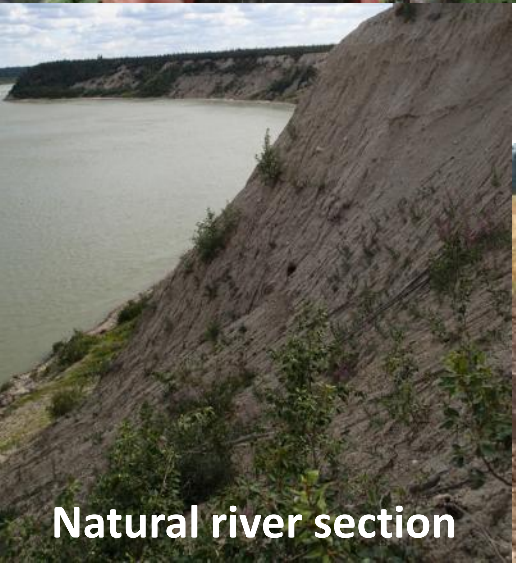
Fieldwork

- At each site, the geologist writes down:
  - **Location**: Latitude and longitude, or UTM coordinates.
  - **Elevation, vegetation, drainage**
  - **Surface expression/landform**: flat, undulating, hummocky, sloping (gentle, moderate, steep), depression, drumlin, terrace, etc.
  - **Sediment/Rock**: matrix grain-size, sorting, stratification.
  - **Clasts**: concentration, shape, rounding, type.
  - **Ice-flow measurement:** orientation, type, relative age, position.

- And if a sample is taken:
  - **Sample**: name, material, depth (top and bottom), soil horizon, position on landform.

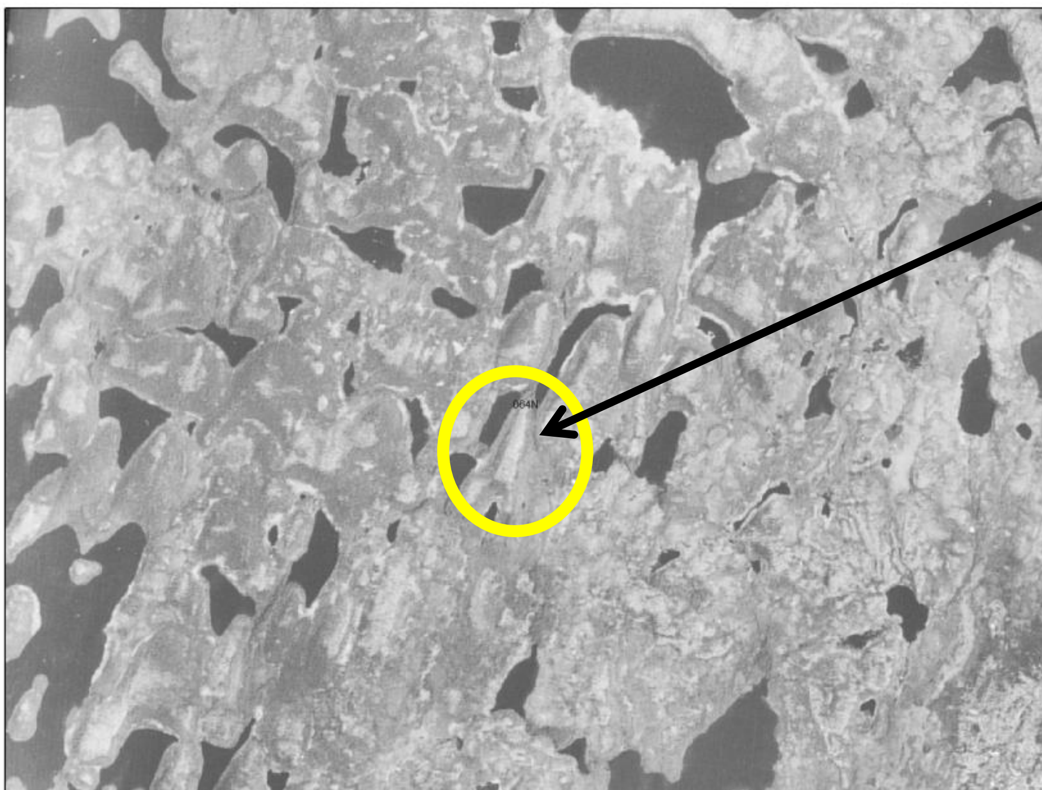
Fieldwork

- In order to characterize the sediment, mappers need to see at least 1 m down into the substrate.



Fieldwork

•As geologists collects more data, their understanding of the region evolves. This allows them to make a more informed/detailed interpretation at subsequent sites – and informs the interpolation process that happens during air photo mapping of areas that haven't been field-checked.



Example

The white top of this drumlin tells the mapper that the area is well-drained. This could be because either:

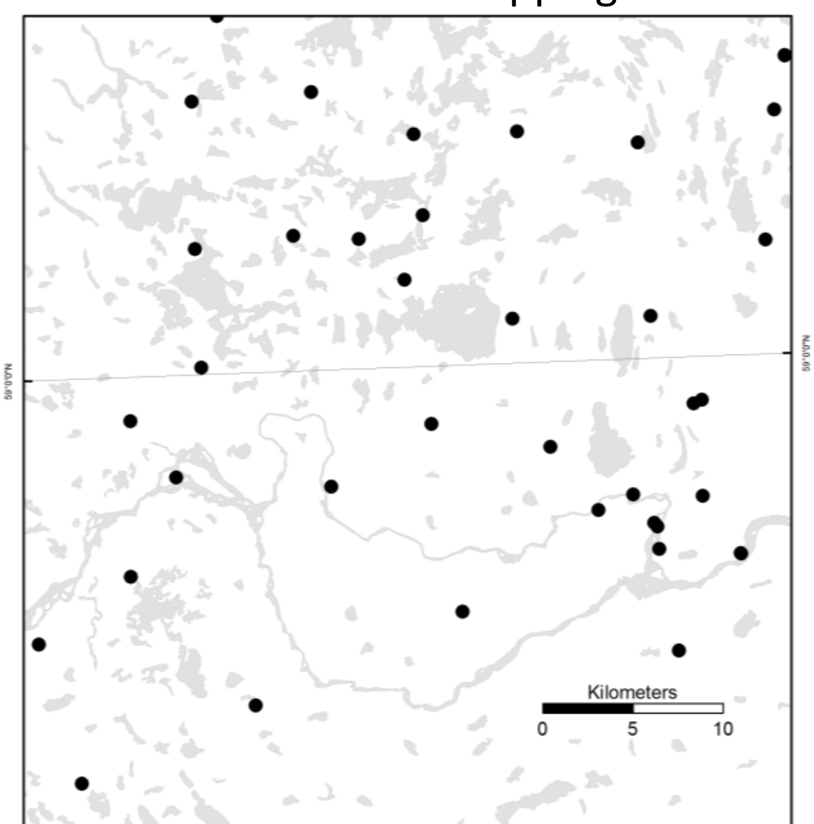
1. The whole area is till but this area is higher, or
2. The drumlin is made mostly of sand and gravel, which is more permeable than till.

The geologist will make sure to dig a hole at this site, so they know the answer.

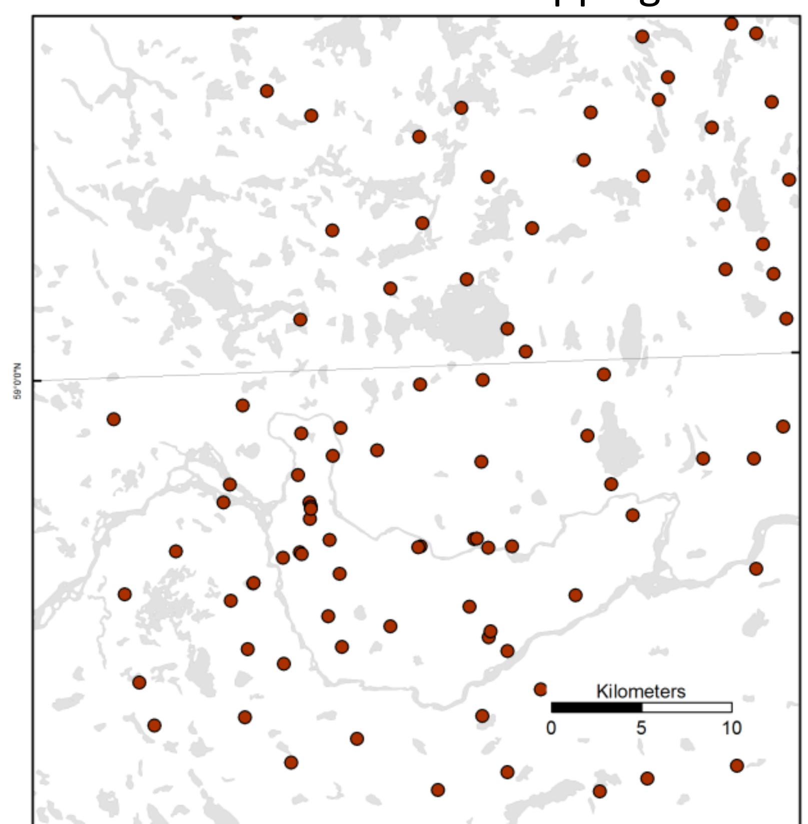
Fieldwork

- Field sites are chosen according to what questions need answers; and to cover 1) enough different types of material, and 2) aerial coverage appropriate for the scale of mapping.

1:250 000 scale mapping



1:50 000 scale mapping



Fieldwork

• Guidelines and Standards to Terrain Mapping in British Columbia (1996)* suggests the following rules:

Table 7. Terrain Survey Intensity Levels.

TERRAIN SURVEY INTENSITY LEVELS	SCALE	% OF POLYGONS FIELD CHECKED*	FIELD CHECKS ** PER 100 ha (1 km^2)	METHOD OF FIELD CHECKING	TYPICAL OBJECTIVES
A	> 1:20,000	75 - 100	> 1.5	foot traverses	slope stability in sensitive areas: residential land planning; hazard zonation
B	1:10,000 to 1:50,000	50 - 75	1.0 to 3	foot and vehicle traverses	slope stability assessment;
C	1:20,000 to 1:100,000	25 - 50	0.5 to > 1.0	foot, vehicle, some flying	inventory mapping; biophysical mapping
D	1:20,000 to 1:250,000	0 - 25	0 to 0.1	vehicle and flying	regional planning; preliminary mapping
E	any scale	0	none	no field work (air photo interp. only)	general reconnaissance

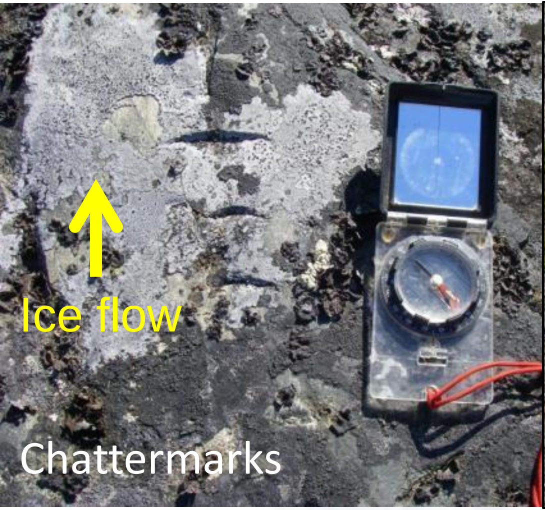
* See Section 7.5 for field checking methods.

**Data in column 4 are based on the following estimates of mean polygon size: 1:10,000 - 25 ha (estimated); 1:20,000 - 50 ha; 1:50,000 - 250 ha; 1:100,000 - 400 ha; 1:250,000 - 2500 ha. (see Table 4):

*http://www.for.gov.bc.ca/hts/risc/pubs/earthsci/012/assets/012.pdf

Fieldwork

- Ice-flow orientation information is collected from bedrock outcrops.



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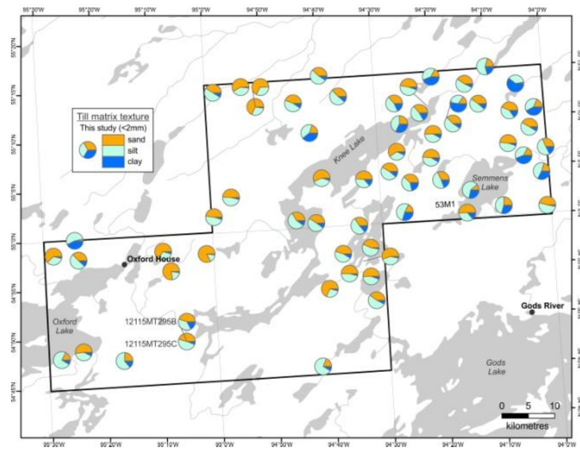
Fieldwork

- Till samples are collected throughout the area.

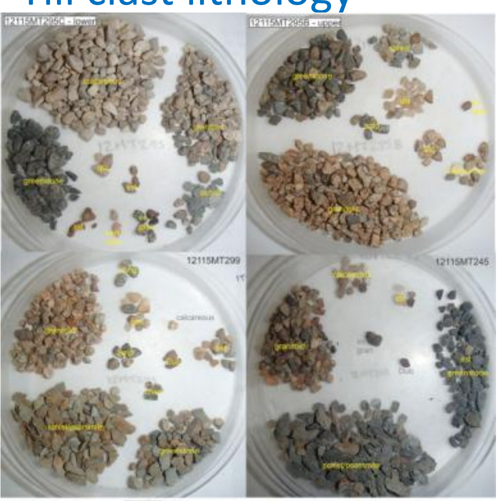
Post-fieldwork

- Till samples are sent for characterization of grainsize, carbonate concentration, major and trace-element geochemistry, and till-clast lithology.

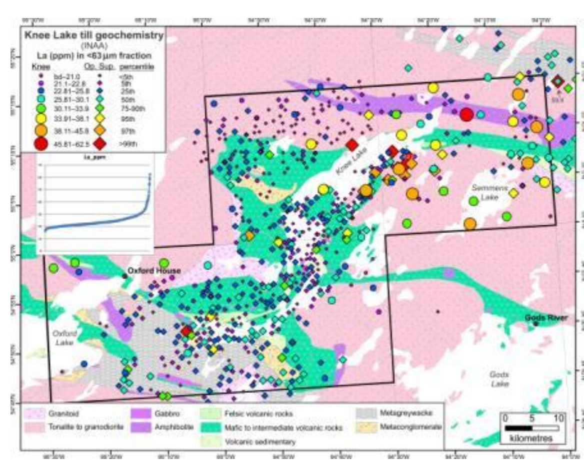
Till-matrix texture



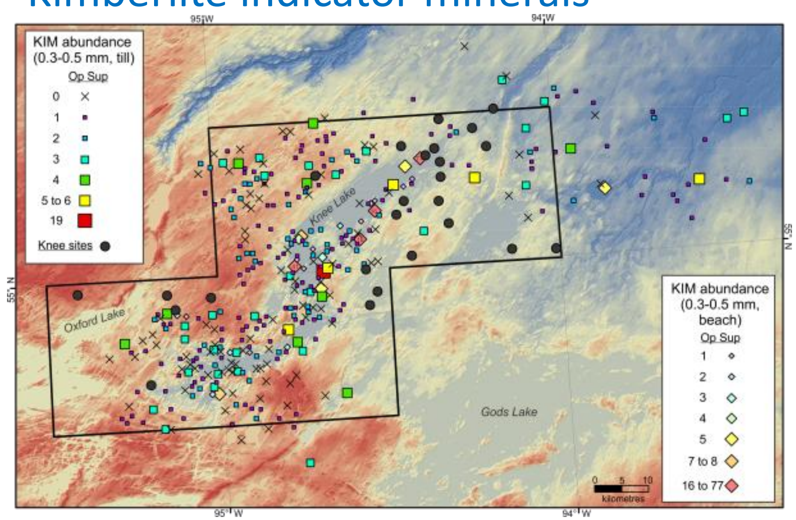
Till clast lithology



Till-matrix geochemistry



Kimberlite indicator minerals



Post-fieldwork

- Composition data may be added to map legends.

GLACIAL DEPOSITS: unsorted to poorly sorted diamicton (till) with a sandy-silt to silty-sand matrix, deposited in subglacial or ice marginal environments. May locally contain blocks of pre-existing sediments and/or stratified drift. Tills consist mainly of granitic material in regions overlying granitic bedrock, and consist of a more variable lithology in supracrustal bedrock regions.
Most of the till was emplaced by ice flowing from the Keewatin Sector, within the Laurentide Ice Sheet. Till denoted at T2 has been emplaced by ice flowing from the Quebec/Labrador Sector. Where the suffix ôxö has been added to the terrain label (e.g. Tvx, Tbx, Tstx, Tux, Thx, Trx) it indicates that the sediments have had significant surface reworking by meltwater and/or the Tyrrell Sea.

T^2 Calcareous, carbonate-bearing till with a clayey-silt matrix encountered within sections along the North Knife River, and at the surface in the southernmost portion of the map area. This till was deposited by ice from the Quebec/Labrador sector of the Laurentide Ice Sheet.

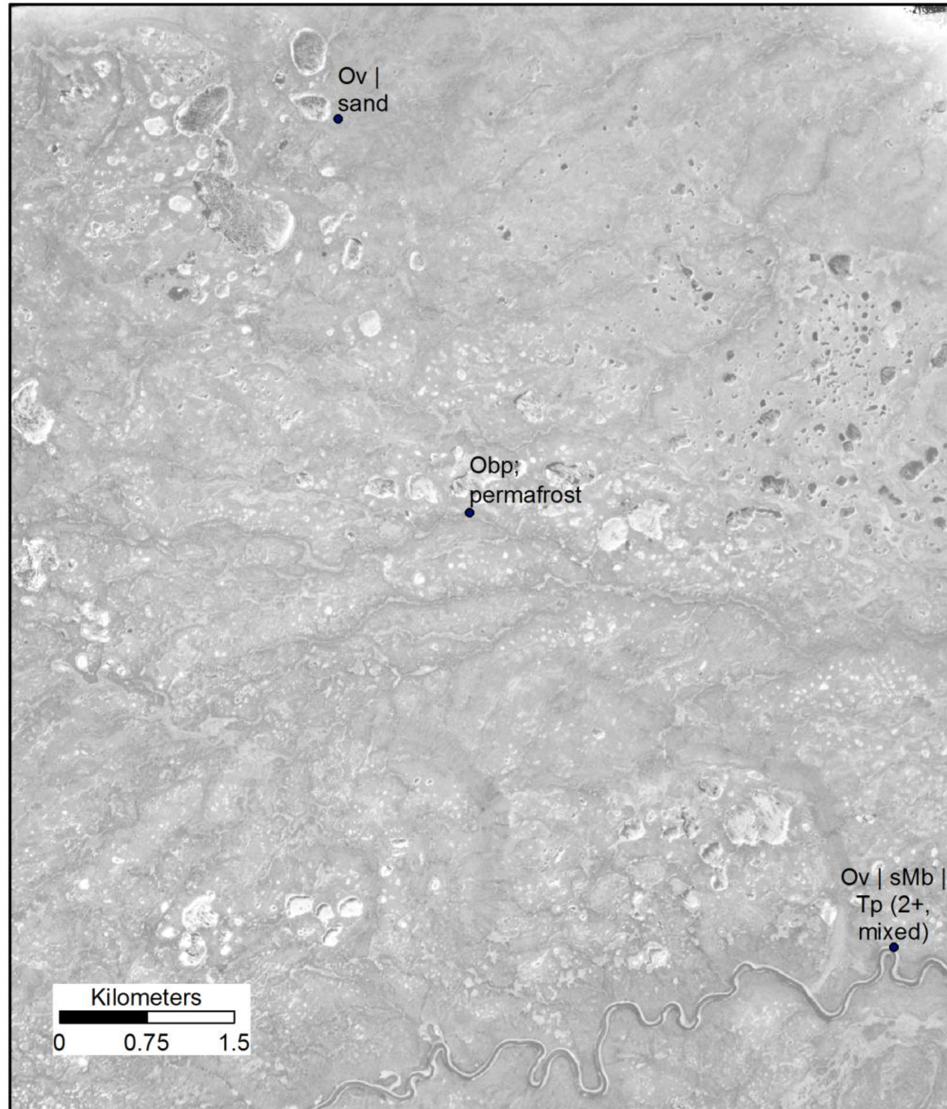
Example

Depending on the carbonate content of the till in this area, the till has been mapped as either T, or T^2. The former is interpreted as till derived from the Keewatin Sector (to the north), while the latter is interpreted as till derived from the Quebec/Labrador Sector (to the east).

The source area of the till is important information for people who use surficial sediments as part of a mineral exploration program.

Post-fieldwork

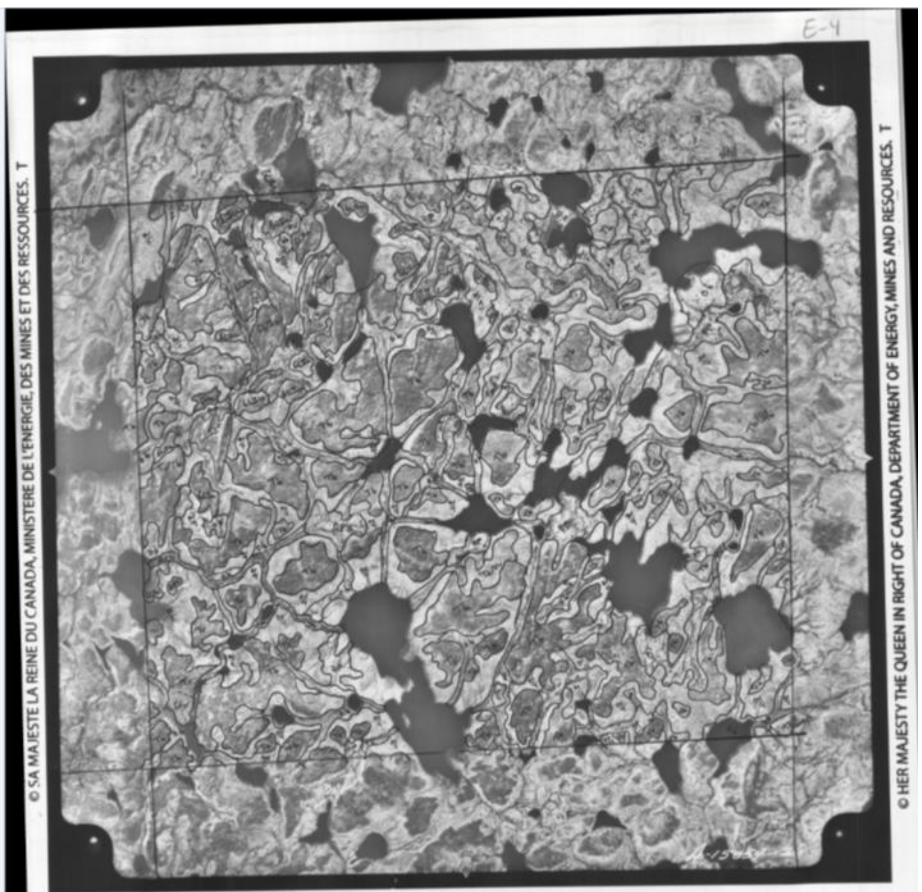
- Field data points are added to air photos.
- Mappers use codes for each surficial material type, and for thickness or surface classification.
  - O = organic
  - M = marine
  - T = till
  - v = veneer
  - b = blanket
  - p = plain



See: Howes and Kenk, 1997, Terrain classification system for British Columbia – Version 2
http://www.for.gov.bc.ca/hts/risc/pubs/teecolo/terclass/terclass_system_1997.pdf

Post-fieldwork

•Using the field data points, and an understanding of glacial and post-glacial environments, a mapper interpolates between the field points to create map polygons across the entire area of study.



•Interpolation is easier in some areas than others

Example

In some areas the map legend or explanatory notes may state that "the occurrence of glaciolacustrine (GL) sediments is highly variable and unpredictable".

This is because within glacial (and modern) lakes, deposition is not always constant. As lakes regress, wave-action may wash sediments from some areas into other areas, in an unpredictable way.

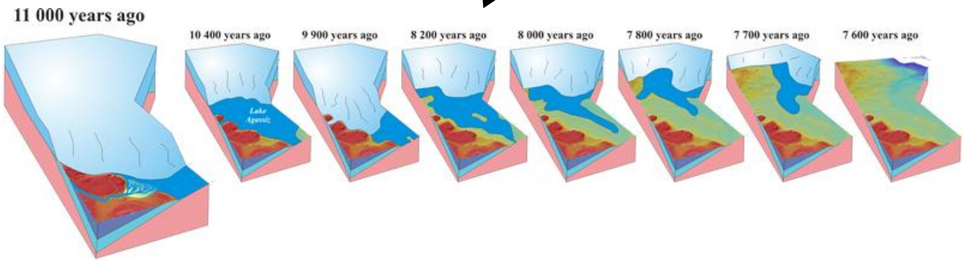
This means that a person using the map should expect to find GL sediment in some areas that aren't mapped as such, and it could be missing from other areas that are mapped as GL.

Post-fieldwork

A mapper does not simply draw lines between one data point and the next ("connect the dots"). Instead, the mapper creates a geologic model for the evolution of the landscape, and then uses and/or modifies this model continually during field work and air photo interpretation.

Mappers must take into consideration:

- Vegetation types, including growing and drainage preferences;
- fire history;
- geological and geomorphic history.



Mills et al. 1978, A guide to biophysical land classification, Oxford House, 53L, Manitoba

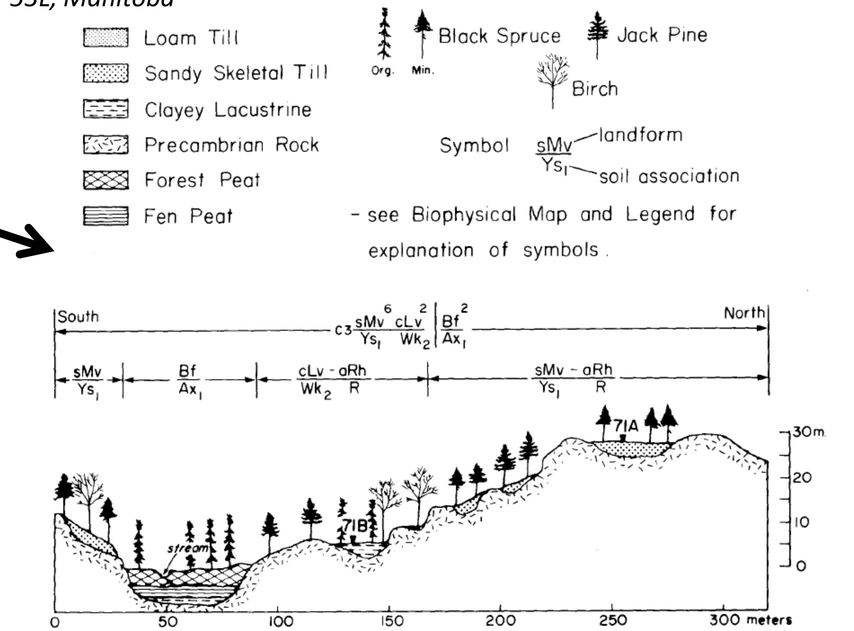


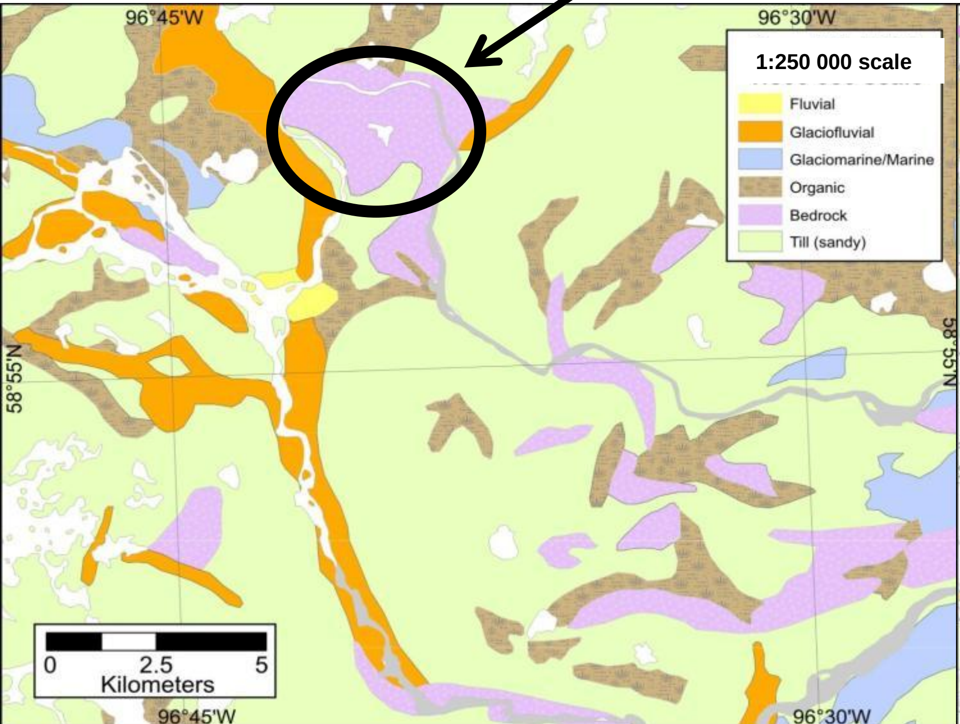
Figure 6 Distribution of morainal and lacustrine veneers in bedrock controlled portions of the Gods Lake Land District (Site 53L-75-71)

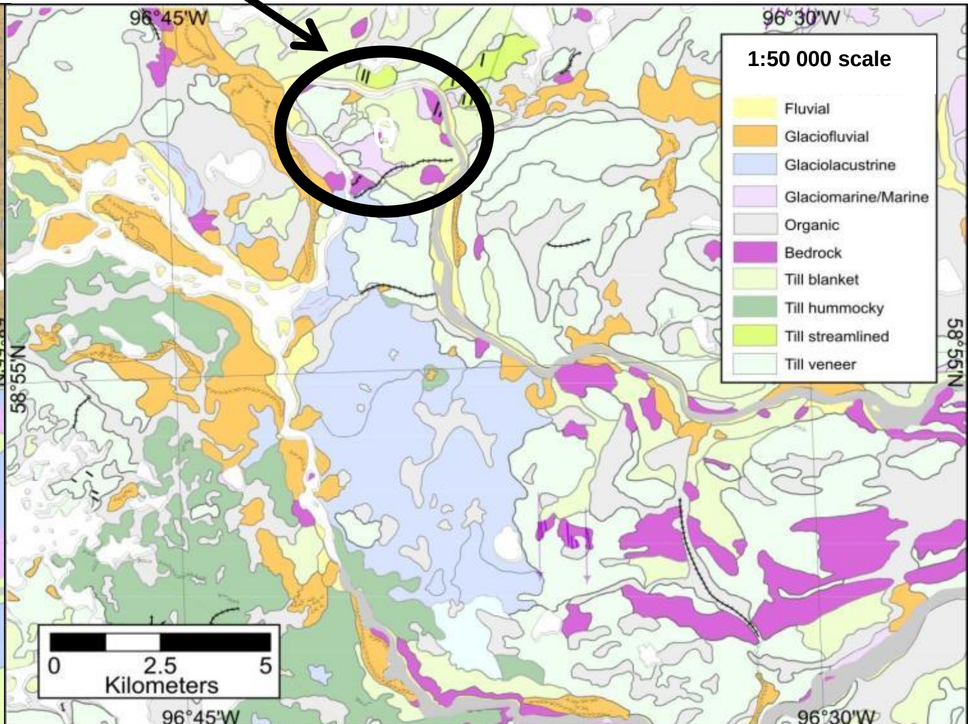
- See section 6.0 of Guidelines and Standards to Terrain Mapping in British Columbia (1996) for guidelines used during air photo interpretation. *http://www.for.gov.bc.ca/hts/risc/pubs/earthsci/012/assets/012.pdf*

Post-fieldwork

•The size of a polygon is dependant on the scale of mapping, so small polygons may be 'lumped' into larger polygons. The smaller the scale of map (1:250 000 vs. 1:50 000), the more lumping has occurred.

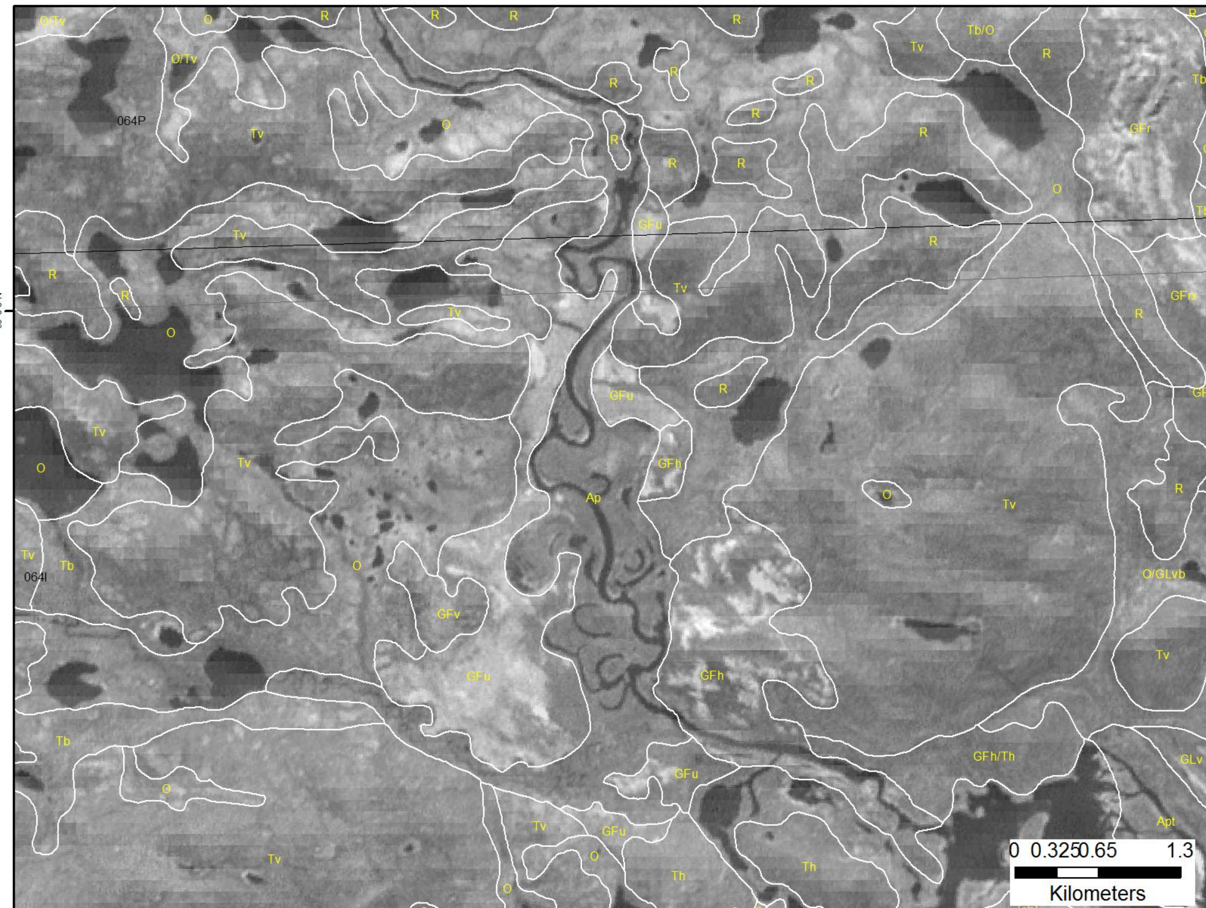
A user of a small-scale map may think this area is all bedrock, but larger-scale mapping shows that this area is a mix of thin till, thick till, bedrock and glaciomarine sediment.





Post-fieldwork

•Map polygons are digitized by a cartographer, in a GIS software program.



•Map polygons are then assembled into a map layout, along with a legend and descriptive or explanatory notes.

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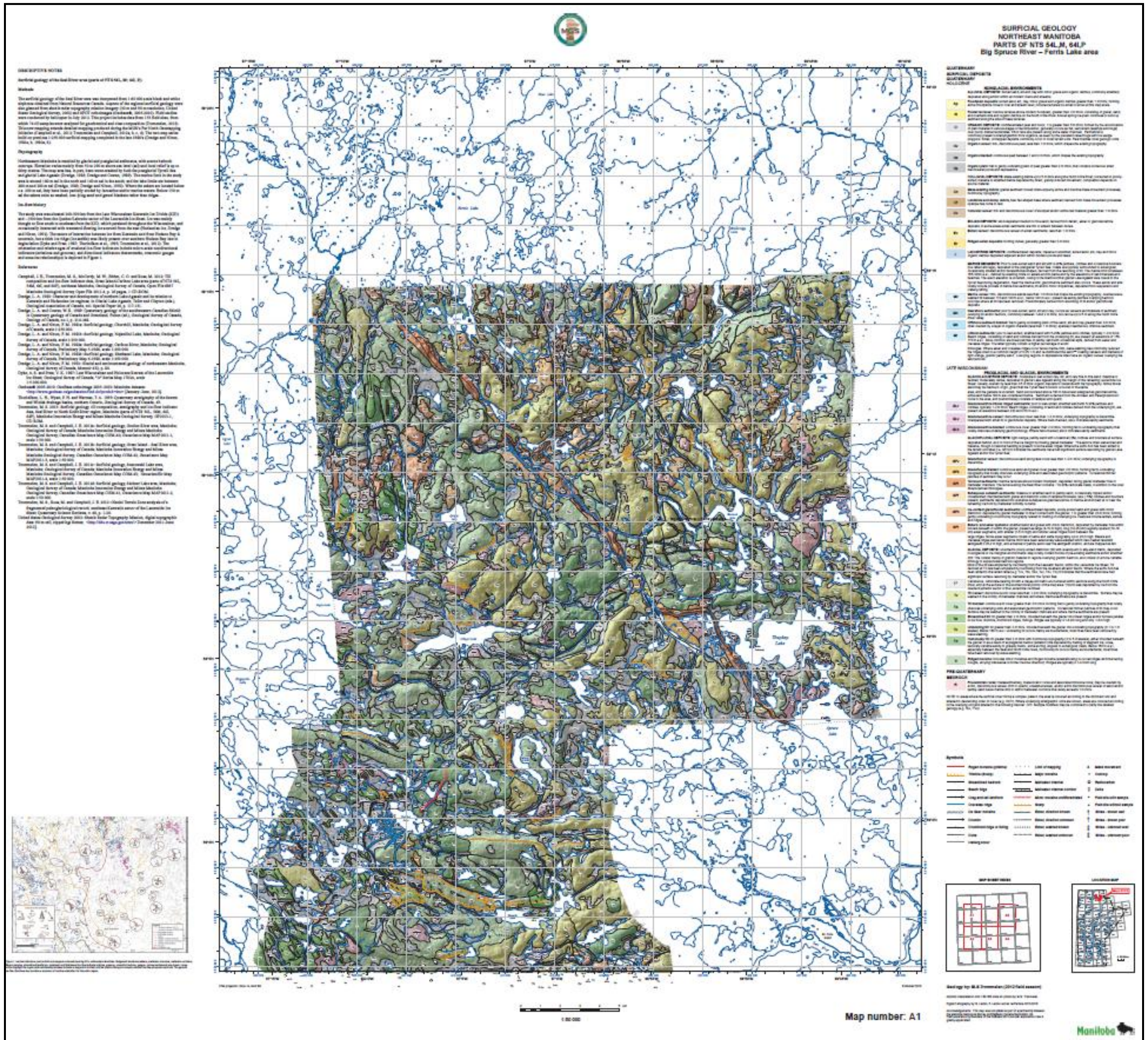
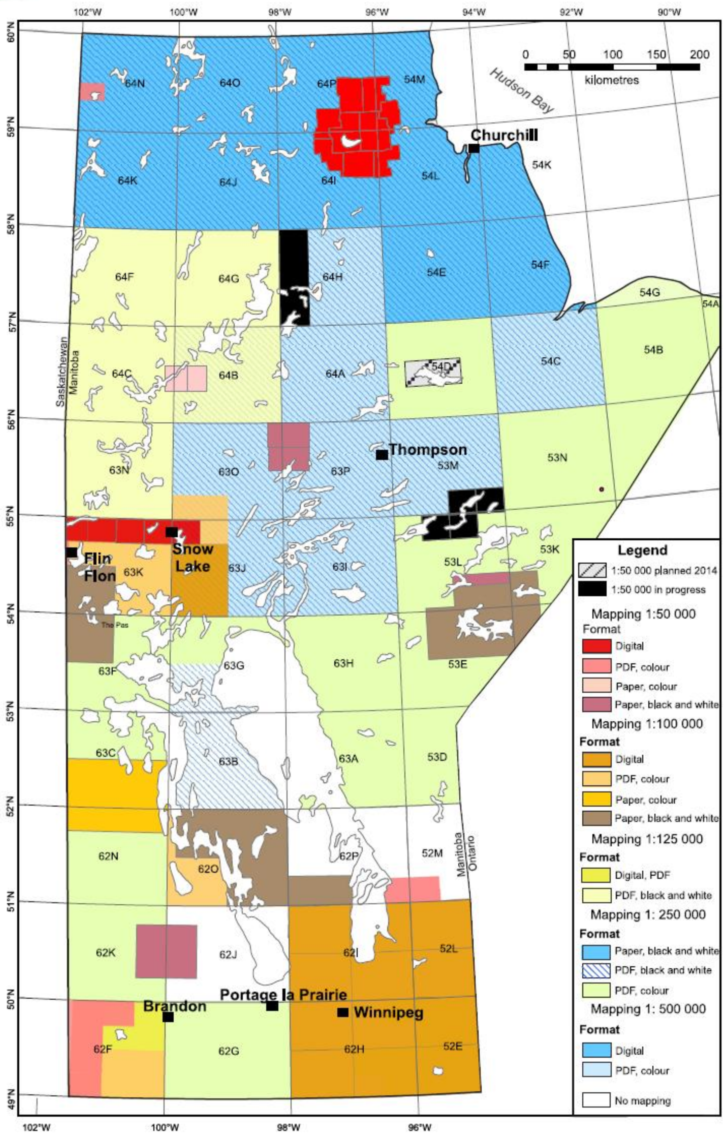
Post-fieldwork

- Maps are released as PDFs and as shapefiles.



- Remember that maps are most accurate when the number of field sites are high, or the sediment was deposited in non-complex environments.

Using surficial geology maps



- Where available, the user should obtain the appropriate scale of map for their purposes.
- All maps should ***not*** be considered accurate for property-scale work, unless there are a high number of field sites in that area.