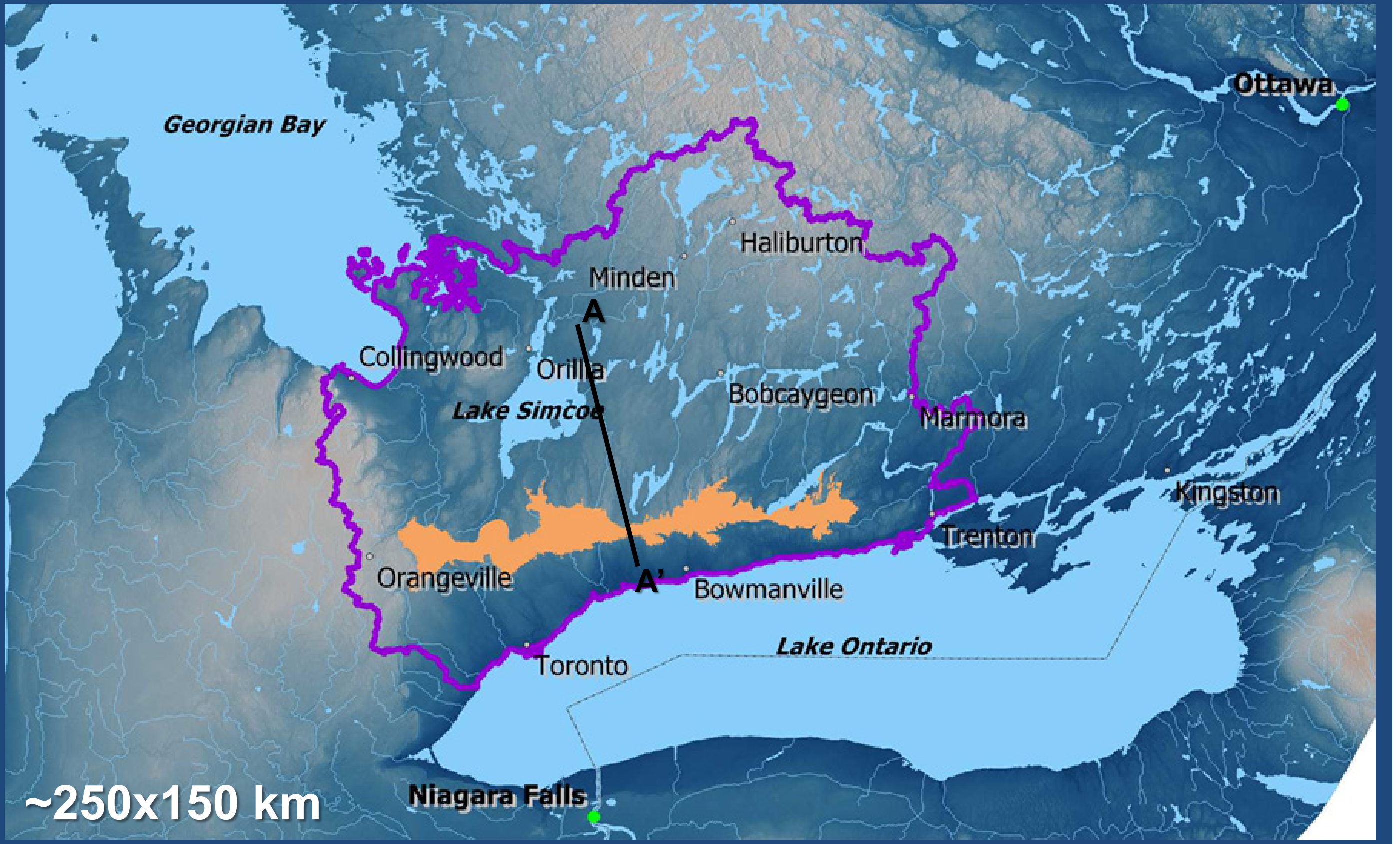
APGO WEBINAR

OakRidgesMoraine GROUNDWATER PROGRAM

2001 ⇨



Steve Holysh & Richard Gerber

ORMGP 17-April-2019

York Region · Region of Peel working with you · Durham Region · Toronto · Central Lake Ontario Conservation · Credit Valley Conservation inspired by nature · Nottawasaga Valley Conservation Authority · Toronto and Region Conservation for The Living City · Lake Simcoe Region Conservation Authority · Ganaraska Conservation · Otonabee Conservation · Kawartha Conservation · Lower Trent Conservation · Ontario · Geological Survey of Canada / Commission géologique du Canada

www.oakridgeswater.ca

CHALLENGES/SUCCESSES

- *Perception*

Ontario needs better data on its groundwater supply, says environmental watchdog

"We're making decisions with our eyes closed," said the environmental commissioner and warned that climate change will increase the amount of stress on water.

Dianne Saxe (Toronto Star, Oct 27, 2016)

The issue of getting good data on the groundwater, and other environmental concerns, is "challenging" for all governments right now, added Murray.

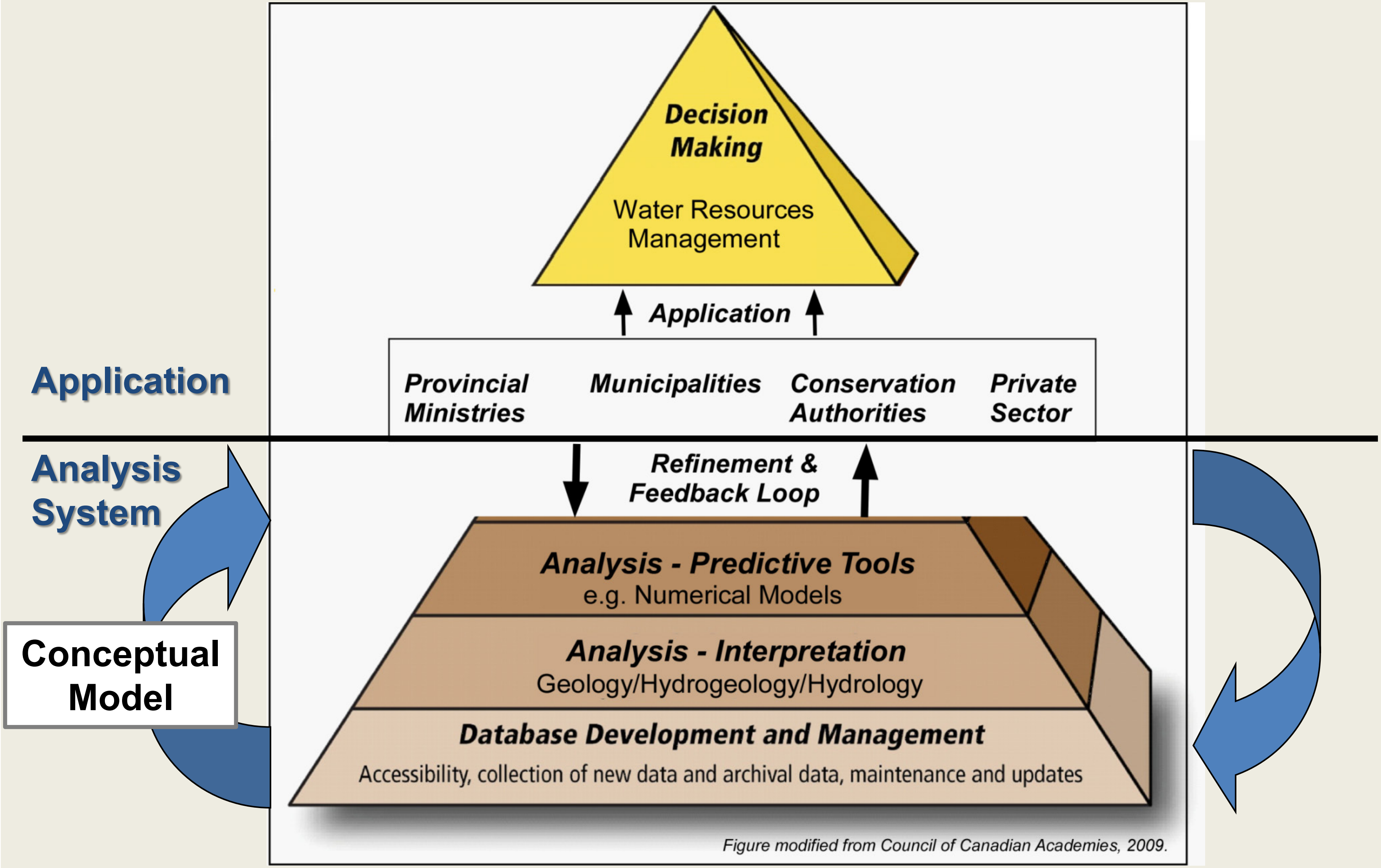
"Climate change is creating such rapidly changing situations with water quality, air and forests that the amount of data you need to manage these things is enormous," he said.

Glen Murray (Toronto Star, Oct 27, 2016)

- *Wealth of Information – not fully utilized*
  - Federal (Streamflow & Climate);
  - Provincial & CA (e.g. PTTW, PGMN); ORMGP; Municipal, private sector………….
- *Disseminate Flow System Understanding*
  - *Ease of access – wider access;*
  - Groundwater Issue/Opportunity Areas ('Hydrogeological Settings')
  - Constant testing/refinement of conceptual model

Water Resource Management (ORMGP 2001⇨)

KNOWLEDGE/TECHNICAL UNDERSTANDING ~ MORE EFFECTIVE WATER RESOURCE MANAGEMENT



(Council of Canadian Academies, 2009; modified from Sharpe *et al.*, 2002

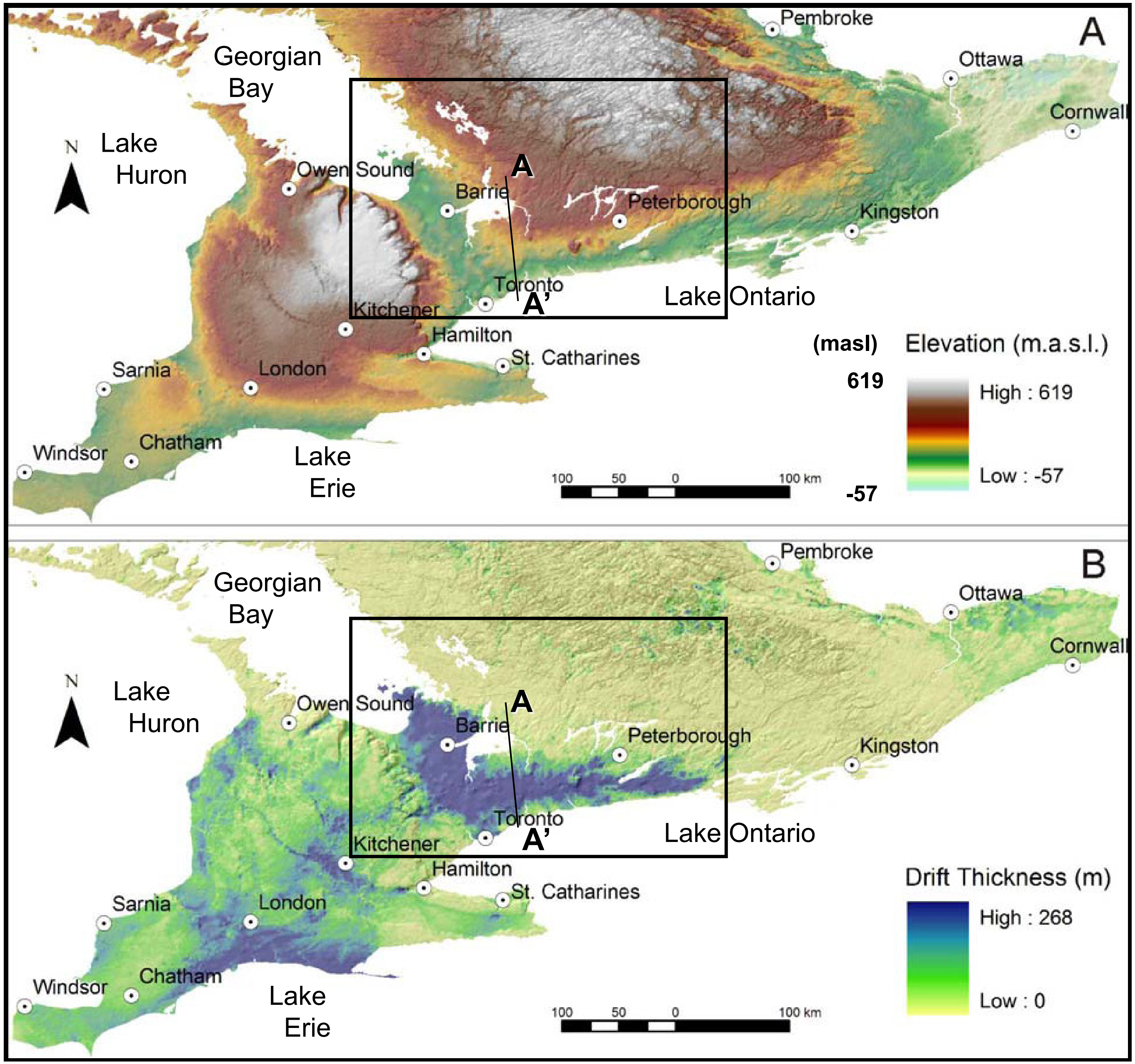
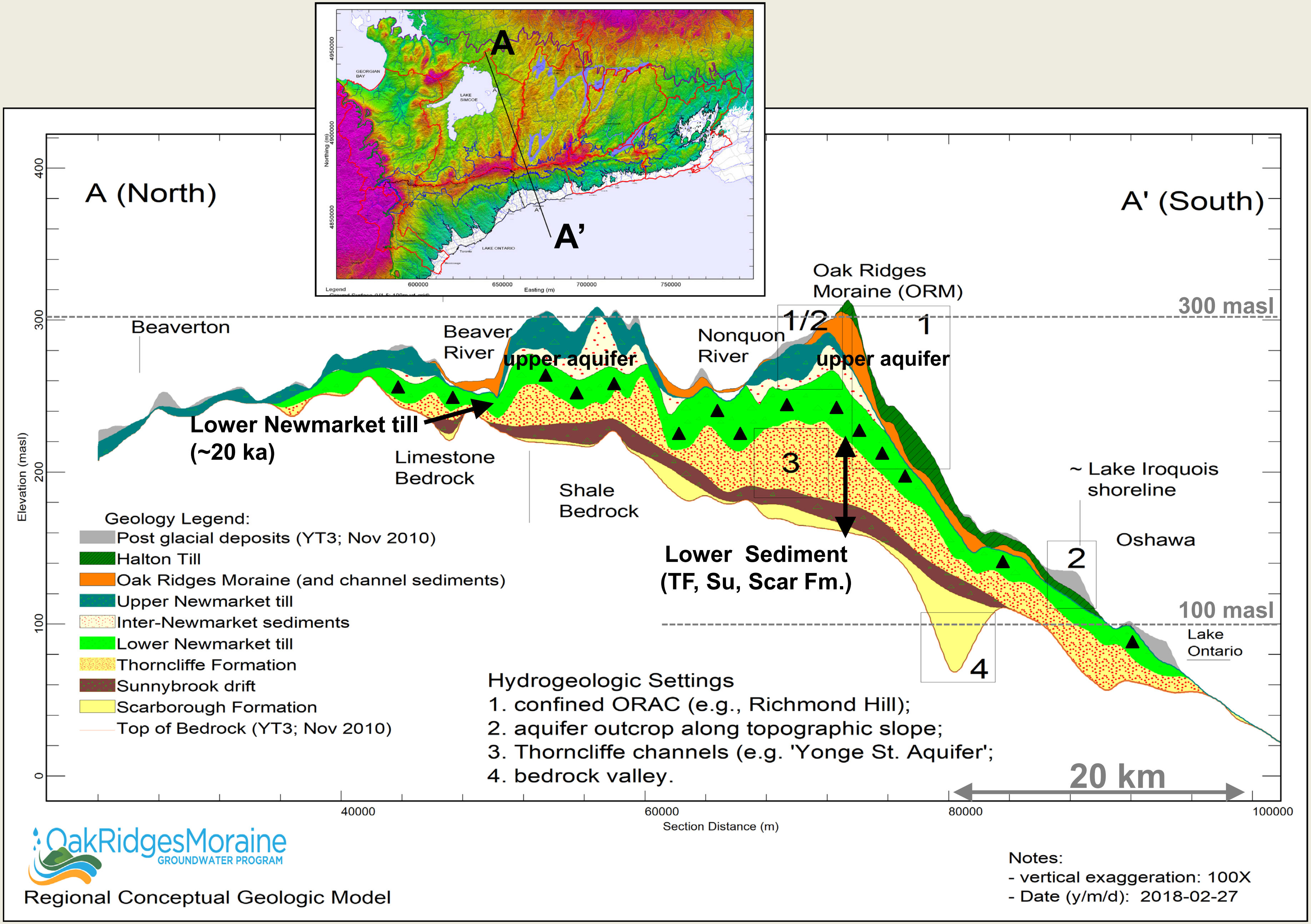


Figure from Gao *et al*., 2006 (OGS)

A) Bedrock topography & B) Drift Thickness



Conceptual Model (oakridgeswater.ca)

- **Steve Holysh**
  - sholysh@owrc.ca; 416-661-6600 x5588

- **Rick Gerber**
  - rgerber@owrc.ca; 416-737-1550

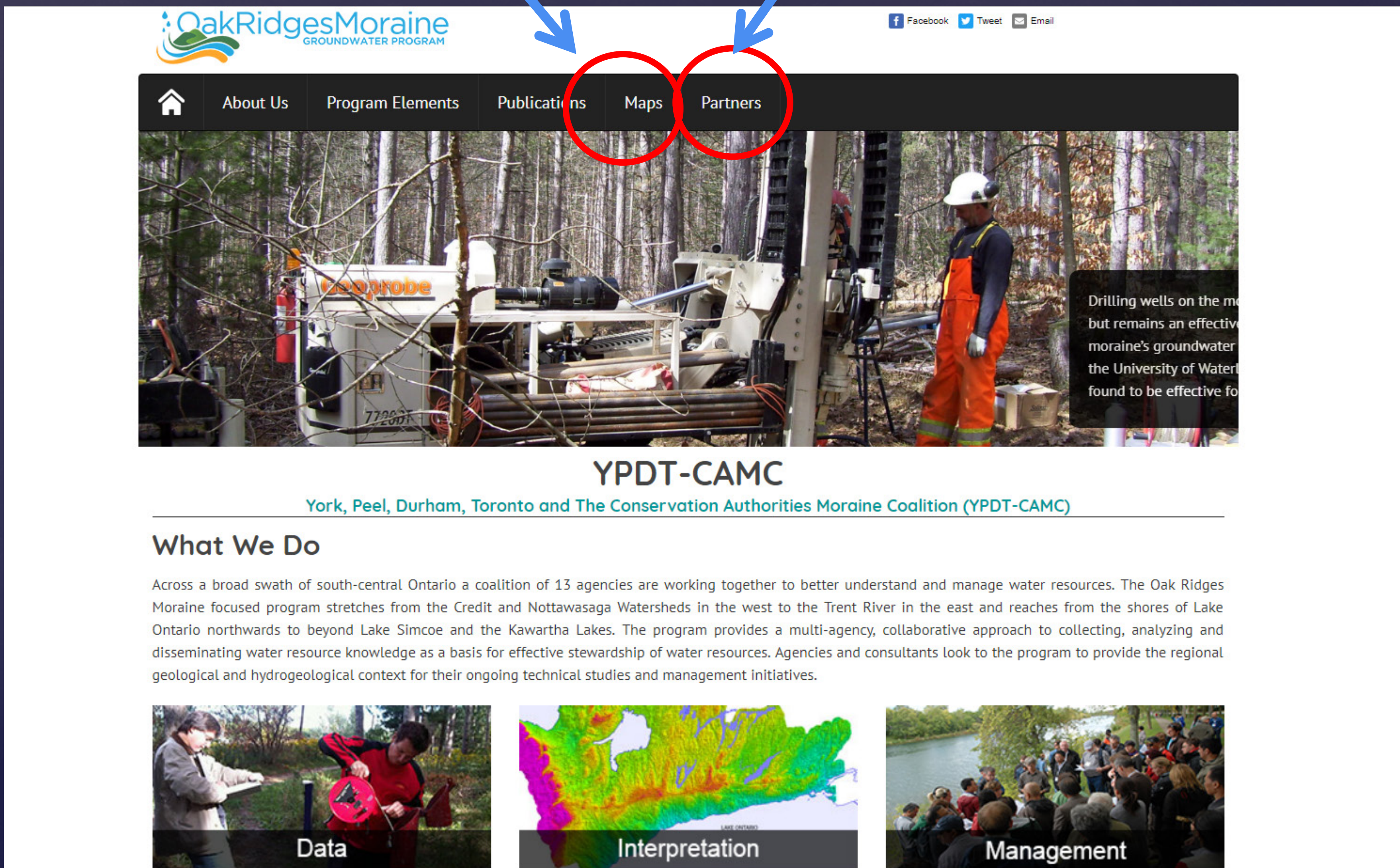
- **oakridgeswater.ca**

Comprehensive Groundwater Data Management and Analysis

Oak Ridges Moraine GW Program

OakRidgesMoraine
GROUNDWATER PROGRAM

PUBLIC PASSWORDED



Partner Agency Data Portal

Maps

Here you will find a series of maps where you can zoom in to your area of interest within the program's boundary and search for different types of locations (e.g. wells, outcrops, reports, etc.). Some of the maps contain embedded information such as the stream-cross-section map.

Maps

Report Library Search

Over 6,000 consultant reports, research papers, and government documents have been scanned and assembled into a comprehensive library of groundwater related documents. Here you area able to search for documents that are related to a geographical area or topic of interest.

Report Library Search

Monitoring Data

Longer term hydrographs are desirable for interpreting flow systems and groundwater response to pumping and precipitation. Many of the key Provincial, Municipal, and Conservation Authority monitoring wells have water level data stretching back decades. Much of that information, as well as stream gauge and precipitation records are searchable here.

Monitoring Data

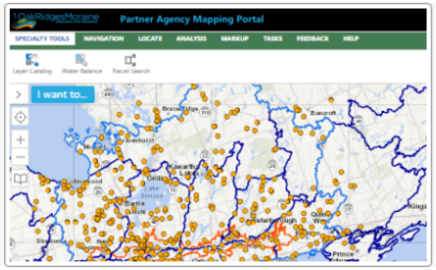
Direct Link to Live Database

Using your provided User Name and Password, you can link directly to the Program's database through Xendesktop for the purposes of adding data or using other tools (e.g. Sitefx, Access, Viewlog, etc.) to explore the database in more detail.

Direct Link to Live Database

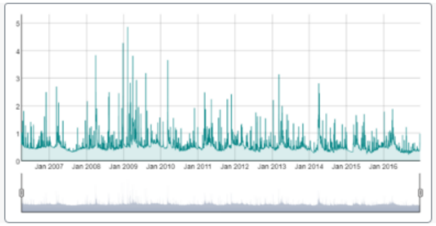
SharePoint Newsfeed OneD

BROWSE PAGE



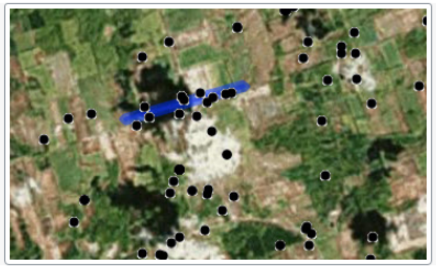
Consolidated Mapping

This site agglomerates many of the maps below into one single site using 'Layer Themes', making it faster and easier to switch between maps. Simply read the Home panel for a description of the available themes, then select a theme from the drop-down menu in the Layers tab and voila!



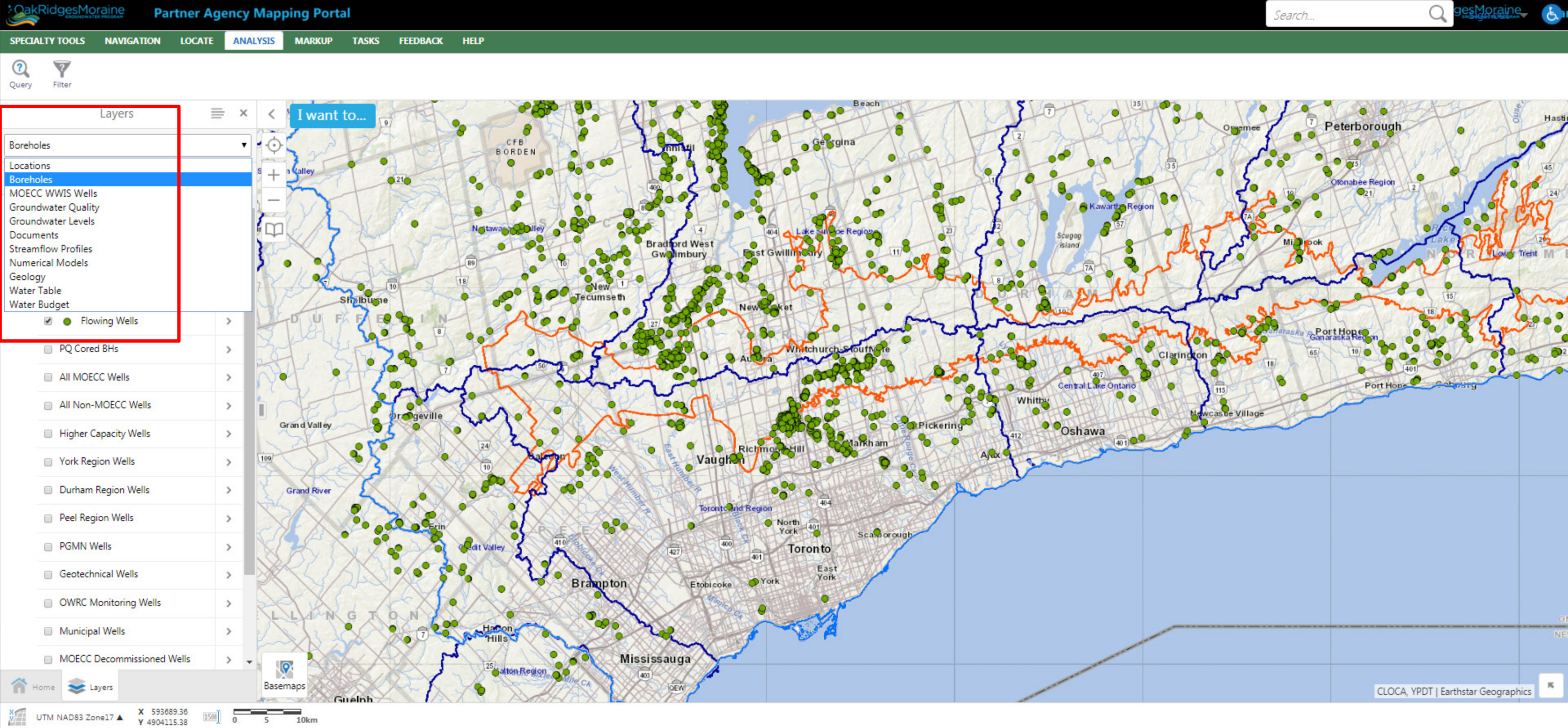
Surface Water Analyses

This map provides stream hydrographs for the long term streamflow monitoring stations managed either through Environment Canada, Ministry of Natural Resources and Forestry or a Conservation Authority. Users can view the long term hydrographs for a particular date range, perform baseflow separation "on the fly" and digitally download all data for further analyses.



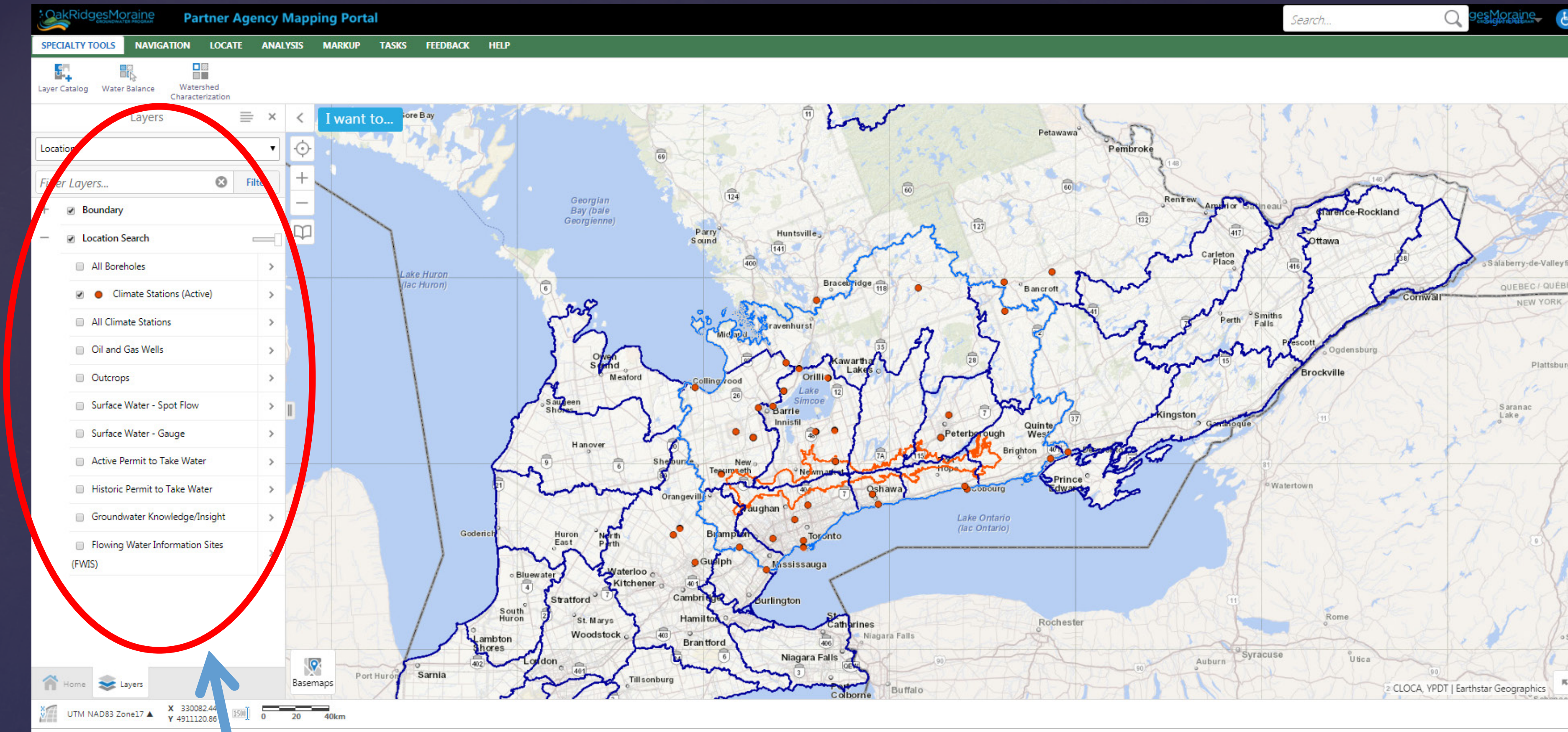
Cross Sections

Here you can cut cross-sections anywhere within the entire program study area and generate cross-sections that display the interpreted geological layering beneath the surface.



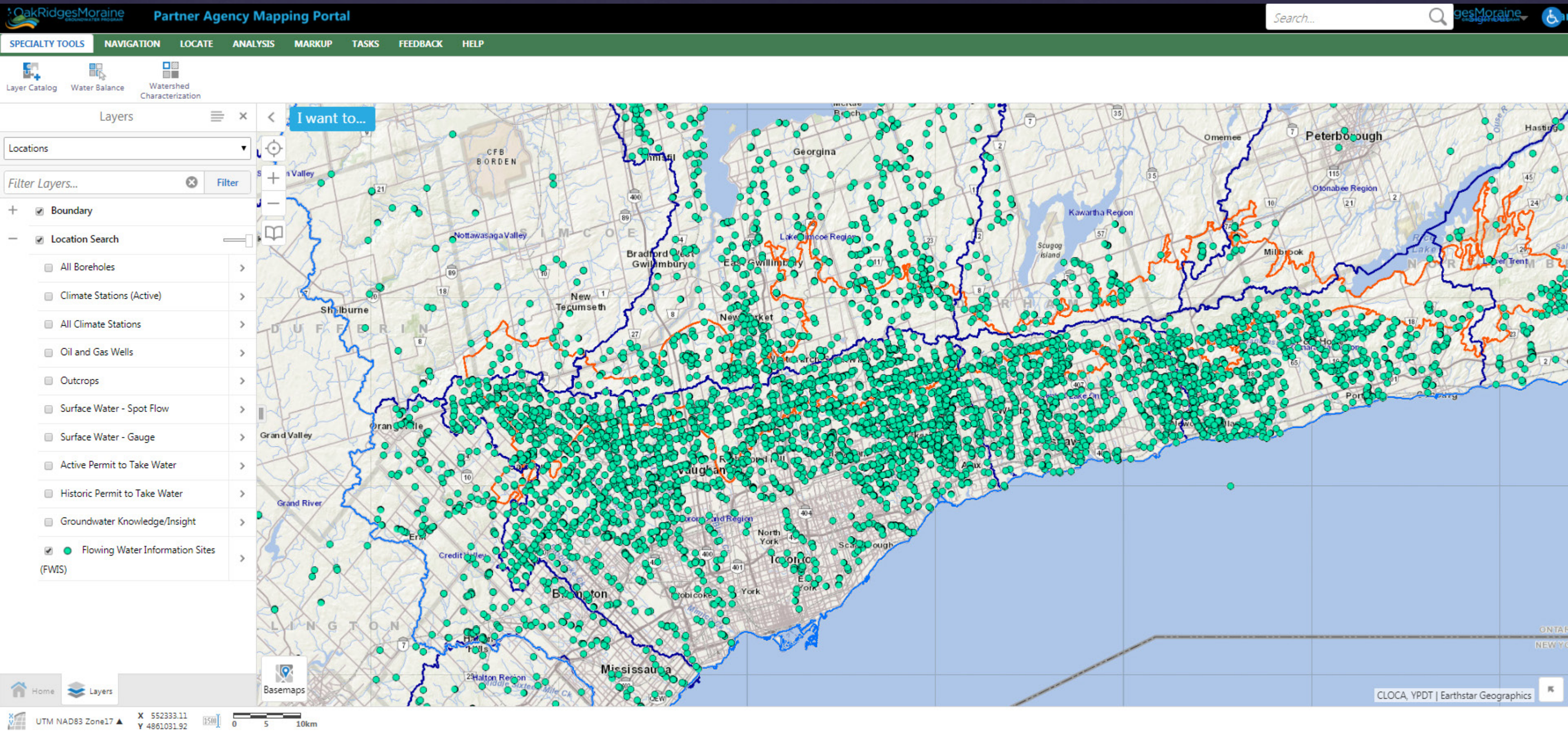
Theme Maps Available

Locations
Boreholes
MOE Wells
GW Quality
GW Levels
Documents
Stream Profiles
Numerical Models
Geology
Water Table
Water Budget



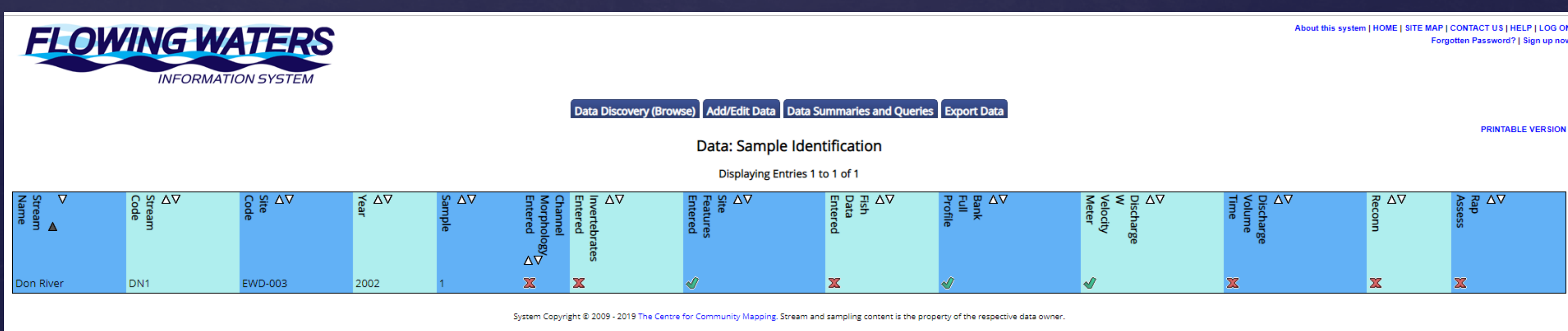
LOCATION MAP

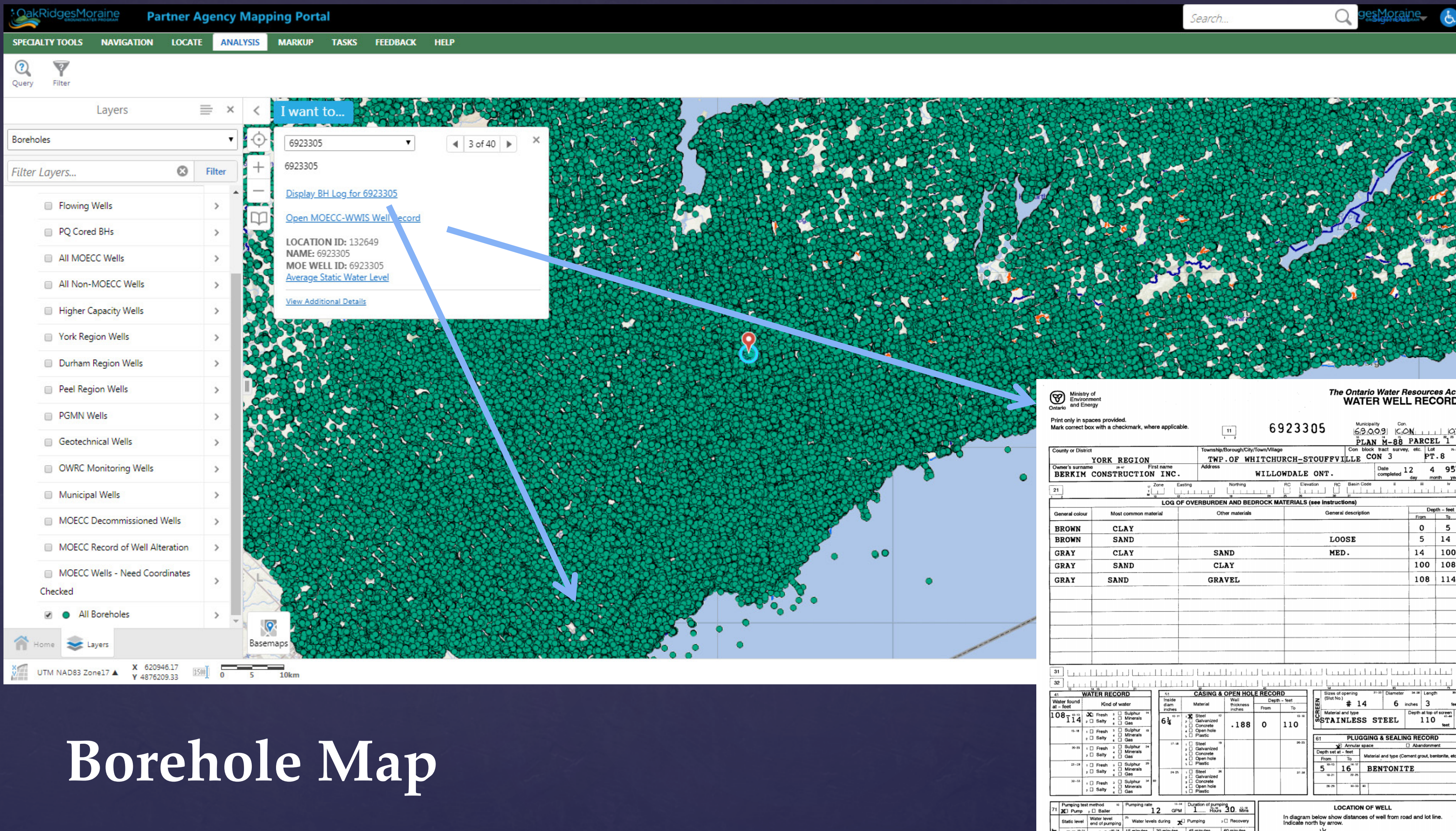
- All Boreholes
- Climate Stations (Active)
- All Climate Stations
- Oil and Gas Wells
- Outcrops
- Surface Water – Spot Flow
- Surface Water - Gauge
- Active PTTW
- Historic PTTW
- Groundwater Knowledge/Insight
- Flowing Water Information Sites



Flowing Water Information Sites

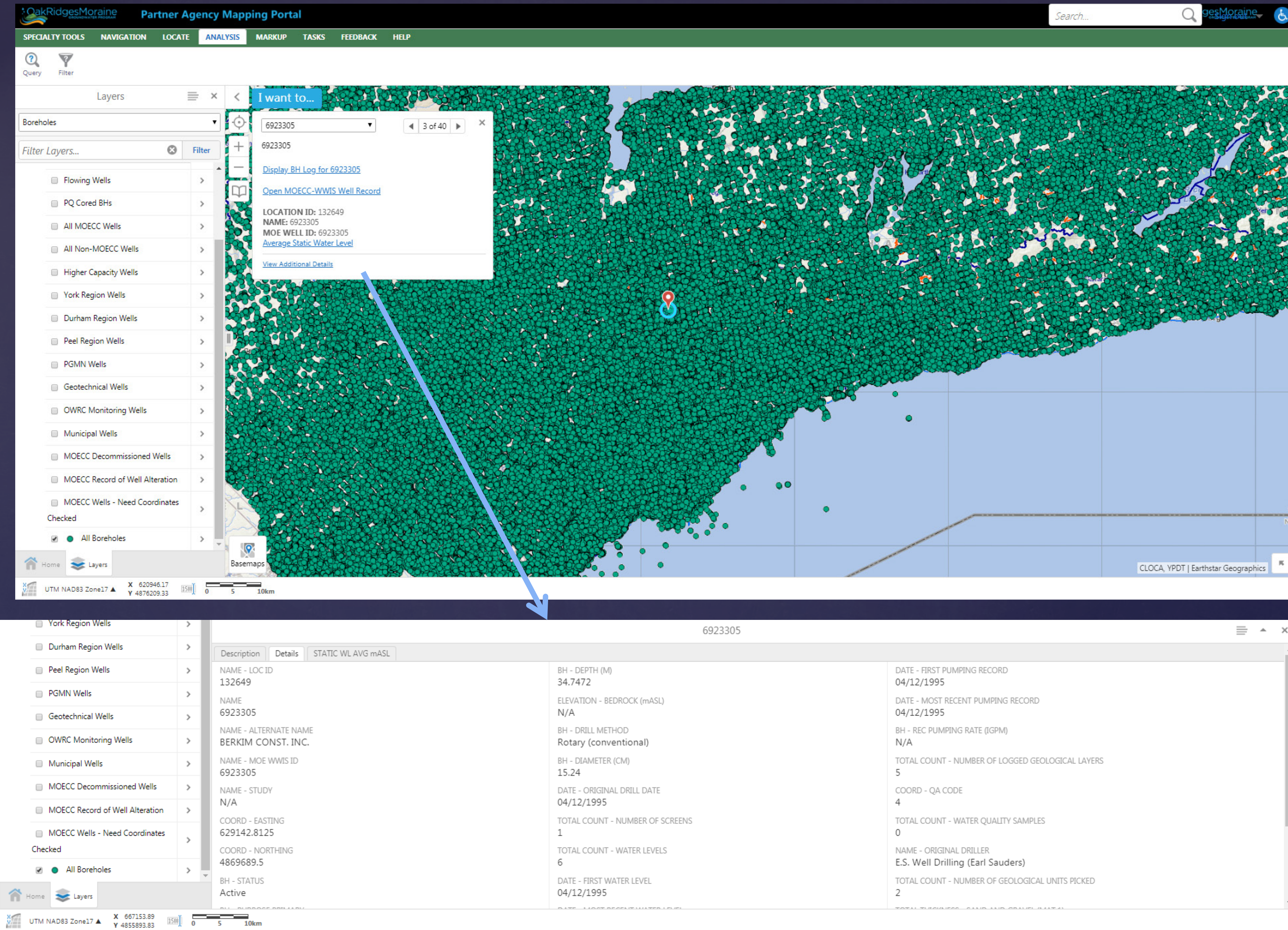
- Links to benthic/fisheries data set stored at University of Waterloo



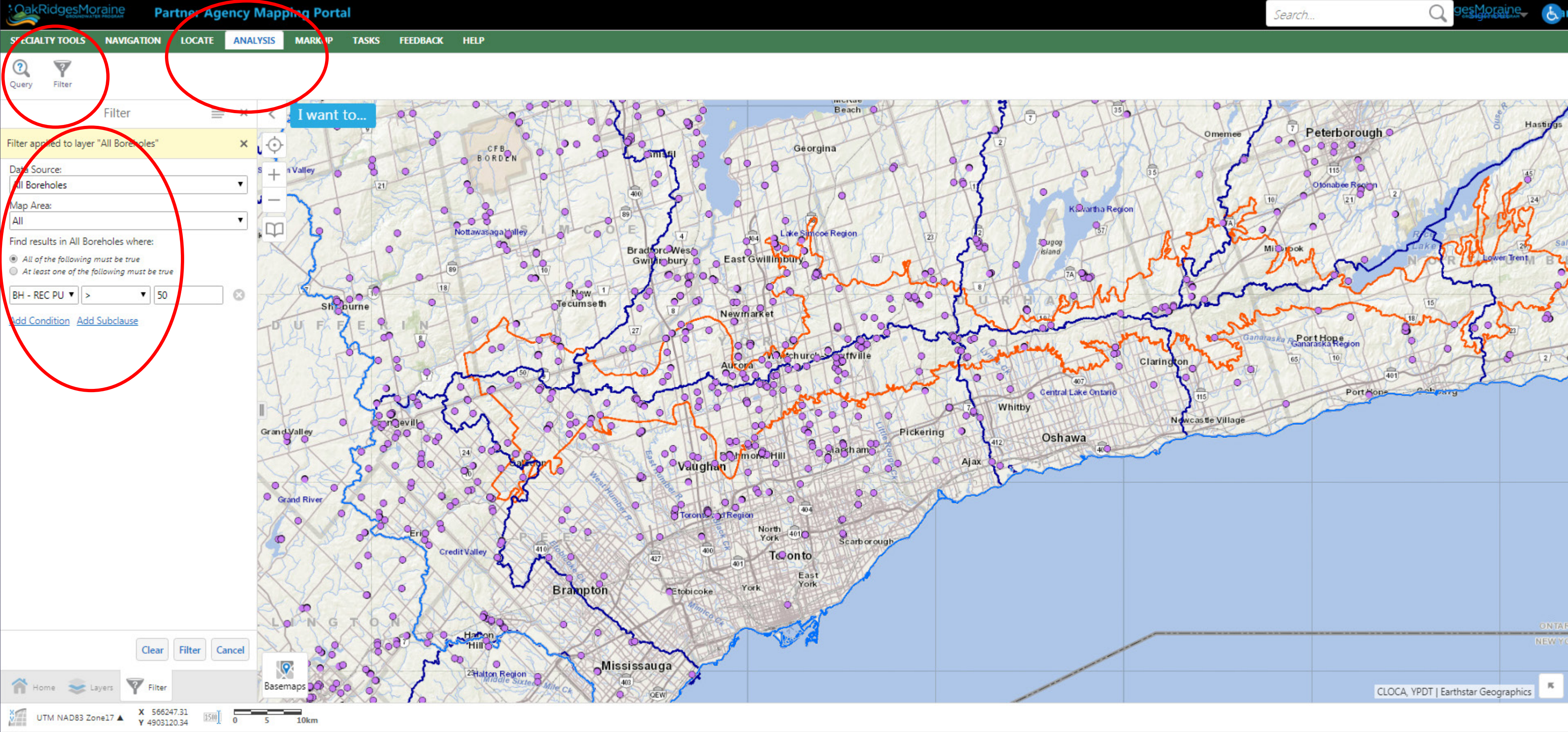


Borehole Map

Flowing Wells/PQ Drilled/
Municipal/MOE Only/Geotech/
PGMN/OWRC + Filtering

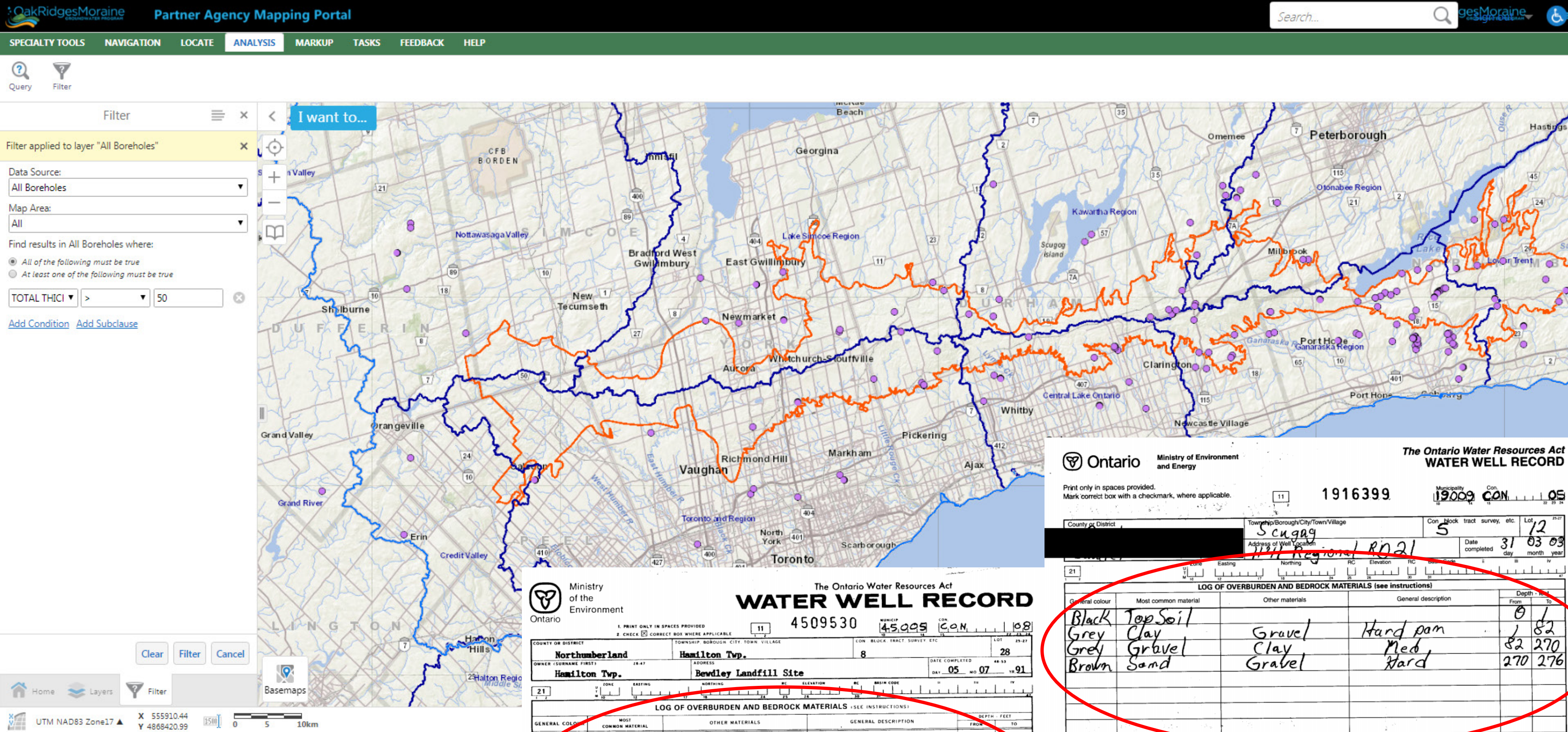


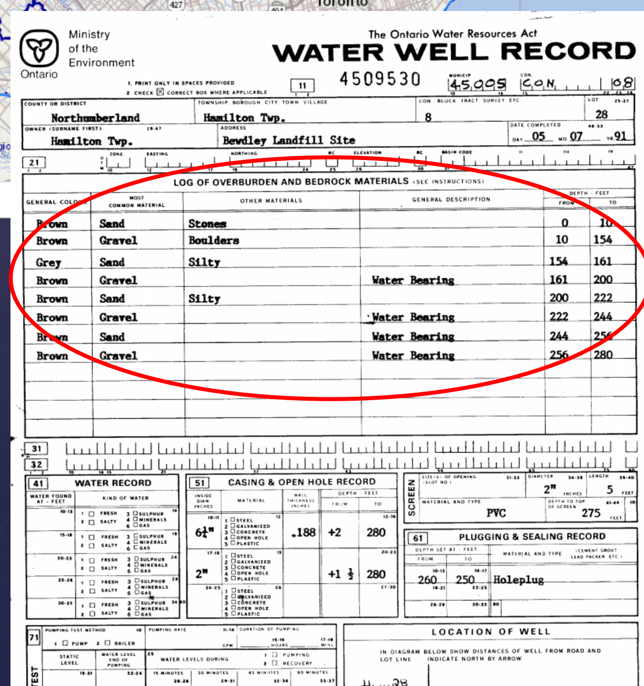
Oak Ridges Moraine
Partner Agency Mapping Portal
Search...
SPECIALTY TOOLS
NAVIGATION
LOCATE
ANALYSIS
MARKUP
TASKS
FEEDBACK
HELP
Query
Filter
Layers
Boreholes
Filter Layers...
Filter
Flowing Wells
PQ Cored BHs
All MOECC Wells
All Non-MOECC Wells
Higher Capacity Wells
York Region Wells
Durham Region Wells
Peel Region Wells
PGMN Wells
Geotechnical Wells
OWRC Monitoring Wells
Municipal Wells
MOECC Decommissioned Wells
MOECC Record of Well Alteration
MOECC Wells - Need Coordinates Checked
All Boreholes
Home
Layers
I want to...
6923305
3 of 40
6923305
Display BH Log for 6923305
Open MOECC-WWIS Well Record
LOCATION ID: 132649
NAME: 6923305
MOE WELL ID: 6923305
Average Static Water Level
View Additional Details
Basemaps
CLOCA, YPDT | Earthstar Geographics
UTM NAD83 Zone17
X 620946.17
Y 4876209.33
0 5 10km
6923305
Description
Details
STATIC WL AVG mASL
NAME - LOC ID
132649
NAME
6923305
NAME - ALTERNATE NAME
BERKIM CONST. INC.
NAME - MOE WWIS ID
6923305
NAME - STUDY
N/A
COORD - EASTING
629142.8125
COORD - NORTHING
4869689.5
BH - STATUS
Active
BH - DEPTH (M)
34.7472
ELEVATION - BEDROCK (mASL)
N/A
BH - DRILL METHOD
Rotary (conventional)
BH - DIAMETER (CM)
15.24
DATE - ORIGINAL DRILL DATE
04/12/1995
TOTAL COUNT - NUMBER OF SCREENS
1
TOTAL COUNT - WATER LEVELS
6
DATE - FIRST WATER LEVEL
04/12/1995
DATE - FIRST PUMPING RECORD
04/12/1995
DATE - MOST RECENT PUMPING RECORD
04/12/1995
BH - REC PUMPING RATE (IGPM)
N/A
TOTAL COUNT - NUMBER OF LOGGED GEOLOGICAL LAYERS
5
COORD - QA CODE
4
TOTAL COUNT - WATER QUALITY SAMPLES
0
NAME - ORIGINAL DRILLER
E.S. Well Drilling (Earl Sauders)
TOTAL COUNT - NUMBER OF GEOLOGICAL UNITS PICKED
2
UTM NAD83 Zone17
X 667153.89
Y 4855893.83
0 5 10km



Filtering of BHs

- Filtered to see all BHs where recommended pumping rate >50 GPM
- Can filter on Depth/Purpose/Name/Drill Date/# of WLs/Chemistry/Gravel thickness, etc.





Ministry of the Environment
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

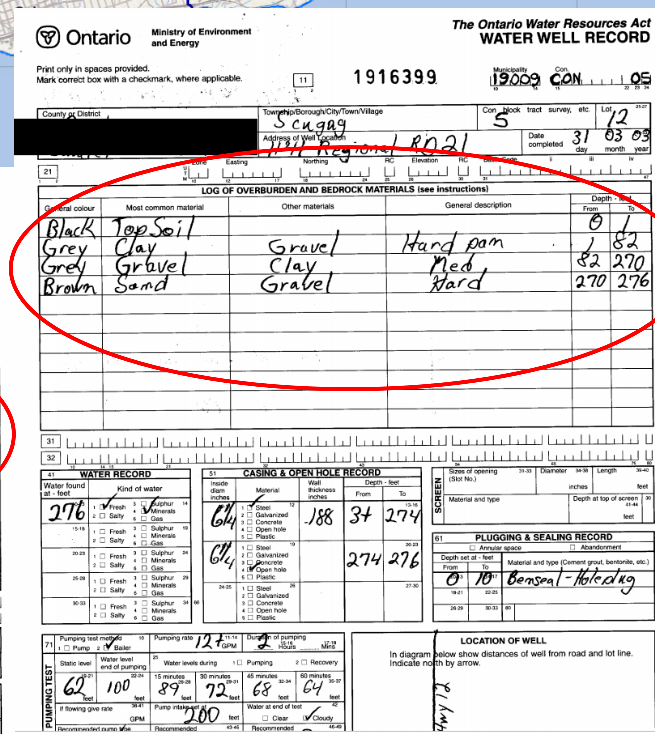
4509530 | 45005 | CON | 08

County or District: Northumberland
Township, Borough, City, Town, Village: Hamilton Twp.
Con, Block, Tract, Survey etc.: 8
Lot: 28
Owner: Hamilton Twp.
Address: Bewdley Landfill Site
Date completed: Day 05 Mo 07 Yr 91

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

General colour	Most common material	Other materials	General description	Depth - feet From	To
Brown	Sand	Stones		0	10
Brown	Gravel	Boulders		10	154
Grey	Sand	Silty		154	161
Brown	Gravel		Water Bearing	161	200
Brown	Sand	Silty		200	222
Brown	Gravel		Water Bearing	222	244
Brown	Sand		Water Bearing	244	256
Brown	Gravel		Water Bearing	256	280

WATER RECORD
CASING & OPEN HOLE RECORD: 6 1/4" .188 +2 280; 2" +1 1/2 280
SCREEN: 2" 5; Material and type PVC; Depth to top of screen 275
PLUGGING & SEALING RECORD: 260 250 Holeplug
PUMPING TEST
LOCATION OF WELL
In diagram below show distances of well from road and lot line. Indicate north by arrow.



Ontario
Ministry of Environment and Energy
The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

1916399 | Municipality 19009 | Con. CON | 05

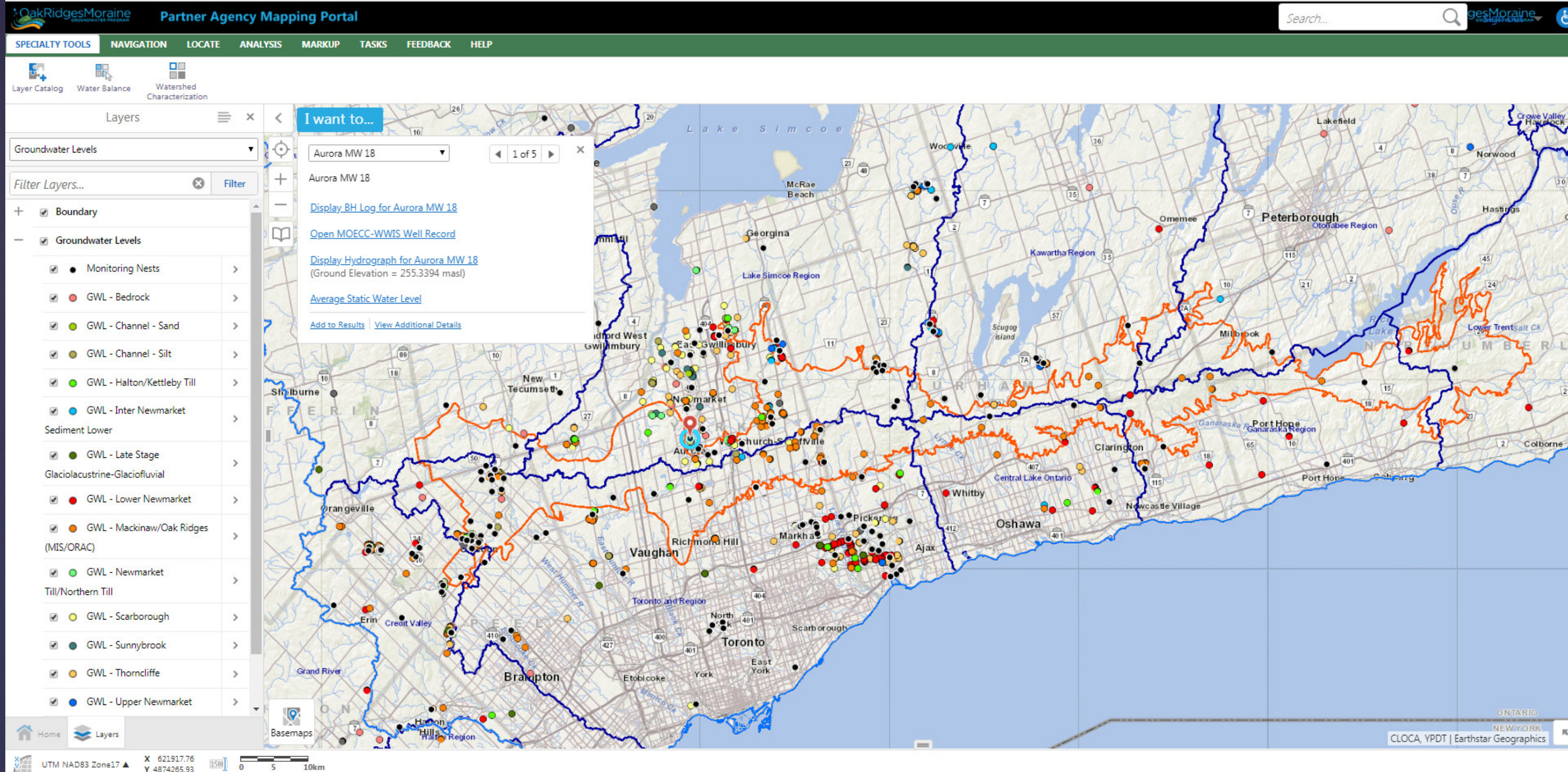
County or District: [redacted]
Township/Borough/City/Town/Village: Scugog
Con block tract survey, etc.: 5
Lot: 12
Address of Well Location: 1181 Regional RD 21
Date completed: 31 day 03 month 03 year

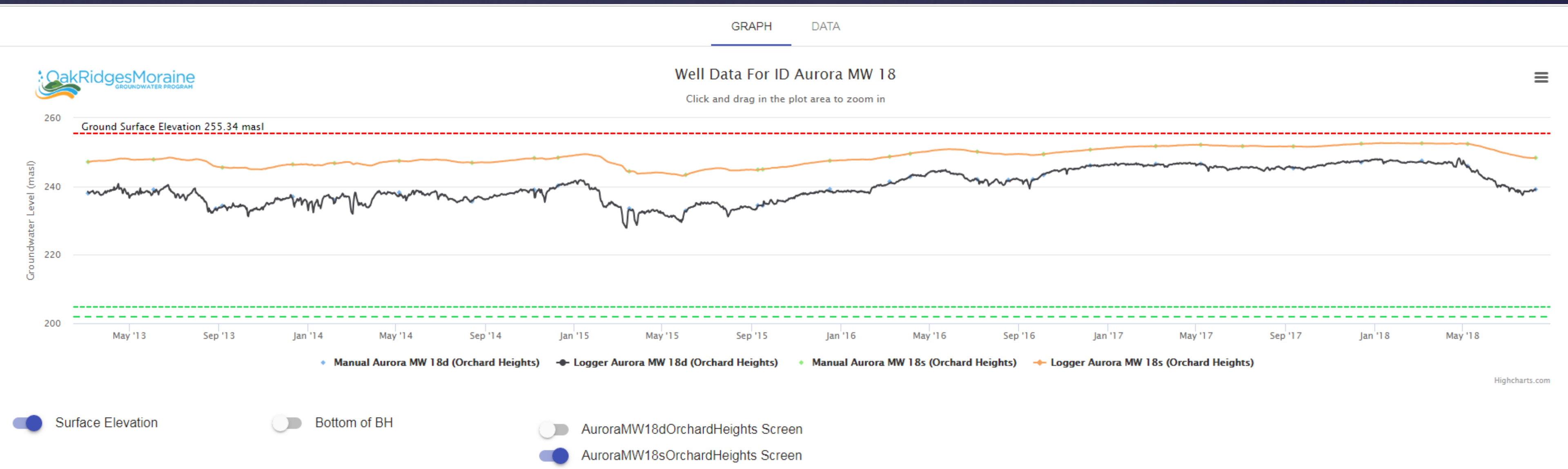
LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

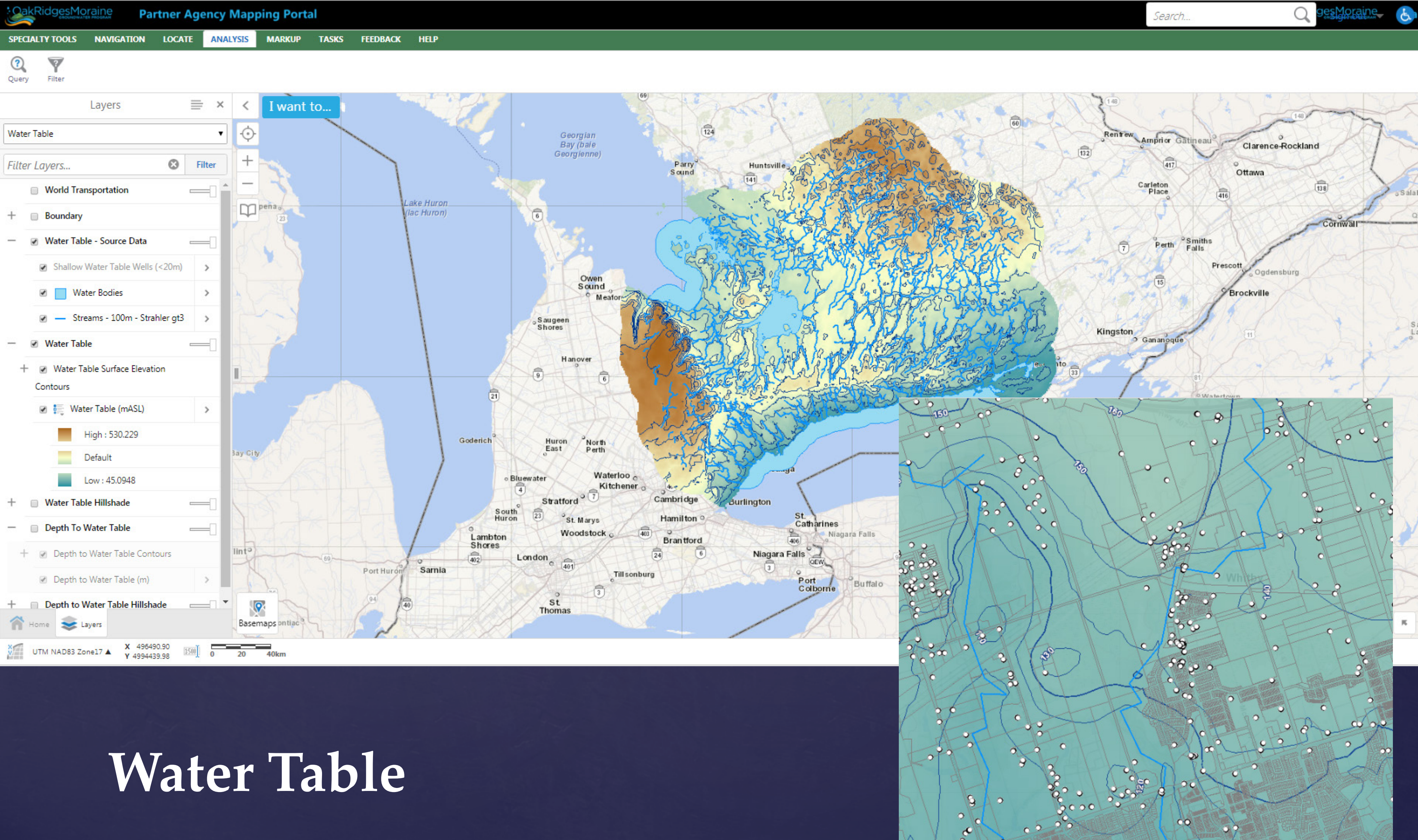
General colour	Most common material	Other materials	General description	Depth - feet From	To
Black	Top Soil			0	1
Grey	Clay	Gravel	Hard pan	1	82
Grey	Gravel	Clay	Med	82	270
Brown	Sand	Gravel	Hard	270	276

WATER RECORD: Water found at 276 feet, Fresh
CASING & OPEN HOLE RECORD: 6 1/4 Steel .188 34 274; 6 1/4 Open hole 274 276
PLUGGING & SEALING RECORD: 0 10 Benseal - Holeplug
PUMPING TEST: Pumping rate 12 GPM; Duration of pumping 2 hours; Static level 62; Water level end of pumping 100; 15 minutes 89; 30 minutes 72; 45 minutes 68; 60 minutes 64; Pump intake set at 200 feet
LOCATION OF WELL
In diagram below show distances of well from road and lot line. Indicate north by arrow.

Filtering for thick gravel (Mat 1) >50 m

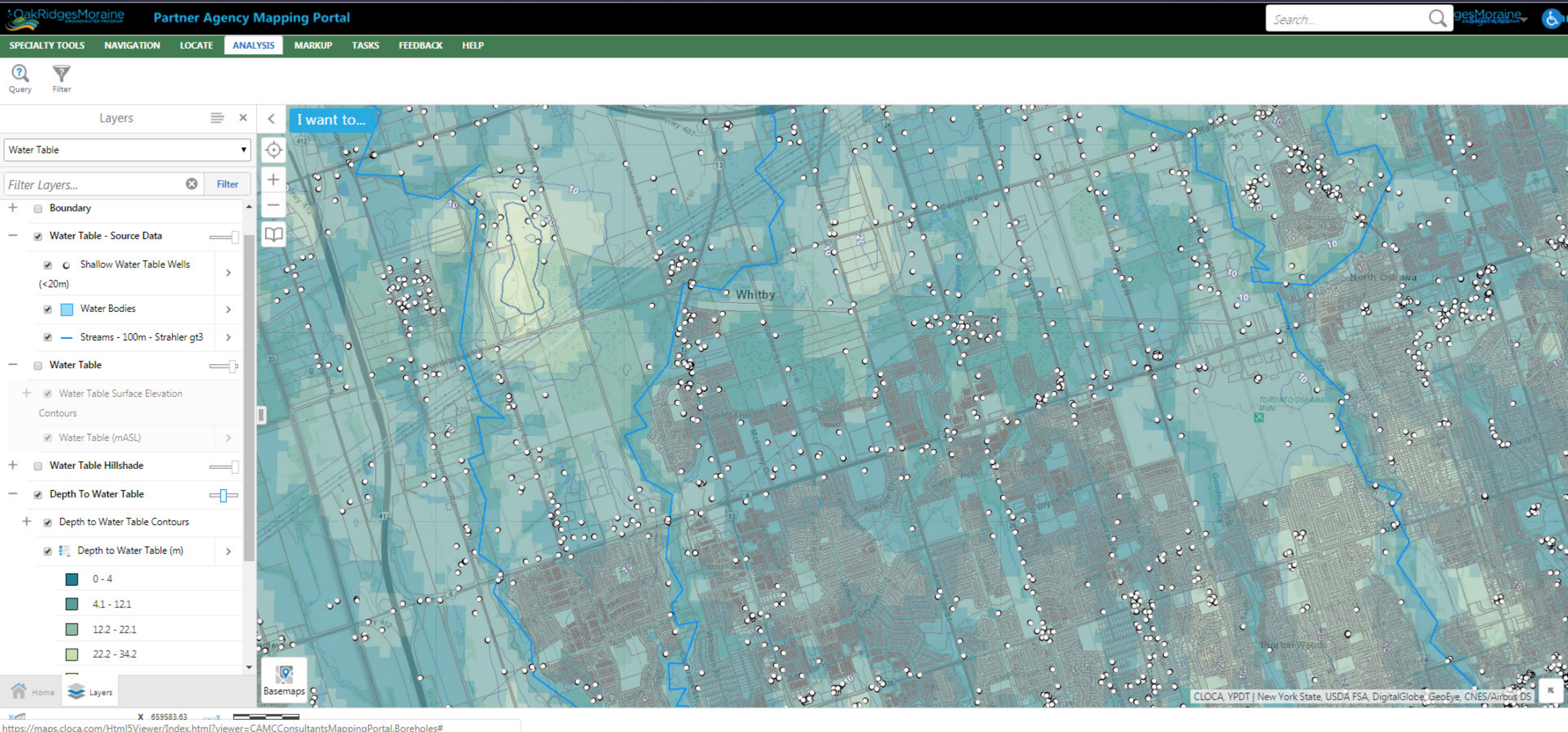

OakRidgesMoraine
Partner Agency Mapping Portal
Search...
SPECIALTY TOOLS
NAVIGATION
LOCATE
ANALYSIS
MARKUP
TASKS
FEEDBACK
HELP
Layer Catalog
Water Balance
Watershed Characterization
Layers
Groundwater Levels
Filter Layers...
Filter
Boundary
Groundwater Levels
Monitoring Nests
GWL - Bedrock
GWL - Channel - Sand
GWL - Channel - Silt
GWL - Halton/Kettleby Till
GWL - Inter Newmarket Sediment Lower
GWL - Late Stage Glaciolacustrine-Glaciofluvial
GWL - Lower Newmarket
GWL - Mackinaw/Oak Ridges (MIS/ORAC)
GWL - Newmarket Till/Northern Till
GWL - Scarborough
GWL - Sunnybrook
GWL - Thorncliffe
GWL - Upper Newmarket
Home
Layers
I want to...
Aurora MW 18
1 of 5
Aurora MW 18
Display BH Log for Aurora MW 18
Open MOECC-WWIS Well Record
Display Hydrograph for Aurora MW 18
(Ground Elevation = 255.3394 masl)
Average Static Water Level
Add to Results
View Additional Details
Basemaps
UTM NAD83 Zone17
X 621917.76
Y 4874265.93
0 5 10km
Lake Simcoe
Peterborough
Oshawa
Toronto
Brampton
Vaughan
Richmond Hill
Newmarket
Whitby
Ajax
Orangeville
Georgina
Clarington
Port Hope
Colborne
Lakefield
Norwood
Shelburne
Erin
Scarborough
Etobicoke
CLOCA, YPDT | Earthstar Geographics


GRAPH
DATA
OakRidgesMoraine
GROUNDWATER PROGRAM
Well Data For ID Aurora MW 18
Click and drag in the plot area to zoom in
Ground Surface Elevation 255.34 masl
Groundwater Level (masl)
260
240
220
200
May '13
Sep '13
Jan '14
May '14
Sep '14
Jan '15
May '15
Sep '15
Jan '16
May '16
Sep '16
Jan '17
May '17
Sep '17
Jan '18
May '18
Manual Aurora MW 18d (Orchard Heights)
Logger Aurora MW 18d (Orchard Heights)
Manual Aurora MW 18s (Orchard Heights)
Logger Aurora MW 18s (Orchard Heights)
Highcharts.com
Surface Elevation
Bottom of BH
AuroraMW18dOrchardHeights Screen
AuroraMW18sOrchardHeights Screen

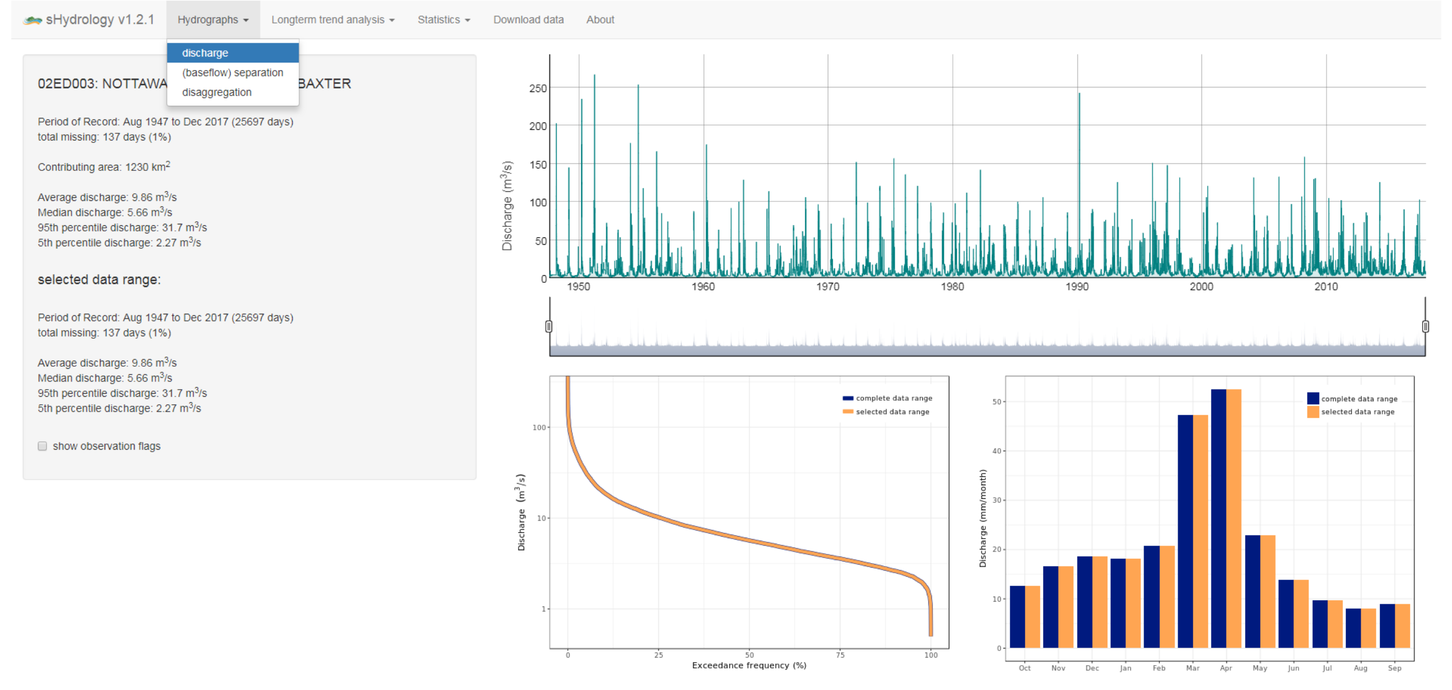


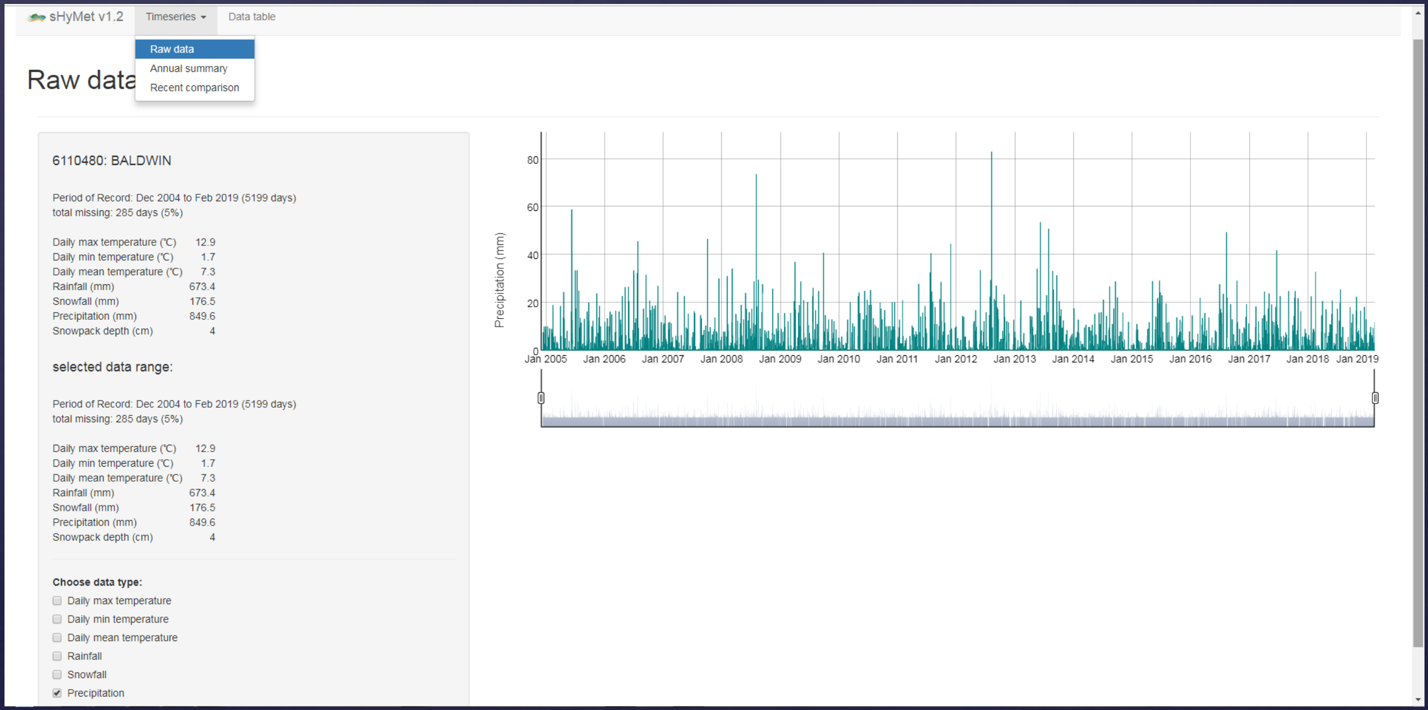
Water Table

Based on: 1) Shallow wells (screen <20 m deep); 2) Class 4 + Streams; 3) Lake shorelines

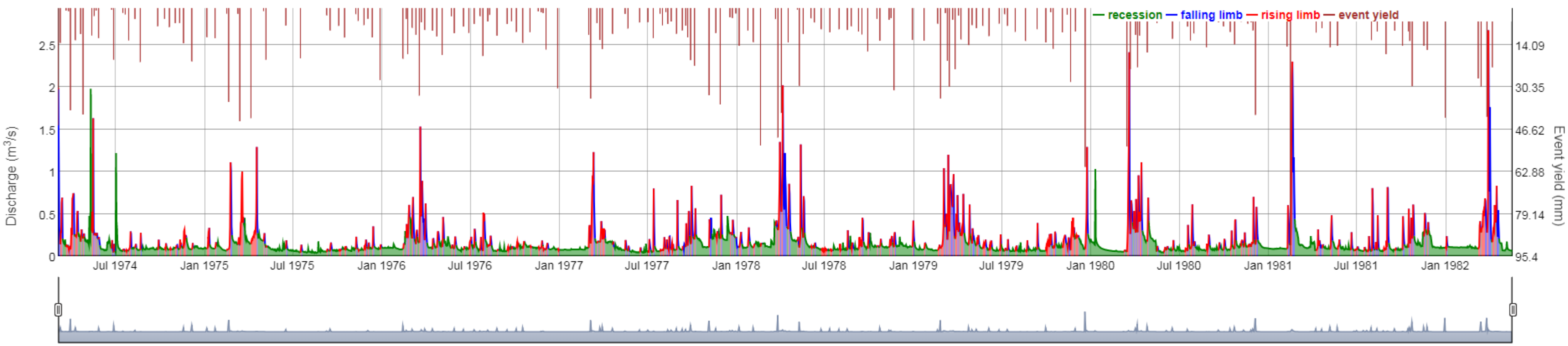


Depth to Water Table


sHydrology v1.2.1
Hydrographs
Longterm trend analysis
Statistics
Download data
About
discharge
(baseflow) separation
disaggregation
02ED003: NOTTAWA
BAXTER
Period of Record: Aug 1947 to Dec 2017 (25697 days)
total missing: 137 days (1%)
Contributing area: 1230 km2
Average discharge: 9.86 m3/s
Median discharge: 5.66 m3/s
95th percentile discharge: 31.7 m3/s
5th percentile discharge: 2.27 m3/s
selected data range:
Period of Record: Aug 1947 to Dec 2017 (25697 days)
total missing: 137 days (1%)
Average discharge: 9.86 m3/s
Median discharge: 5.66 m3/s
95th percentile discharge: 31.7 m3/s
5th percentile discharge: 2.27 m3/s
show observation flags
Discharge (m3/s)
1950
1960
1970
1980
1990
2000
2010
complete data range
selected data range
Exceedance frequency (%)
Discharge (mm/month)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep


sHyMet v1.2
Timeseries
Data table
Raw data
Annual summary
Recent comparison
Raw data
6110480: BALDWIN
Period of Record: Dec 2004 to Feb 2019 (5199 days)
total missing: 285 days (5%)
Daily max temperature (°C) 12.9
Daily min temperature (°C) 1.7
Daily mean temperature (°C) 7.3
Rainfall (mm) 673.4
Snowfall (mm) 176.5
Precipitation (mm) 849.6
Snowpack depth (cm) 4
selected data range:
Period of Record: Dec 2004 to Feb 2019 (5199 days)
total missing: 285 days (5%)
Daily max temperature (°C) 12.9
Daily min temperature (°C) 1.7
Daily mean temperature (°C) 7.3
Rainfall (mm) 673.4
Snowfall (mm) 176.5
Precipitation (mm) 849.6
Snowpack depth (cm) 4
Choose data type:
Daily max temperature
Daily min temperature
Daily mean temperature
Rainfall
Snowfall
Precipitation
Precipitation (mm)
Jan 2005
Jan 2006
Jan 2007
Jan 2008
Jan 2009
Jan 2010
Jan 2011
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019

02HC035: STOUFFVILLE CREEK BELOW STOUFFVILLE



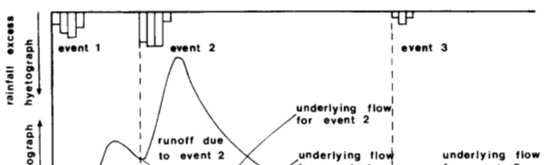
Hydrograph Disaggregation

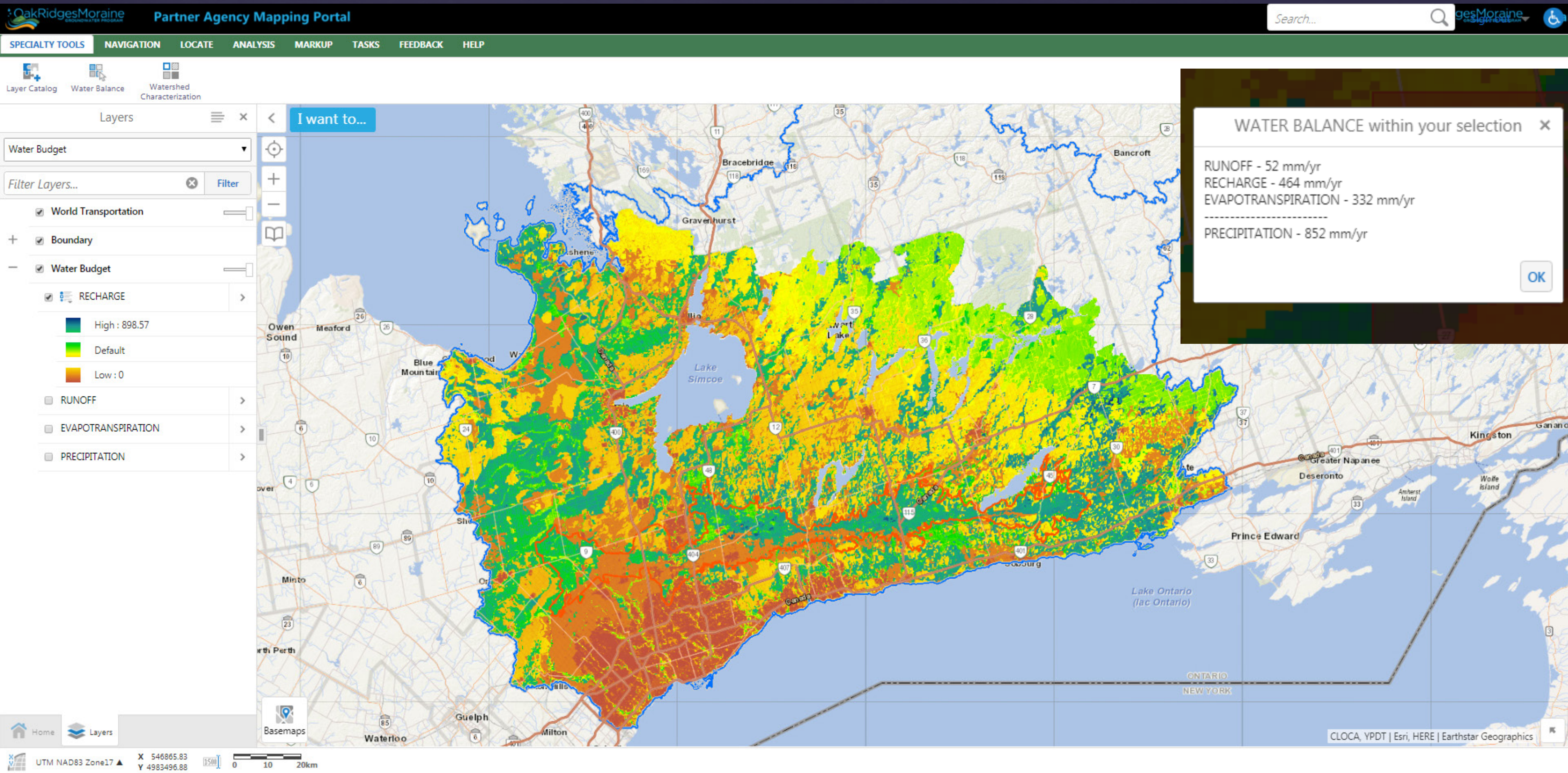
This algorithm is used to parse the hydrograph into three main constituents:

1. The rising limb – the rapid increase in discharge following a storm/melt event;
2. The falling limb – the rapid decrease in discharge following the rising limb; and,
3. Streamflow recession – the gradual decline in discharge as the watershed drains.

Event yields

Event yields are calculated using an algorithm that locates the onset of a rising limb and projects streamflow recession as if the event had never occurred. This projected streamflow, termed "underlying flow" by Reed et.al. (1975), is subtracted from the total observed flow to approximate the runoff volume associated with the event as indicated by the hydrograph. The calculation of event yields, in effect, "discretizes" the continuous hydrograph such that it can be better compared with measured (i.e., rainfall/smowmelt) event volumes.

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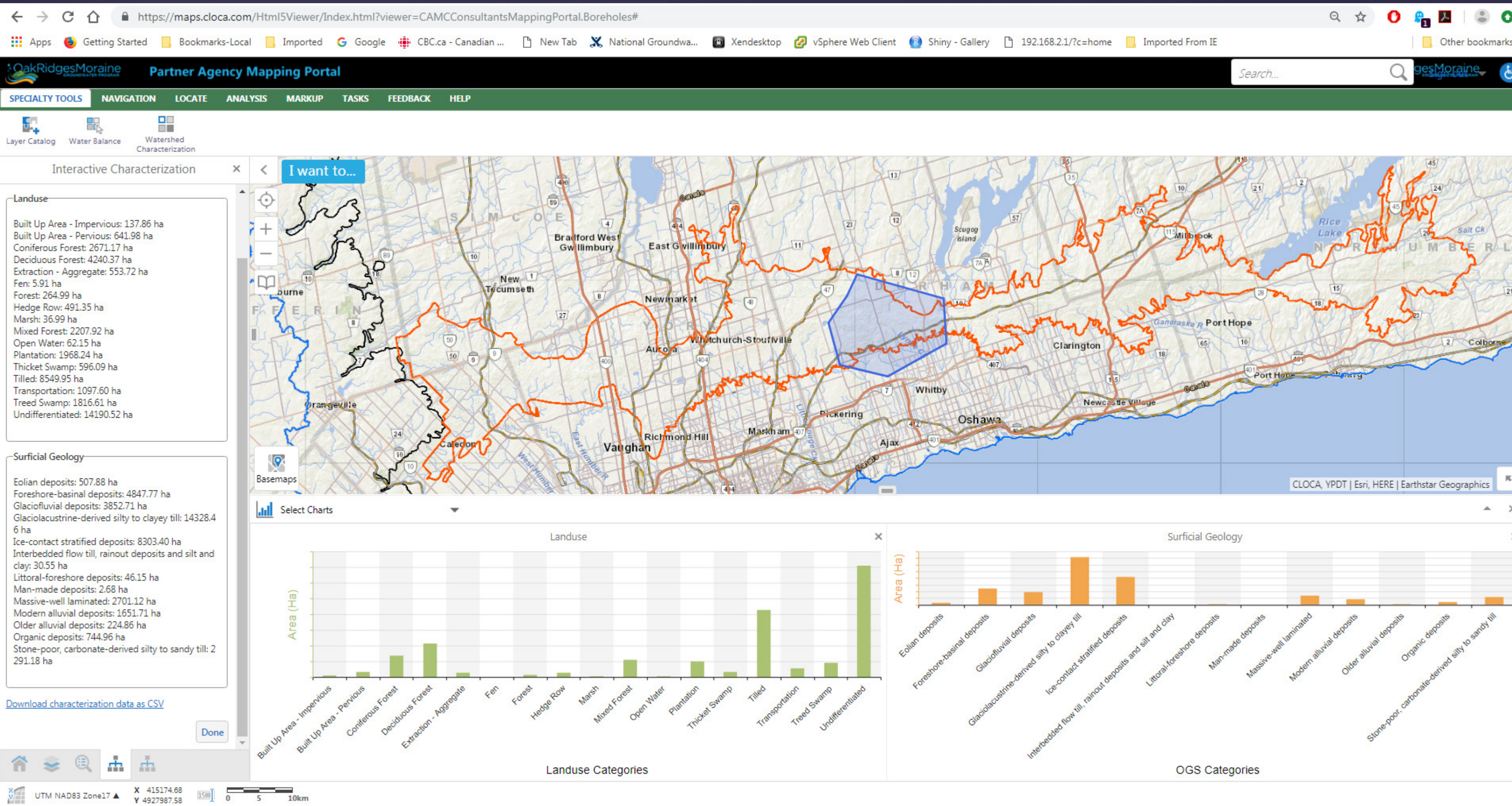
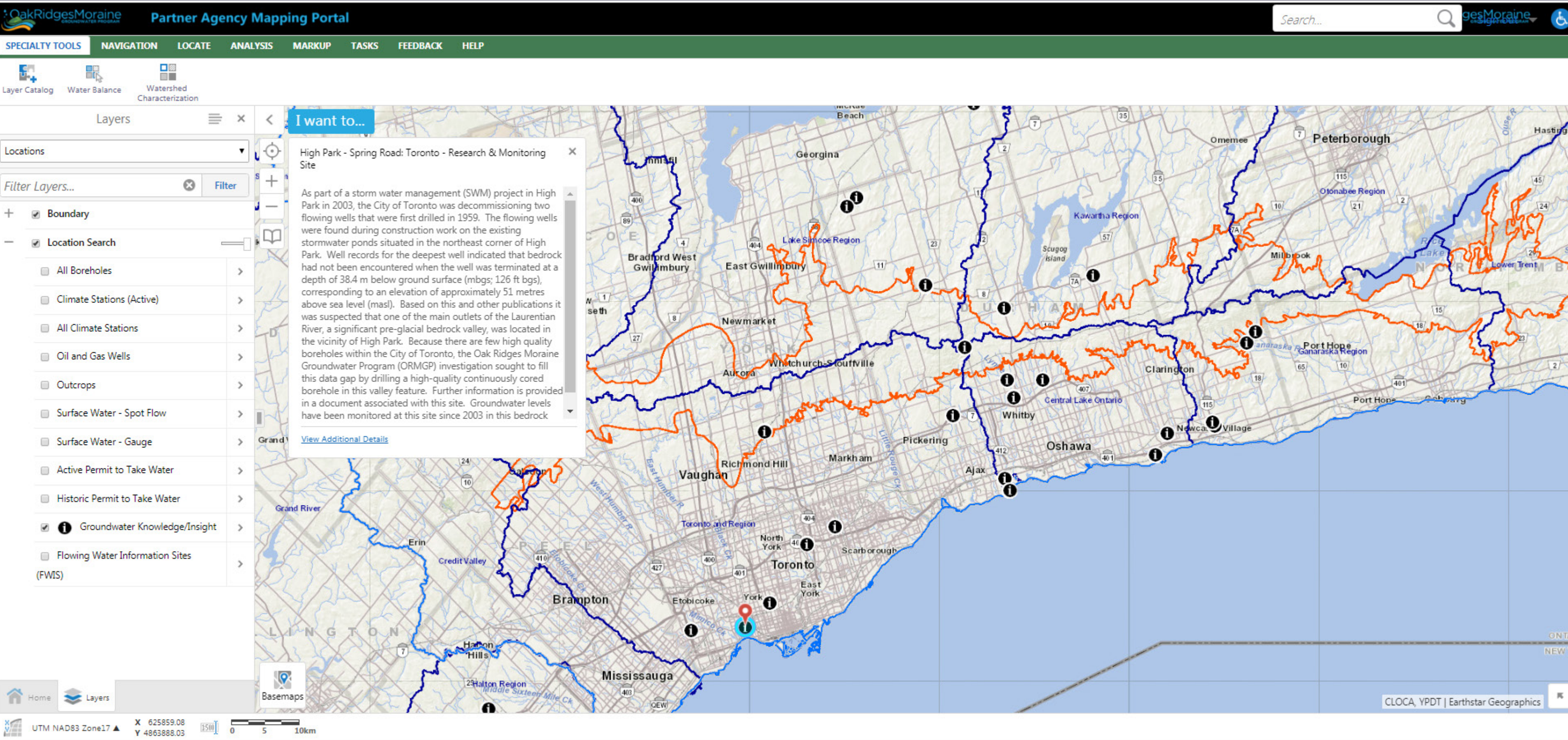
Partner Agency Mapping Portal
Search...
SPECIALTY TOOLS
NAVIGATION
LOCATE
ANALYSIS
MARKUP
TASKS
FEEDBACK
HELP
Layer Catalog
Water Balance
Watershed Characterization
Layers
Water Budget
Filter Layers...
Filter
World Transportation
Boundary
Water Budget
RECHARGE
High : 898.57
Default
Low : 0
RUNOFF
EVAPOTRANSPIRATION
PRECIPITATION
I want to...
WATER BALANCE within your selection
RUNOFF - 52 mm/yr
RECHARGE - 464 mm/yr
EVAPOTRANSPIRATION - 332 mm/yr

PRECIPITATION - 852 mm/yr
OK
Bracebridge
Bancroft
Gravenhurst
Owen Sound
Meaford
Blue Mountains
Lake Simcoe
Kingston
Greater Napanee
Deseronto
Prince Edward
Lake Ontario (lac Ontario)
ONTARIO
NEW YORK
Minto
Guelph
Waterloo
Milton
Basemaps
CLOCA, YPDT | Esri, HERE | Earthstar Geographics
Home
Layers
UTM NAD83 Zone17
X 546865.83
Y 4983496.88
0 10 20km


https://maps.cloca.com/Html5Viewer/Index.html?viewer=CAMCConsultantsMappingPortal.Boreholes#
Partner Agency Mapping Portal
SPECIALTY TOOLS
NAVIGATION
LOCATE
ANALYSIS
MARKUP
TASKS
FEEDBACK
HELP
Layer Catalog
Water Balance
Watershed Characterization
Interactive Characterization
Landuse
Built Up Area - Impervious: 137.86 ha
Built Up Area - Pervious: 641.98 ha
Coniferous Forest: 2671.17 ha
Deciduous Forest: 4240.37 ha
Extraction - Aggregate: 553.72 ha
Fen: 5.91 ha
Forest: 264.99 ha
Hedge Row: 491.35 ha
Marsh: 36.99 ha
Mixed Forest: 2207.92 ha
Open Water: 62.15 ha
Plantation: 1968.24 ha
Thicket Swamp: 596.09 ha
Tilled: 8549.95 ha
Transportation: 1097.60 ha
Treed Swamp: 1816.61 ha
Undifferentiated: 14190.52 ha
Surficial Geology
Eolian deposits: 507.88 ha
Foreshore-basinal deposits: 4847.77 ha
Glaciofluvial deposits: 3852.71 ha
Glaciolacustrine-derived silty to clayey till: 14328.46 ha
Ice-contact stratified deposits: 8303.40 ha
Interbedded flow till, rainout deposits and silt and clay: 30.55 ha
Littoral-foreshore deposits: 46.15 ha
Man-made deposits: 2.68 ha
Massive-well laminated: 2701.12 ha
Modern alluvial deposits: 1651.71 ha
Older alluvial deposits: 224.86 ha
Organic deposits: 744.96 ha
Stone-poor, carbonate-derived silty to sandy till: 2291.18 ha
Download characterization data as CSV
Done
I want to...
Basemaps
CLOCA, YPDT | Esri, HERE | Earthstar Geographics
Select Charts
Landuse
Area (Ha)
Landuse Categories
Surficial Geology
OGS Categories
UTM NAD83 Zone17
X 415174.68
Y 4927987.58
0 5 10km



Groundwater Knowledge/Insight Locations

- Provides straightforward way to pass lessons to future practitioners – long memo field in database summarizes the “story” or “lesson”
- e.g. flowing conditions/poor water quality/permanent dewatering sites/GW surprises, etc.

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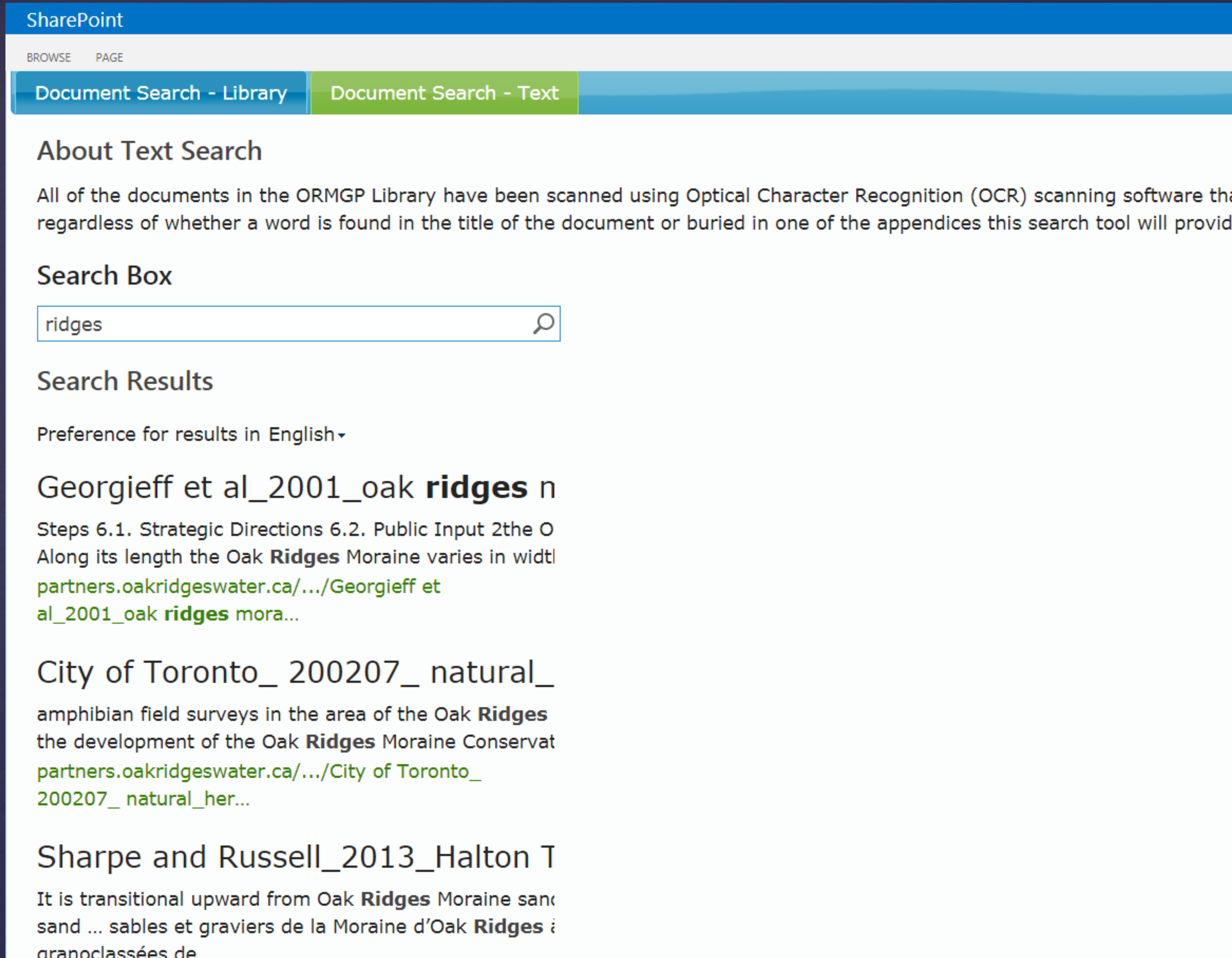
Library Search

Ontario	1996	and D.R. Sharpe	University of Ottawa	1056	Moraine
Enhanced Digital Elevation Models for Quaternary and Terrain Mapping in Glaciated Terrains; Examples from the Oak Ridge Moraine Southern Ontario	1997	Kenny, F.M., Russele, H.A., Sharpe, D.R., Bamett, P.J. and Brennand, R.A.	Canada - Geological Survey of Canada	7618	Provincial - Ontario
Potential springs in the Oak Ridges Moraine, Southern Ontario: Mapping from Aerial Thermography	1997	Dyke, L.D., Sharpe, D.R., Ross, I., Hinton, M. and Stacey, P.	Canada - Geological Survey of Canada	2416	Oak Ridges Moraine
Surficial Geology of the Greater Toronto and Oak Ridges Moraine area, Southern Ontario	1997	Sharpe et al	Canada - Geological Survey of Canada	4096	To Be Classified
Water Resources Investigations of the Oak Ridges Moraine, Ontario: Geology and Hydrogeology	1997	H.A.J.Russell, D.R.Sharpe, M.J.Hinton and F.Johnson	Canada - Geological Survey of Canada	18397	Oak Ridges Moraine
Where is the water? Regional geologic/hydrogeologic framework, Oak Ridges Moraine Area, Southern Ontario. Field trip A1, 17-18 May 1997	1997	Sharpe, D.R. and Barnett, P.J.	Canada - Geological Survey of Canada	2213	Oak Ridges Moraine
Bedrock Topography of the Greater Toronto and Oak Ridges Moraine areas, southern Ontario	1998	Brennand T.A., A. Moore, C. Logan, F.M. Kenny, H.A.J. Russell, D.R. Sharpe, and P.J. Barnett	Canada - Geological Survey of Canada	987	Oak Ridges Moraine
Coding Sediment Descriptions From Drilling Records: Documentation of MOEE Waterwell Coding	1998	Russell, H.A.J., Brennand, T.A., Logan, C. and Sharpe, D.R.	Canada - Geological Survey of Canada	7613	Regional
On the origin of the Oak Ridges Moraine	1998	P.J.Barnett, D.R.Sharpe, H.A.J.Russell, T.A. Brennand, G. Gorrell, F.Kenny and A.Pugin		18392	Oak Ridges Moraine

Search by key fields (Author; Author Agency; Year; Title) From Document Table



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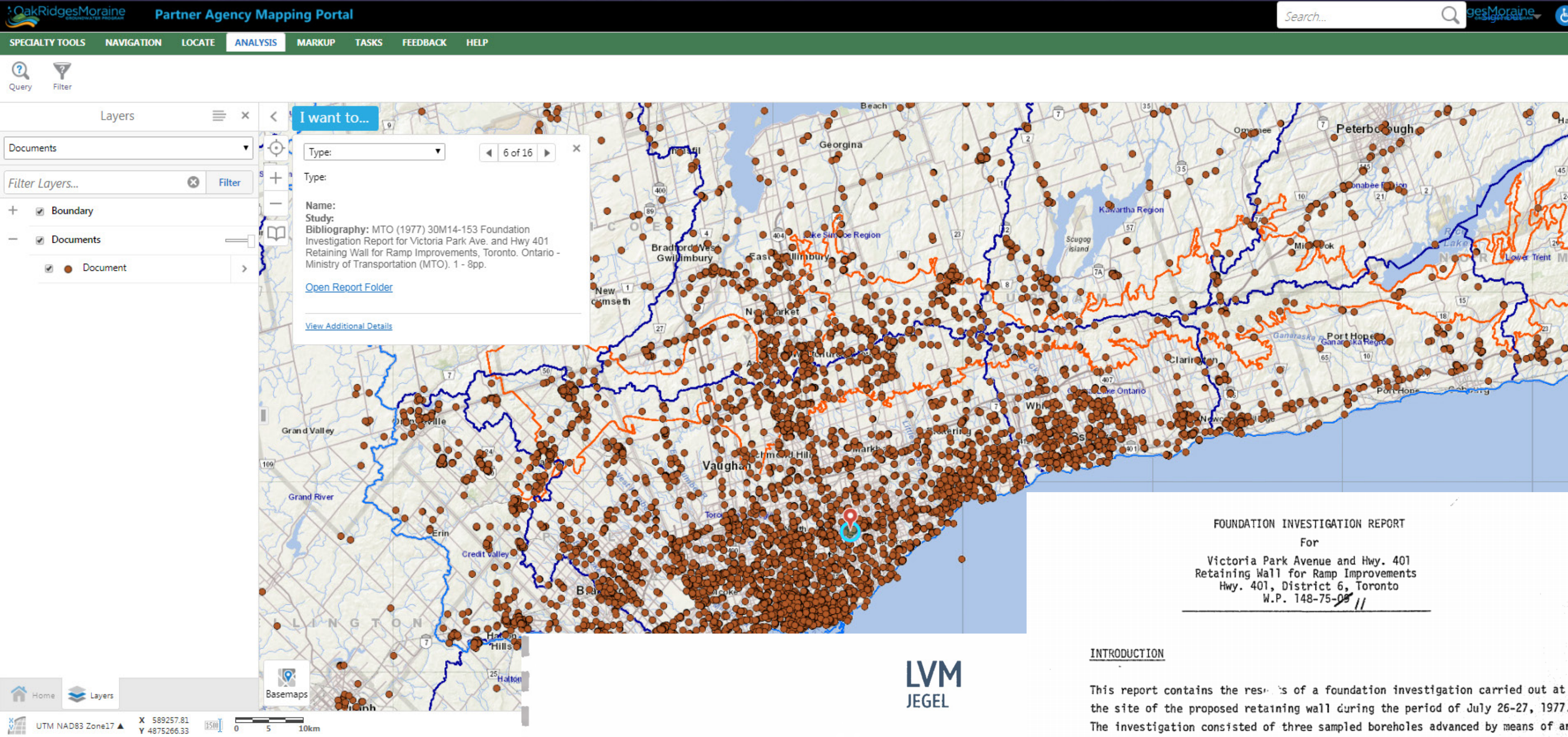

LVM
JEGEL

TORONTO

CITY OF TORONTO

Stand Alone Watermain Replacement Project
Geotechnical Investigation
East District – Report 1
Armitage Drive, Budea Crescent
Carthage Avenue and Crocus Drive
City of Toronto

Final Report

Date: 2010 02 16
O/Ref.: 124-P028005-101-01-GE-0001-00

FOUNDATION INVESTIGATION REPORT
For
Victoria Park Avenue and Hwy. 401
Retaining Wall for Ramp Improvements
Hwy. 401, District 6, Toronto
W.P. 148-75-05 11

INTRODUCTION

This report contains the res· ·s of a foundation investigation carried out at the site of the proposed retaining wall during the period of July 26-27, 1977. The investigation consisted of three sampled boreholes advanced by means of an auger machine to a depth of 16 feet below ground surface.

SITE AND GEOLOGY

The site is on the north side of the westbound collector of Hwy. 401 between the Victoria Park Avenue Underpass and the Warden Avenue Underpass in the Borough of Scarborough, Metropolitan Toronto. At this location, Hwy. 401 is in a shallow cut, in the order of about 5 to 8 feet. In the areas where the retaining wall is to be constructed, the cut stands at a slope of approximately 2½:1 to 4:1 and the slope is covered with grass and young pine trees. A barrier wall is also located on the top of the slope. The area is well drained.

Geologically, the site is located in a physiographic region known as the South Slope. Ground moraines and till plains are the predominant landforms in this area.

SUBSURFACE CONDITIONS

The overburden at the site was investigated to a depth of 16 feet below the sloping ground surface of the existing cut. Subsoil revealed by our borings is a glacial till composed of sandy silt with some gravel and a trace of clay. Typical grain size distribution curves in an envelope form of the glacial till are shown in Fig. (1). The upper 2½ feet of the glacial deposit has been reworked by weathering a·· as a result of this has a compact relative density. Below the reworked zone, the stratum has a dense to very dense relative

THE GLACIAL AND INTERGLACIAL STRATA OF SCARBORO' HEIGHTS,

AND

OTHER LOCALITIES NEAR TORONTO, ONTARIO.

(WITH A PLATE.)

BY MR. GEORGE JENNINGS HINDE, F.G.S.

(Read before the Canadian Institute, February 3rd, 1877.)

There is perhaps no other portion of the great inland basin of North America where the strata, showing the different changes which have occurred from the commencement of the Glacial period up to the present, are better displayed than along the shores of Lake Ontario and the country bordering on it. The south shore of the lake in the State of New York is described by Professor Hall as one continuous section; at Niagara the interest attached to the Falls has caused the superficial strata to be closely studied, not only by American geologists, but by such men as Lyell and Ramsay; and a late article by Mr. Thos. Belt, F.G.S.,* shows that their entire history is not yet satisfactorily determined. Between Niagara and Dundas, Ontario, at the western extremity of the lake, the southern shores present glacial beds of great interest, but which have not yet been fully described. On its northern shores, from the commencement of the channel of the St. Lawrence at the Thousand Isles, westwards as far as Scarboro', Ontario, the banks of the lake are generally low and without features of importance, and beyond Scarboro' the shores are again low to the western extremity.

This general deficiency in conspicuous sections along the north shore is more than compensated by the display, perhaps unequalled anywhere round the lake, of glacial strata at the Scarboro' Cliff. This cliff, generally known by the name of the Scarboro' Heights, commences near Port Union, about fifteen miles east of Toronto, and from thence extends along the lake shore, in a general south-westerly direction, for about nine and a half miles. It is low at its easterly end, but gradually

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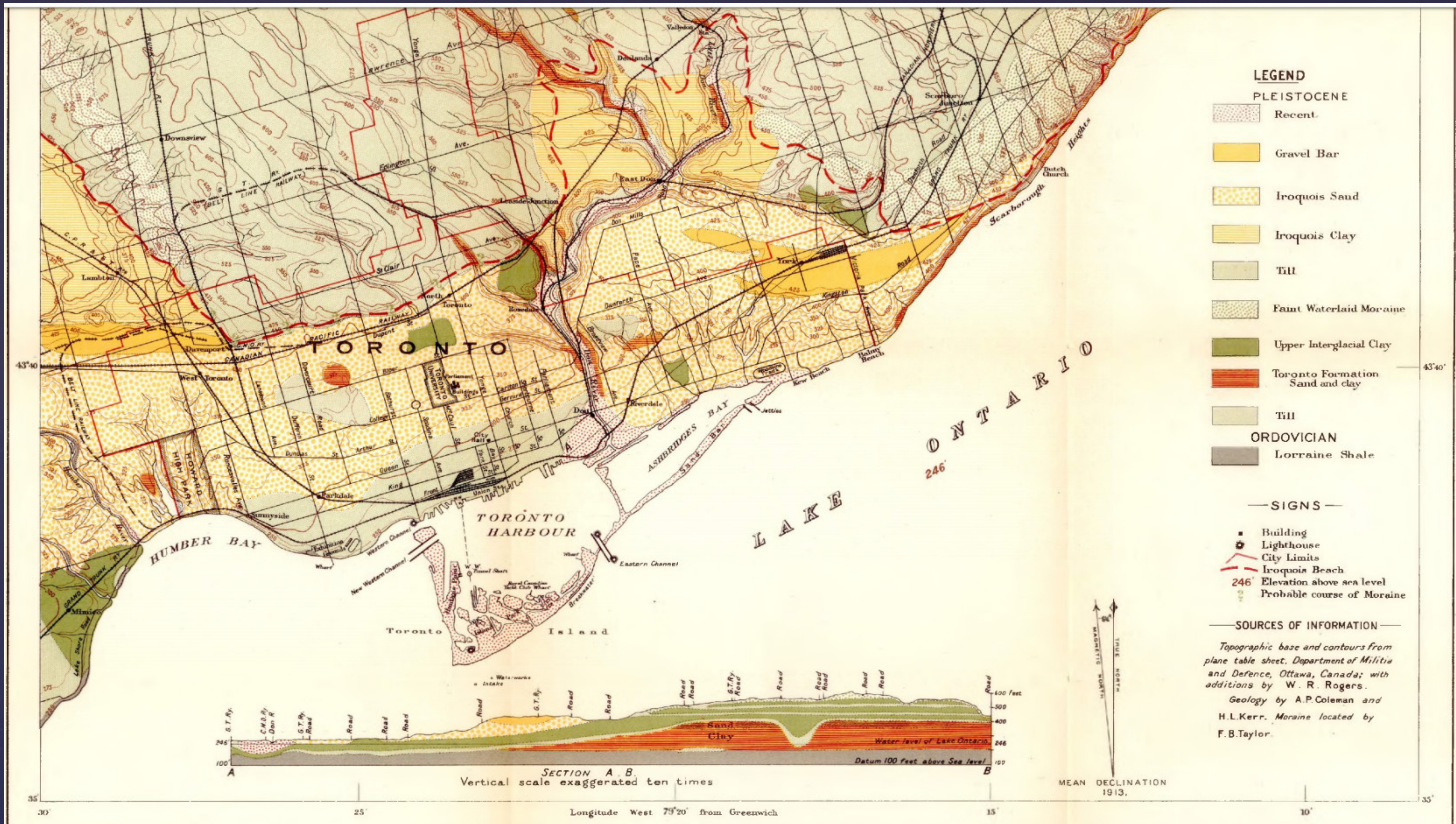
* *Quarterly Journal of Science*, April, 1875.


LEGEND
PLEISTOCENE
Recent
Gravel Bar
Iroquois Sand
Iroquois Clay
Till
Faint Waterlaid Moraine
Upper Interglacial Clay
Toronto Formation Sand and clay
Till
ORDOVICIAN
Lorraine Shale
SIGNS
Building
Lighthouse
City Limits
Iroquois Beach
246 Elevation above sea level
Probable course of Moraine
SOURCES OF INFORMATION
Topographic base and contours from plane table sheet, Department of Militia and Defence, Ottawa, Canada; with additions by W. R. Rogers.
Geology by A.P. Coleman and H.L.Kerr. Moraine located by F.B.Taylor.
TORONTO
LAKE ONTARIO
TORONTO HARBOUR
HUMBER BAY
ASHBRIDGES BAY
Toronto Island
Scarborough Heights
HIGH PARK
SECTION A.B.
Vertical scale exaggerated ten times
Water level of Lake Ontario
Datum 100 feet above Sea level
MEAN DECLINATION 1913.
Longitude West 79°20' from Greenwich

1916- [illegible]

GORE & STORRIE
CONSULTING ENGINEERS
CHARLES-BAY BUILDING
160 BAY STREET
TORONTO 5

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NORMAN G. McDONALD
JAMES F. MacLAREN
JOHN W. ARGO
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TORONTO AND YORK PLANNING BOARD

REPORT

ON

WATER SUPPLY AND SEWAGE DISPOSAL

FOR THE

CITY OF TORONTO

AND

RELATED AREAS

September, 1949.

largely to the related areas, as indicated in the following table:

	YEAR 1930	1935	1940	1947	1948	Estimate for 1970
Toronto	621,596	638,271	648,098	695,302	670,035	725,000
Outside Areas	162,362	200,008	226,688	293,956	319,468	550,000
Totals	783,958	838,279	874,786	989,258	989,503	1,275,000
Increase in						
Toronto		16,675	9,827	47,204	25,267-	54,965
Outside Areas		37,646	26,680	67,268	25,512	230,532
Total Increase		54,321	36,507	114,472	245	285,497

- Denotes decrease

In the foregoing table populations have been estimated for the year 1970 and are believed to be along conservative lines. It is possible the populations for 1970 may exceed those estimated. Populations of this magnitude will change the character of these related areas from rural and suburban to suburban and urban. Such large populations in the related areas will inevitably affect the quality of the water supply and bathing beaches unless a comprehensive plan for sewage disposal is developed and proper works are built as needed to control the pollution adequately. By this is meant that the locations of the existing water works intakes in Lake Ontario will be satisfactory and that present water purification facil-

REPORT

on

SUBSURFACE EXPLORATION

for

PROPOSED OVERPASS

INTERSECTION OF ORILLIA BY-PASS

and

OLD HIGHWAY N° 11

DISTRICT N° 6

ONTARIO

INTRODUCTION

The Highways Department of the Province of Ontario are planning the construction of an overpass at the intersection of Orillia By-Pass and old Highway N° 11 in the township of Orillia, county of Simcoe, where traffic is at present regulated by signal lights.

In order to evaluate the properties of the soil with respect to excavation and foundation design for the overpass structure, the Department authorized Universal GEOTECHNIQUE Limited to carry out subsurface exploration comprising soil borings and accordingly the work was carried out during the period 4th to 12th June, 1957.

The extent of the exploration conformed to the information indicated on drawing N° DM.4333, scheme 9, dated March 13th, 1957.

SUBSURFACE EXPLORATION

Subsurface exploration comprised a total of 4 exploratory boreholes located in the positions shown on D.H.O. drawings which were staked by D.H.O. personnel from the Forest Home office. The locations of the boreholes have also been indicated on drawing N° 1 forming part of this Report.

The levels of the ground surface at each borehole have been given on the borehole logs.

Boreholes BH.1 and BH.3 were taken to a depth of 35 feet and because of the information obtained from these boreholes it was decided that economy could be effected by terminating the other 2 borings at a depth of 15 feet. The strata encountered was extremely difficult to penetrate but it was considered desirable to carry 2 of the borings to a depth of 35 feet in order to obtain authentic data to a depth of about 10 feet below the possible underside of spread footings.

TORONTO TRANSPORTATION COMMISSION

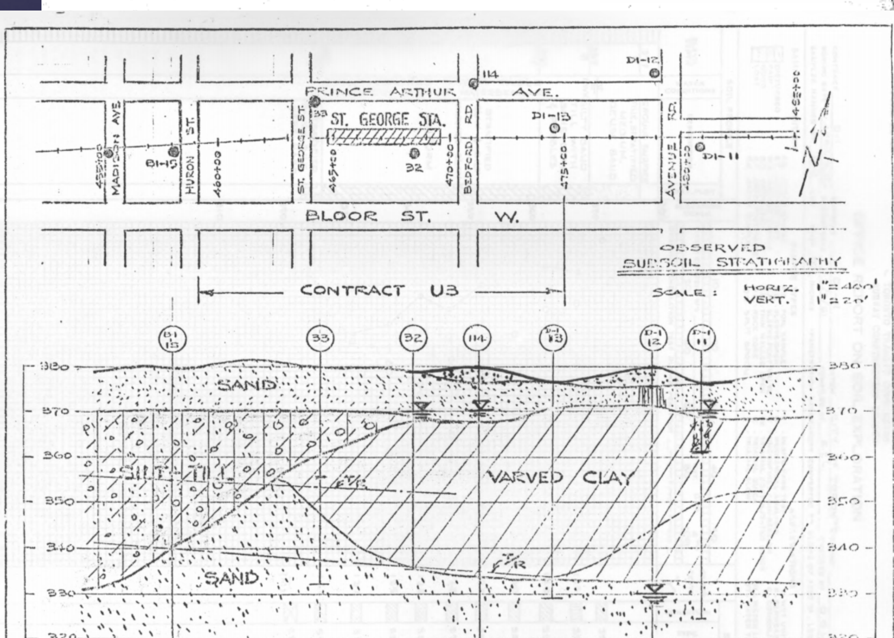
RAPID TRANSIT DEPARTMENT

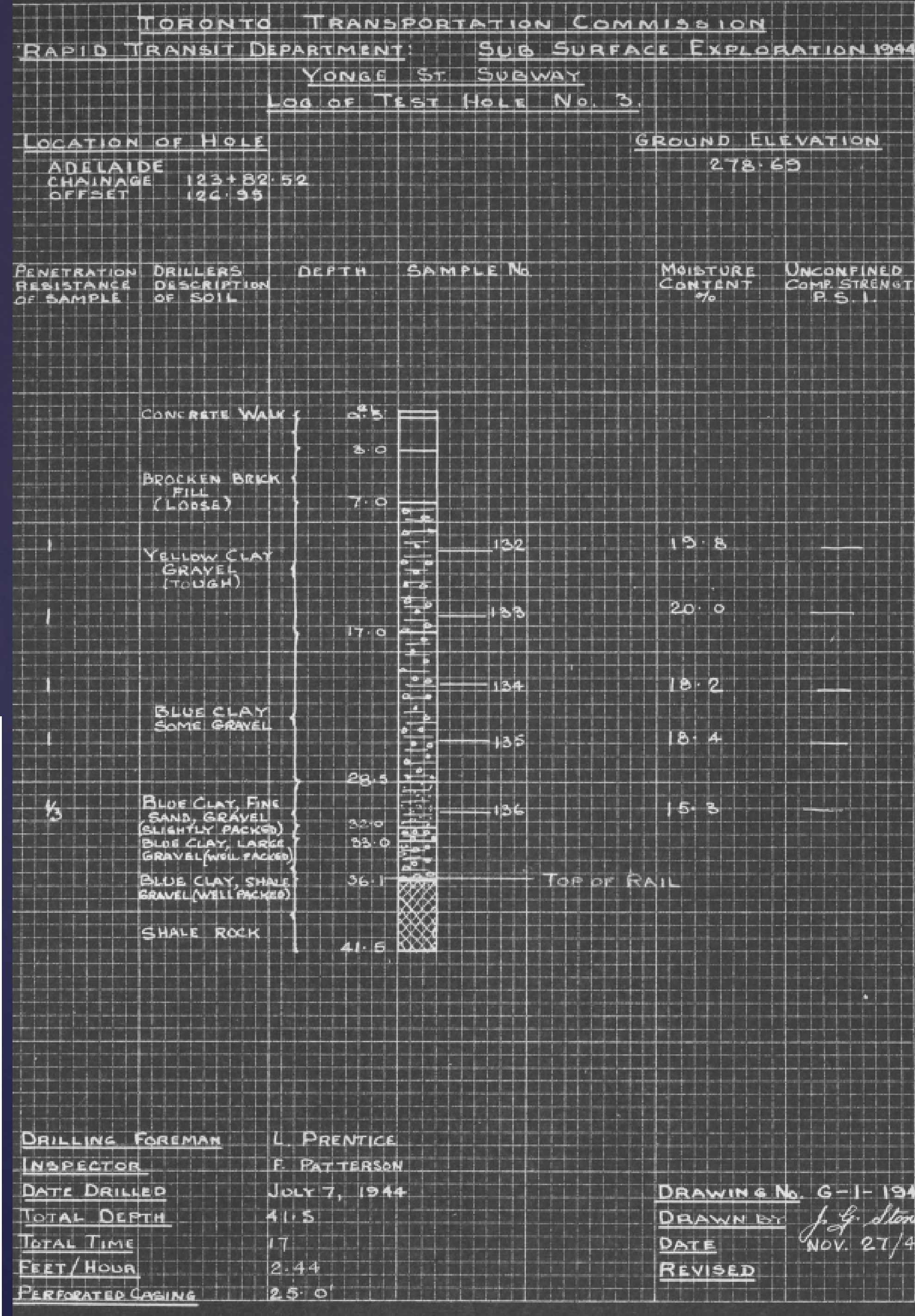
PROPOSED YONGE STREET SUBWAY

PRELIMINARY SUB-SURFACE INVESTIGATION

1944

FINAL REPORT





THE GLOBE AND MAIL

CANADA'S NATIONAL NEWSPAPER • FOUNDED 1844 • SATURDAY, JULY 3, 1999

Riders pass a field of sunflowers during Stage 12 of last year's Tour de France between Tarascon and Le Cap D'Adge. The Tour, which starts today, hopes to recover from the drug scandal of 1998. Story, A24. ALEX LIVESEY/Allsport

WEEKEND EDITION

Books

Gerald Regan's acquittal on sexual-assault charges last winter may have cleared the former Nova Scotia premier in the eyes of the law, but writer Stephen Kimber says stories about him were circulating for years. His new book paints a seamy picture

Bottlers free to drain off groundwater

Permits that allow 18 billion litres a year to be taken from pristine aquifers raise questions of sustainability

MARTIN MITTELSTAEDT
Environment Reporter

Commercial bottlers have been given the right to drain, free of charge, more than 18 billion litres a year from Ontario's supply of high-quality water, fuelling fears that nature will be unable to replace the loss.

Figures obtained by The Globe and Mail show that bottlers are now permitted to process five litres a day for every person in the province. That's 30 times the amount allocated to a company planning to export Lake Superior water to Asia before a public outcry prompted the province to rescind its permission last July.

Information from the Ontario Ministry of Environment and from the provincial computer registry of permit applicants suggests that requests now pending could add several billion more litres to the total. The state of record-keeping means that a precise tally is difficult to determine.

The 48 free permits that have been issued grant long-term access (meaning for up to 10 years, or in some cases indefinite) to a resource worth millions of dollars in the retail market.

Some legal experts and environment-protection officials now worry that Ontario's aquifers, pristine sources of water that in some areas are legacies from the last ice age, are being tapped unsustainably.

However, the Ministry of Environment insists that the resource is being managed well.

Please see **WATER** *on page* **A7**

Streams, icebergs

How the provinces regulate the bottled water industry

On the origin of the Oak Ridges Moraine[1]

P.J. Barnett, D.R. Sharpe, H.A.J. Russell, T.A. Brennand, G. Gorrell, F. Kenny, and A. Pugin

Abstract: Landscape analysis, mapping, sedimentology, shallow geophysics, and borehole data are integrated to better understand the complex landform–sediment geometries and event sequences of the Oak Ridges Moraine, southern Ontario. A model for the origin of the Oak Ridges Moraine is based on the recognition that the moraine is built on a high-relief, erosional surface (unconformity) consisting of drumlin uplands and a network of deep, steep-walled, interconnected valleys (tunnel channels). The development of the moraine is thought to have occurred in four stages: I, subglacial sedimentation; II, subaqueous fan sedimentation; III, fan to delta sedimentation; IV, ice-marginal sedimentation. The model traces the transition from subglacial to proglacial conditions during moraine formation and examines the order and timing of sedimentation. It is thought that the early stages of moraine construction are better exposed in the east; in the west, these stages are buried by later stages.

Résumé : Les études de paysage, cartographie, sédimentologie, géophysique de subsurface et des carottes de trous des sondages ont été menées conjointement pour chercher à mieux comprendre les configurations complexes des formes de relief–sédiments, et les séquences des événements qui ont affecté la Moraine d'Oak Ridges, dans le sud de l'Ontario. Un modèle interprétant l'origine de la Moraine d'Oak Ridges est fondé sur le fait que cette moraine fut édifiée sur une surface d'érosion (discordance) en terrain à topographie accentuée, comprenant des drumlins sur terres élevées et des vallées à parois subverticales interconnectées (chenaux tunnels). Le modèle propose un développement de la moraine en quatre phases : I, sédimentation sous-glaciaire; II, sédimentation d'un éventail sous-aquatique; III, sédimentation de l'éventail évoluant vers un dépôt deltaïque; IV, sédimentation en bordure d'un glacier. Le modèle retrace la transition de conditions sous-glaciaires à proglaciaires durant la formation de la moraine, et traite de l'ordre et de la chronologie du sédiment. Il apparaît que c'est dans le secteur oriental que les premières phases de l'édification de la moraine sont le mieux exposées; tandis que dans le secteur partie occidental, elles sont enfouies sous le sédiment des phases plus tardives.

[Traduit par la Rédaction]

Introduction

The Oak Ridges Moraine (ORM) is the most prominent, stratified moraine complex in southern Ontario. It is one of several linear moraines (e.g., Hartman, Harricana, Valley Heads, St. Narcisse) in the Great Lakes region (Fig. 1). The origins of these stratified moraines are poorly understood and to truly understand their genesis and landform character requires the application of multiple approaches (including subsurface surveys; e.g., Sharpe et al. 1992; Brennand and Shaw 1996). To what extent are these moraines the product of glaciofluvial and glaciolacustrine processes as opposed to ice-dynamic processes? Was sedimentation subglacial, ice supported, and (or) ice marginal? Was it time transgressive or synchronous? Was sedimentation rapid and sporadic or slow and more continuous? How does this knowledge allow one to improve predictions of lithofacies occurrence and transitions that are important to environmental reconstruction and, for example, hydrogeologic understanding?

Studies completed on the Hartman Moraine have identified glaciofluvial and glaciolacustrine features and sedimentological characteristics of meltwater floods (Sharpe and Cowan 1990; Sharpe et al. 1992). The Harricana Moraine is a glaciofluvial complex that may represent time-transgressive formation at receding ice margins (Veillette 1986) or synchronous but episodic, high-energy sedimentation within a conduit (Brennand and Shaw 1996). The Valley Heads Moraine formed from ice-marginal sedimentation downflow of tunnel channels now occupied by the Finger Lakes (Mullins and Hinchy 1989; Petruccione et al. 1996). Parts of the St. Narcisse Moraine are the product of subaqueous fan sedi-

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T.A. Brennand. Department of Geography, Simon Fraser University, Burnaby, BC V5A 1S6, Canada.
G. Gorrell. Gorrell Resources Investigations, RR1, Oxford Mills, ON K0G 1S0, Canada.
F. Kenny. Ontario Ministry of Natural Resources, Peterborough, ON K9J 8M5, Canada.
A. Pugin. Institut F.-A. Forel, route de Suisse 10, CH-1290 Versoix, Switzerland, and Département de géologie, 13, rue des Marachers, 1211 Géneve 4, Switzerland.

NRC Research Press

ARTICLE

Converging ice streams: a new paradigm for reconstructions of the Laurentide Ice Sheet in southern Ontario and deposition of the Oak Ridges Moraine

S. Sookhan, N. Eyles, and L. Arbelaez-Moreno

Abstract: Geomorphological mapping using detailed morphometric analyses of newly available high-resolution (5 m) digital elevation datasets across more than 9000 km² of southern Ontario shows that the Greater Toronto Area and its immediate environs, Canada's largest urban area, is built across the former till beds of two fast-flowing ice streams (the newly named Simcoe Ice Stream (SIS) and the Halton Ice Stream (HIS)) within the last Laurentide Ice Sheet (LIS). These formed during regional deglaciation sometime around 13 000 years before present and are directly analogous to fast-flowing (>3 km year^{-1}) ice streams in today's Antarctic and Greenland ice sheets. Their subglacial footprint in southern Ontario consists of flow sets of highly elongated and closely spaced flow-parallel till ridges up to 4 km in length and 100 m in width (megascale glacial lineations) that converge on the Oak Ridges Moraine (ORM) from the north (SIS) and south (HIS). ORM is southern Ontario's largest glacial landform extending from the Niagara Escarpment to Kingston over some 160 km and was deposited as a series of en echelon glaciolacustrine fan deltas in a complexly evolving glaciolacustrine depocenter trapped between the converging ice streams; meltwater channels cut into the bed of the Simcoe Ice Stream suggest that glaciofluvial sediment was primarily supplied from the north. The sedimentology of the ORM is comparable to "morainal banks" at the margins of ice streams terminating in water; some 70 km³ of sediment accumulated very rapidly (>300 years?) reflecting the ability of ice streams to move very large fluxes of sediment, combined with trapping of sediment between SIS and HIS. To date, more than 117 paleo ice streams have been recognized in the LIS and this study confirms the presence of additional corridors of fast-flowing ice in its eastern Great Lakes sector. The ice stream paradigm provides a uniformitarian foundation for a comprehensive re-evaluation of much existing glacial geologic mapping and stratigraphic work in southern Ontario that hitherto stressed the role of catastrophic regional subglacial megaflooding in the formation of the ORM and many other landforms. This paper advocates complete remapping of the glacial landscapes of southern Ontario using an "ice stream landsystem" approach to determine the full number of ice streams in the eastern Great Lake sector of the last ice sheet.

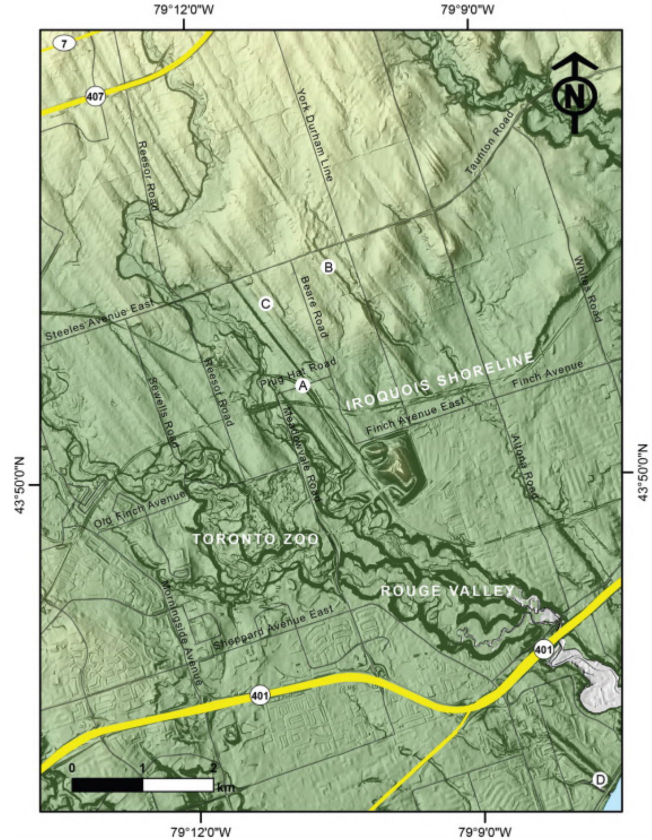
Résumé : La cartographie géomorphologique à l'aide d'analyses morphométriques détaillées de nouveaux ensembles de données d'élévation numériques de haute résolution (5 m) couvrant plus de 9 000 km² dans le sud de l'Ontario montre que la région du Grand Toronto et ses environs immédiats, première région urbaine du Canada, reposent sur d'anciens lits de till de deux coulées glaciaires à écoulement rapide (la coulée glaciaire de Simcoe, SIS, récemment nommée, et la coulée glaciaire de Halton, HIS) dans l'inlandsis laurentidien (LIS). Ces coulées se sont formées durant la déglaciation régionale, autour de 13 000 a BP et sont directement analogues aux coulées glaciaires à écoulement rapide (> 3 km a^{-1}) actuelles dans les inlandsis de l'Antarctique et du Groenland. Leur empreinte sous-glaciaire dans le sud de l'Ontario consiste en des dépôts d'écoulement de crêtes de till très allongées et rapprochées orientées parallèlement à l'écoulement, de jusqu'à 4 km de longueur et 100 m de largeur (méga-linéations glaciaires) qui convergent sur la moraine de Oak Ridges (ORM) du nord (SIS) et du sud (HIS). L'ORM est la plus grande forme de relief glaciaire dans le sud de l'Ontario, s'étalant de l'escarpement du Niagara jusqu'à Kingston, sur quelque 160 km, et elle a été déposée en une série de deltas alluvionnaires glaciolacustres dans un centre de dépôt glaciolacustre à évolution complexe piégé entre les coulées glaciaires convergentes; des chenaux d'eau de fonte creusés dans le lit de la coulée glaciaire de Simcoe indiqueraient que les sédiments fluvioglaciaires provenaient principalement du nord. La sédimentologie de l'ORM est comparable aux « bancs morainiques » en bordure de coulées glaciaires se terminant dans l'eau; quelque 70 km³ de sédiments s'y sont accumulés très rapidement (> 300 ans?), reflétant la capacité des coulées glaciaires de transporter de très grands flux de sédiments, combinée au piégeage de sédiments entre la SIS et la HIS. À ce jour, plus de 117 paléo-coulées glaciaires ont été recensées dans l'inlandsis laurentidien, et l'étude confirme la présence d'autres couloirs de glace à écoulement rapide dans le secteur est des Grands Lacs. Le paradigme des coulées glaciaires constitue une base uniformitariste pour la réévaluation exhaustive de quantité de travaux cartographiques et stratigraphiques de géologie glaciaire dans le sud de l'Ontario qui, jusqu'à maintenant, mettaient l'accent sur le rôle de méga-inondations sous-glaciaires régionales catastrophiques dans la formation de l'ORM et de nombreuses autres formes de relief. Par conséquent, il serait pertinent de refaire la cartographie exhaustive des formes de relief glaciaire dans le sud de l'Ontario en utilisant une approche basée sur les « systèmes paysagers de coulées glaciaires » et pour déterminer le nombre de coulées glaciaires dans le secteur de l'est des Grands Lacs du dernier inlandsis. [Traduit par la Rédaction]

Received 31 August 2017. Accepted 22 December 2017.

Paper handled by Associate Editor Alan Trenhaile.

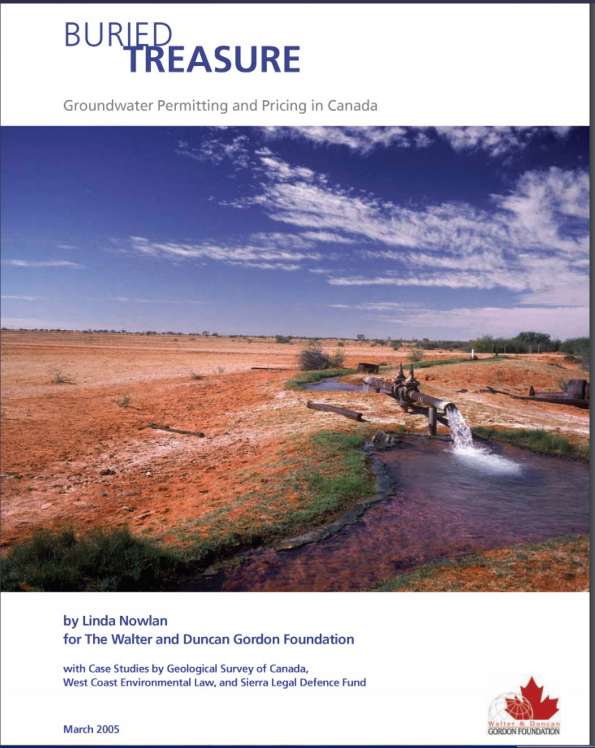
S. Sookhan, N. Eyles, and L. Arbelaez-Moreno. Department of Physical and Environmental Sciences, University of Toronto at Scarborough, 1065 Military Trail, Scarborough, ON M1C 1A4.

Fig. 9. Flow set of megascale glacial lineations on the surface of the Halton Till in Scarborough, north of Toronto Zoo recording northwesterly flow of Halton Ice Stream toward the Oak Ridges Moraine (see Fig. 8 for location). Sites A–D are locations of images shown in Figs. 10 and 11. [Colour online.]



tion of larger parent drumlin bedforms by streams of deforming subglacial debris (defined as an "erodent layer" by Eyles et al. 2016). Geologic and geophysical data from numerous MSGL ridges cut by Highway 407 indicate that they are composed in the main of NT and result from erosion of that older till and are only par-

Analysis of digital elevation datasets also identifies so-called "palimpsest" drumlins (e.g., Knight et al. 1999) composed of NT, now partially draped by HT (Figs. 8, 13). These drumlins were originally oriented northeast–southwest and were reshaped by the northwestward flowing HIS; Karrow 1967 (p. 13) reported them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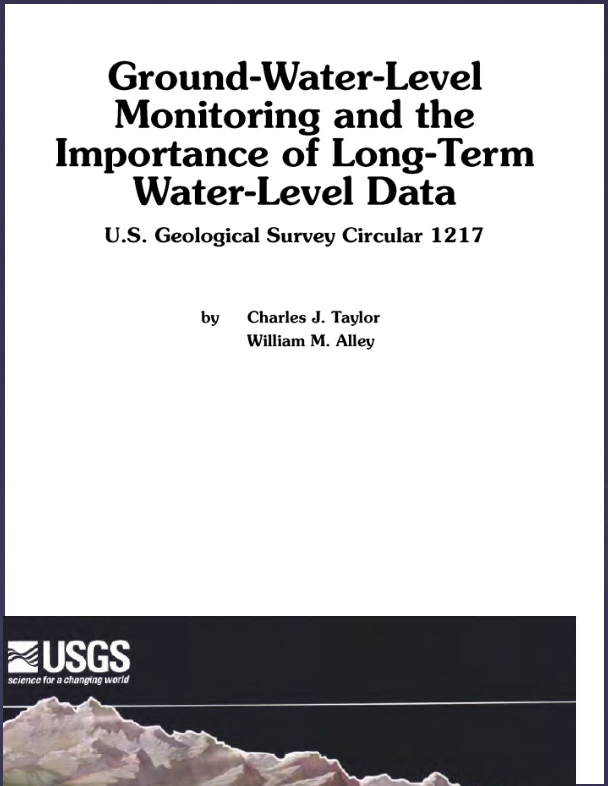
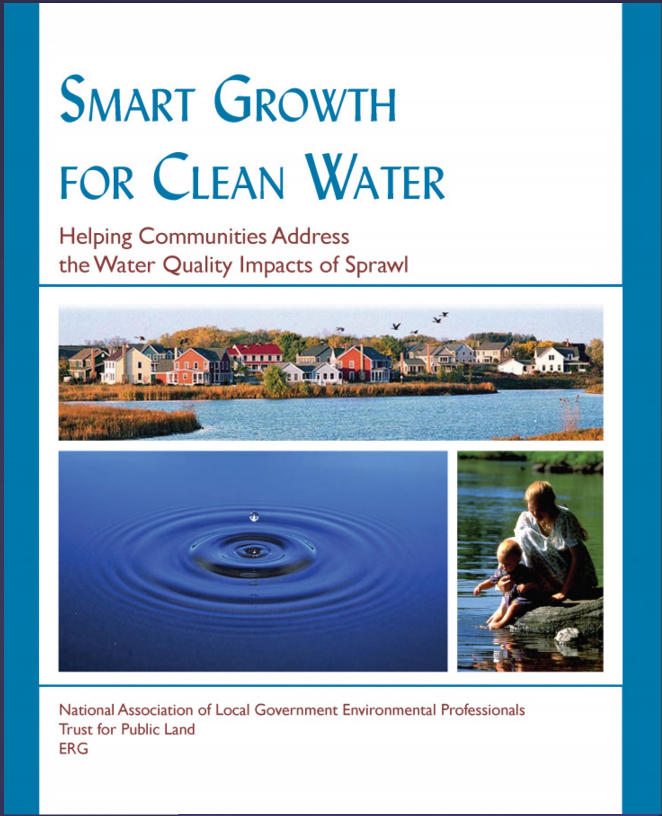

Ground-Water-Level
Monitoring and the
Importance of Long-Term
Water-Level Data
U.S. Geological Survey Circular 1217
by Charles J. Taylor
William M. Alley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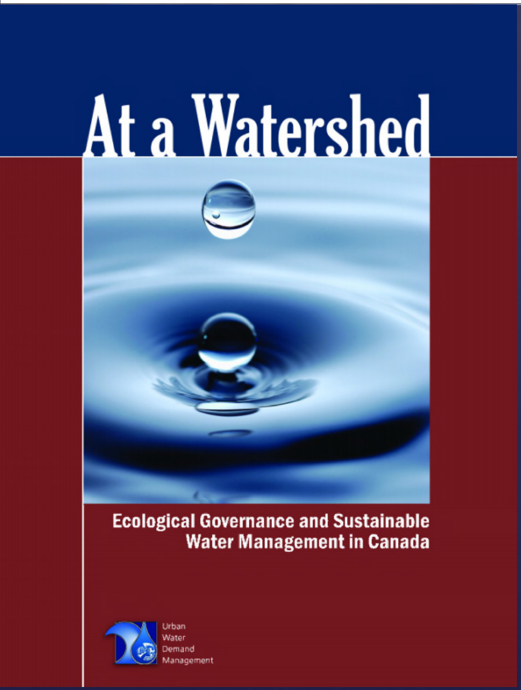
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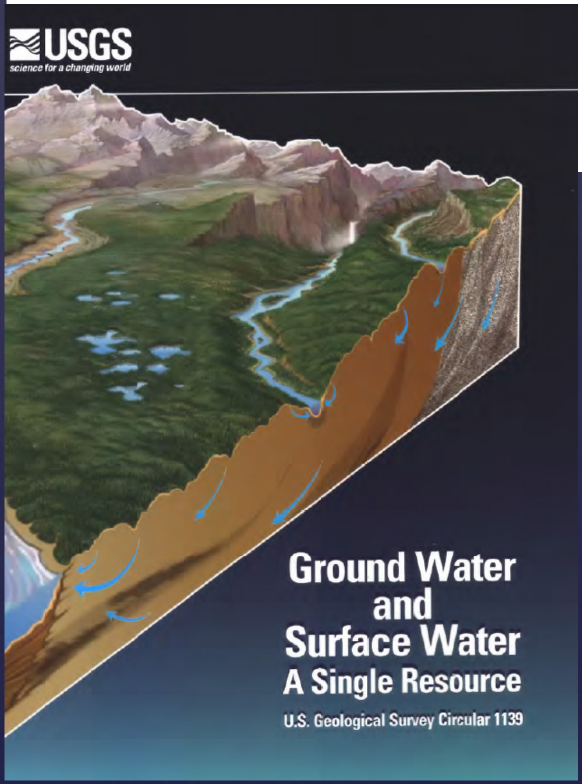
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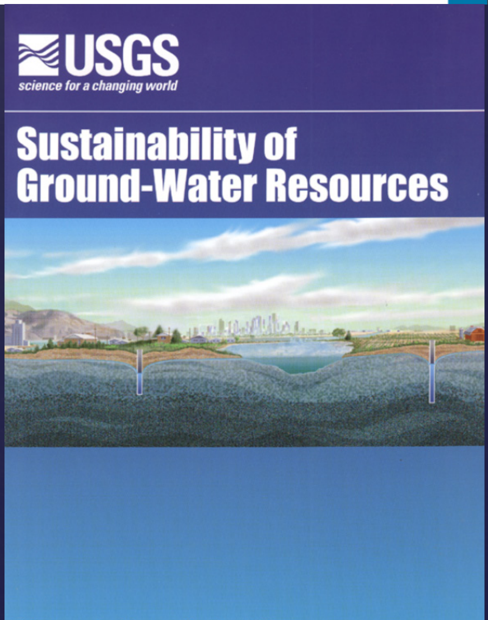
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Sustainability of
Ground-Water Resources

Predictive Accuracy of a Ground-Water Model — Lessons from a Postaudit

by Leonard F. Konikow[a]

1986 Vol. 24(2) 173-184

ABSTRACT

Hydrogeologic studies commonly include the development, calibration, and application of a deterministic simulation model. To help assess the value of using such models to make predictions, a postaudit was conducted on a previously studied area in the Salt River and lower Santa Cruz River basins in central Arizona. A deterministic, distributed-parameter model of the ground-water system in these alluvial basins was calibrated by Anderson (1968) using about 40 years of data (1923-64). The calibrated model was then used to predict future water-level changes during the next 10 years (1965-74). Examination of actual water-level changes in 77 wells from 1965-74 indicates a poor correlation between observed and predicted water-level changes. The differences have a mean of −73 ft—that is, predicted declines consistently exceeded those observed—and a standard deviation of 47 ft. The bias in the predicted water-level change can be accounted for by the large error in the assumed total pumpage during the prediction period. However, the spatial distribution of errors in predicted water-level change does not correlate with the spatial distribution of errors in pumpage. Consequently, the lack of precision probably is not related only to errors in assumed pumpage, but may indicate the presence of other sources of error in the model, such as the two-dimensional representation of a three-dimensional problem or the lack of consideration of land-subsidence processes. This type of postaudit is a valuable method of verifying a model, and an evaluation of predictive errors can provide an increased understanding of the system and aid in assessing the value of undertaking development of a revised model.

INTRODUCTION

Hydrogeologic studies commonly include the use of deterministic, distributed-parameter, ground-water models to predict responses of an aquifer system to changes in stresses. The extreme example of using such models for predictions may be in the planning of high-level radioactive waste repositories, where regulators desire and require projections of ground-water flow and transport for 1,000 to 10,000 years into the future. Is there any evidence, either on the basis of a postaudit of the outcome of past predictive efforts or otherwise, that deterministic simulation models can indeed accurately predict future responses in ground-water systems? Is forecasting the only or primary motivation for applying a deterministic ground-water model, or does the modeling exercise have some other value?

The underlying philosophy of process-simulating deterministic-modeling approaches is that, given a comprehensive understanding of the processes by which stresses on a system produce subsequent responses in that system, the system's response to any set of stresses can be defined or predetermined through that understanding of the governing (or controlling) processes, even if the magnitude of the new stresses falls outside of the range of historically observed stresses. Predictions made this way assume an understanding of cause-

Rates of Water Movement Through the Floors of Selected Stormwater Basins in Nassau County, Long Island, New York

By Henry. F.H. Ku and Donald R. Aaronson

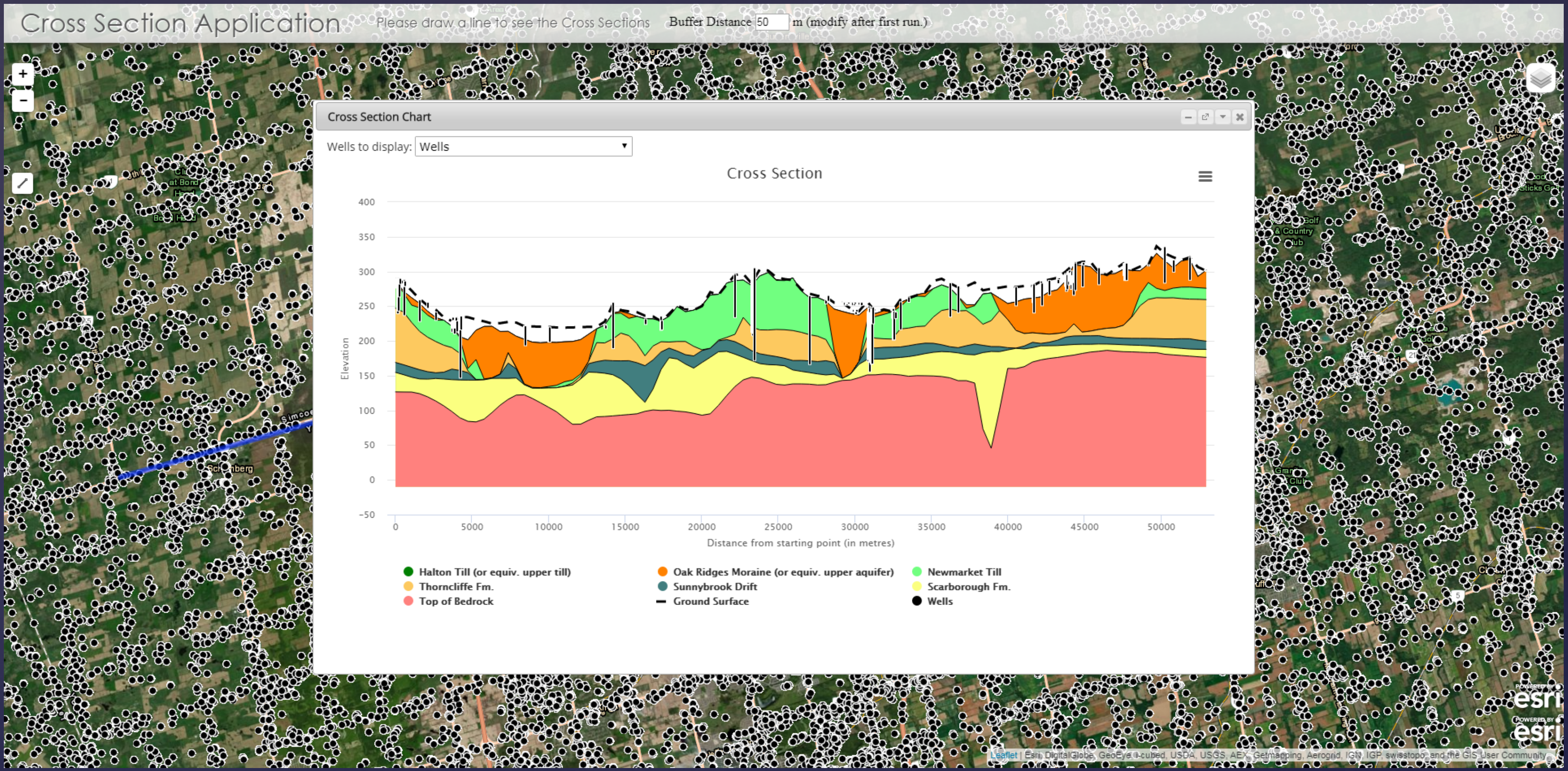
U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 91-4012

Prepared in cooperation with the
NASSAU COUNTY DEPARTMENT OF PUBLIC WORKS

Syosset, New York

1992



Cross Section Application
Please draw a line to see the Cross Sections
Buffer Distance 50 m (modify after first run.)
Cross Section Chart
Wells to display: Wells
Cross Section
Elevation
400
350
300
250
200
150
100
50
0
-50
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Distance from starting point (in metres)
Halton Till (or equiv. upper till)
Oak Ridges Moraine (or equiv. upper aquifer)
Newmarket Till
Thorncliffe Fm.
Sunnybrook Drift
Scarborough Fm.
Top of Bedrock
Ground Surface
Wells

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