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resources & energy

EcoNomics™

Regional Groundwater Monitoring Network Implementation: NAOS Region

Design and Implementation

Presented by:

Jon Fennell, Ph.D., P.Geol. P.Geo.





	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Water Act												
Water for Life Strategy												
Rosenburg International Forum												
W4L Renewal												
W4L Action Plan												
GW management frameworks												
NAOS Regional Monitoring												

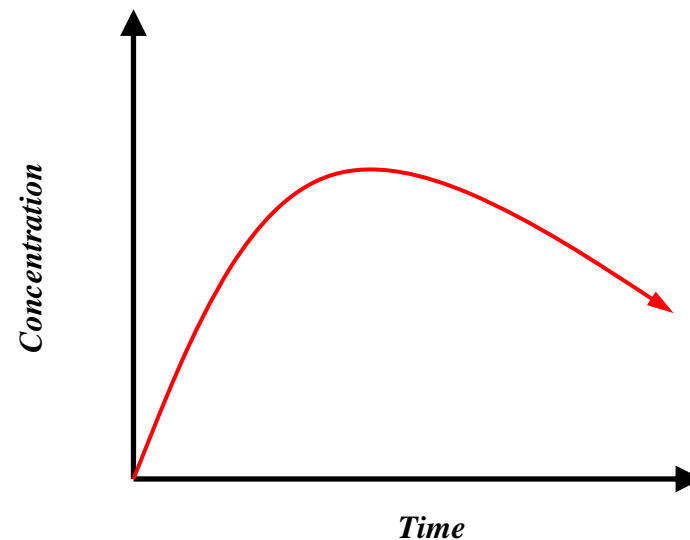


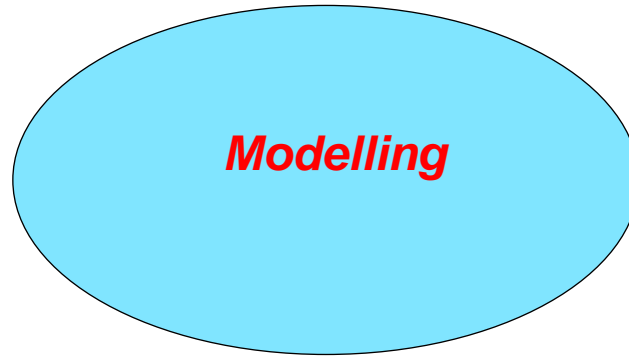
Why is this being done?

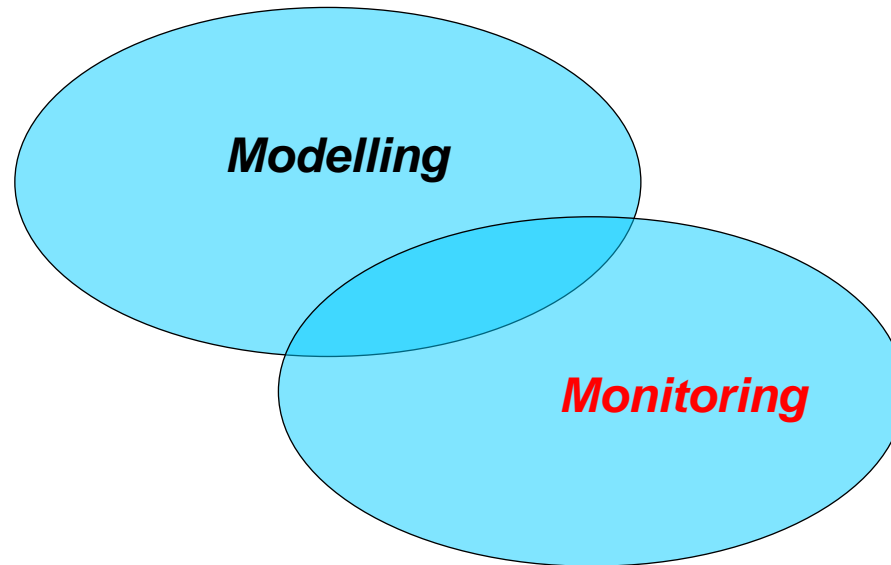
- ▶ Assess the current state of GW resources within the study area (*and address public concerns*)
- ▶ Define / refine baseline and range of natural variability
- ▶ Provide a means to detect and assess changes to GW resources from future development activities or natural events

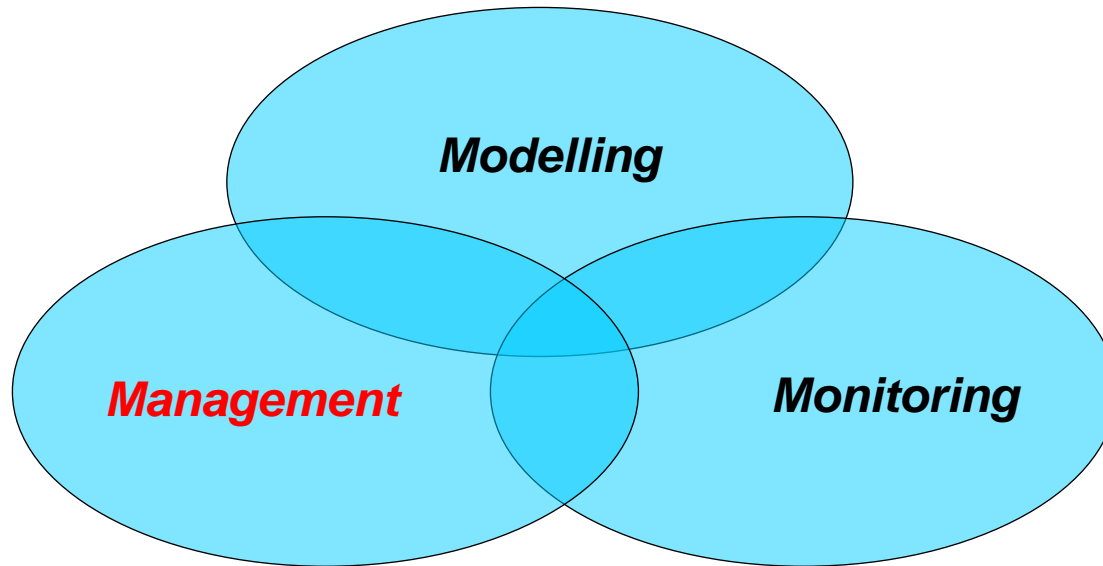


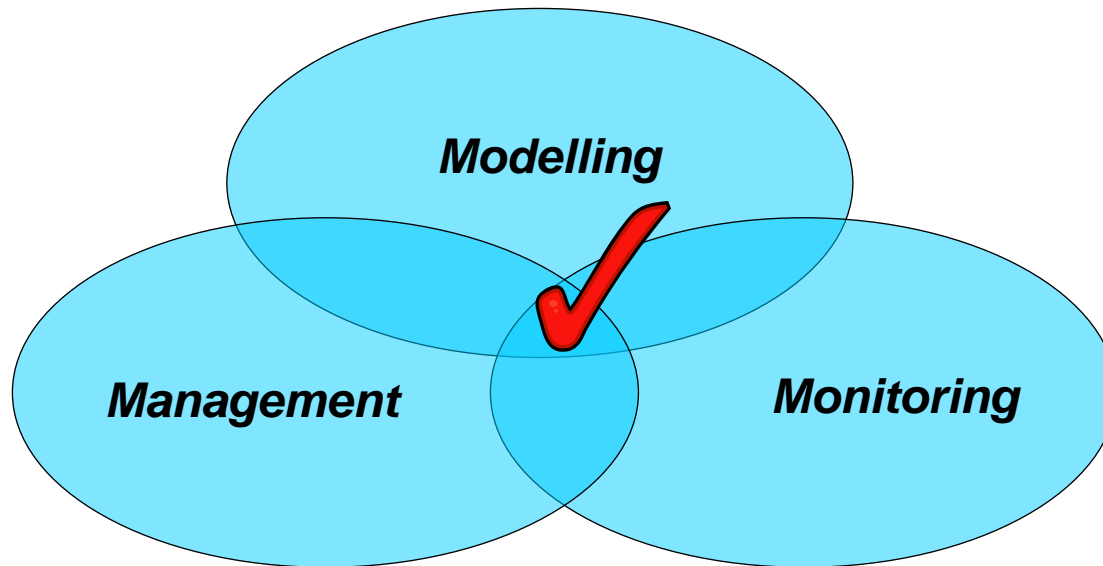
- ▶ Cumulative effects analysis (& verification of EIA results)
- ▶ Pollution prevention / avoidance
- ▶ Reversal of trends





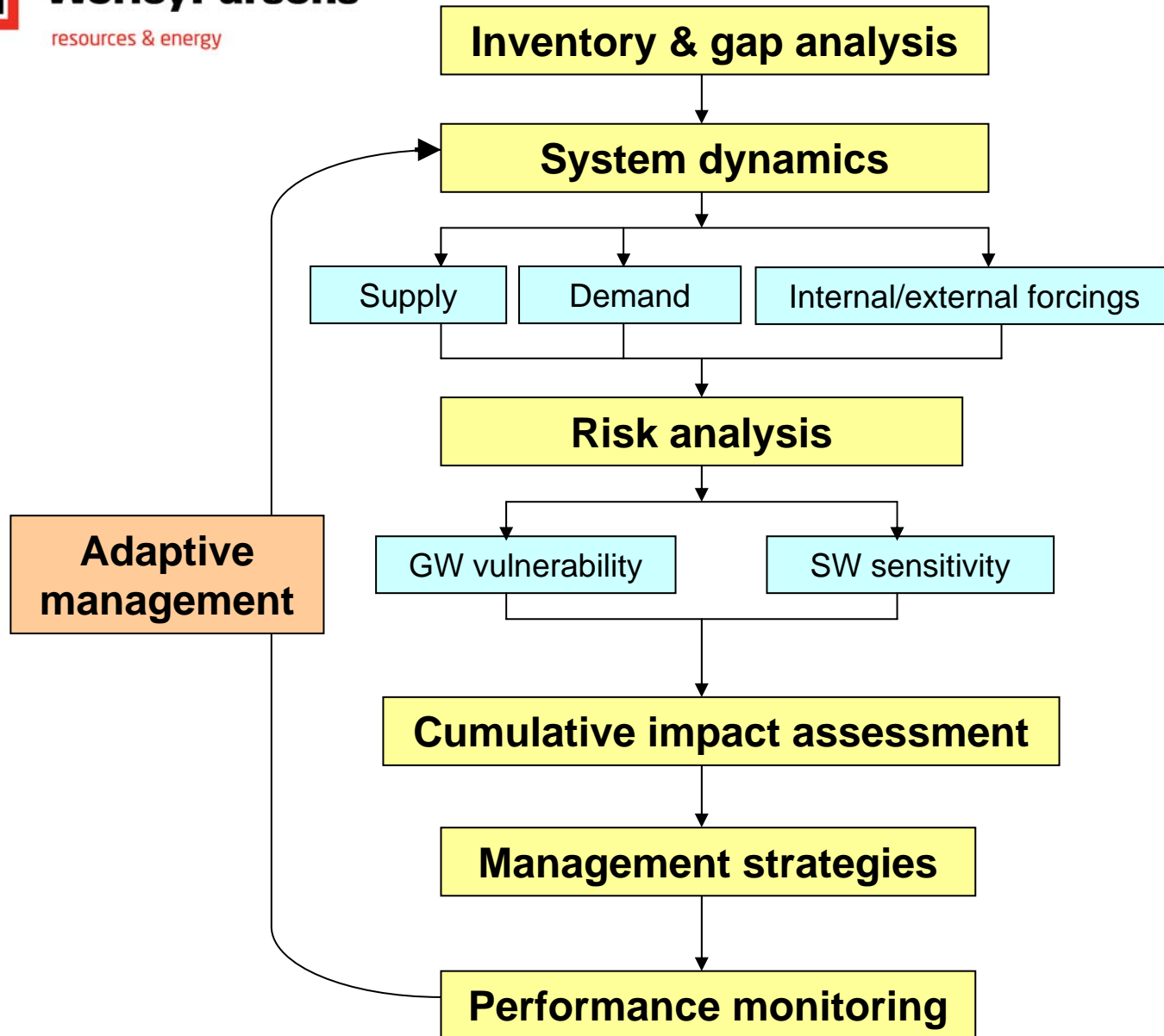








The process

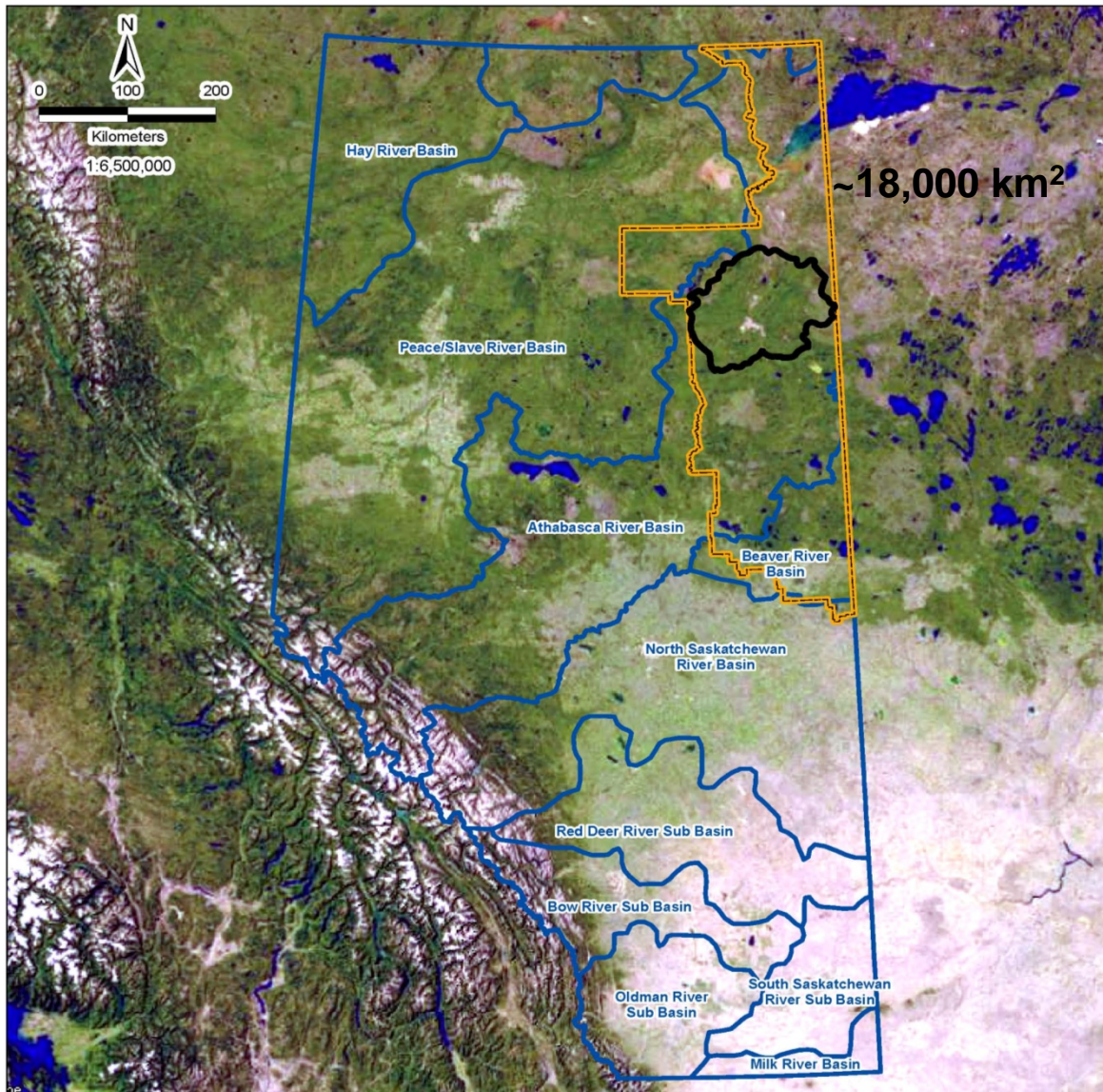




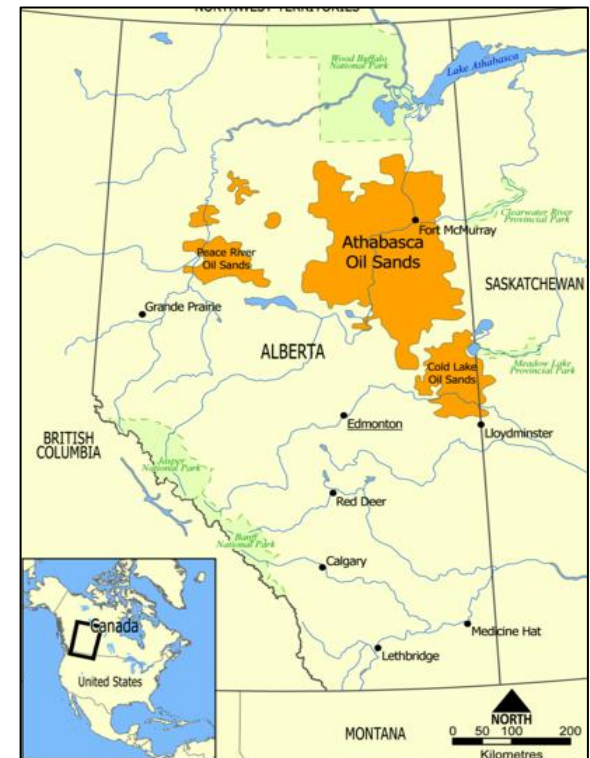
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Study area

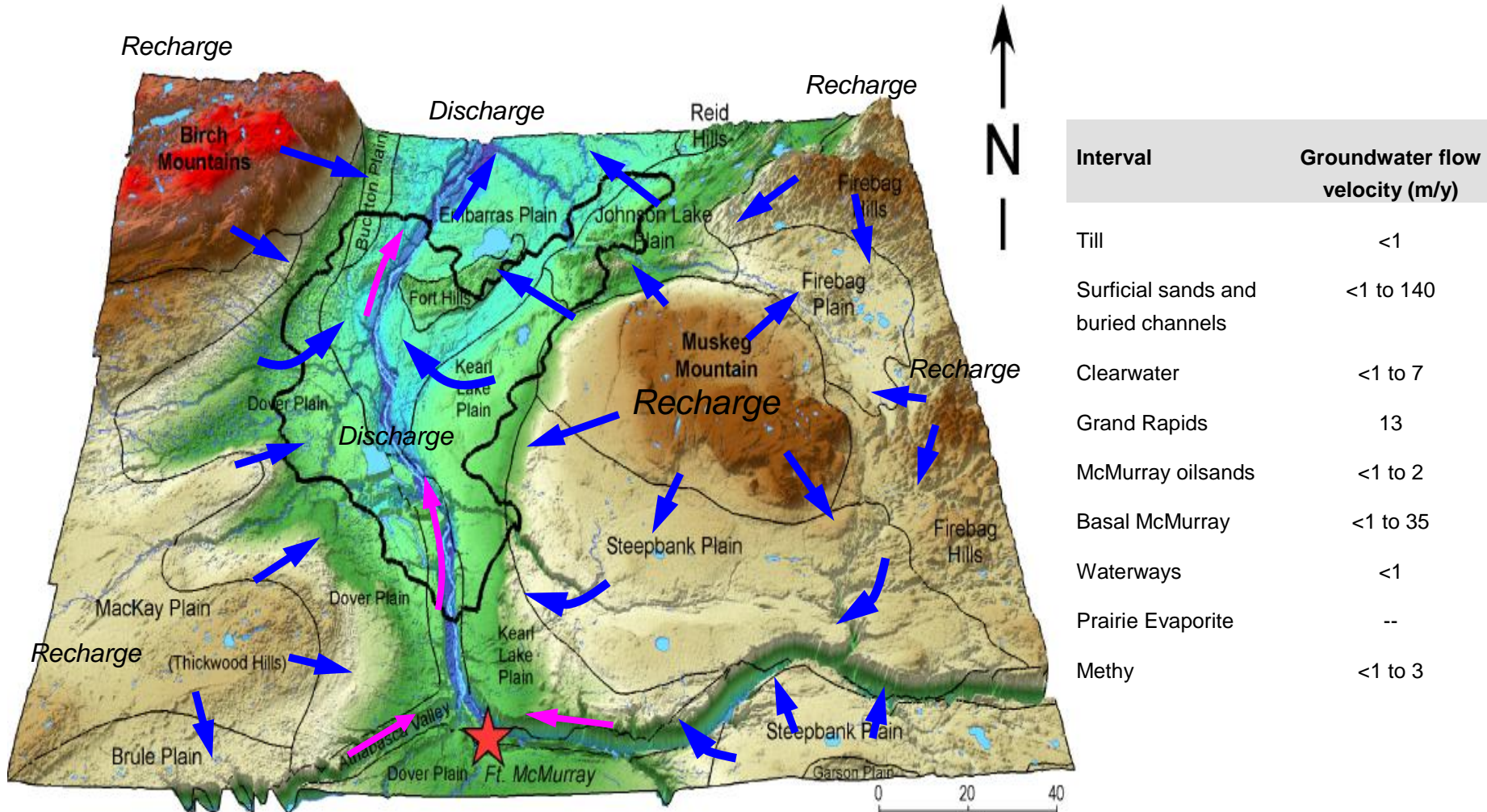


- Study Area
- Land Use Framework Planning Region: North-East
- Alberta River Basins





General Flow Patterns & Rates



Modified from Andriashek & Atkinson 2007



Natural:

- Discharge of water from saline bedrock formations (*Devonian, Basal McMurray, Wabiskaw*)
- Leaching of hydrocarbons & salts from exposed bedrock (*e.g., McMurray, Clearwater*)
- Discharge of organics & associated trace elements from muskeg waters (*e.g., NAs, DOC, trace elements*)
- Leaching of rafted oilsands & marine shale in surficial deposits



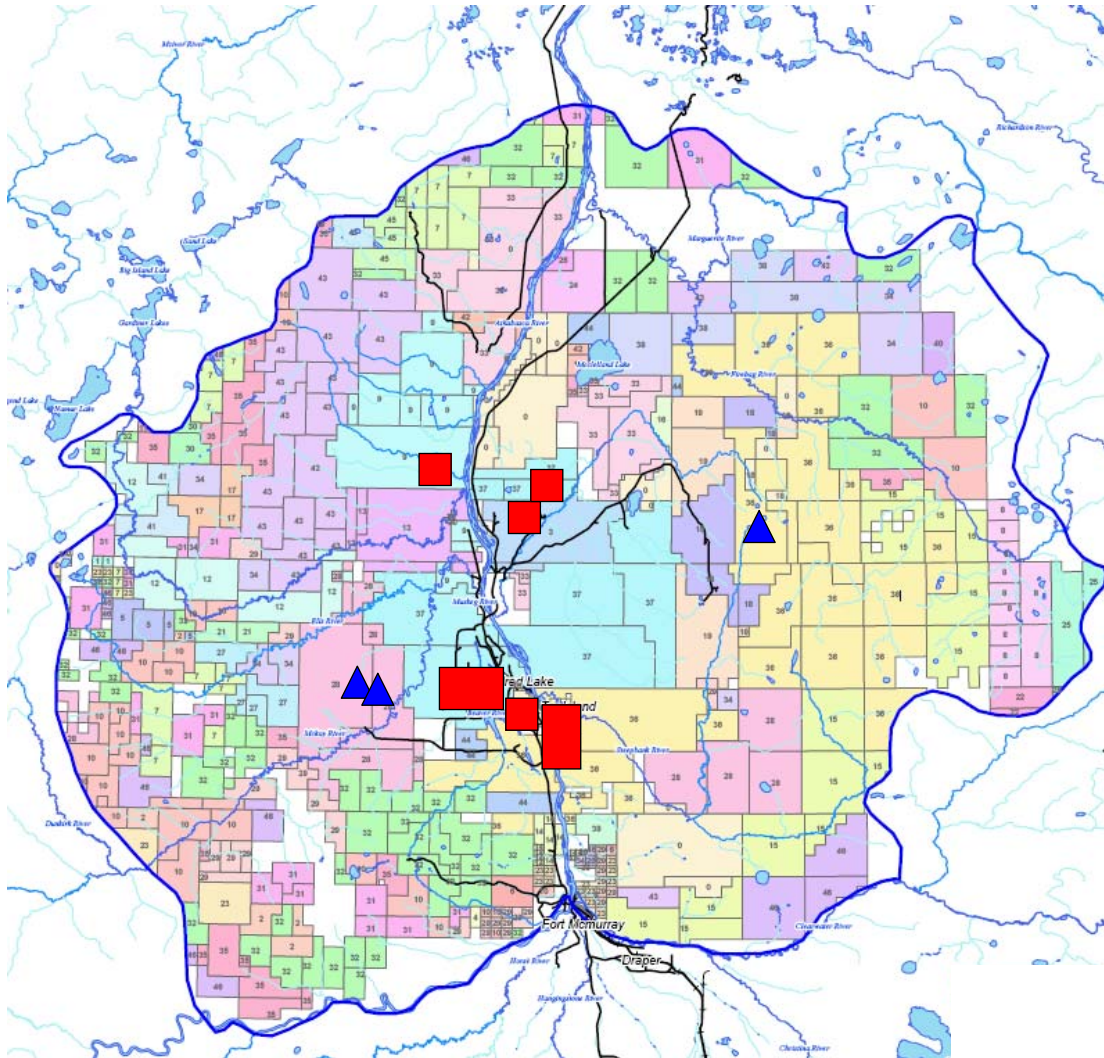
Anthropogenic:

- Seepage from mine structures (tailings ponds, pit backfill, overburden storage areas, reclamation landforms)
- Operational upsets (*very localized*)
- Effects from mine dewatering, water disposal, water use (*regional effects*)
- Heat from in-situ operations (*localized*)
- Municipal waste water & urban runoff
- Other up-stream releases (*e.g. pulp mills; agricultural runoff*)





Posted leases & active operations



Legend

STUDY AREA

Oil Sands Leases

0, UNSPECIFIED

1, 1226591AB

2, AGADIR

3, ALBIAN

4, ANTELOPE

5, BLACK RAIN

6, CALICO

7, CANADIAN COASTAL

8, CANADIAN LANDMASTERS

9, CANADIAN NATURAL

10, CAVALIER

11, CENTENNIAL

12, CHEVRON

13, DEER

14, E-T ENERGY

15, ENCANA

16, EXXONMOBIL

17, GRIZZLY

18, HUSKY

19, IMPERIAL

20, JOSLYN

21, KOCH

22, LAND GROUP

23, MAVERICK

24, MERIDIAN

25, OILSANDS

26, PAN PACIFIC

27, PARAMOUNT

28, PETRO-CANADA

29, PETROLAND

30, ROCHESTER

31, SASKATOON

32, SCOTT

33, SHELL

34, STANDARD

35, STONE

36, SUNCOR

37, SYNCRUDE

38, SYNENCO

39, TALISMAN

40, TECHNOECONOMICS

41, TOTALFINAELF

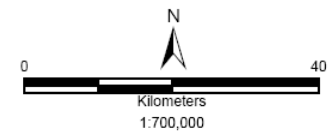
42, UTS ENERGY

43, VALUE

44, WESTERN LAND

45, WESTERN OIL

46, WINDFALL

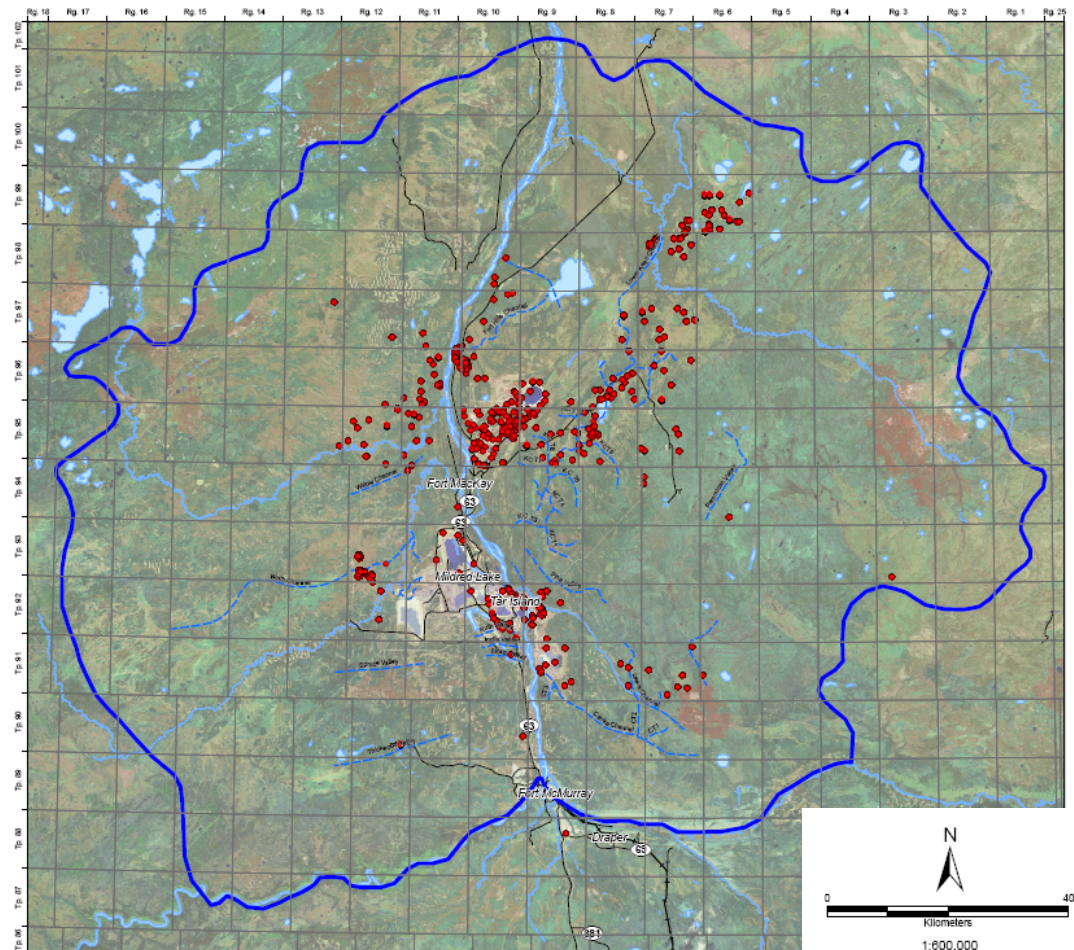


Active mine

Active in situ

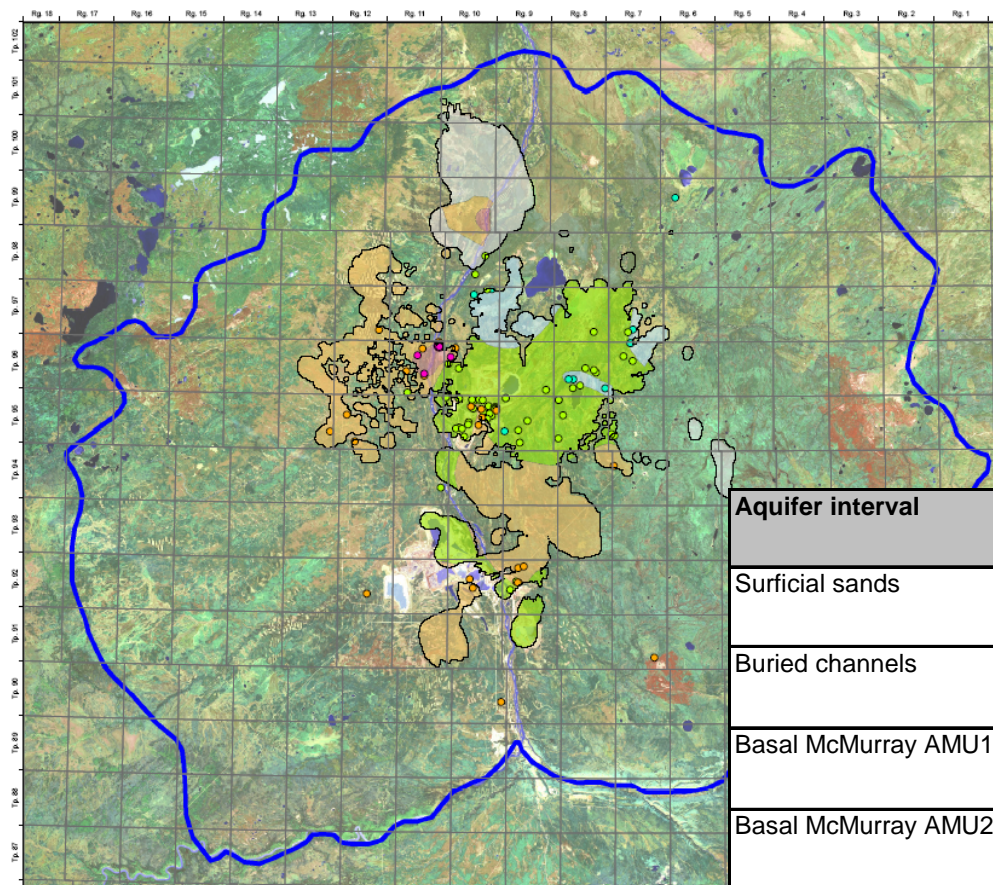


- ▶ Initial review (*initiated Summer 2007*)
- ▶ 1,478 monitoring wells reviewed (*over 132,000 data records*)
- ▶ Highly variable, baseline groundwater quality conditions identified
- ▶ Proposed locations for further long-term monitoring selected based on risk mapping





Natural variability



Legend

Study Area

Basal McMurray Formation

TDS (mg/L)

< 500
500 - 4,000
4,000 - 30,000
> 30,000

TDS (mg/L)

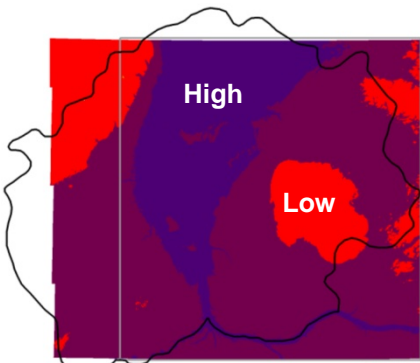
No Data
< 500
500 - 4,000
4,000 - 30,000
> 30,000

Aquifer interval	Statistics	TDS (mg/L)	NH ₃ (mg/L)	NAs (mg/L)
Surficial sands	Range	62 – 3,740	0.1 – 2.0	<1 – 7
	Count	127	53	65
Buried channels	Range	109 – 1,150	0.1 – 2.0	<1 – 9
	Count	24	8	18
Basal McMurray AMU1	Range	182 – 470	0.8	<1 – 6.3
	Count	12	1	5
Basal McMurray AMU2	Range	511 – 3,973	0.9 – 1.2	3 – 32
	Count	71	2	25
Basal McMurray AMU3	Range	4,351 – 23,300	2 – 10	12 – 24
	Count	39	7	7
Basal McMurray AMU4	Range	36500 – 278340	6 – 23	7
	Count	17	2	1
Methy Fm.	Range	614 – 337,600	--	5 – 7
	Count	13	--	2

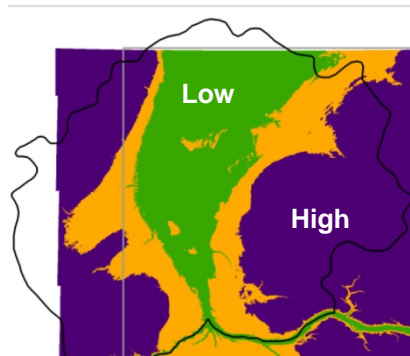


Focusing efforts (vulnerability mapping)

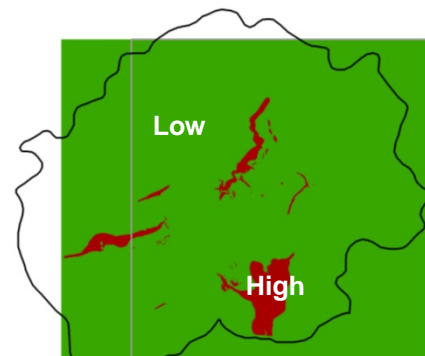
Depth to water



Recharge/ discharge



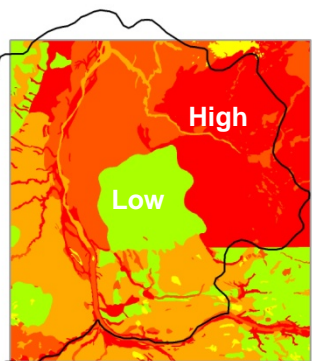
Aquifer media



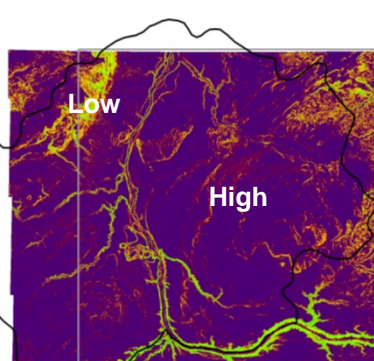
Rating

10 High
↑
1 Low

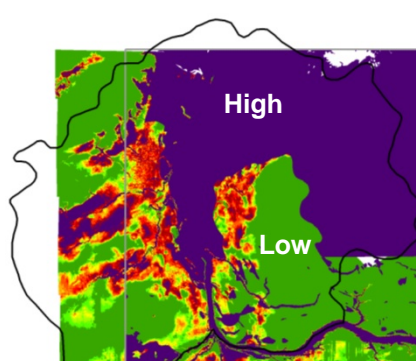
Soil type



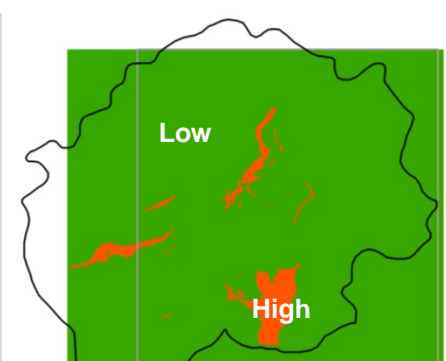
Topography
(%slope)



Infiltration potential
(overburden thickness)

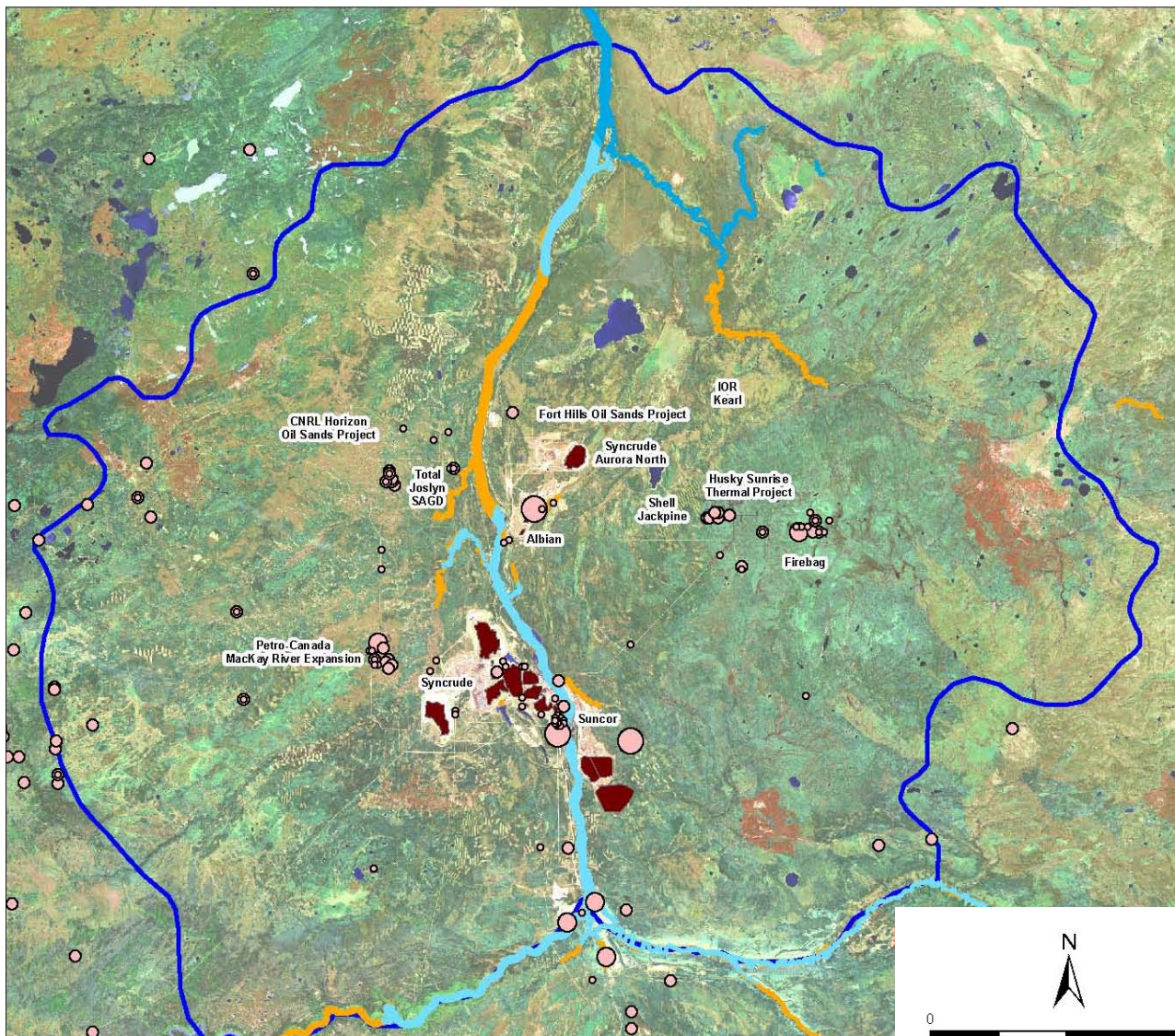


Conductivity
(hydraulic)

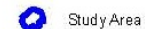




Source area identification



Legend



Study Area

Contaminant Sources

Current Risk Rating



1 - Satellite, Injections, Terminals, Gas Gathering System, Tank Farm, Line Heater, Stations: Pump, Meter, Meter Regulator, Regulator



2 - Compressor Station, Battery



3 - Waste Plants, Golf Course



4 - Gas Plants



4 - Open Mine Pit



5 - Strip/Clear, Plant Site Infrastructure



6 - Overburden/Muskeg Dump Stockpile



7 - Reclaimed area / Reclaimed material



8 - External tailings area / Out of pit tailings area



9 - Tailings pond / Tailings dump/storage



10 - Devonian McMurray



NOTE: Facility data obtained from Accumap



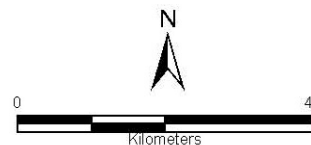
Dw - Waterways Formation



Ds - Slave Point Formation



DM - Middle Devonian

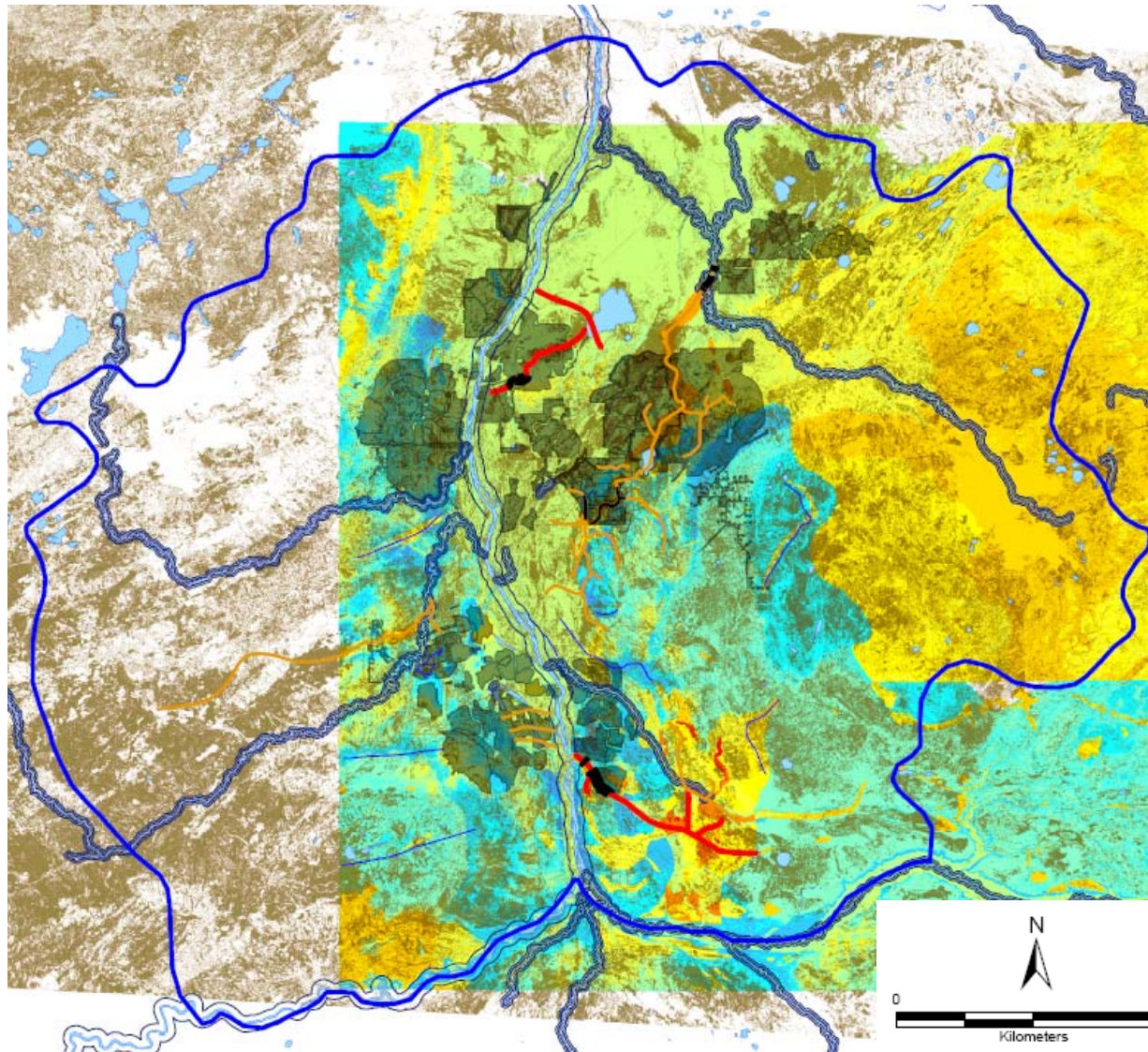




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Overall risk



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Types of Receptors

- Wetlands
- Athabasca River - Buffer 1 km
- Tributary Rivers - Buffer 500 m

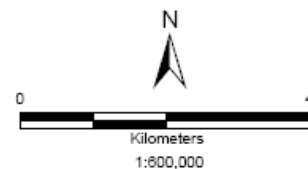
Relative Aquifer Vulnerability Rating

- 48 - 56
- 57 - 64
- 65 - 72
- 73 - 80
- 81 - 88
- 89 - 95
- 96 - 103
- 104 - 111
- 112 - 119
- 120 - 127
- 128 - 135
- 136 - 143
- 144 - 151
- 152 - 159
- 160 - 167
- 168 - 174
- 175 - 182
- 183 - 190
- 191 - 198
- 199 - 206

- Study Area
- Lakes / Rivers
- Potential Risk Based on Intrinsic Vulnerability and Level of Development
 - Low
 - Moderate
 - High
- Potential Future Development Footprint

Pathway Type Vulnerability Rating

- Low
 - Disconnected Channels
- Moderate
 - Channels Connected to Tributaries
- High
 - Channels Connected to Athabasca River





- ▶ Provide good regional coverage to establish baseline quality conditions in key aquifers
- ▶ Assess long-term quality trends
- ▶ Assess potential cumulative effects of natural and anthropogenic inputs
- ▶ Differentiate between natural versus human-influences





Groundwater Observation Well Network (GOWN)

- AENV-operated
- 16 wells actively monitored at 5 sites within the AOS region

Alberta Geological Survey Wells (AGS)

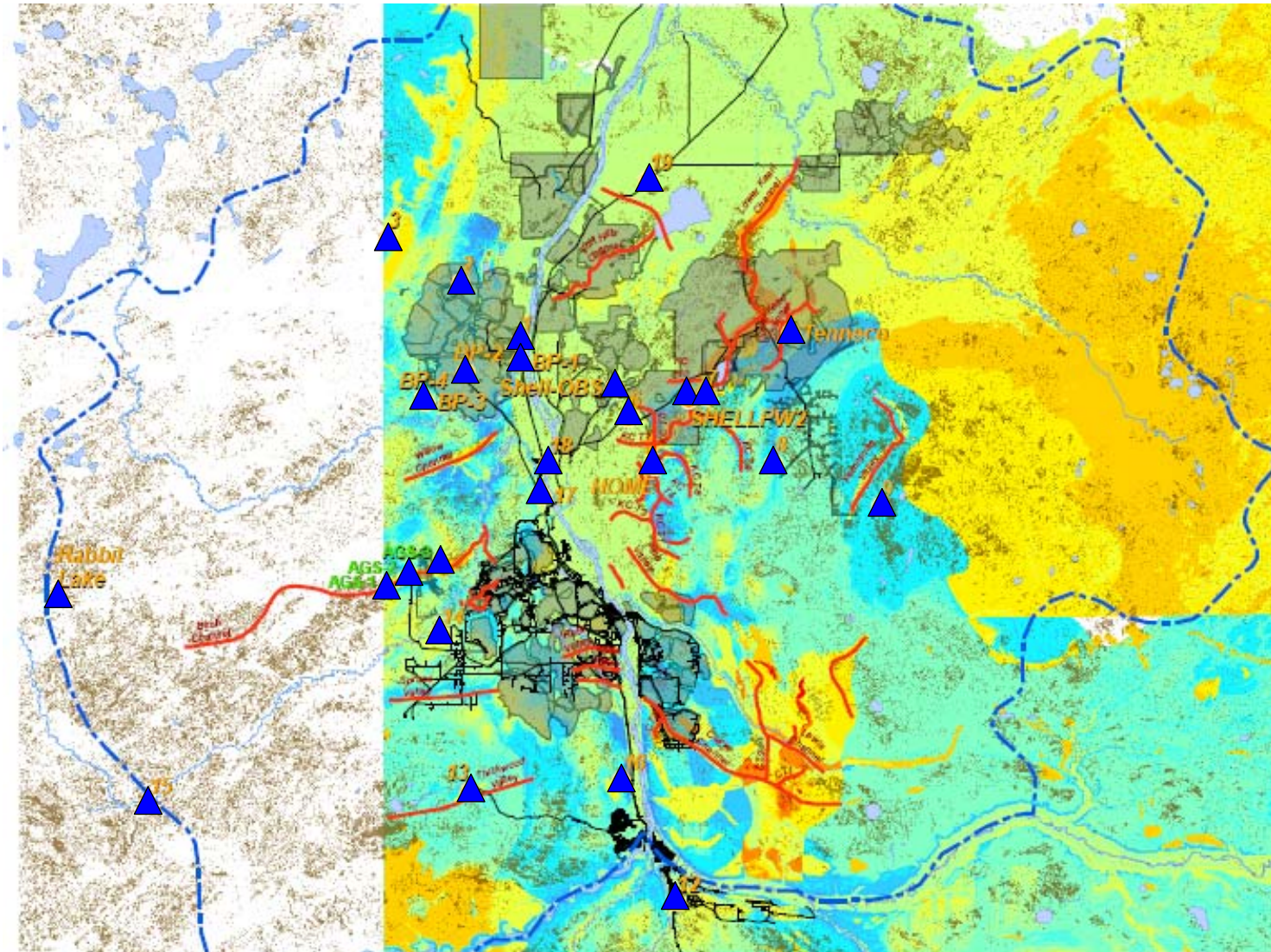
- 13 wells at 3 sites within the AOS region
- AGS ownership transferred to AENV for use in AOS network

Operator Wells:

- Approximately 9 operators within the Fort McMurray area have representatives on the AOS network
- Agreements made to have wells and/or associated data used to support network



Spatial distribution





Compilation of historical data

- ▶ Historical datasets for the GOWN, AGS and Operators monitoring wells
- ▶ Well lithology and completion details
- ▶ Temporal groundwater surface elevations
- ▶ Historical water quality results





Reconnaissance (air & on-the-ground)

- ▶ Verification of location and existence of 27 select GOWN and AGS sites throughout the project study area
- ▶ Determine potential access routes to each site
- ▶ Review of well condition & initial testing





Well prioritization

Selection based on:

- Completion interval
- Spatial distribution of wells in study area
- Accessibility of well location
- Well condition

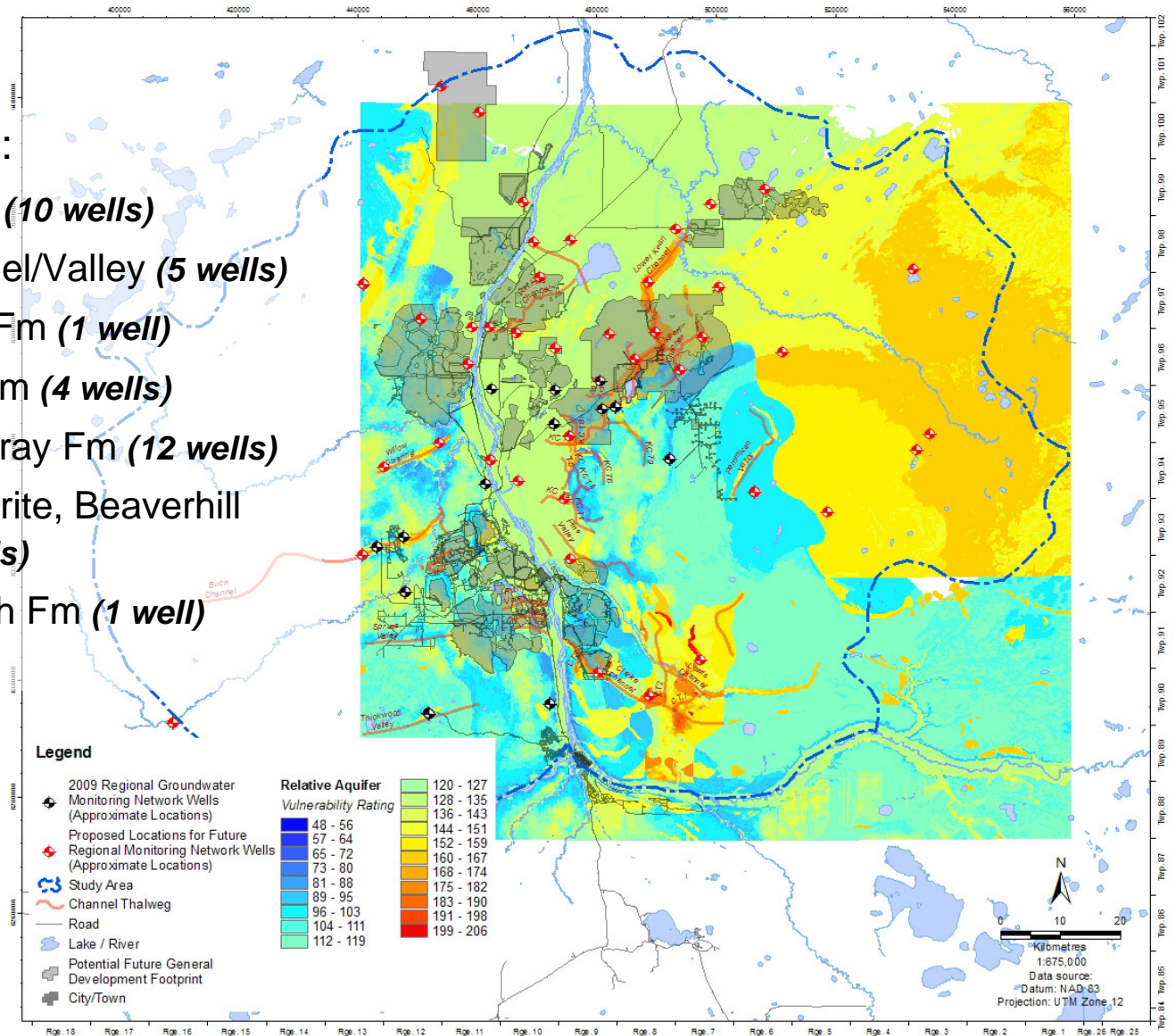




Current deployment

40 wells / 13 locations:

- SS = Surficial Sands (**10 wells**)
- BCH = Buried Channel/Valley (**5 wells**)
- GR = Grand Rapids Fm (**1 well**)
- CWR = Clearwater Fm (**4 wells**)
- BAS = Basal McMurray Fm (**12 wells**)
- PBM = Prairie Evaporite, Beaverhill Lake or Methy (**8 wells**)
- GRA = Granite Wash Fm (**1 well**)





Sampling program

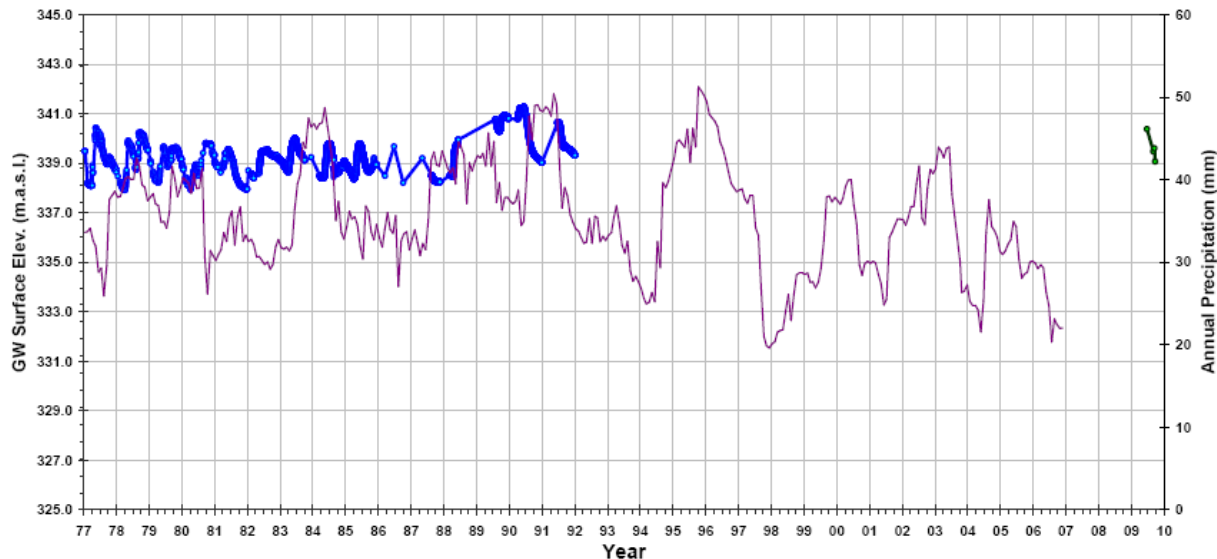
22 wells sampled for:

- Field parameters (pH, EC, temp.)
- General indicators
- Dissolved hydrocarbons and phenols
- Dissolved metals and trace elements
- Polycyclic aromatic hydrocarbons
- Stable & radiogenic isotopes





- ▶ 40 wells equipped with P transducers + data loggers
- ▶ Water levels and temperatures every 12 hrs
- ▶ Wells with historical data utilized to extend record





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Well summary sheets

GWN-06-60(BAS)

Historical ID: BAS-26

Location

Northing: 6343949 **Easting:** 472874 **Elevation (Top of PVC):** 294.56 masl
LSD: 01-18-95-09 W4M **DRS:** 840185 **AENV Record:** 233818



Access: Truck and Argo

Directions: The site can be accessed from parking lot where the Canterra Road intersects with the Muskeg River Mine access road. An argo was used from the parking lot on a gravel road and cut line to the site.



Well Details

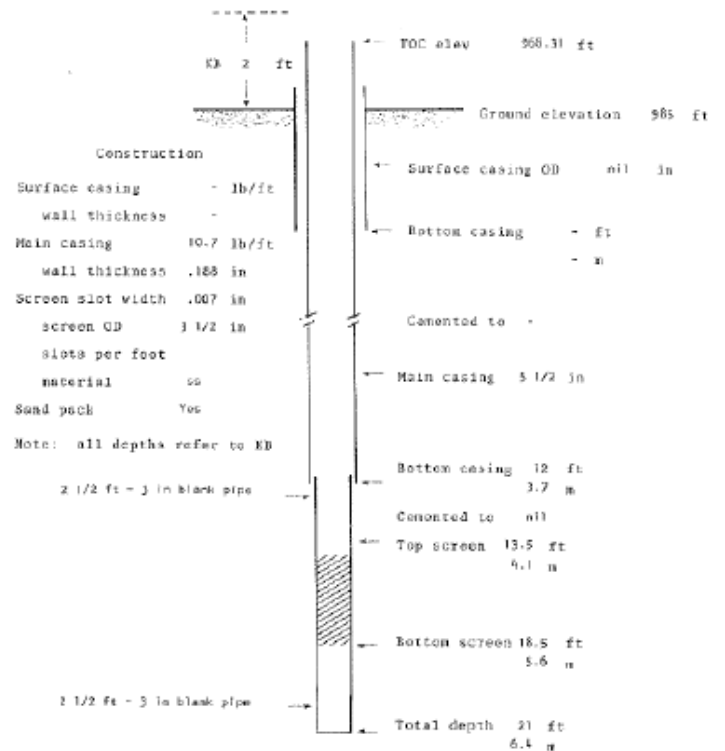
Status: Active	Damages: None	Total Depth (mbtoc): 6.4
Stick-up (m): 0.43	Well Diameter: 139 mm	Screened Interval (mbgs): 4.1 - 5.6
Transmissivity (m²/day): Unavailable	Hydraulic Conductivity (m/s): Unavailable	
Field Parameters (September 2009)		Water Level (mbtoc): 2.165
EC: 670 µS/cm	pH: 6.822	Temperature: 7.3°C
Purge Volume Calculation (L): 45.5 x (TD - WL)		Sampling Device: 1" Waterra
Datalogger: Solinst DRC	DRC Length (m): 15	Total Depth of Logger (mbtoc): 5.19

Comments: Clear, rust particles, rust odour. Well narrows at 2.99 mbtoc.

6-21-G-76

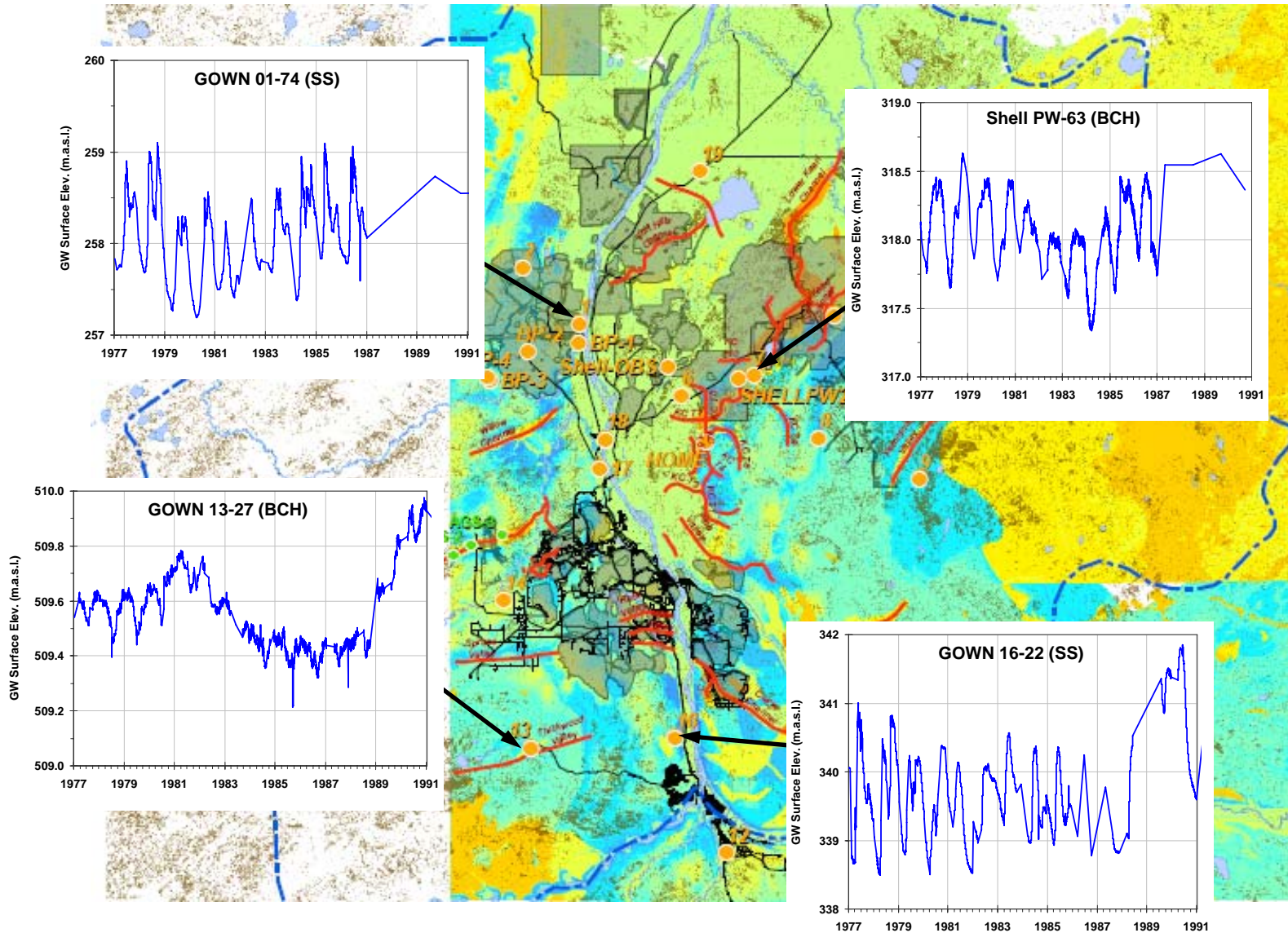
WELL CONSTRUCTION

OBSERVATION WELL NUMBER: 6-21
Lsd: 1 Sec 18 Tp 95 R 9 N4th
Alberta Research Council





Groundwater levels (Surficial deposits)

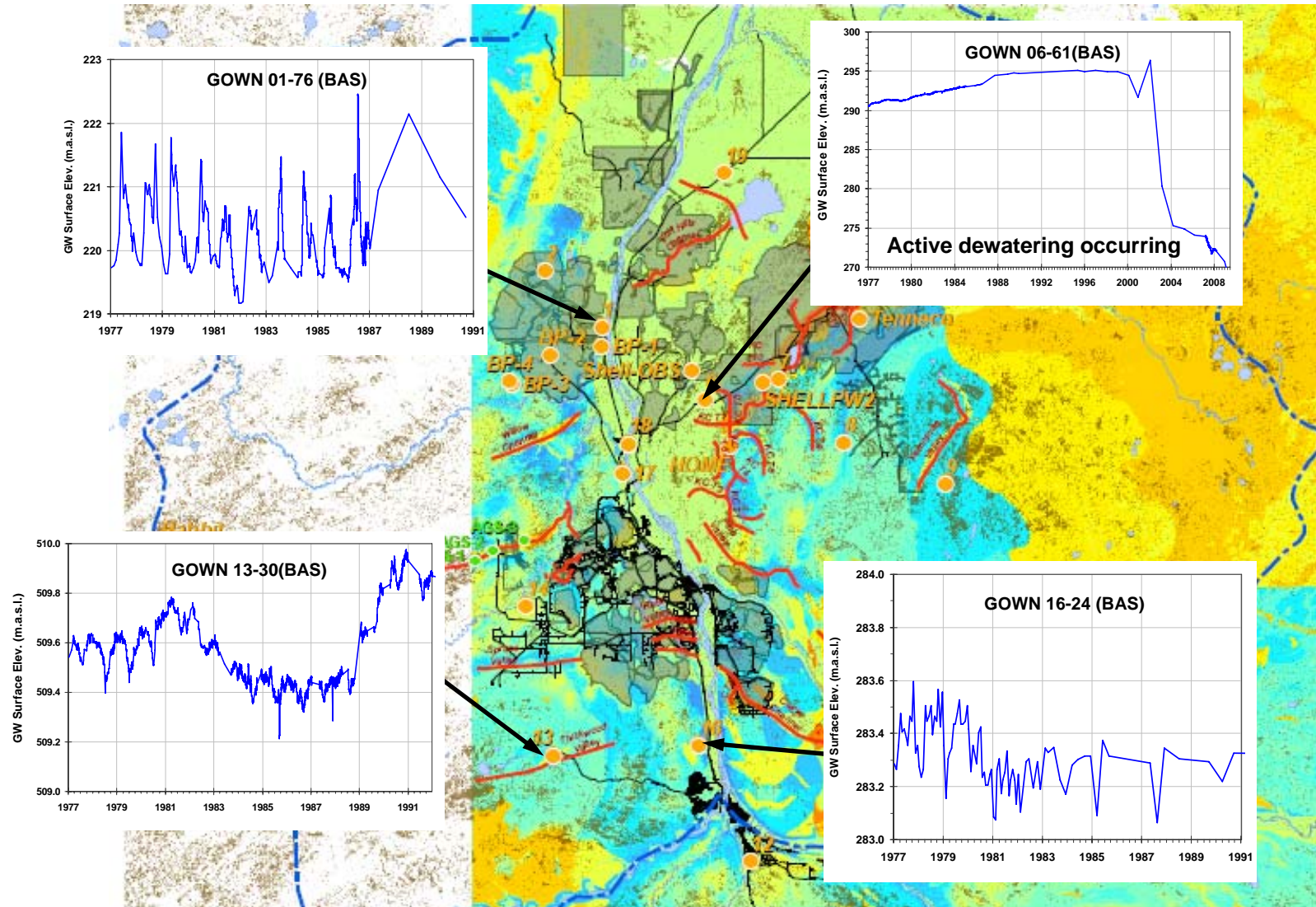




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Groundwater levels (Basal McMurray)

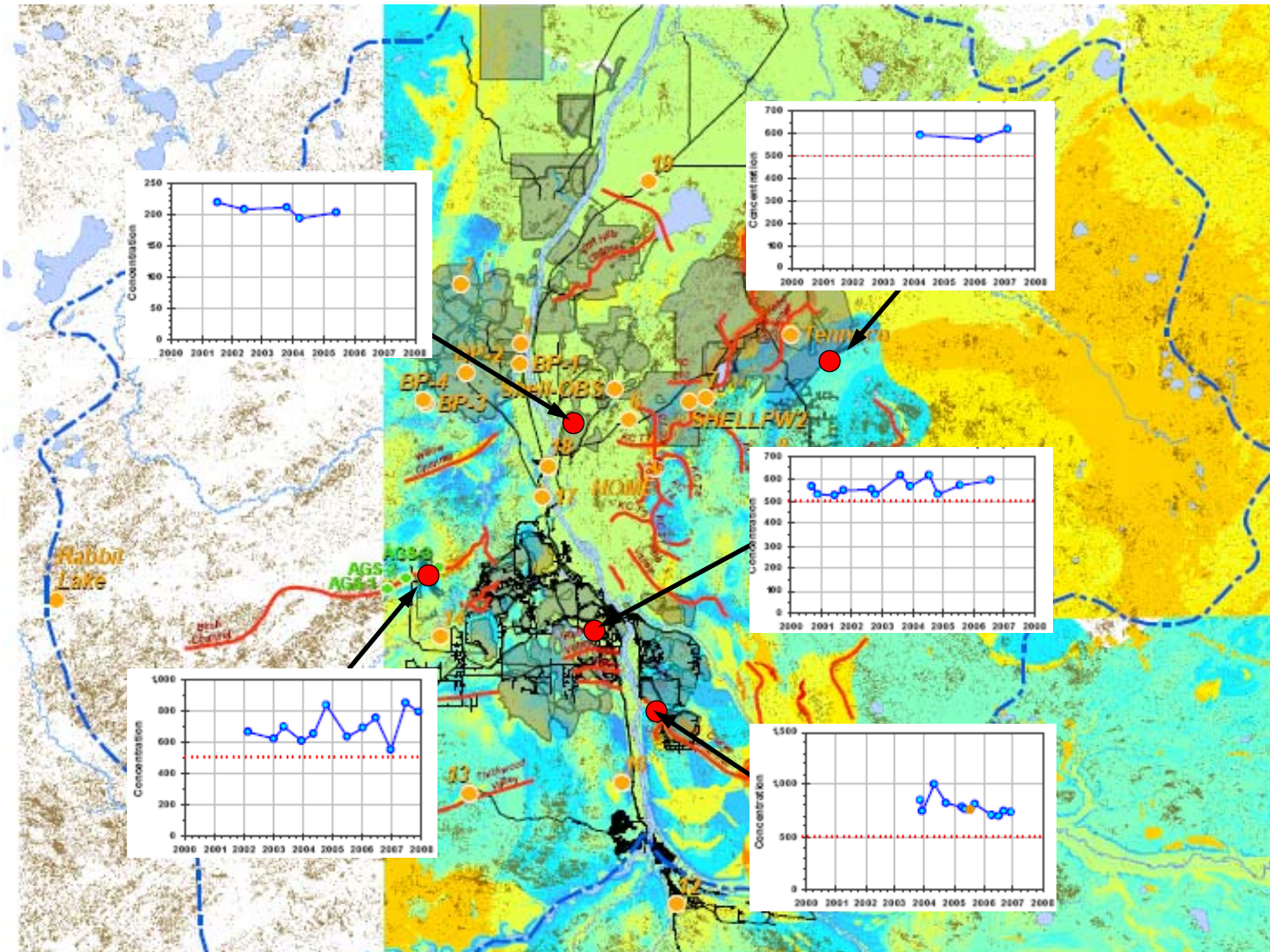




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Groundwater quality trends (TDS in surficial deposits)

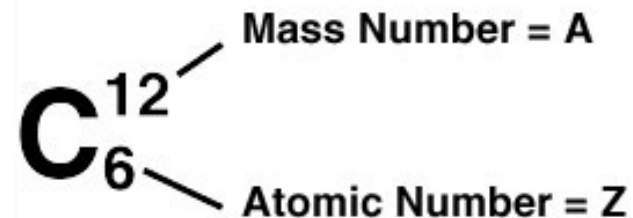
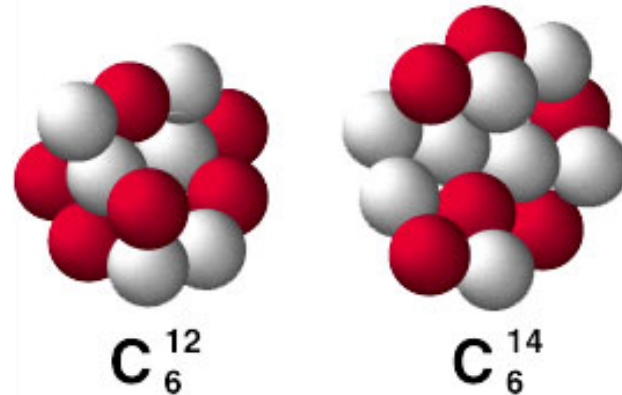




Stable & radiogenic isotopes

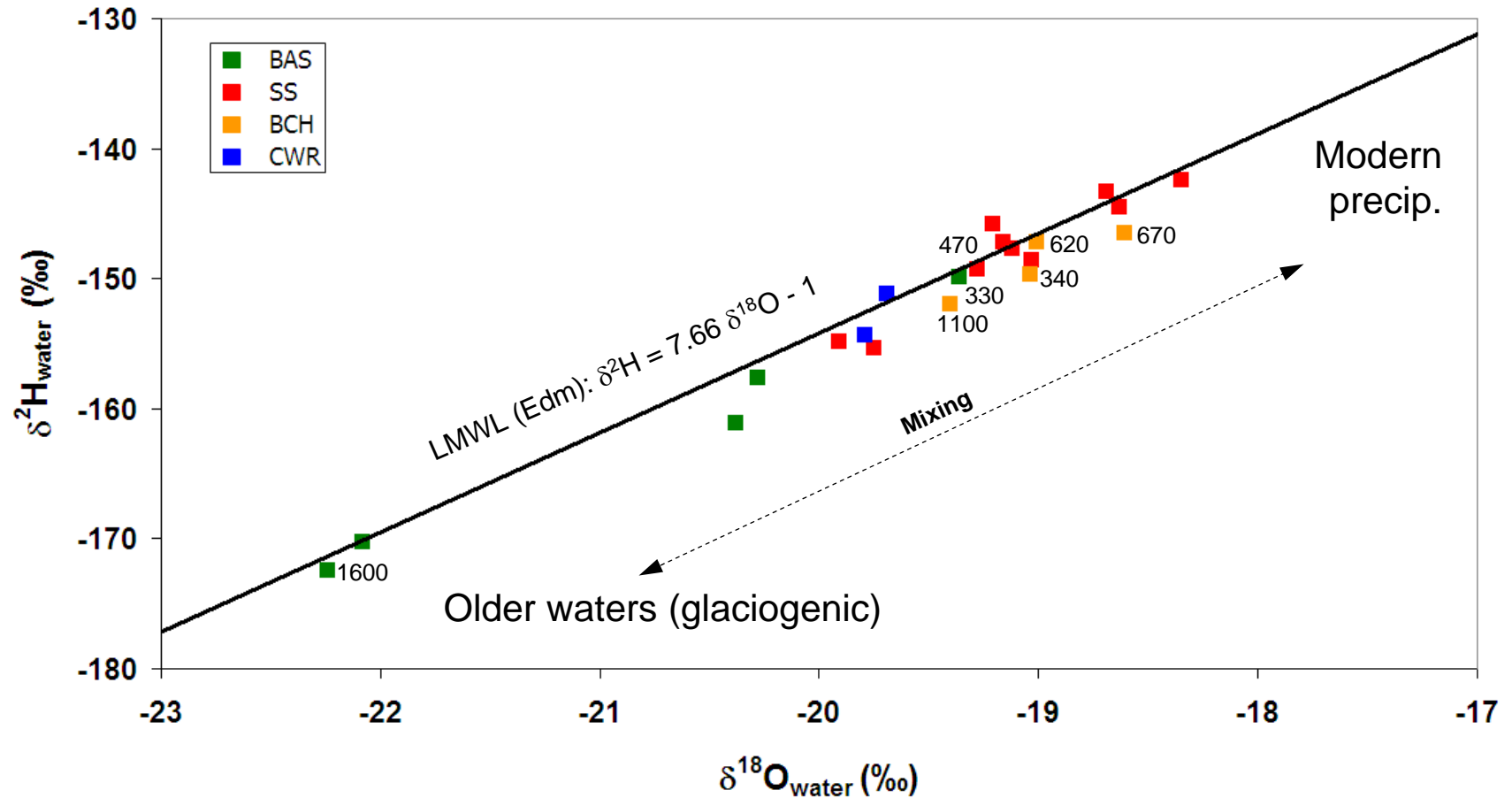
Analysed for:

- ▶ $\delta^{18}\text{O}$
- ▶ $\delta^2\text{H}$
- ▶ $\delta^{13}\text{C}$ -DIC (for age correction)
- ▶ ^{14}C activity (PMC)



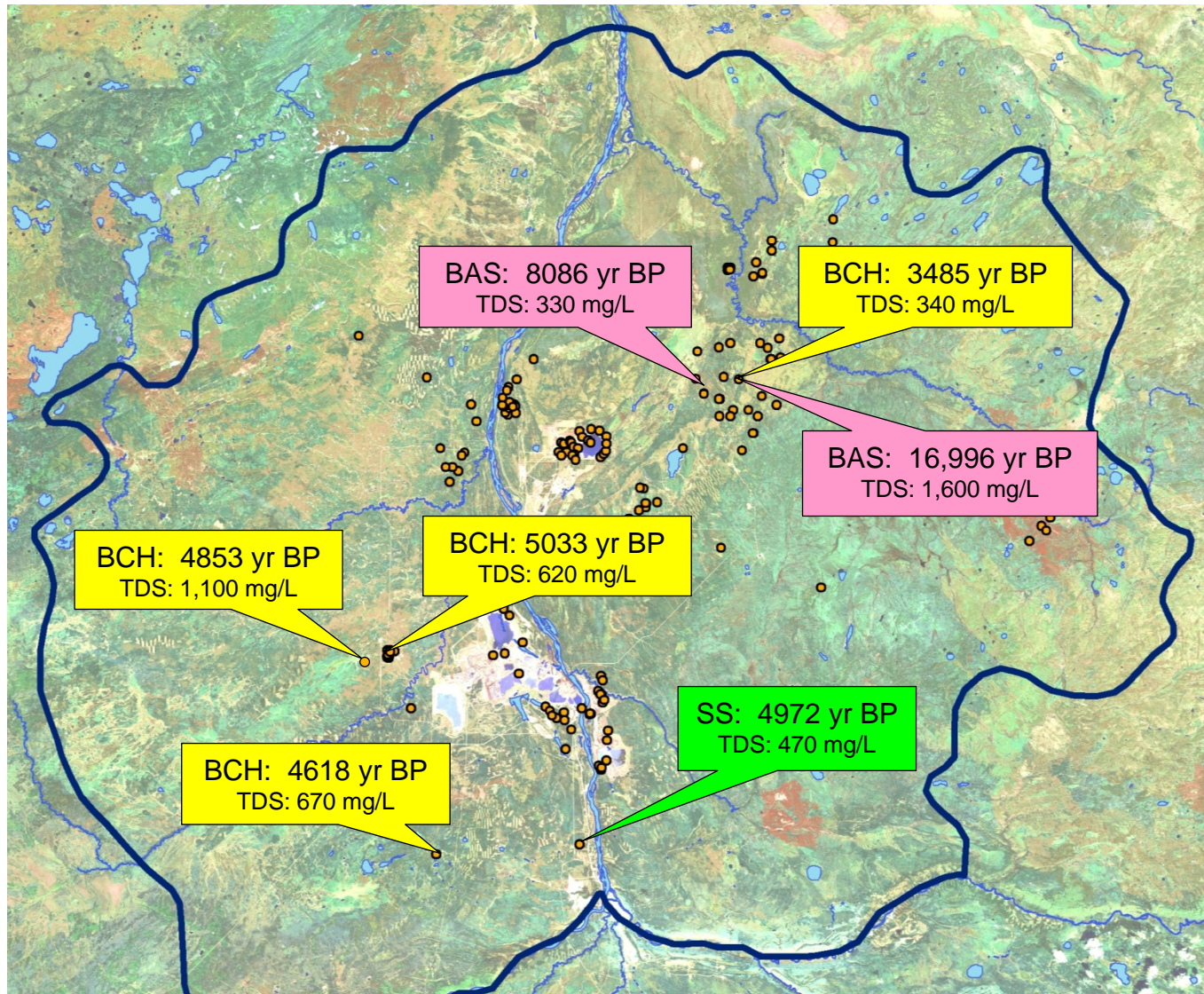


Oxygen & Deuterium



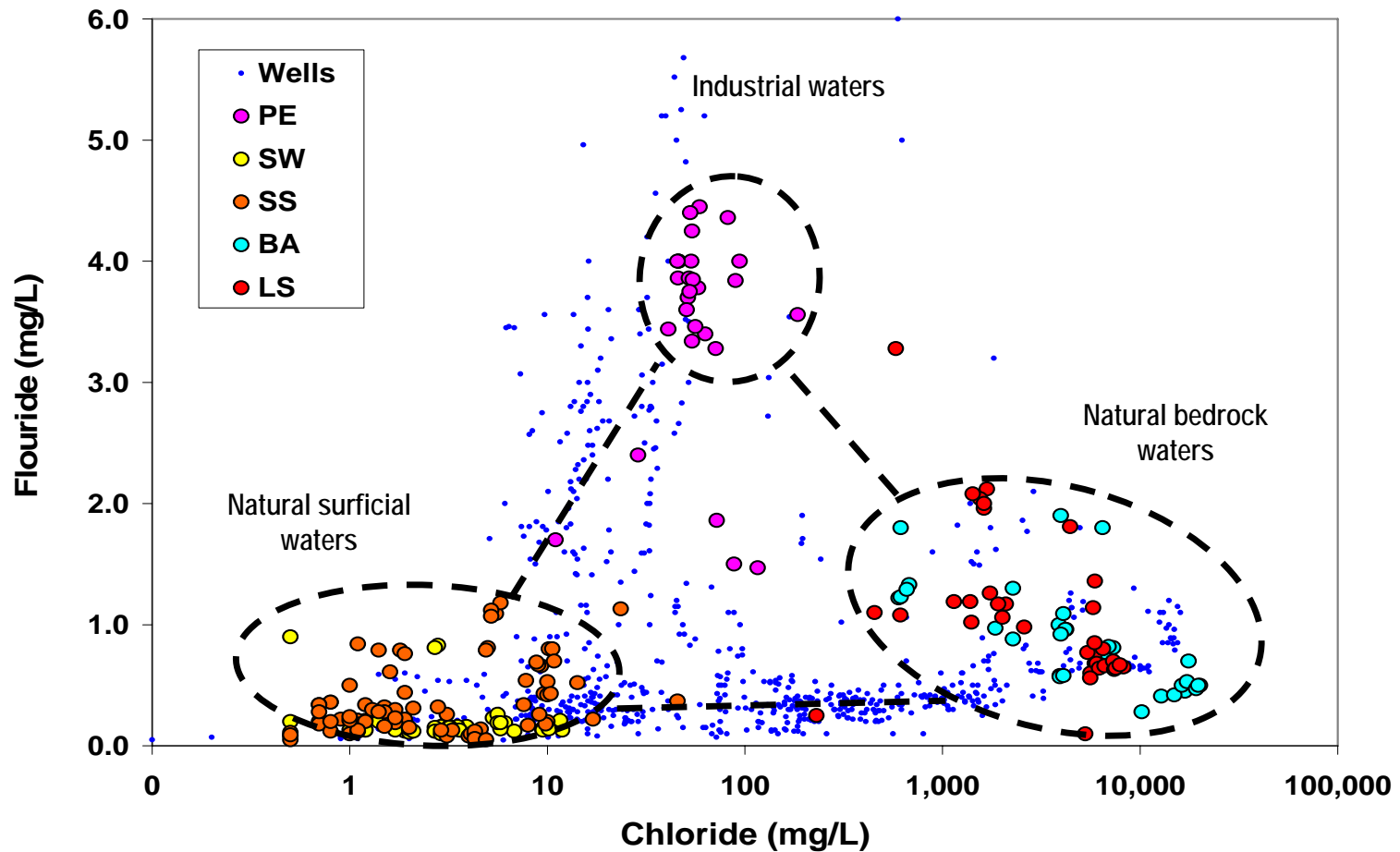


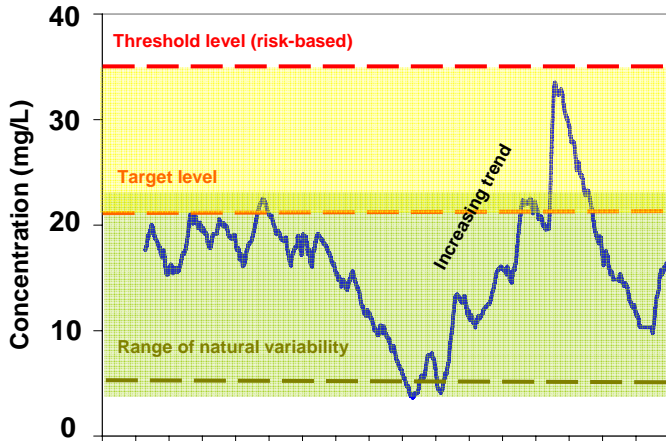
Groundwater ages

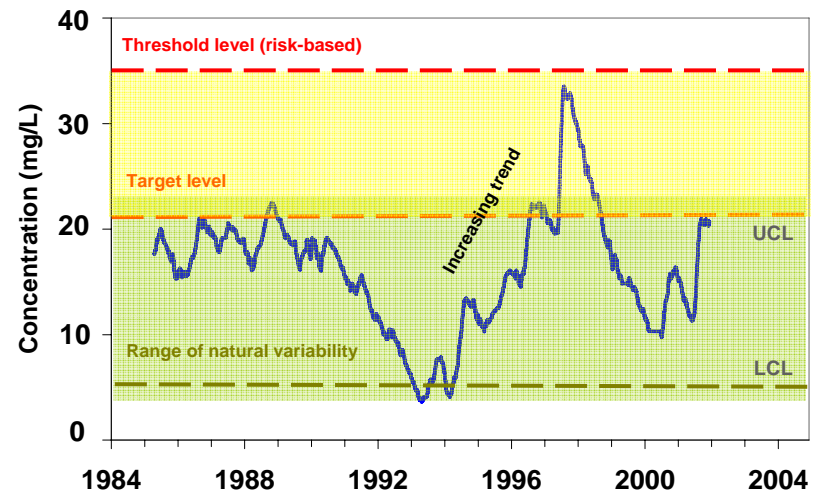




Differentiation & fingerprinting



- ▶ Continue monitoring, evaluation and reporting (2010)
 - ▶ Implement GW management framework - defined goals, targets & thresholds – (2010/11)
 - ▶ Develop GW working group to administer network & communicate results (2010/11)
 - ▶ Respond to events per the regional investigation plan (as needed)
 - ▶ Expand network to include additional locations
- 
- The graph displays groundwater concentration in mg/L on the y-axis (0 to 40) against an unlabeled x-axis representing time. A blue line shows the concentration fluctuating between approximately 5 and 25 mg/L. A red dashed line at 35 mg/L is labeled 'Threshold level (risk-based)'. A yellow dashed line at 20 mg/L is labeled 'Target level'. A green shaded area between 5 and 10 mg/L is labeled 'Range of natural variability'. An arrow points to the rising part of the blue line, labeled 'Increasing trend'.





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Thank you



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of Alberta** ■