

Integrated Assessment of Water Resources to Support Unconventional Play Development, West-Central Alberta*

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Abstract

The Integrated Assessment of Water Resources Project (IAWR) characterizes surface and subsurface water resources across broad unconventional oil and gas play fairways in west-central Alberta, and provides a basis for future, more detailed characterization projects addressing specific unconventional developments. Technical work is being performed by independent consulting groups, while project governance and financial support is provided by a consortium of oil and gas producers under the umbrellas of PTAC (Petroleum Technology Alliance of Canada) and CAPP (Canadian Association of Petroleum Producers). Several shale and tight sandstone and carbonate reservoirs are now being developed in the heart of the Western Canada Sedimentary Basin using horizontal wells and multistage completions. Devonian Swan Hills carbonates and Duvernay shales, Triassic Montney siltstones, and Cretaceous Cardium sandstones are the best-known and most widespread plays. While drilling and completions methodologies vary by play and are still being optimized in many cases, there is a clear need for large source water volumes and secure water disposal zones to support these operations. A revised regulatory framework being put into place by the Alberta Energy Regulator demands that operators plan their development operations, including water sourcing and disposal, on a play-wide basis, and in collaboration with other operators where possible. It is important, therefore, that operators have regional knowledge of water resources, and the ability to interact readily with nearby competitors. In response to these needs, the IAWR Project has been designed to assess water resources at surface, in surficial sediments and shallow non-saline aquifers, and in deep saline aquifers. Initial work focused on data collection, cataloguing, and display in an integrated GIS-driven website. As the project reaches completion, more detailed modeling and analytical / predictive work is being completed. Collaboration with the Regulator ensures that Project work can be used directly in regulatory applications. Ultimately, Project results will be made public so that all concerned stakeholders can gain a common understanding of the best technical solutions for use of both non-saline and saline water resources. The IAWR Project is an excellent example of the collaborative work that the industry needs to undertake in order to demonstrate environmental sensitivity in developing unconventional resources.

Reference Cited

Lyster, S., and L.D. Andriashek, 2012, Geostatistical Rendering of the Architecture of Hydrostratigraphic Units within the Paskapoo Formation, Central Alberta: Energy Resources Conservation Board, Alberta Geological Survey, Bulletin 66, 115 p.

INTEGRATED ASSESSMENT OF WATER RESOURCES TO SUPPORT UNCONVENTIONAL PLAY DEVELOPMENT, WEST-CENTRAL ALBERTA

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INTEGRATED
WATER
RESOURCES

Water Resources for Unconventional Oil and Gas Plays in Western Canada

- Western Canada is becoming one of the world's leading provinces for development of unconventional oil and gas reservoirs
 - Significant water demands for hydraulic fracturing and waterfloods
 - Flowback and produced waters require safe disposal
- Surface water supplies are limited
 - Limited precipitation, depleting water reserves in montane glaciers
- Many competing water demands
 - Domestic and agricultural
 - Industrial – power plants, pulp and paper
 - Conventional oil and gas, oil sands development
- Society is concerned that water use associated with unconventional hydrocarbon development could impact clean water supplies

Unconventional Reservoirs – West-central Alberta

- **Duvernay**
 - Widespread, organic-rich shale with broad liquids-rich gas fairway
 - Intensive (and expensive) exploration and appraisal since 2009
- **Montney**
 - Deep Basin gas, liquids-rich gas, and locally oil
- **Swan Hills**
 - Tight carbonate reservoir facies flanking conventional reefal oil pools
- **Cardium**
 - Tight sandstones in broad oil-prone fairway
 - Within existing pools, halo/fringe plays, broad tight sand sheets
 - Water sources to support large waterfloods also required

Water Resources – Regulatory Framework

- Existing regulatory framework governing water usage by the petroleum industry was designed for conventional hydrocarbon development
 - **Not adequate** to address the larger water source and disposal needs of unconventional development
- Alberta Energy Regulator has recognized the need to create an Unconventional Regulatory Framework (URF)
 - Regional, play-based water use planning – instead of single-well approvals
 - Must build upon a comprehensive regional knowledge of water resources

Integrated Assessment of Water Resources (IAWR) for Unconventional Oil & Gas Plays, West-Central Alberta

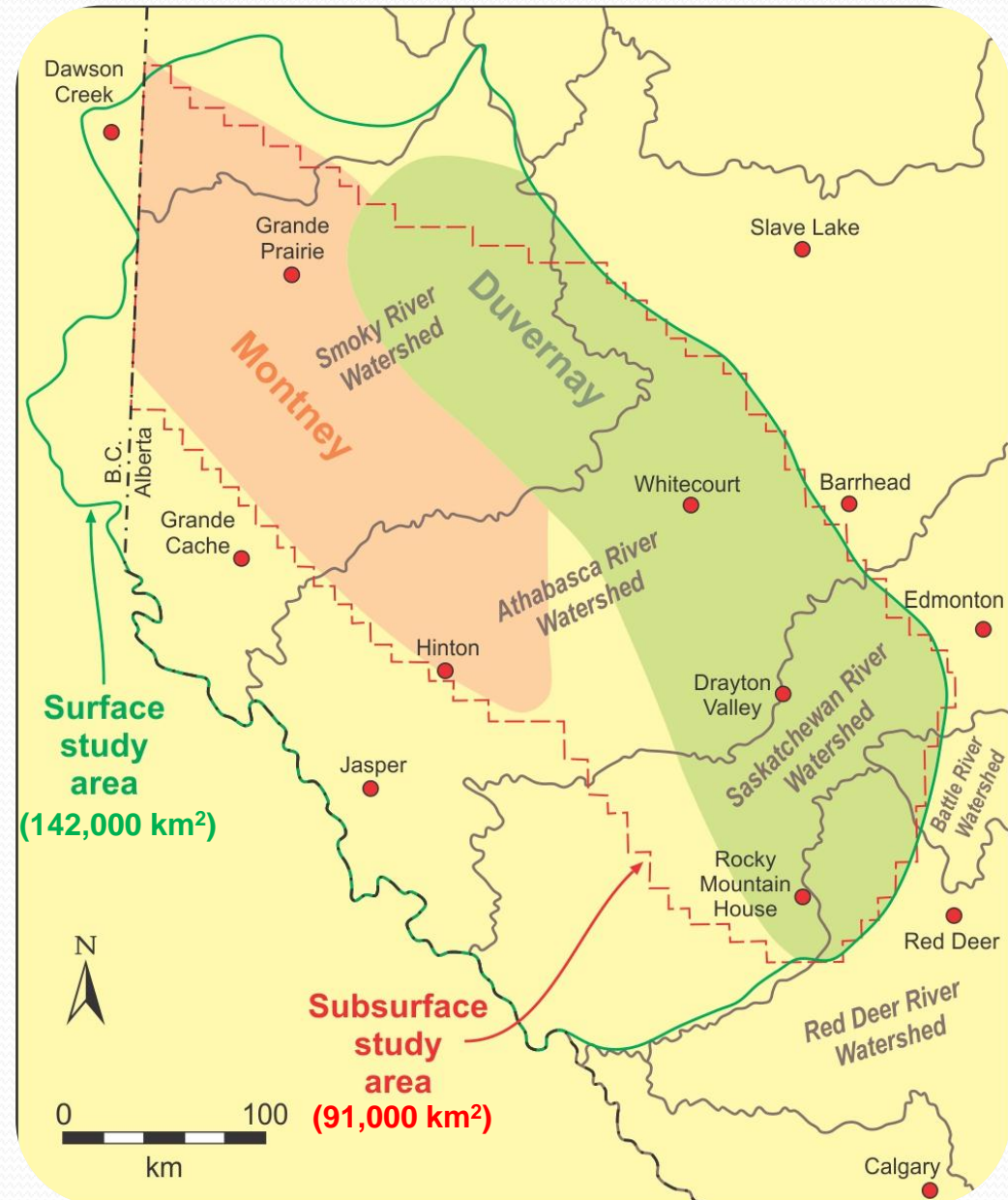
- A systematic assessment of all water resources to support best decisions on water sourcing and disposal by unconventional hydrocarbon operators
 - Surface waters
 - Shallow non-saline aquifers in unconsolidated sediments and shallow bedrock
 - Deep saline aquifers
- Project sponsors:
 - Petroleum Technology Alliance Council (PTAC)
 - 10 operating companies in 2014
 - Alberta government agencies – AESRD and AER – providing technical data and logistical / regulatory guidance

Models for the IAWR Project

- Horn River Basin Deep Saline Aquifer Assessment Project
 - Geoscience BC, Horn River Basin Producers Group (2008-2010)
- Montney Water Project
 - Geoscience BC, Montney producers (2010-2011)
- Liard Basin Deep Saline Aquifer Assessment
 - Geoscience BC, Liard exploration companies (2014)
- Central Mackenzie Valley and Deh Cho Territory Deep Saline Aquifer Characterization Projects
 - Northwest Territories Geoscience Office (2012-2013)
- Northeast Water Tool (NEWT) Development
 - B.C. Oil & Gas Commission (2011)

Study Area

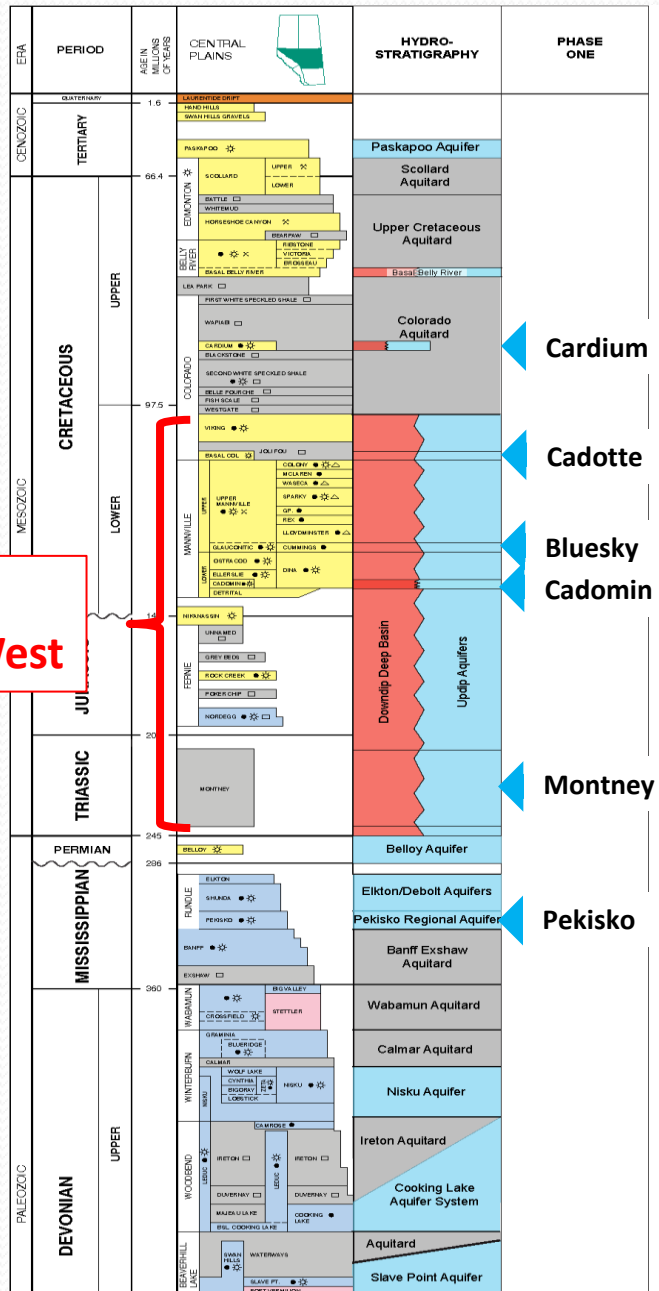
- Built around outlines of Montney and Duvernay unconventional play fairways
- Includes other unconventional fairways such as Cardium and Swan Hills
- Surface study area includes headwaters of watersheds



Integrated Assessment of Water Resources for Unconventional Oil & Gas Plays, West-Central Alberta

- **Component 1: Deep saline aquifers**
- Component 2: Shallow non-saline aquifers
- Component 3: Surface waters

Deep Saline Aquifers Regional Hydrostratigraphy



Deep Basin
Regime in West

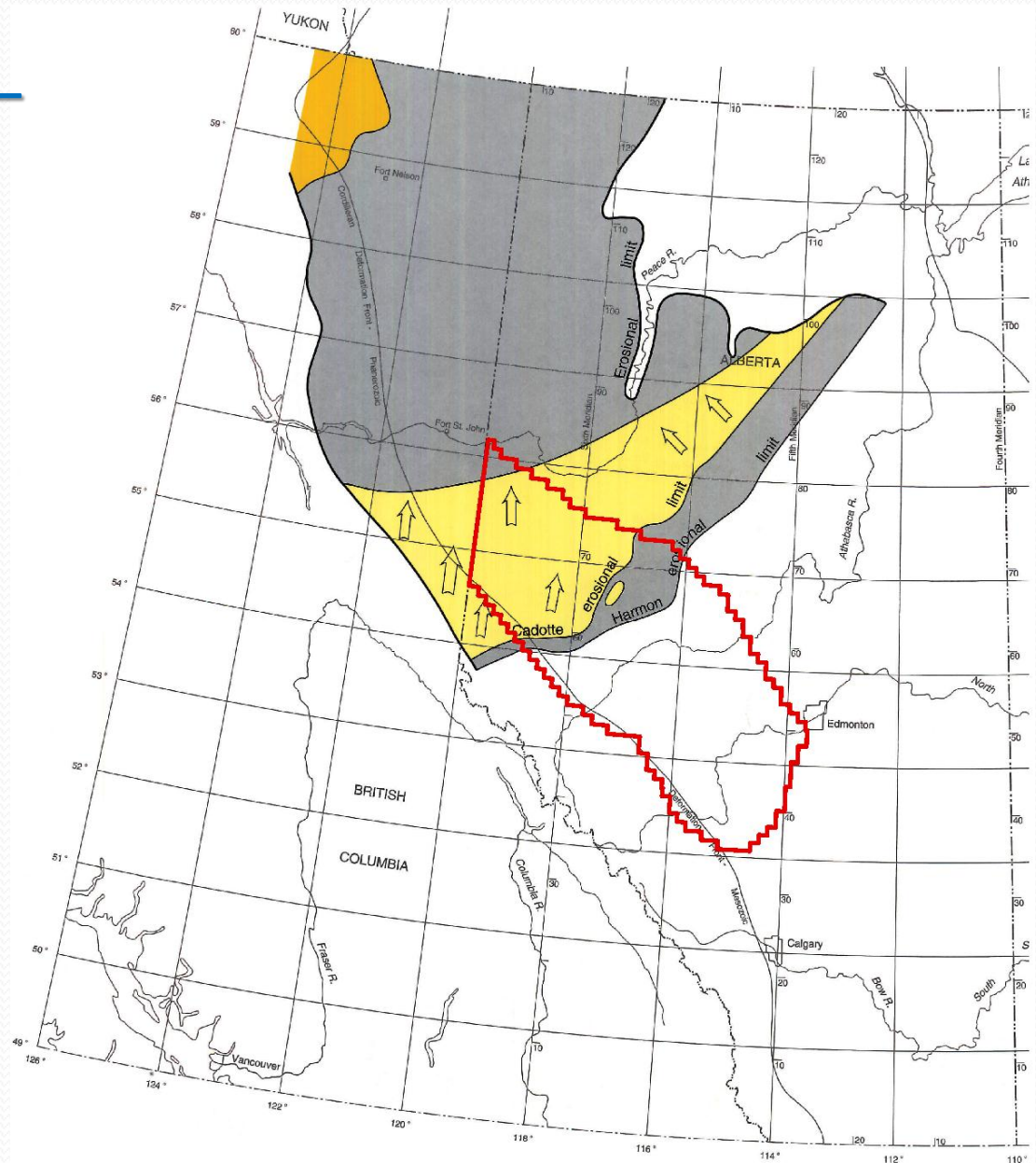
Deep Saline Aquifers

Deep Saline Aquifers – Characterization Process

- Characterize reservoir distribution and quality
 - Create stratigraphic database
 - Integrate lithological / reservoir quality information – cores, sample cuttings, logs
 - Map reservoir unit – gross thickness, net porous reservoir
- Hydrogeological analysis
 - Characterize fluid distributions and hydrogeological regimes using test and pressure data
 - Map and assess water chemistry / quality
 - Analyze water production and injection performance

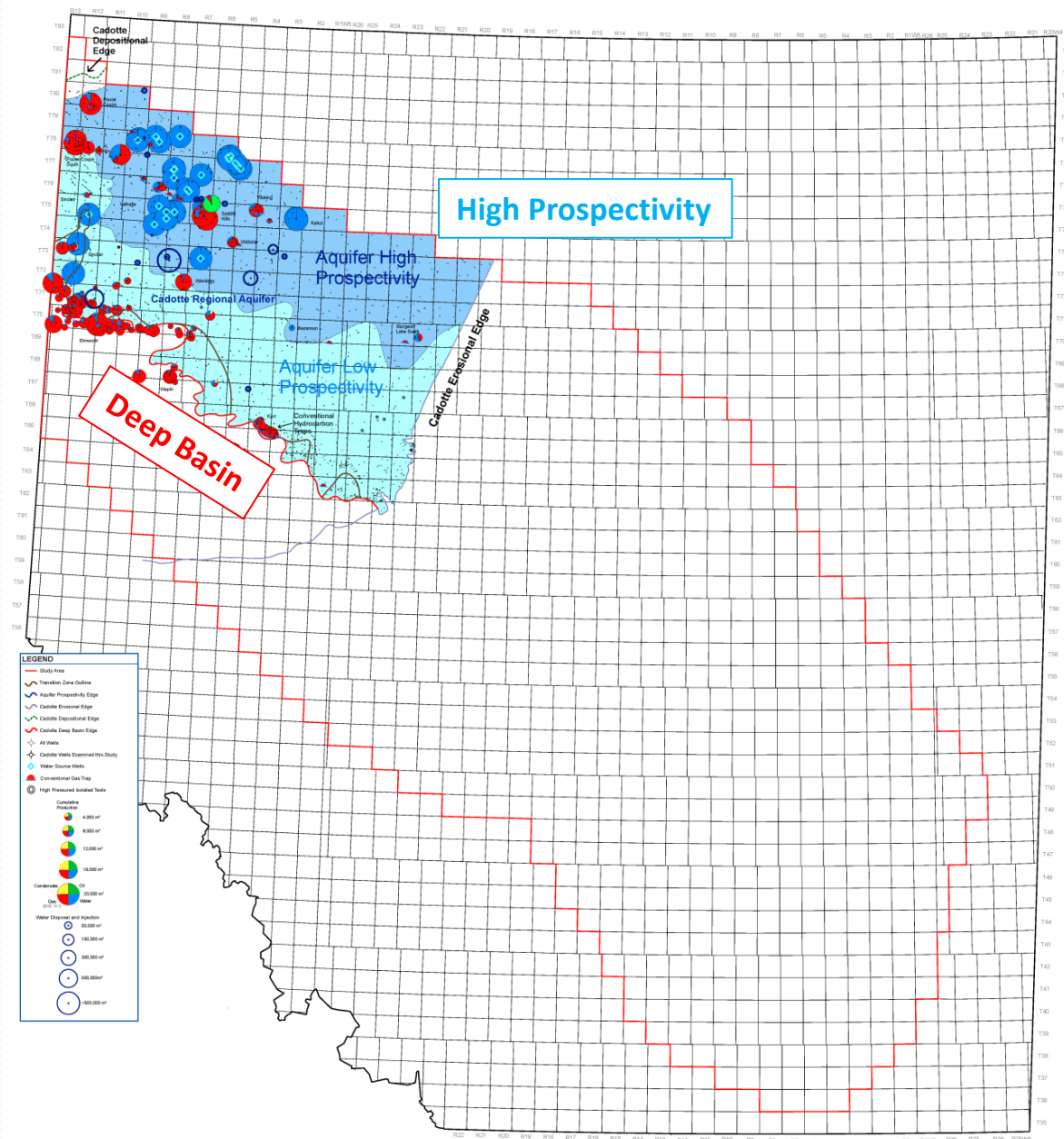
Deep Saline Aquifers – Cadotte Member

- Progradational shoreface complex
 - Sharp erosional limit in the south, shales out seaward to north
- Generally >15m thick, good continuity along shoreline trends

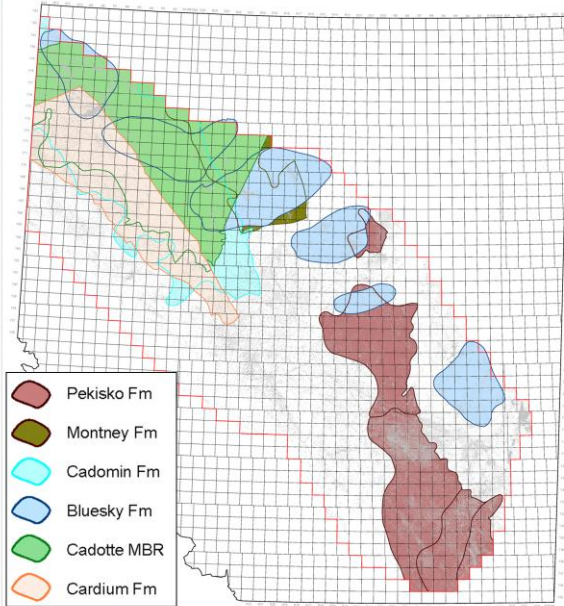


Cadotte Hydrogeology

- Regional aquifer is prospective updip of Deep Basin
 - Abundant water source wells
- Mapping, tests, and water source well performance outline high/low prospectivity aquifers
- 15,000-25,000 mg/L TDS



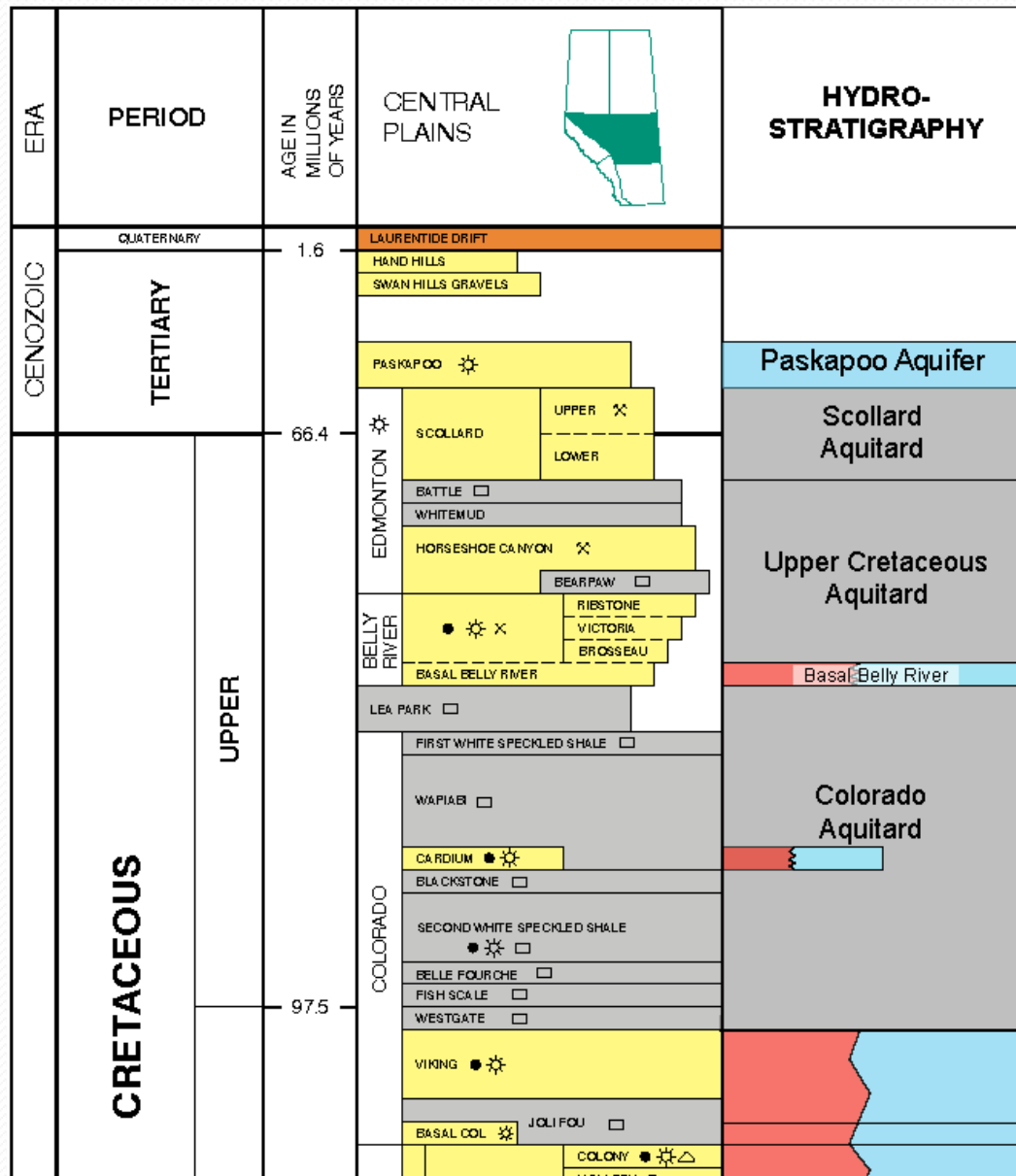
Distribution of Deep Saline Aquifers



- Northern areas have multiple deep saline options
- Southern areas have few or none

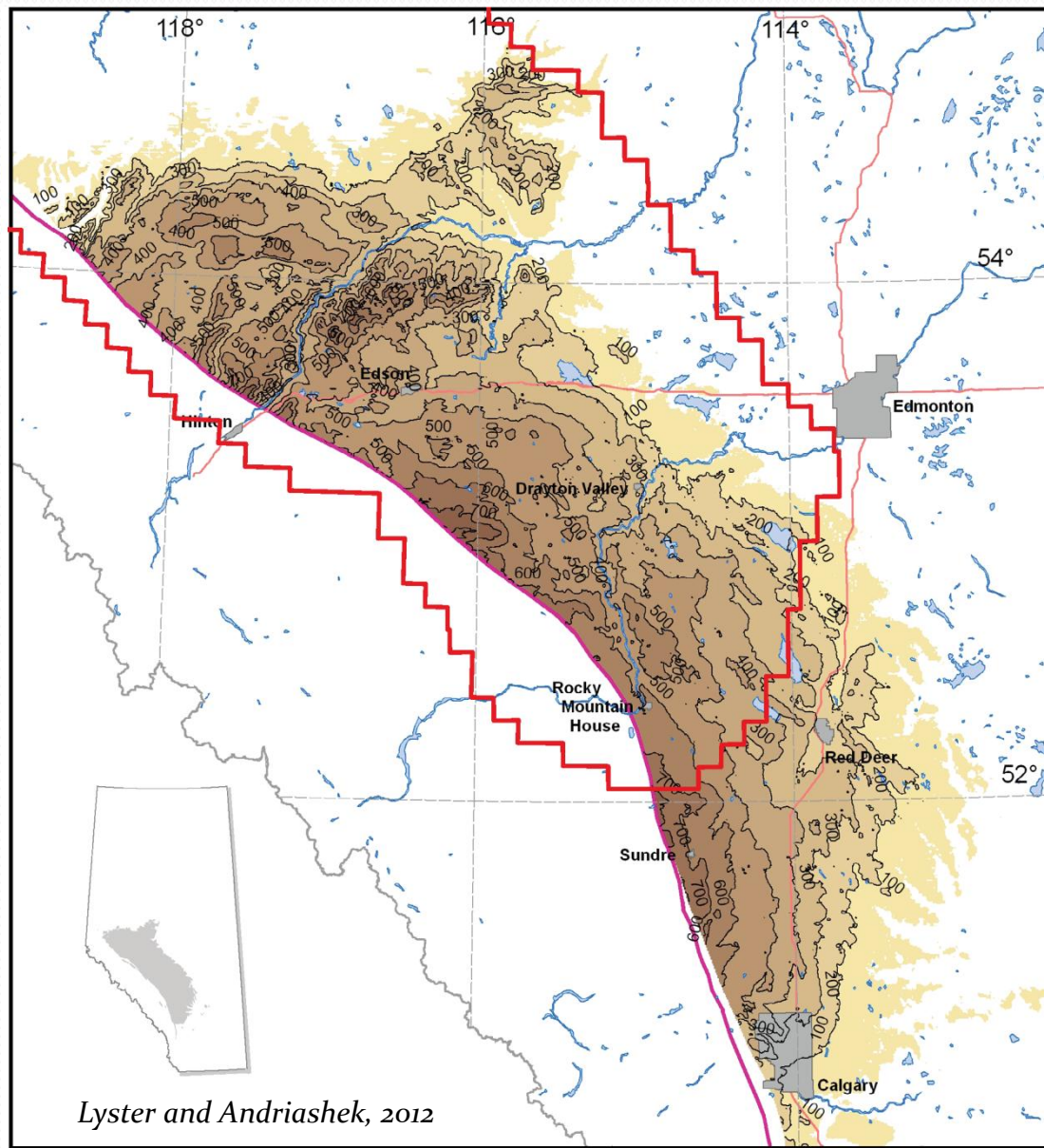
Integrated Assessment of Water Resources for Unconventional Oil & Gas Plays, West-Central Alberta

- Component 1: Deep saline aquifers
- **Component 2: Shallow non-saline aquifers**
- Component 3: Surface waters



Shallow Bedrock Hydrostratigraphy

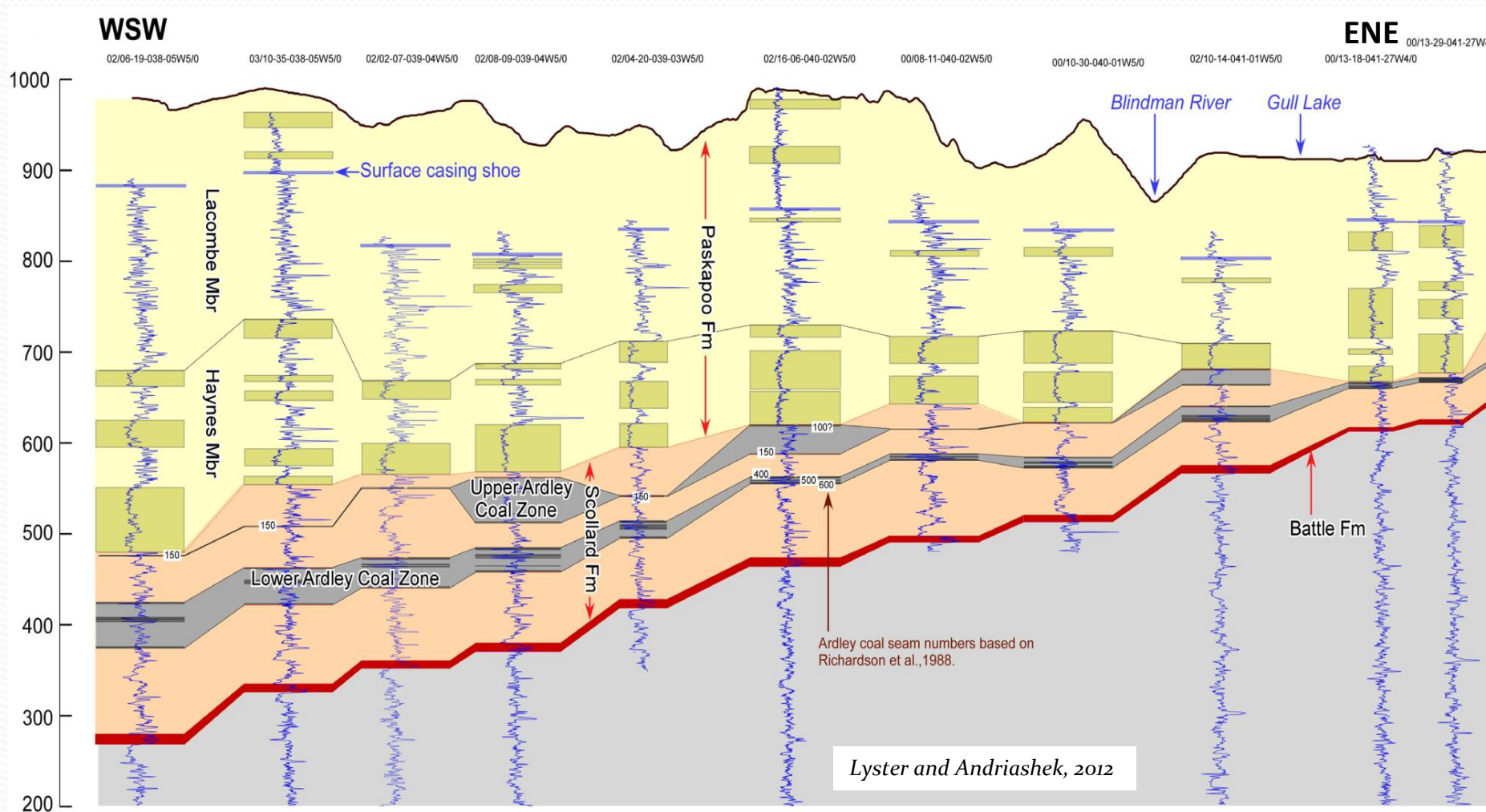
- Section dominated by aquitards or local channel aquifers
- Basal Belly River carries brackish to locally non-saline waters
- Paskapoo aquifer carries fresh water



Paskapoo Formation – Regional Isopach

- >700 m thick in subsurface close to Foothills; some outcrop sections up to 1000 m

Paskapoo Stratigraphy



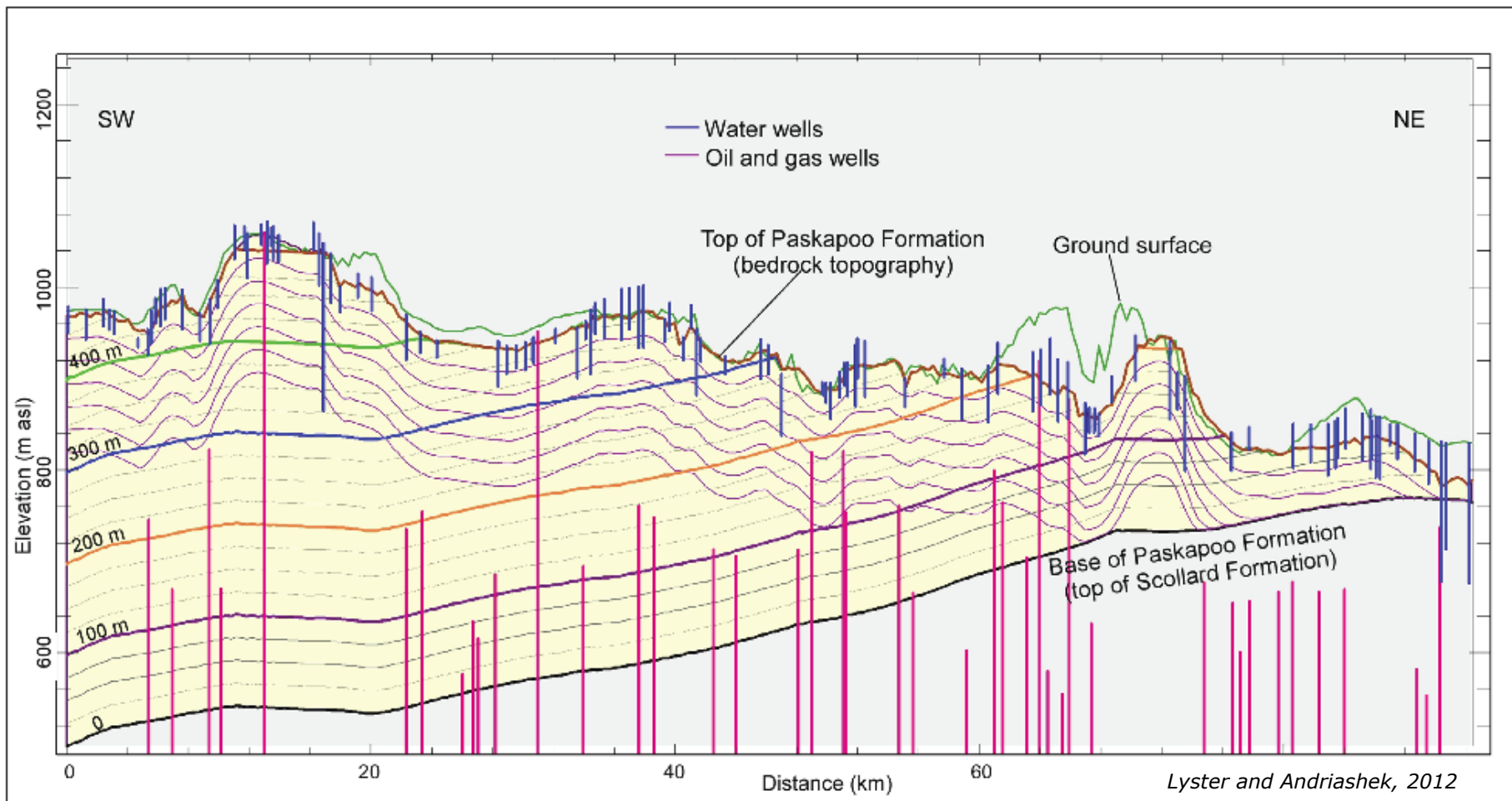
Paskapoo Aquifer Characterization

- Focus on western areas where basal Paskapoo sandstones (Haynes Member) are buried relatively deeply
 - Waters are expected to be non-saline, but below depths normally drilled for domestic / agricultural / industrial water wells
- Characterizing substantial non-saline water resources not accessible to shallow water wells may support consideration of “deep” Paskapoo as a source zone for unconventional hydrocarbon development
 - Particularly important in southern areas where little deep saline source potential exists

Shallow Non-Saline Aquifer Characterization – Data Integration Challenges

- Capturing and integrating shallow data (above base of surface casing in petroleum boreholes) is a major challenge
 - Historical hydrogeological studies
 - Driller's log and flow information from shallow water wells
 - Through-casing logs from petroleum boreholes
 - Alberta Research Council logged/cored stratigraphic boreholes
 - Mineral exploration borehole cores
 - Surface mapping

Shallow Non-Saline Aquifer Characterization – Data Integration Challenges



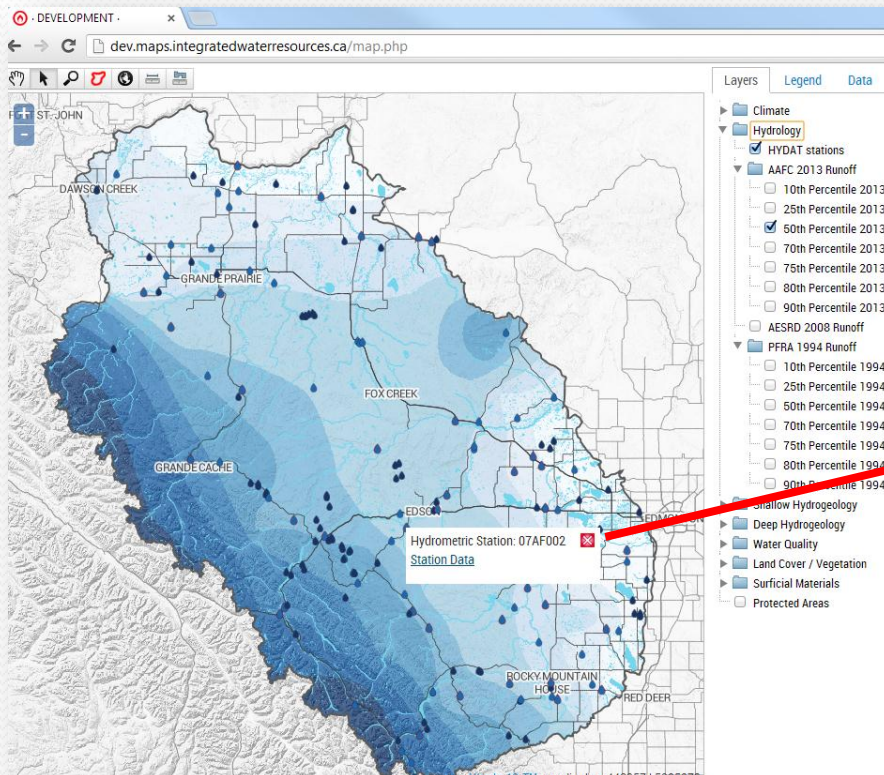
Integrated Assessment of Water Resources for Unconventional Oil & Gas Plays, West-Central Alberta

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- **Component 3: Surface waters**

Surface Watershed Databasing and Analysis

- Systematically assemble relevant climate and hydrography data to support assessment and modeling of surface water availability at all locations
 - Climate
 - Hydrology
 - Land Cover
 - Surficial Geology
 - Shallow Hydrogeology

Surface Watershed Databasing and Analysis



Hydrologic Analysis
(183 hydrometric stations)

07AF002 :: MCLEOD RIVER ABOVE EMBARRAS RIVER

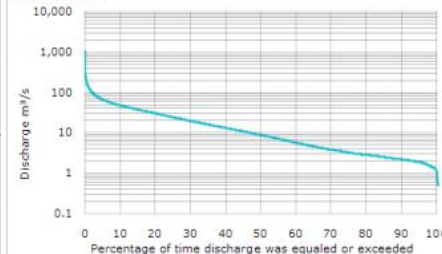
Station Metadata

Province: AB
Regional Office: CALGARY
Hyd Status: Active
Latitude/Longitude: 53.4702, -116.632
Gross Drainage Area: 2561.6 km²
Eff Drainage Area: 2551.3 km²
RBN: 1
Real Time: 1
Contributor ID: WATER SURVEY OF CANADA (DOE) (CANADA)
Operator ID: WATER SURVEY OF CANADA (DOE) (CANADA)
Datum ID: ASSUMED DATUM

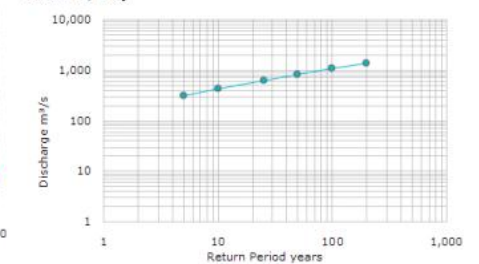
[Graphic Metadata](#)



Flow Duration

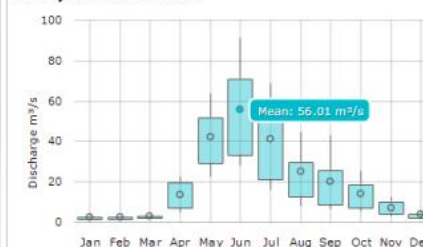


Flood Frequency

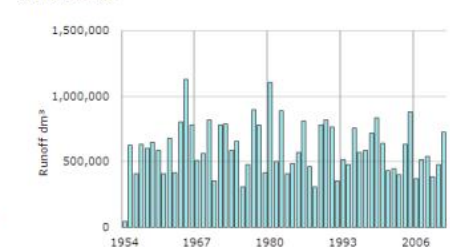


[Flood Frequency Table](#)

Monthly Mean Flow Statistics

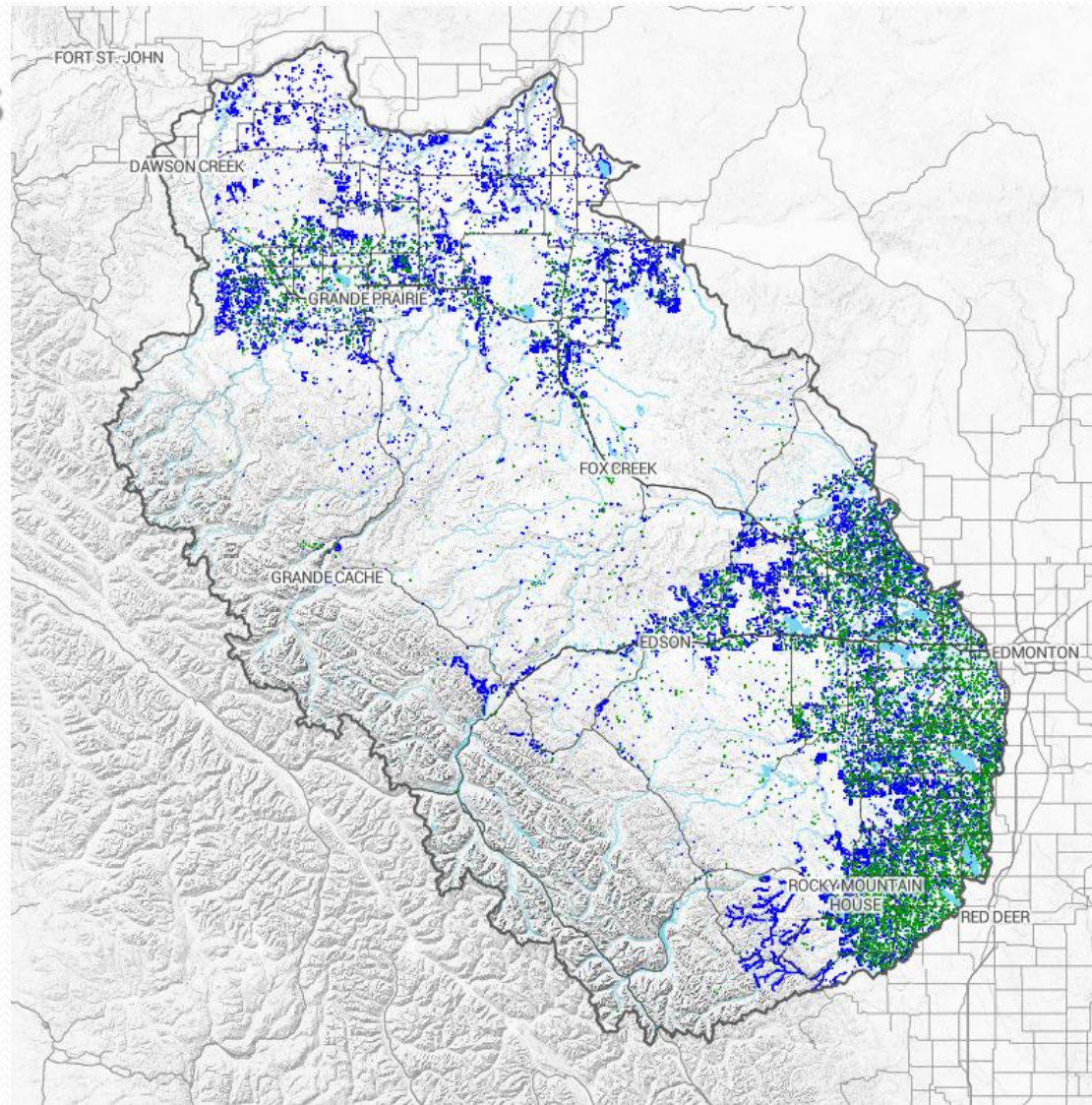


Annual Runoff



Surface Water and Groundwater Allocations

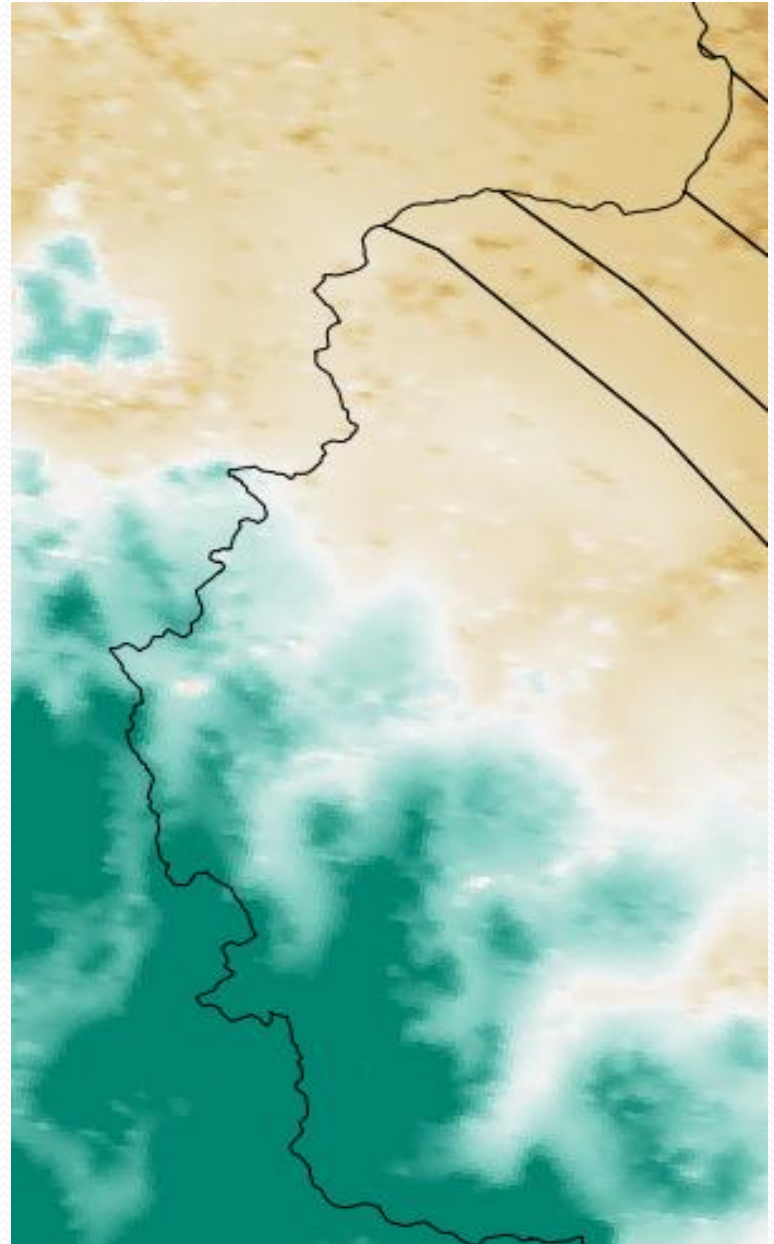
- > 30,000 existing allocations
 - 2 : 1 ratio in number of licenses, SW:GW
 - 3.3 : 1 ratio in consumptive use, SW:GW
- > 1 billion m³ of water managed under license
- Commercial / industrial are largest water users
- Greatest number of licenses are traditional agricultural



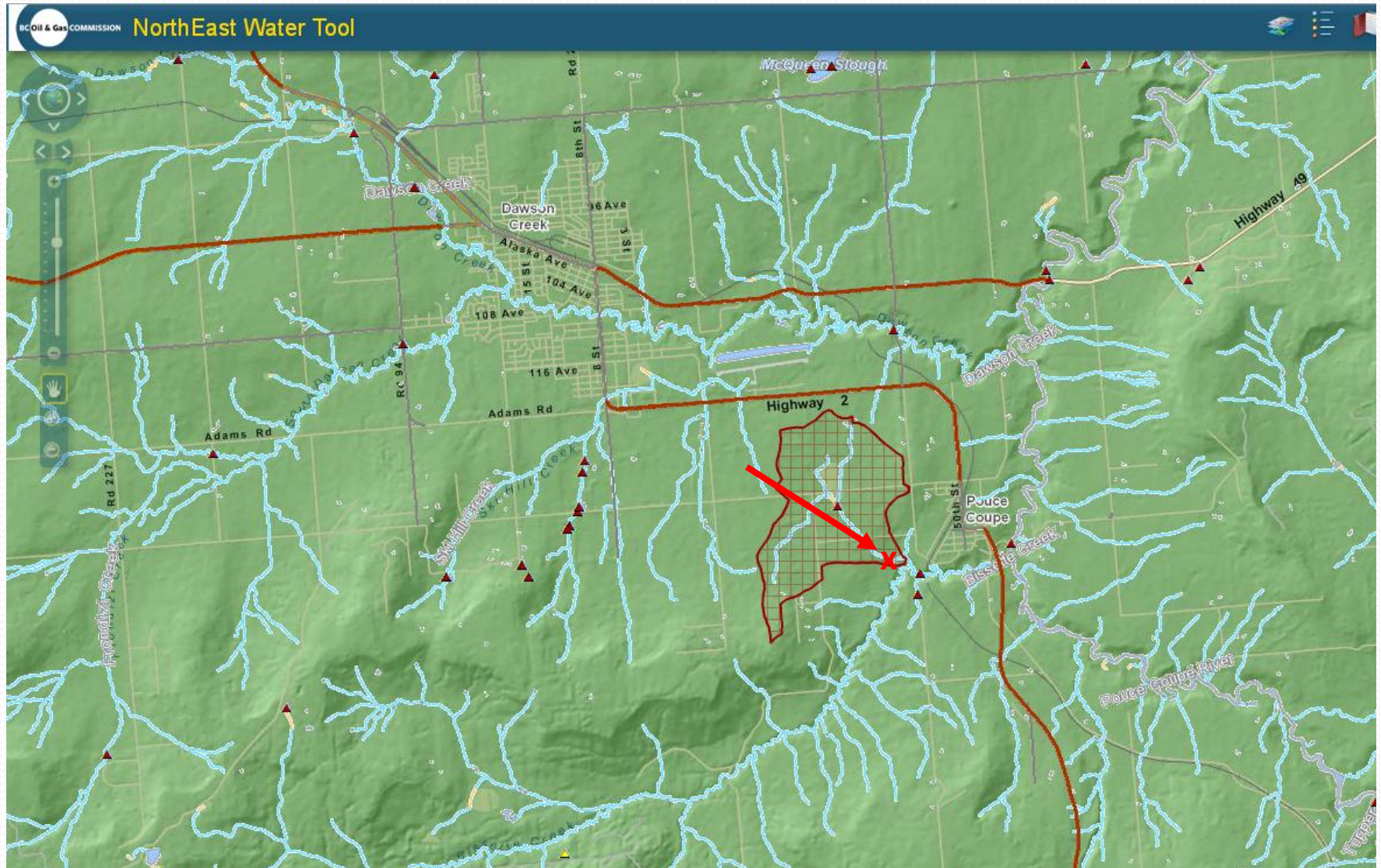
Surface Water Flow Modeling

- Modeling of surface flow being undertaken using:
 - Detailed drainage network and catchment boundaries
 - Flow data from hydrometric stations
 - Existing surface and groundwater allocations
 - Climate and vegetation data
- Iterative process with stochastic elements; must match results across watershed boundaries

Comparison of scale between model output and existing contoured products



Customized Surface Water Query Tools



Customized Surface Water Query Tools



Northeast Water Assessment Tool (NEWT) Query

Query Location:
UTM-EASTING: 817775
UTM-NORTHING: 617730
NAME: Police Coupe River
DATE: Mon Jun 24 2013

Query Watershed:
Drainage Area: 513 ha
Average Annual Precipitation: 406.6 mm
Average Elevation (m): 621.6 m
Basin Centre - Easting: 617595 m
Basin Centre - Northing: 617930 m
Average Annual Unit Runoff: 53.5 mm
Average Annual Volume Runoff: 274,525 m³
Average Annual Discharge: 0.81 m³/s



Month	Average Runoff (mm)	Average Discharge (m³/s)	Average Runoff (mm)	Reserved for Environmental Flow (m³/s)	Potential Maximum Allocation (m³/s)	Existing Allocation (Licenses or Approvals) (m³/s)	Remaining Potential for Allocation (m³/s)	Note
Jan	0.2	0	1,029	875	154	15,832	-15,776	Winter Flow Limited
Feb	0.2	0	917	694	123	15,832	-15,810	Winter Flow Limited
Mar	0.5	0	2,596	2,173	393	15,832	-15,540	Winter Flow Limited
Apr	2.8	0.01	14,229	12,897	2,133	15,832	-13,799	
May	17.4	0.03	88,523	76,895	13,628	15,832	-2,204	
Jun	12	0.02	61,732	52,472	9,260	15,832	-6,573	
Jul	9.9	0.02	55,529	43,201	7,824	15,832	-8,309	
Aug	5.1	0.01	26,194	22,266	3,629	15,832	-12,083	
Sep	3	0.01	15,469	13,141	2,319	15,832	-13,614	
Oct	1.5	0	7,595	6,422	1,133	15,832	-14,799	
Nov	0.5	0	2,367	2,012	355	15,832	-15,577	
Dec	0.4	0	2,247	1,910	337	15,832	-15,895	Winter Flow Limited
Annual	53.5	0.81	274,525	233,347	41,178	121,140	-158,011	



OGC Water Management Basin:
Drainage Area: 353,190 ha
Average Annual Precipitation: 322.7 mm
Average Elevation (m): 770.6 m
Basin Centre - Easting: 672286 m
Basin Centre - Northing: 617930 m
Average Annual Unit Runoff: 76.7 mm
Average Annual Volume Runoff: 255,655,252 m³
Average Annual Discharge: 8.1 m³/s

Month	Average Runoff (mm)	Average Discharge (m³/s)	Average Runoff (mm)	Reserved for Environmental Flow (m³/s)	Potential Maximum Allocation (m³/s)	Existing Allocation (Licenses or Approvals) (m³/s)	Remaining Potential for Allocation (m³/s)	Note
Jan	0.4	0.04	1,448,363	1,231,836	217,348	275,691	-59,354	Winter Flow Limited
Feb	0.3	0.4	672,842	627,000	145,841	275,691	-127,644	Winter Flow Limited
Mar	0.7	0.9	2,416,346	2,048,837	361,558	275,691	-84,968	Winter Flow Limited
Apr	3.7	4.77	12,365,722	10,510,854	1,854,868	275,629	-1,579,229	
May	34	29.82	79,886,848	67,888,871	11,997,877	275,691	-11,720,986	
Jun	17.2	22.08	57,191,819	48,612,308	8,579,611	326,140	-8,252,491	
Jul	13.8	17.2	46,078,858	38,167,823	6,911,035	325,902	-6,585,025	
Aug	7.8	9.68	25,595,628	22,045,282	3,550,344	325,902	-3,224,442	
Sep	4.6	5.69	15,365,098	12,576,723	2,788,375	291,726	-2,496,653	
Oct	2.6	3.2	8,678,547	7,291,340	1,387,207	275,691	-1,111,596	
Nov	1	1.26	3,261,267	2,772,894	488,373	275,629	-213,944	
Dec	0.7	0.86	2,308,454	1,962,143	346,311	275,629	-23,682	Winter Flow Limited
Annual	76.7	8.1	255,655,252	217,333,272	38,322,006	3,480,630	-34,872,887	

Disclaimer:
The Northeast Water Tool (NEWT) has been developed and posted on this website by the Oil and Gas Commission (Commission) for the convenience of industry and the public. Information relating to NEWT is believed to be representative, but technical inaccuracies and uncertainties may exist. NEWT carries no guarantee of any kind, express or implied. The Commission accepts no liability or damage for loss or damages incurred by any person or business entity based on the use of NEWT.



Ministry of
Forests, Lands and
Natural Resource Operations



- Modeling will support development of a query tool like BC's Northeast Water Tool (NEWT)
- GIS-based hydrology decision support tool
- In response to queries, will present predicted stream flow, existing allocations and environmental flow needs corresponding to query location, for any location

IAWR Project Summary

- Integrated Assessment of Water Resources provides a complete water source and disposal inventory
 - Basis for informed decisions on water in support of unconventional hydrocarbon development
- Collaboration among industry partners, government agencies, and technical consultants essential to project completeness and credibility
- Supports development of appropriate regulatory regime governing unconventional hydrocarbon development, based on data and technical work available to all stakeholders
- Provides a regional framework upon which operators can base more detailed mapping and analyses to support specific projects
 - Spatially enabled database management allows integration of custom datasets and real-time data transparency

Acknowledgements

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- PRCL Staff