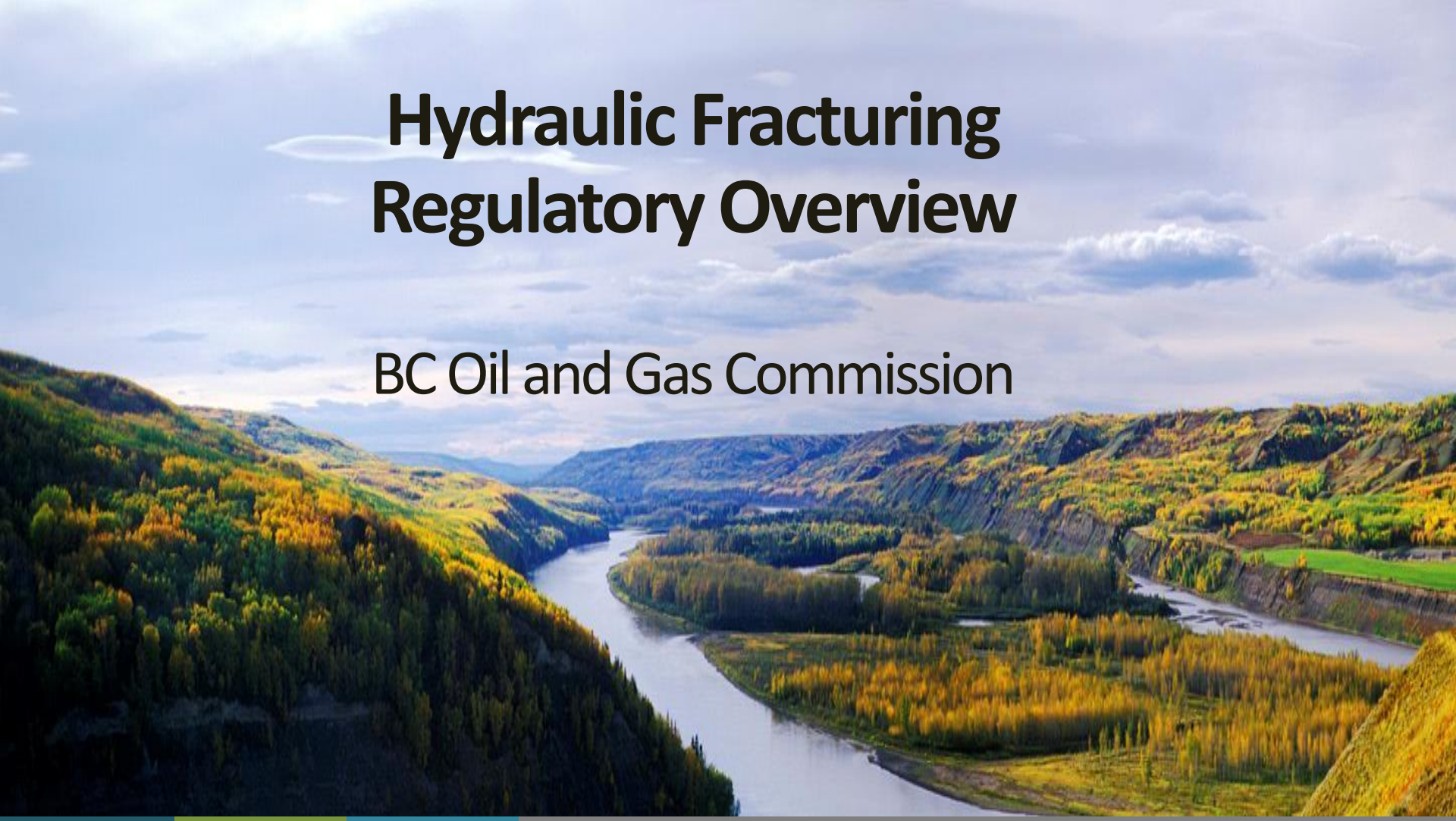
Hydraulic Fracturing Regulatory Overview

BC Oil and Gas Commission



Presentation To FNCI
January 2020

BC Oil & Gas COMMISSION
20TH ANNIVERSARY

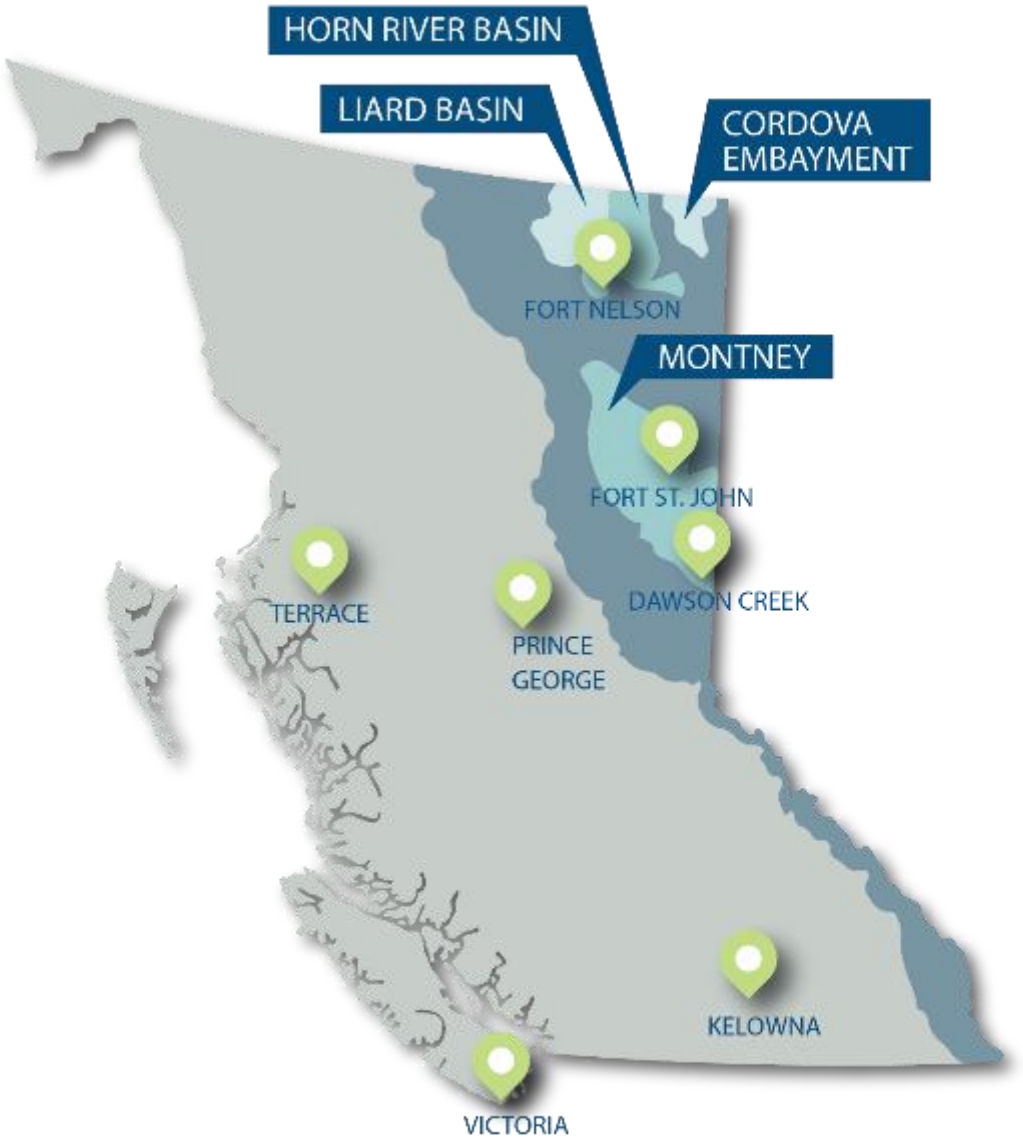
TOPICS

1. Oil and Gas Commission Overview
2. BC Unconventional Gas Development
3. Water Use in Hydraulic Fracturing
4. Hydraulic Fracturing Water Contamination Risks
5. Induced Seismicity
6. Cumulative Effects Assessment and Management

Commission - Overview

- Established as a Crown Corporation in 1998
- Independent agency – report to a Board
- Single-Window Regulatory Agency for upstream oil & gas activities
- 7 Offices throughout BC
- Pure regulator of oil and gas activities – do not issue tenures or administer royalties
- Do not set policy or administer legislation – power to establish Board regulations for technical matters
- Funded by a combination of application / annual fees and levies on oil and gas production

THE COMMISSION IN B.C.



Oil and Gas Activities Act:

Commission is a single-window agency
Permits for oil and gas activities
Authorizations for related activities

Land Act:

Licence of Occupation
Right of Way
Lease

Water Sustainability Act:

Short Term Use of Water
Changes in & About a Stream
Water Licences

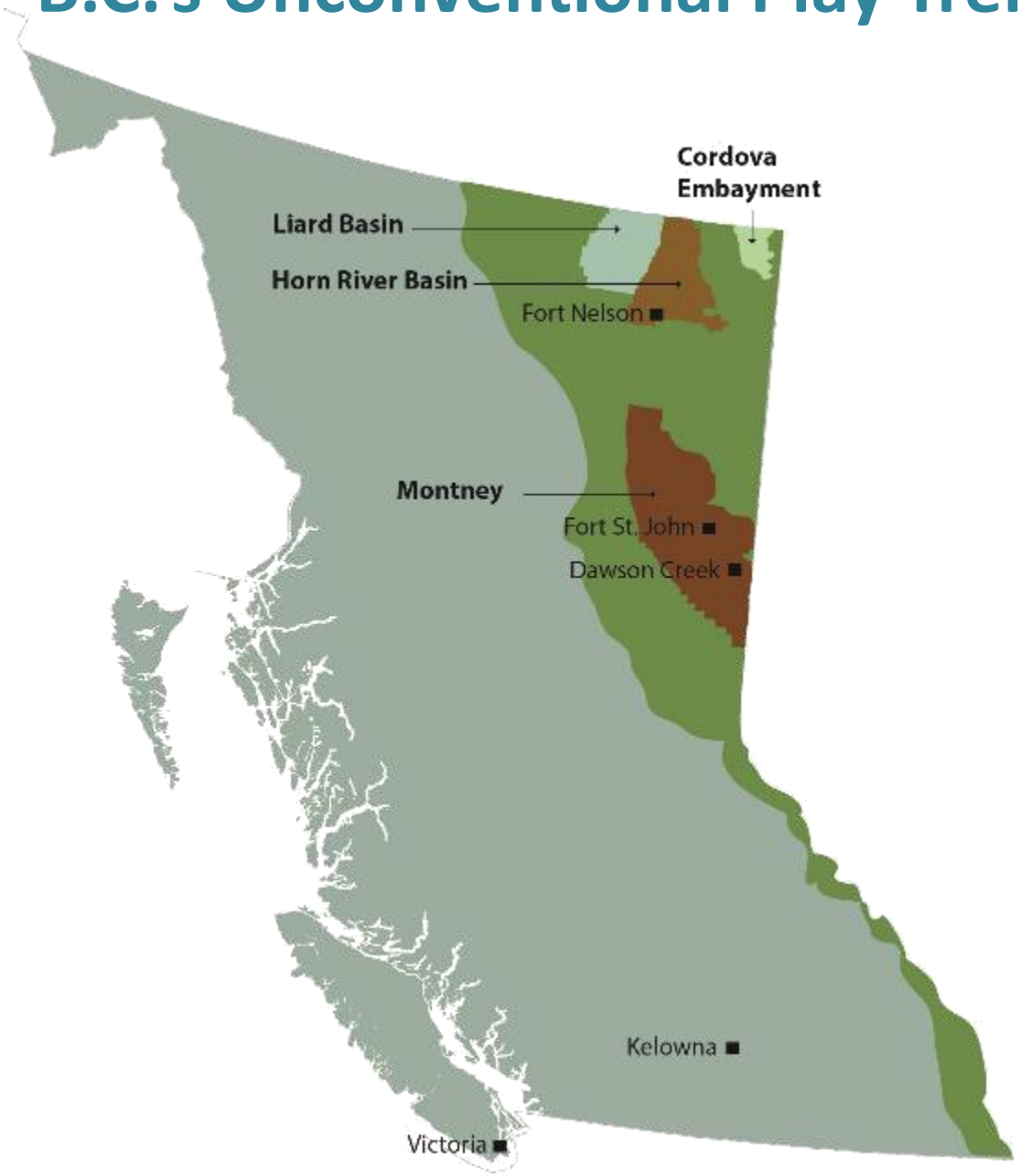
Forest Act:

Master Licence to Cut
Road Use Permit

Other Enactments:

Heritage Conservation Act
Environmental Management Act
ALC Act Delegation Agreement

B.C.’s Unconventional Play Trends



Liard Basin - Devonian

- 9,340 sq km
- OGIP – no estimate (large)
- 3 wells
- cumulative production is confidential

Horn River Basin - Devonian

- 11,400 sq km
- OGIP – 448 TCF
- 169 wells
- daily production- 430 MMcf/d
- cumulative production – 320 BCF

Cordova Embayment - Devonian

- 2,690 sq km
- OGIP – 200 TCF (preliminary)
- 9 wells
- daily production is confidential
- cumulative production is confidential

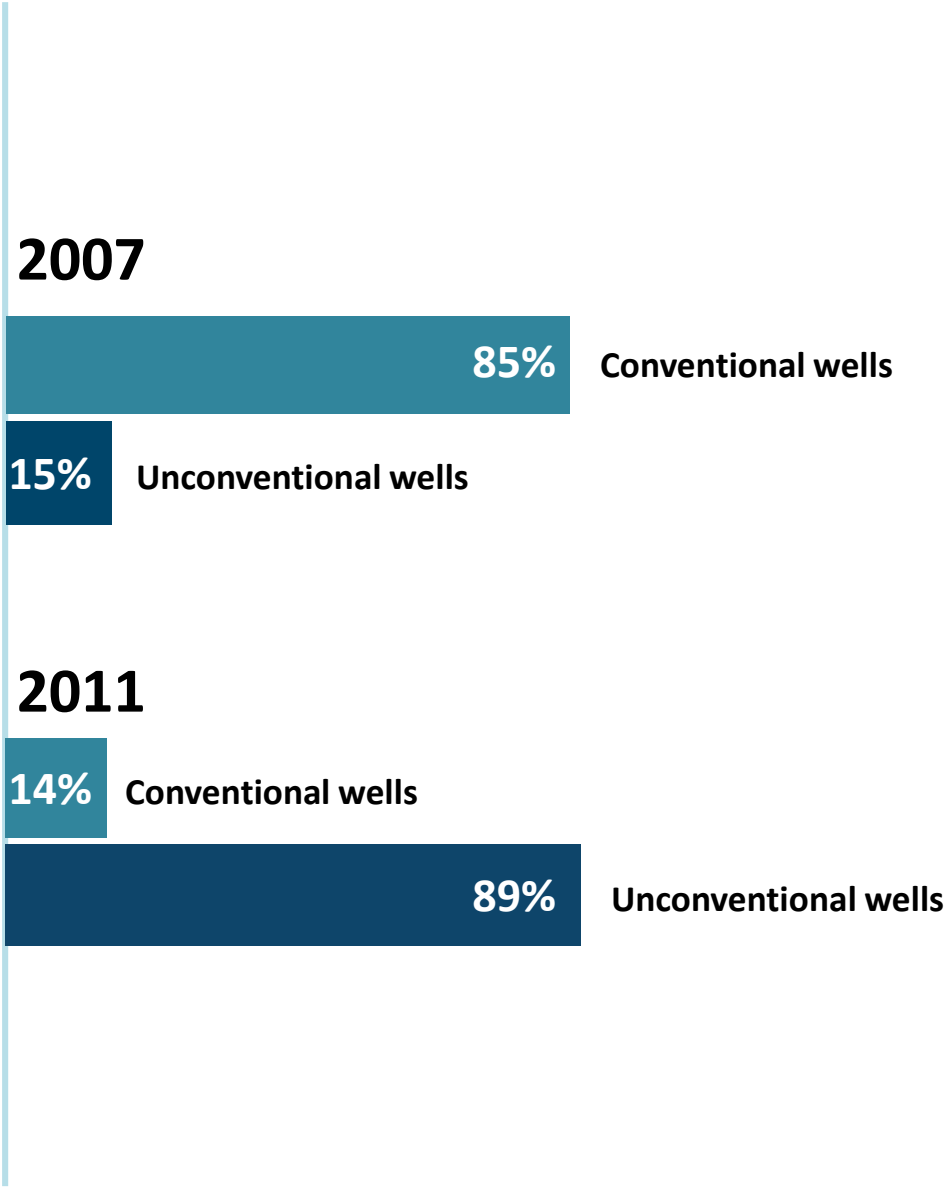
Montney - Triassic

- 29,850 sq km
- OGIP – 450 TCF (under review)
- 1166 wells
- daily production 1.5 BCF/d
- cumulative production – 1.3 TCF

Rise in Unconventional Gas in B.C.

CONVENTIONAL
- Single-well pads
- More infrastructure
- Shorter reserve life

UNCONVENTIONAL
- Multi-well pads
- More predictable placing
- Longer reserve life



From this:

Single well pad
< 1.5 ha


To this:
multi-well pads
3 – 10+ ha
10 - 30+ wells

Hydraulic Fracturing – Water Use

The Hydraulic Fracturing Water Use Lifecycle

Diversion / Procurement

↓

Transport, Storage & Use

↓

Recycling / Reuse

↓

Disposal

Water Diversion / Procurement

Key Principles:

1. Protect environmental flows for aquatic life and wildlife
2. Protect present and future water needs for communities
3. Understand and **manage for natural variability** and **future change**
4. Recognize and respond to low flow conditions (eg. seasonal low flows; drought)
5. Be **fully transparent** with information and decisions
6. Coordinate and collaborate with other government agencies involved in regulating water diversion and storage (FLNRO / MOE)

Water Procurement & Use

Water Storage Reservoirs:

- needed to manage timing of water availability, use and reuse
- wide variation in sizes
- Most capture groundwater which is now regulated
- some are regulated dams
- OGC and FLNRO coordinating on assessment

Transport, Storage and Use

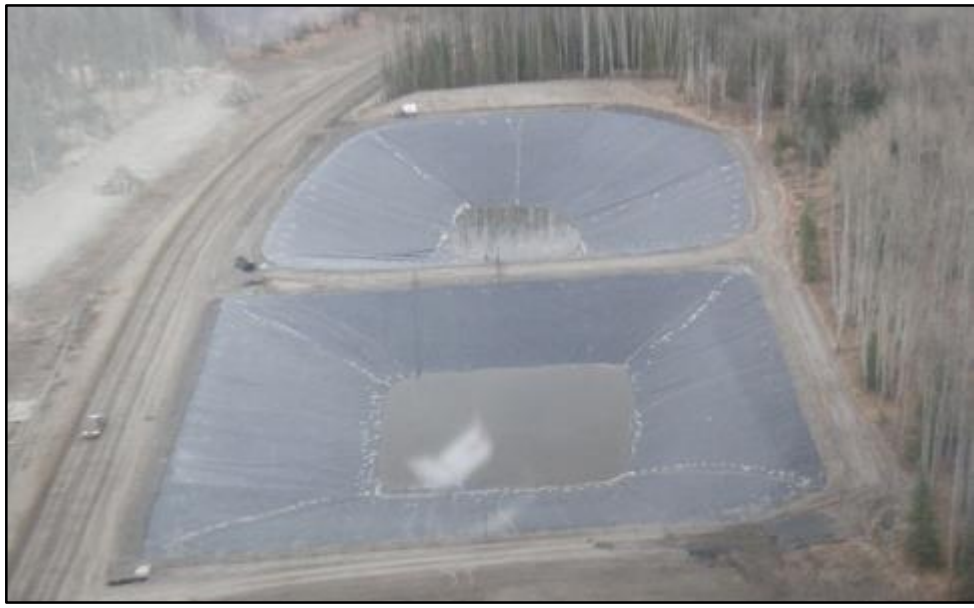
Accessing and transporting water for hydraulic fracturing is a significant cost and logistical challenge for the industry.

The industry is evolving from accessing truckloads of water at numerous locations (streams, dugouts, borrow pits) under short term approvals to…

- Fewer diversion points generally from larger water sources
- Transporting water by pipeline between wellsites and sophisticated water hubs
- Storage in large tanks and reservoirs including dams

Flowback Water Management

- Significant volumes stored and/or treated for re-use
- If no reuse, flowback is injected into disposal wells
- Currently no surface discharge of flowback – treatment and discharge option being assessed
- Strict storage pond requirements:
  - No hydrocarbons
  - Multiple liners
  - Leak detection / monitoring
  - Wildlife / bird protection
  - Time limited storage

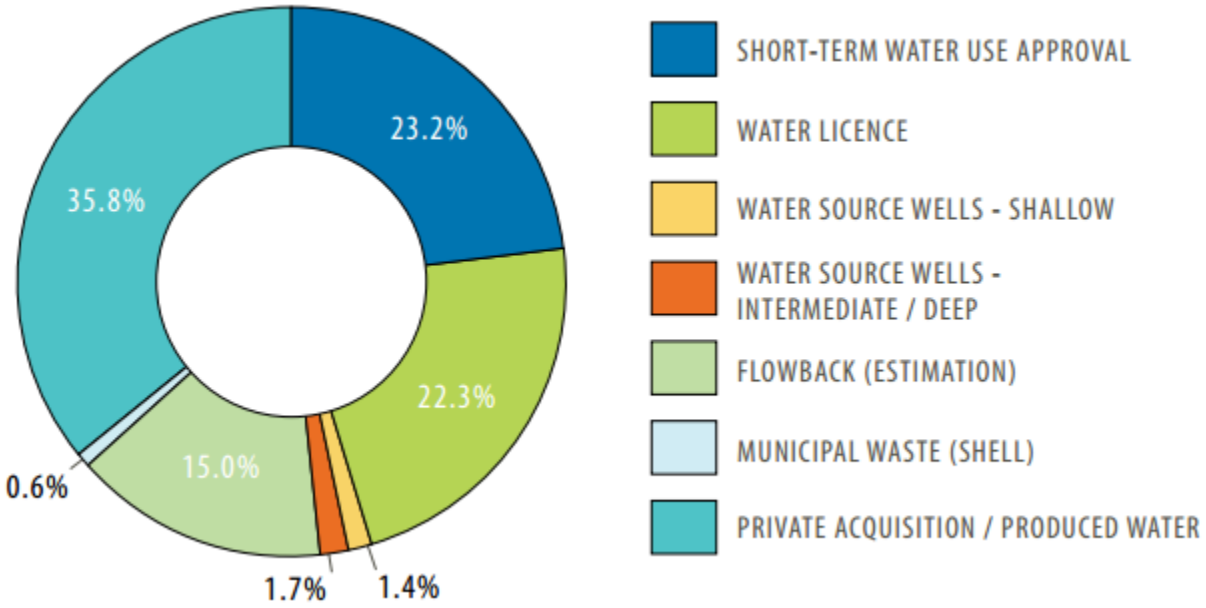


Disposal

Regulation of disposal by the OGC involves:

- Assessment of the disposal reservoir to verify fluid containment
- Assessment and testing of disposal wells to ensure integrity
- Restrictions on disposal pressures and reservoir pressures
- Ongoing monitoring and reporting

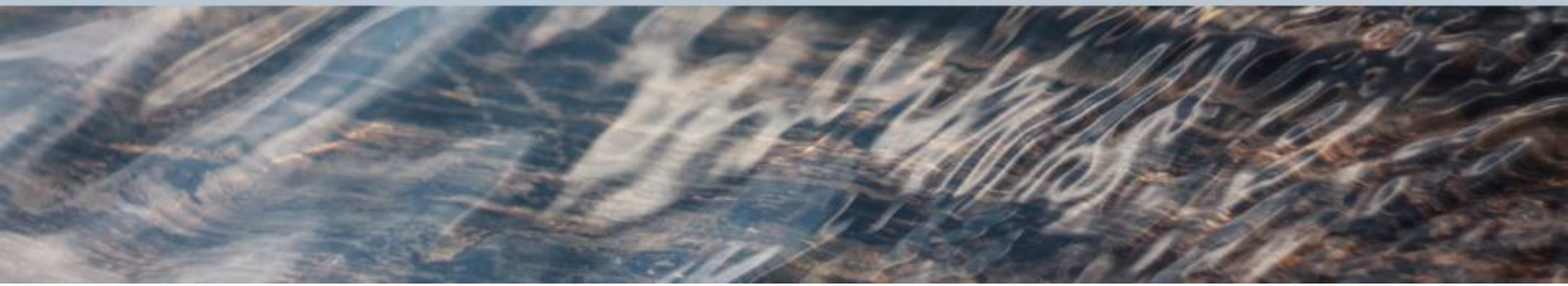
Water Sources



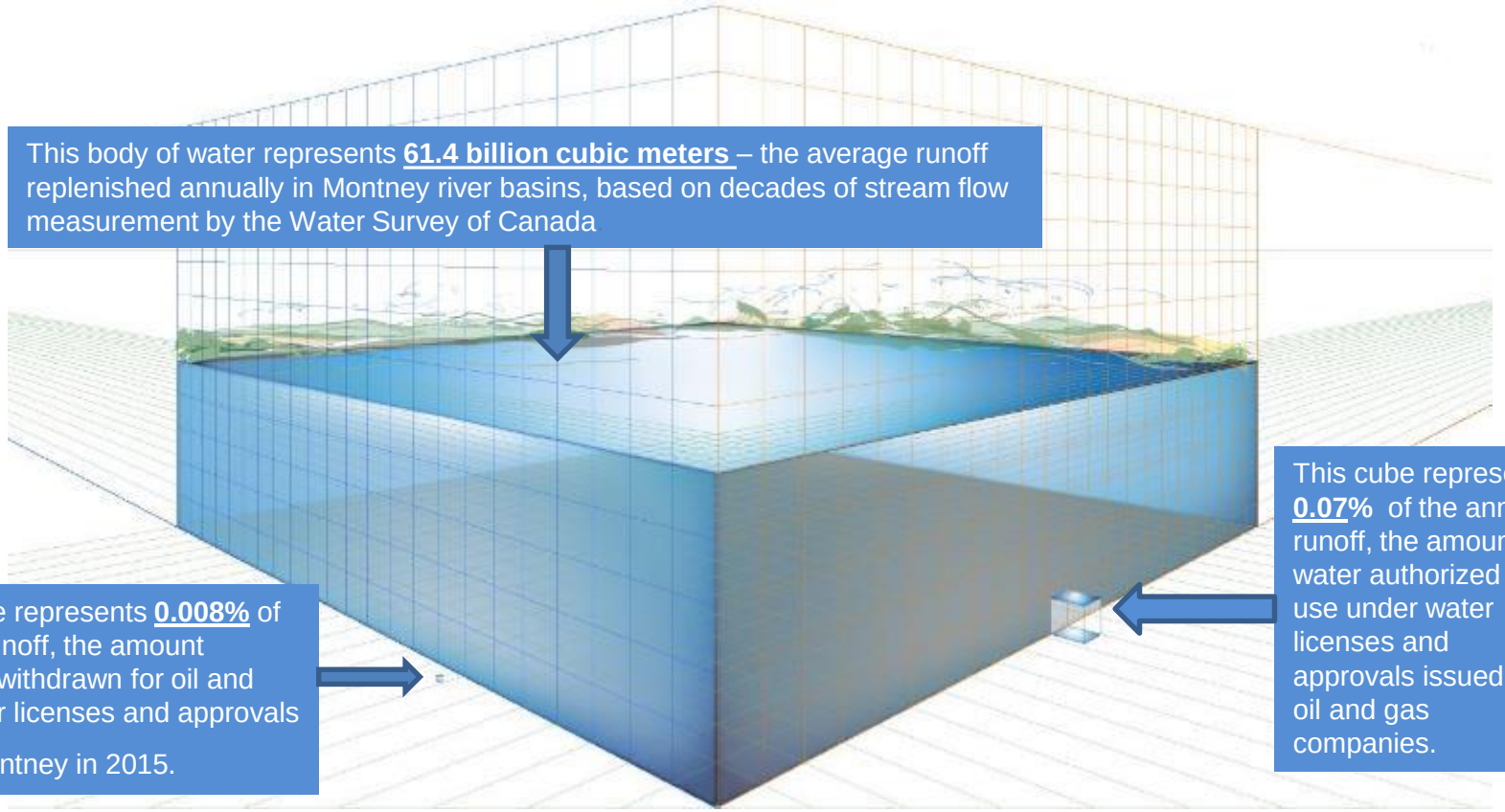
- Trend to more sourcing from water licences rather than short-term approvals
- Current reuse is likely greater based on trends with disposal volumes
- Requirements introduced with Water Sustainability Act (2016) enables better regulation and quantification of private acquisition volumes

How Much Water is Used?

	2012			2013		
PLAY	NUMBER OF WELLS	MEAN (m^3/WELL)	TOTAL WATER USE (m^3)	NUMBER OF WELLS	MEAN (m^3/WELL)	TOTAL WATER USE (m^3)
HORN RIVER BASIN	50	76,923	3,846,142	18	79,069	1,423,242
MONTNEY - HERITAGE	205	6,684	1,370,235	206	8,356	1,721,239
MONTNEY - NORTH	136	10,053	1,367,177	197	10,907	2,148,703
LIARD BASIN	1	144	144	1	20,106	20,106
CORDOVA EMBAYMENT	15	36,739	551,080	0		0
OTHER	12	221	2,651	11	2,577	28,345
TOTAL	**419**	**17,034**	**7,137,429**	**433**	**12,336**	**5,341,635**



How Much Surface Water is Used?



This body of water represents **61.4 billion cubic meters** – the average runoff replenished annually in Montney river basins, based on decades of stream flow measurement by the Water Survey of Canada

This cube represents **0.008%** of annual runoff, the amount reported withdrawn for oil and gas water licenses and approvals

in the Montney in 2015.

This cube represents **0.07%** of the annual runoff, the amount of water authorized for use under water licenses and approvals issued to oil and gas companies.

Water Associated with Hydraulic Fracturing

Current Challenges and Responses:

1. Ensuring Water Availability for Priority Uses

- Assessment of environmental flow needs
- Where water availability is limited seasonally – provide for withdrawls during periods of high flows – requires storage
- Suspension of withdrawls during low flows and droughts

2. Water Transport & Reuse

- Greater use of pipelines significantly reduces impact of truck traffic on landowners and road users
- Water hubs promote efficient reuse and reduce disposal

Water Associated with Hydraulic Fracturing

Current Challenges and Responses (cont'd):

3. Disposal Capacity

- Restrictions on reservoir pressures limits capacity in current facilities
- Will be a greater concern when development phase ramps down
- Costs and capacity driving assessment of other options
- Some assessment of future disposal capacity by OGC / Geoscience BC

4. Public Concerns Regarding Water Use and Risk of Contamination

- Transparency
- Research
- Regulatory update

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Frac Focus
Chemical Disclosure Registry

Home | Hydraulic Fracturing

Hydraulic Fracturing
HOW IT WORKS

This technique uses a specially blended liquid which is pumped into a well under extreme pressure causing cracks in rock formations underground. These cracks in the rock then allow oil and natural gas to flow, increasing resource production. more

SITE SETUP

Setting up a well site takes several weeks.

Time considerations must be made for leveling the constructing the pad site, possibly building roads t and preparing for the drilling rig. Once preparation will begin the drilling process; which includes cas completing the well.

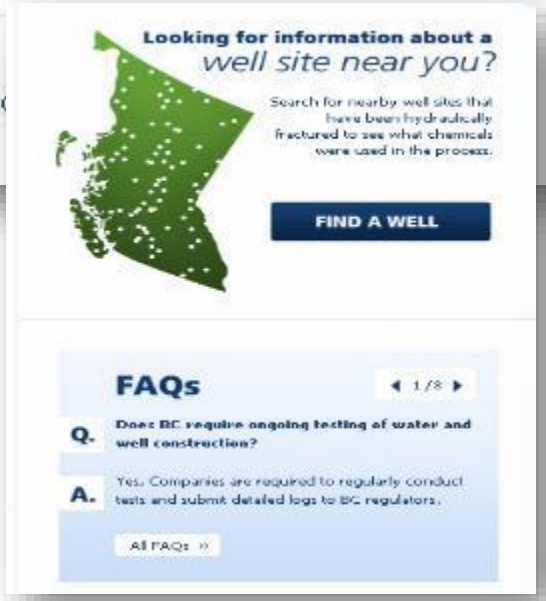
more

Chemicals Glossary »

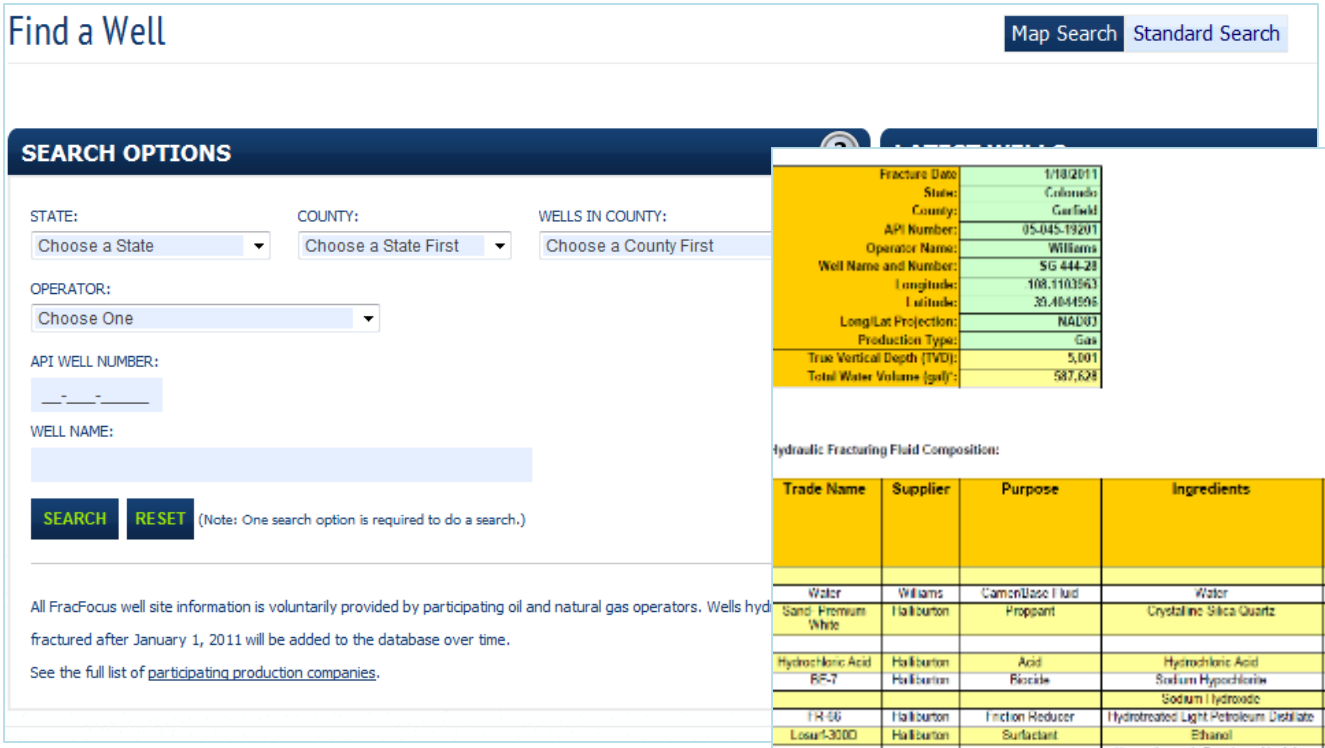
How It Works »

Regulations »

Privacy Policy / Terms



Disclosure
of Hydraulic Fracturing Fluids



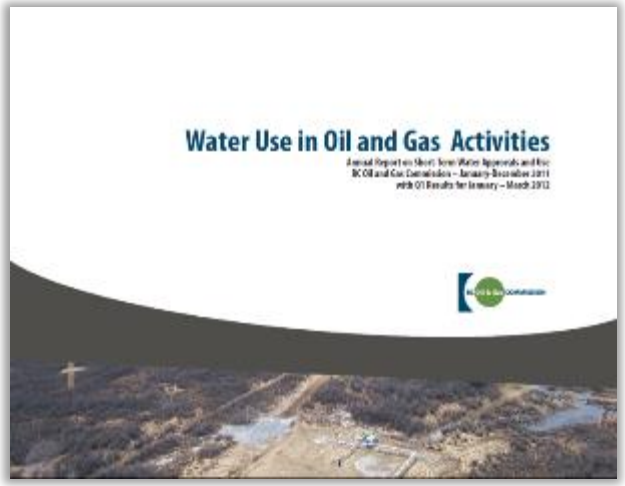
Fracture Date:	1/18/2011
State:	Colorado
County:	Garfield
API Number:	05-045-19201
Operator Name:	Williams
Well Name and Number:	SG 444-28
Longitude:	108.1103563
Latitude:	39.4844596
Long/Lat Projection:	NAD83
Production Type:	Gas
True Vertical Depth (TVD):	5,001
Total Water Volume (gal)*:	587,628

Hydraulic Fracturing Fluid Composition:

Trade Name	Supplier	Purpose	Ingredients	Chemical Abstract Service Number (CAS #)	Maximum Ingredient Concentration in Additive (% by mass)**	Maximum Ingredient Concentration in HF Fluid (% by mass)**	Comments
Water	Williams	Carrier/Base Fluid	Water	7732-18-5	100.00%	84.90079%	
Sand, Premium White	Halliburton	Proppant	Crystalline Silica Quartz	14808-60-7	100.00%	11.94460%	
Hydrochloric Acid	Halliburton	Acid	Hydrochloric Acid	7647-01-0	10.00%	0.04232%	
BE-7	Halliburton	Biocide	Sodium Hypochlorite	7681-52-9	30.00%	0.00307%	
			Sodium Hydroxide	1310-73-2	6.00%	0.00054%	
FR-66	Halliburton	Friction Reducer	Hydrotreated Light Petroleum Distillate	64742-47-8	30.00%	0.00683%	
Losurf-300D	Halliburton	Surfactant	Ethanol	64-17-5	60.00 %	0.00039%	
			Heavy Aromatic Petroleum Naphtha	64742-94-5	30.00 %	0.00019%	
			Poly(Oxy-1,2-Ethanediyl), Alpha-(4-Nonylphenyl)-Omega-Hydroxy-Branched	127087-87-0	5.00 %	0.00003%	
			Naphthalene	91-20-3	5.00 %	0.00003%	
			1,2,4-trimethylbenzene	95-63-6	1.00 %	0.00001%	
SandWedge WF	Halliburton	Conductivity Enhancer	Isopropanol	67-63-0	60.00 %	0.03814%	
			Heavy Aromatic Petroleum Naphtha	64742-94-5	10.00 %	0.00636%	
			Methanol	67-56-1	5.00 %	0.00318%	
HAI-404M	Halliburton	Corrosion Inhibitor	Quaternary Ammonium Salt		10.00%	0.00007%	
			1-(Benzyl)quinolinium chloride	15619-48-4	10.00%	0.00007%	
			Methanol	67-56-1	30.00%	0.00021%	
			Aldehyde		30.00%	0.00021%	
			Isopropanol	67-63-0	30.00%	0.00021%	
FE 1A Acidizing Composition	Halliburton	Additive	Acetic Anhydride	108-24-7	100.00 %	0.00307%	
			Acetic Acid	64-19-7	60.00 %	0.00252%	

Public reporting of Water Information

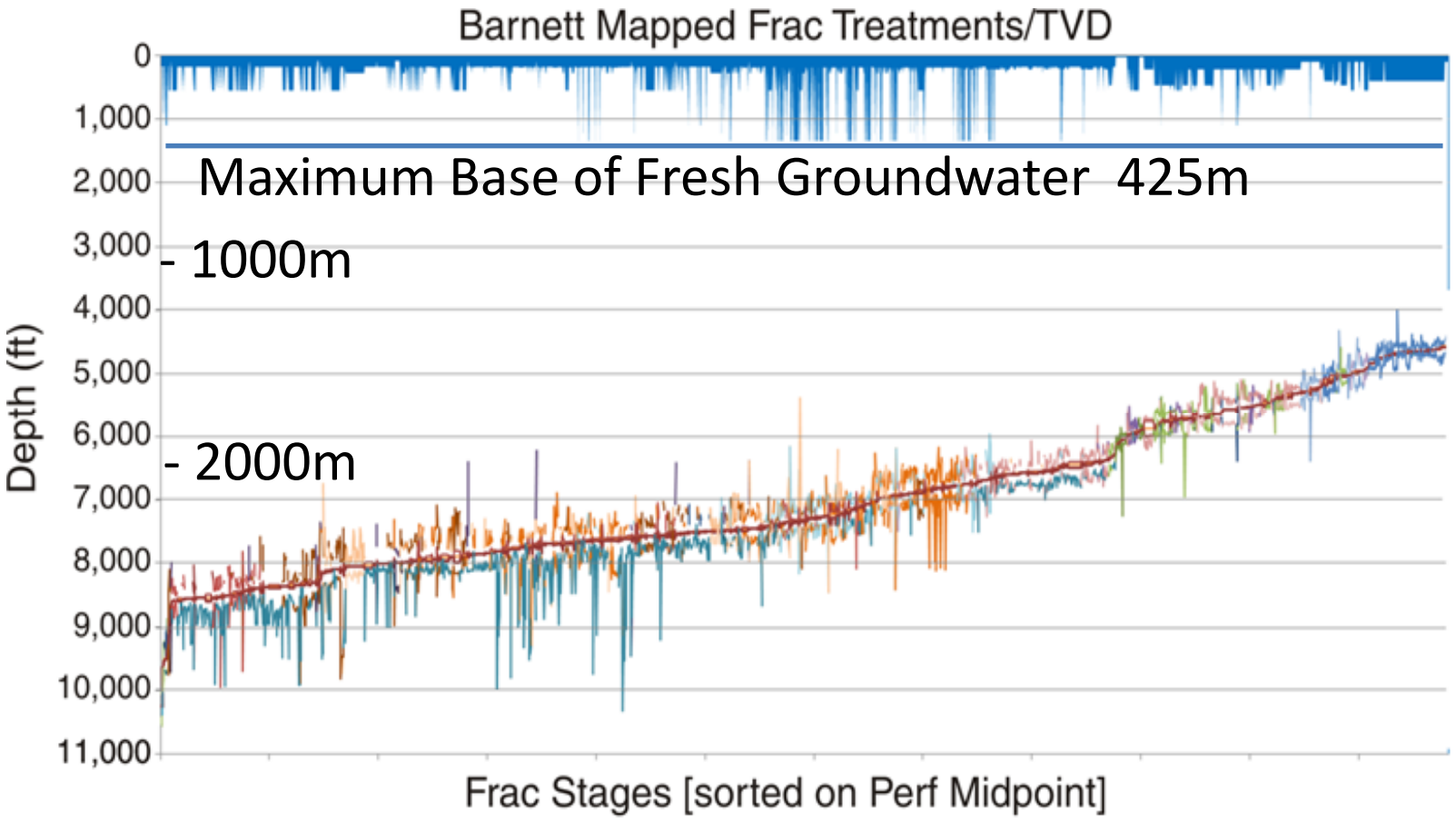
Full and transparent public reporting:
http://bcogc.ca/publications/reports.aspx



Major Basin Name	Sub-Basin Name	Section 8 Water Use Approvals - Oil and Gas Commission: Number of Section 8 Approvals (OGC)	Total Volume Approved (m^3)	Total Volume Approved as % of Mean Annual Runoff	Total Volume Withdrawn (m^3) (2012)	Total Volume Withdrawn as % of Mean Annual Runoff	FLNRO Water Licenses: Number of Water Licenses (FLNRO)	Total Volume Licensed (m^3)	Total Volume Licensed as % of Mean Annual Runoff	River Discharge and Runoff: Mean Annual Discharge (m^3/s)	Mean Annual Runoff (m^3)
Beatton River											
	Upper Beatton River	13	304,371	0.079%	19,125	0.005%				12.2	386,248,504
	Middle Beatton River	7	50,350	0.009%	2,030	0.000%				18.7	590,127,120
	Milligan Creek	6	372,710	0.127%	264	0.000%				9.3	292,529,786
	Blueberry River	12	645,924	0.192%	44,547	0.013%	16	175,436	0.052%	10.7	336,659,474
	Doig	3	46,045	0.019%	1,409	0.001%	8	3,375,662	1.389%	7.7	243,054,492
	Lower Beatton River	1	81,000	0.007%	0	0.000%	43	8,200,857	0.673%	38.6	1,218,123,360
	Beatton Total	**42**	**1,500,400**	**0.088%**	**67,375**	**0.004%**	**67**	**11,751,955**	**0.688%**	**54.1**	**1,708,660,566**
Pine River											
	Burnt						2	34,784	0.007%	15.9	501,765,840
	Sukunka						5	121,079	0.008%	45.4	1,432,715,040
	Upper Pine						13	2,455,457	0.200%	38.9	1,227,590,640
	Murray River	4	399,600	0.015%	0	0.000%	37	28,129,268	1.069%	83.4	2,631,903,840
	Lower Pine River	9	288,300	0.005%	0	0.000%	27	5,576,477	0.093%	189	5,964,386,400
	Pine Total	**13**	**687,900**	**0.012%**	**0**	**0.000%**	**84**	**36,317,065**	**0.607%**	**189**	**5,980,515,840**
Kiskatinaw River											
	East Kiskatinaw River	6	358,740	0.374%	1,293	0.001%	5	2,871,174	2.993%	3.0	95,935,104
	West Kiskatinaw River									2.9	90,570,312
	Middle Kiskatinaw						9	3,719,705	1.455%	8.1	255,616,560
	Lower Kiskatinaw River	6	331,150	0.105%	5,174	0.002%	20	1,171,180	0.371%	10.0	315,576,000
	Kiskatinaw Total	**12**	**689,890**	**0.210%**	**6,467**	**0.002%**	**34**	**7,762,059**	**2.367%**	**10.4**	**327,904,045**

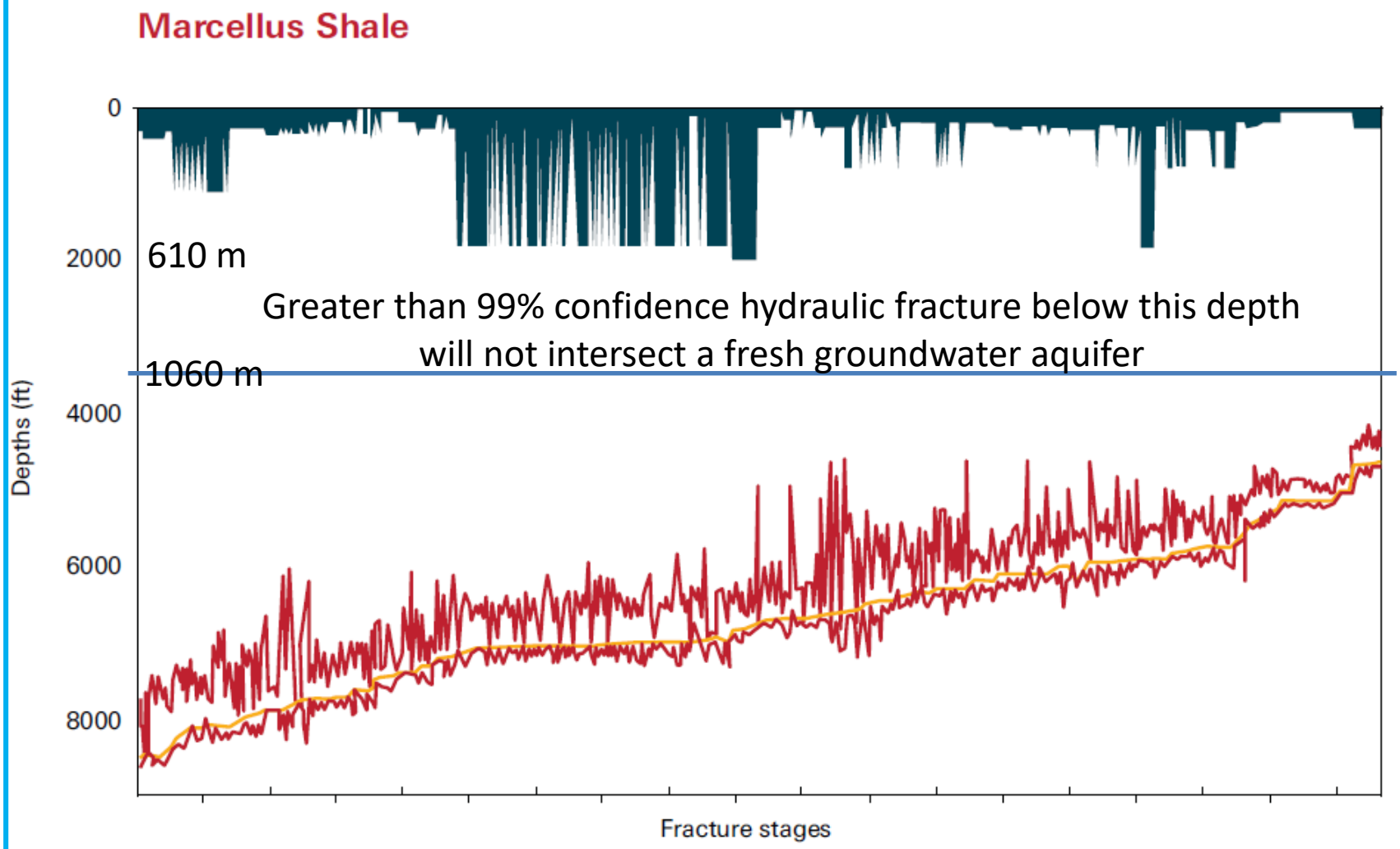
Hydraulic Fracture Propagation

Fisher and Warpinski (2011) - Microseismic Data for 12,000 hydraulic fracture simulations, Barnet example below

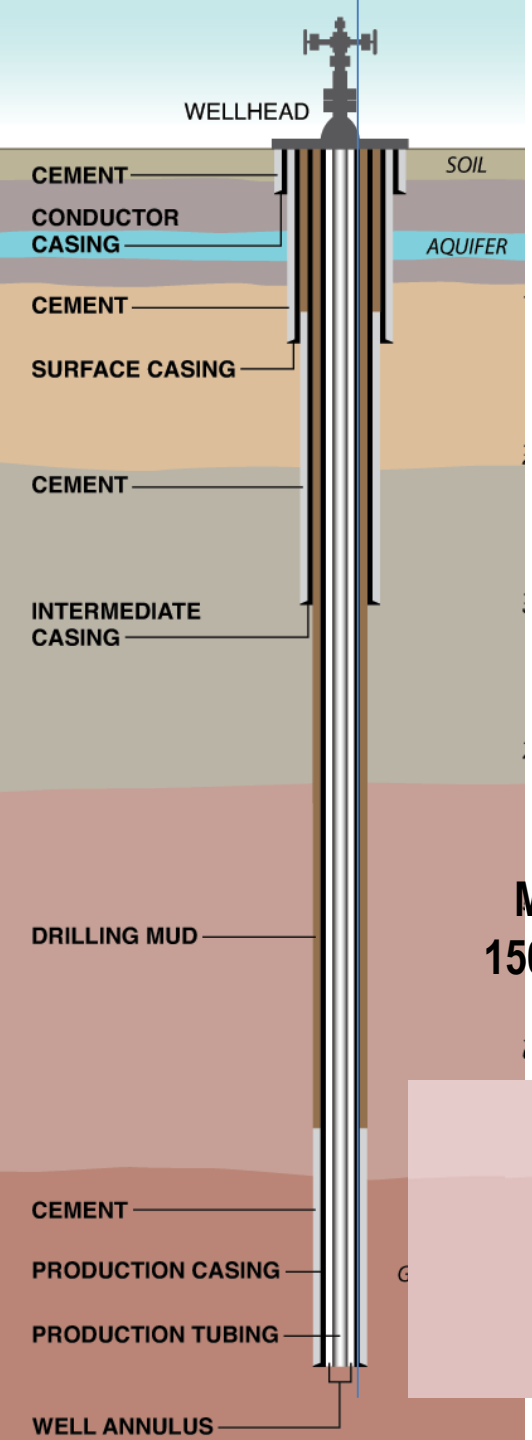


From: Fisher and Warpinski (2011), SPE 145949

Hydraulic Fracture Height Growth



From: Davies et al. (2012), Marine and Petroleum Geology, 37:1-6
In Royal Society (2012)



Basin Depths

Montney
1500-3500m

Cordova
1500-2300m

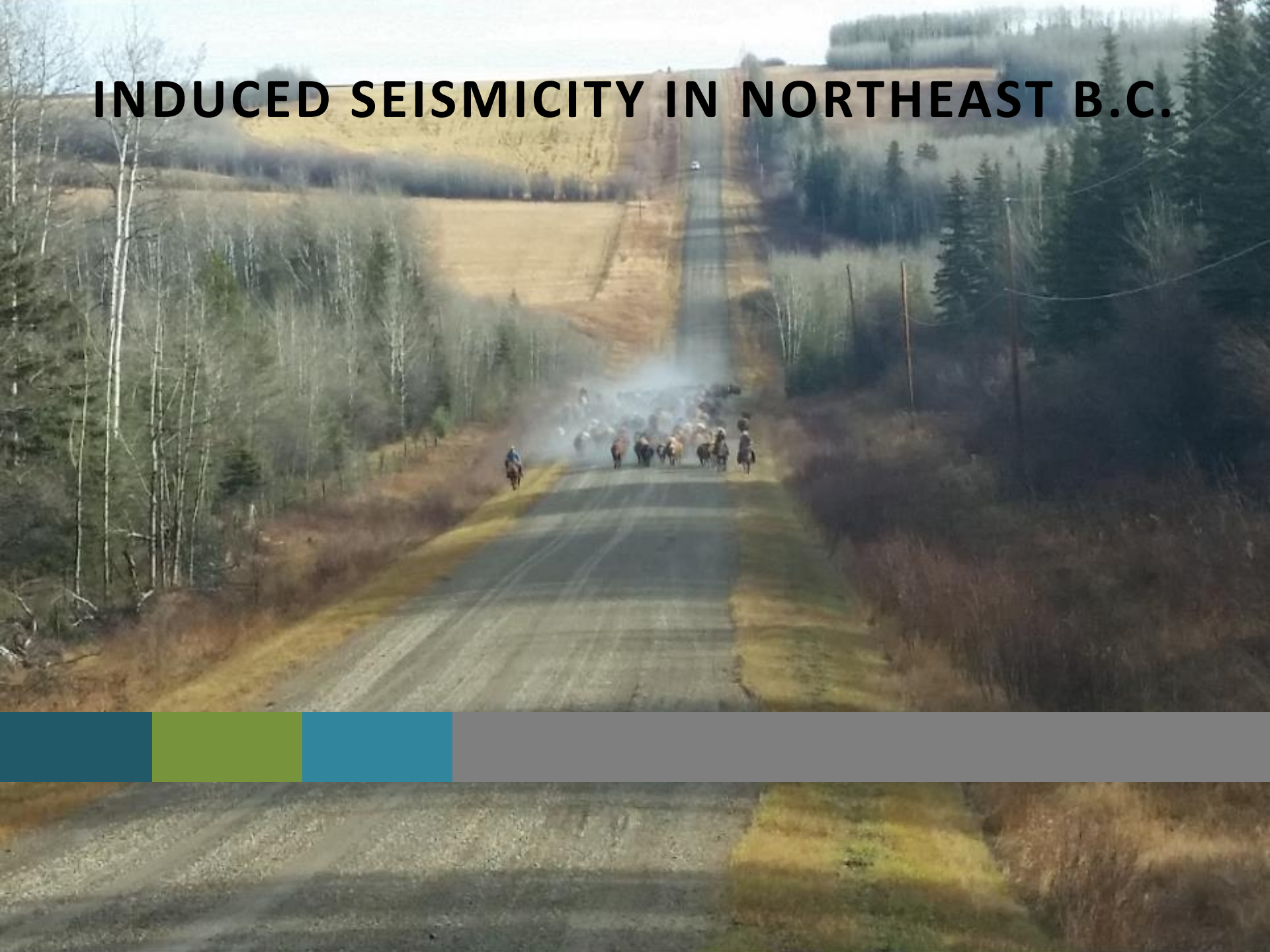
Horn River
2200-3100m

Liard
3000-3900m

Research Conclusions – Fracturing Risk to Groundwater

- **"there is no known case of migration of HF fluids from the deep shale zone to the groundwater level directly through the overburden rock"** (Canadian Council of Academies, 2014)
- "***Fracture propagation is an unlikely cause of contamination.*** *The risk of fractures propagating to reach overlying aquifers is very low provided that shale gas extraction takes place at depths of many hundreds of metres or several kilometres*." (The Royal Society: Royal Academy of Engineering, 2012)
- "*The characteristics of sedimentary basins in which black shales are located do not allow for rapid upward migration of HF fluid or brine over short timescales. Overall, the rapid upward migration scenarios that have been recently suggested …* ***are not physically plausible***". (Flewelling and Sharma, Groundwater, 2014)

INDUCED SEISMICITY IN NORTHEAST B.C.

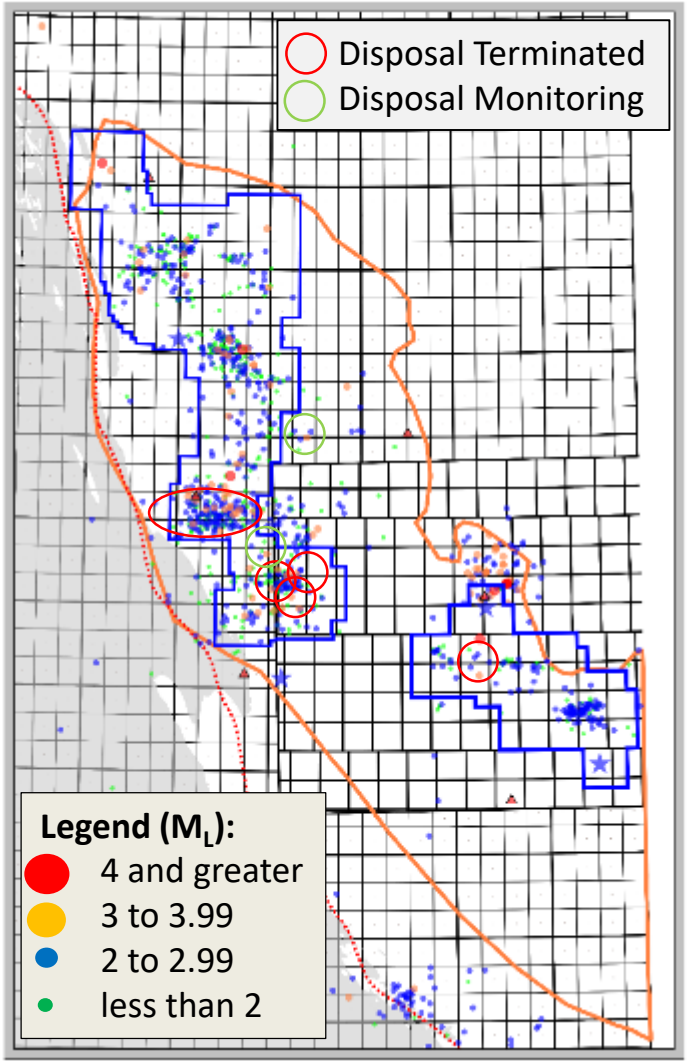


History in Oil and Gas Development

Disposal Induced Seismicity

- Not new – links identified in BC and elsewhere since the 1980's
- 110 active disposal wells in NEBC in 2015
  - 4 linked to Induced Seismicity
    - 2 have ceased operation (Graham, Pintail)
    - 2 under ongoing examination (Halfway, Septimus)
- Enhanced disposal measurement, testing and reporting requirements now in place
- Imposed limits on reservoir pressure

Disposal Oversight



In British Columbia (BC), oversight of disposal into contained reservoirs includes:

- Defined application and pre-assessment process
- Limit wellhead injection pressure below fracture gradient
- Require monthly reporting of injection pressures, volume disposed and hours of operation
- Know your fluid density and therefore the hydrostatic column pressure
- Annually measure average reservoir pressure
- Limit maximum reservoir pressure. When the limit is reached, disposal at this site ceases.

Regulatory Success:

- When small events occur, reduce injection rate and wellhead injection pressure. Events have been been minimized to less than magnitude 2.5
- Province wide, event frequency and magnitude is continuously declining

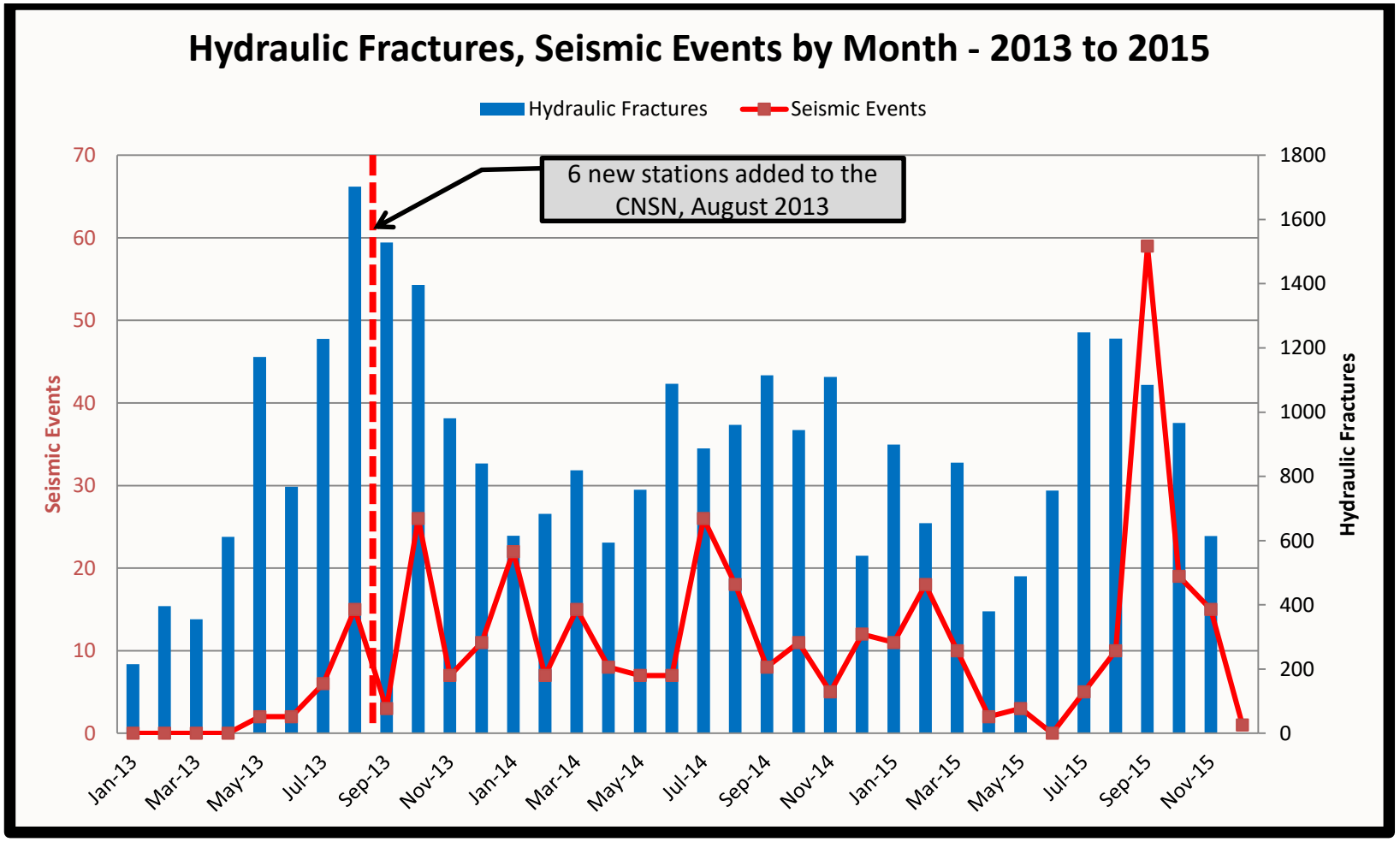
Recent Knowledge

Hydraulic Fracture (HF) Induced Seismicity

- Linkage first reported by the OGC in 2012 (Horn River)
- Identified in the Montney (2014 report)
- Over 26,000 fractures completed (Aug/13 – Dec/15)
- 358 NRCan recorded events in NEBC during above period (less than 1.5% of fractures)
  - 17 HF-induced events >M3.0 recorded in NEBC (4.7% of seismic events and 0.07% of fractures)
  - 2 HF-induced events >M4.0 recorded in NEBC (0.6% of seismic events and 0.008% of fractures)
- Events infrequent and higher magnitude events rare.
- Duration of events is short limiting potential for infrastructure damage

Some Observations

- The number of induced events, magnitude of events and the number of HF completions do not always correlate
- Proximity to susceptible faults is key to triggering HF-induced events



Courtesy Kathryn Archibald, OGC

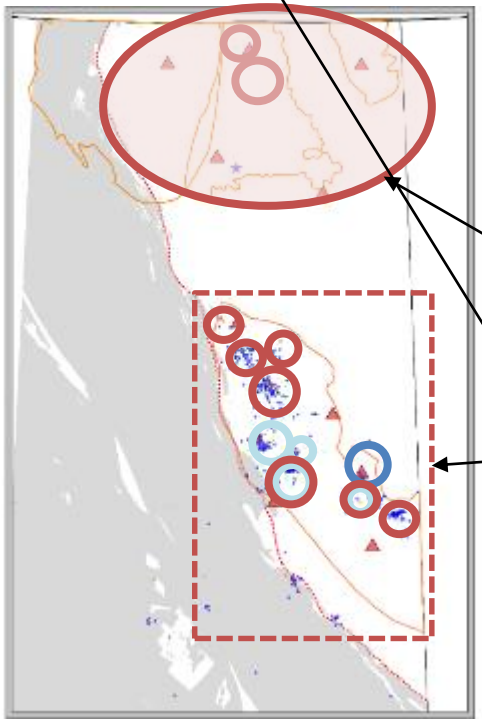
WHERE are we focused now?

2014 to 2019(Oct 1, 2019)
3 & greater M_L: 47
4 & greater M_L: 4

Event Count (≥3M_L): 47

EOR:	0 (0)	HF:	28 (4)
Disposal:	14 (0)	HF/Disp:	2 (0)
Natural:	2	Prod:	1 (0)

Suspected Cause Induced Events
- EOR
- Disposal
- Hydraulic Fracturing



Legend (M_L):
- 4 and greater
- 3 to 3.99
- 2 to 2.99
- less than 2

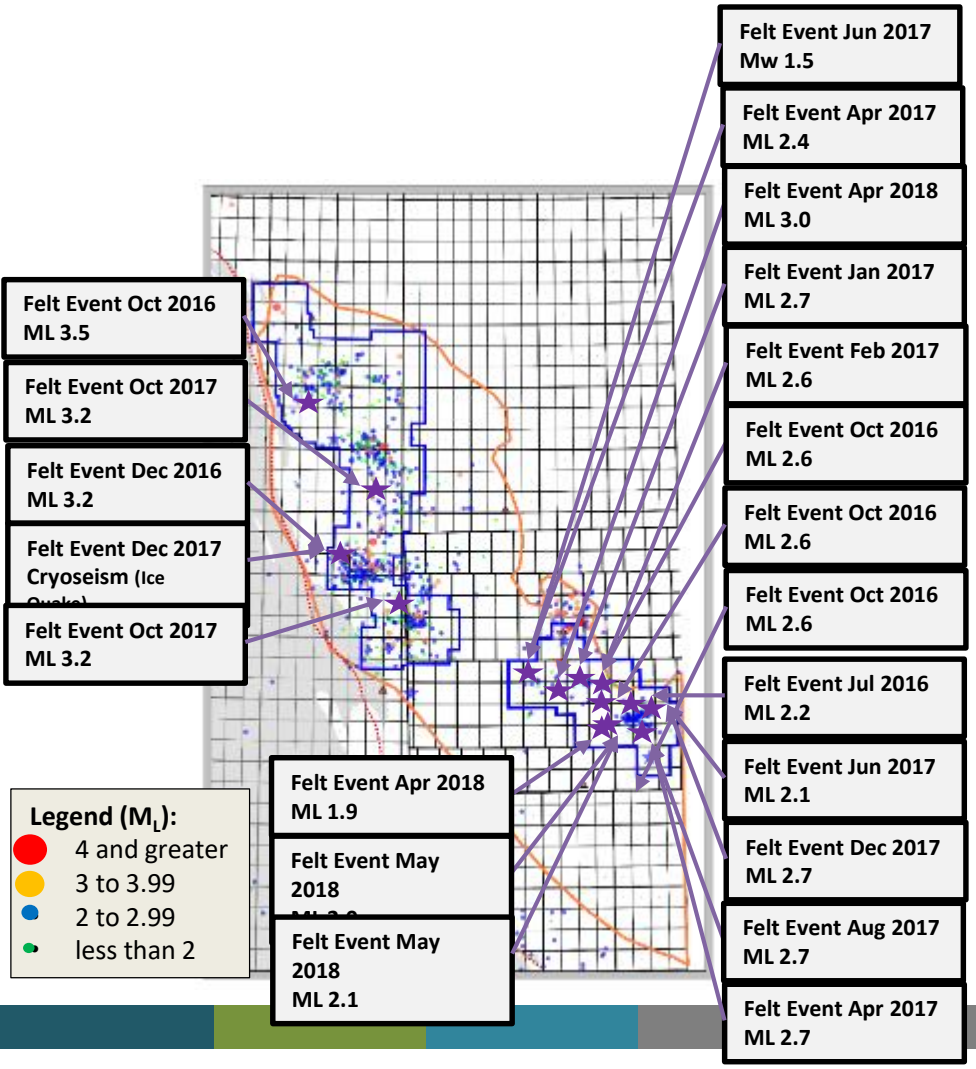
Disposal wells related to cataloged M3+ events have been shut-in due to either seismicity and/or reaching their defined operational (pressure) limits or have enhanced monitoring in place.

No significant events in Horn River Basin, which initiated induced seismicity permit conditions and regulatory enhancements

FOCUS AREA: Montney Trend

Why - FOCUS AREA: All four (4) Magnitude 4+ events have occurred in the Montney Trend due to Fracturing

WHAT is the distribution of felt events?



- Complaints logged by the Commission and followed up on by technical staff
- Qualitative analysis only possible from description
- Common descriptions:
- "There was a large bang, followed by rattling"
- "Felt rumbling"
- "House shook and windows rattled"
- "Rumble, followed by a strong thump that made dishes rattle"

Regulatory Tools

ORDERS (S. 75)

- Immediately in-place for all prescribed activities
- Quick to implement
- Can be amended to meet desired outcomes
- Localized, operator specific or broadly applied
- All Disposal wells approved via S. 75
- Example: Kiskatinaw Seismic Monitoring and Mitigation Area

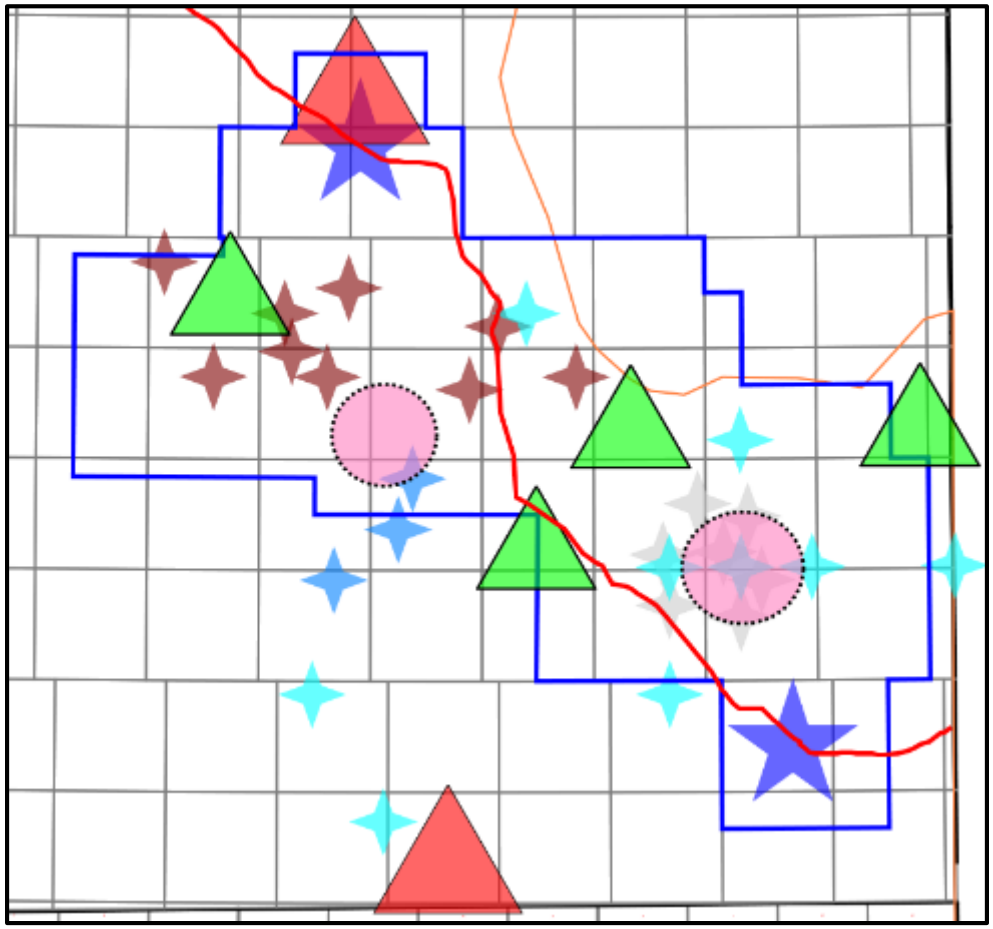
PERMIT CONDITIONS

- Situation based, go-forward for all prescribed activities
- Area specific (usually), can be regionally/provincial
- Permit conditions provide flexibility in their application
- Implementation fairly straight forward
- Can provide test case(s) for future regulation
- Example: Ground Motion Monitoring Areas

REGULATION

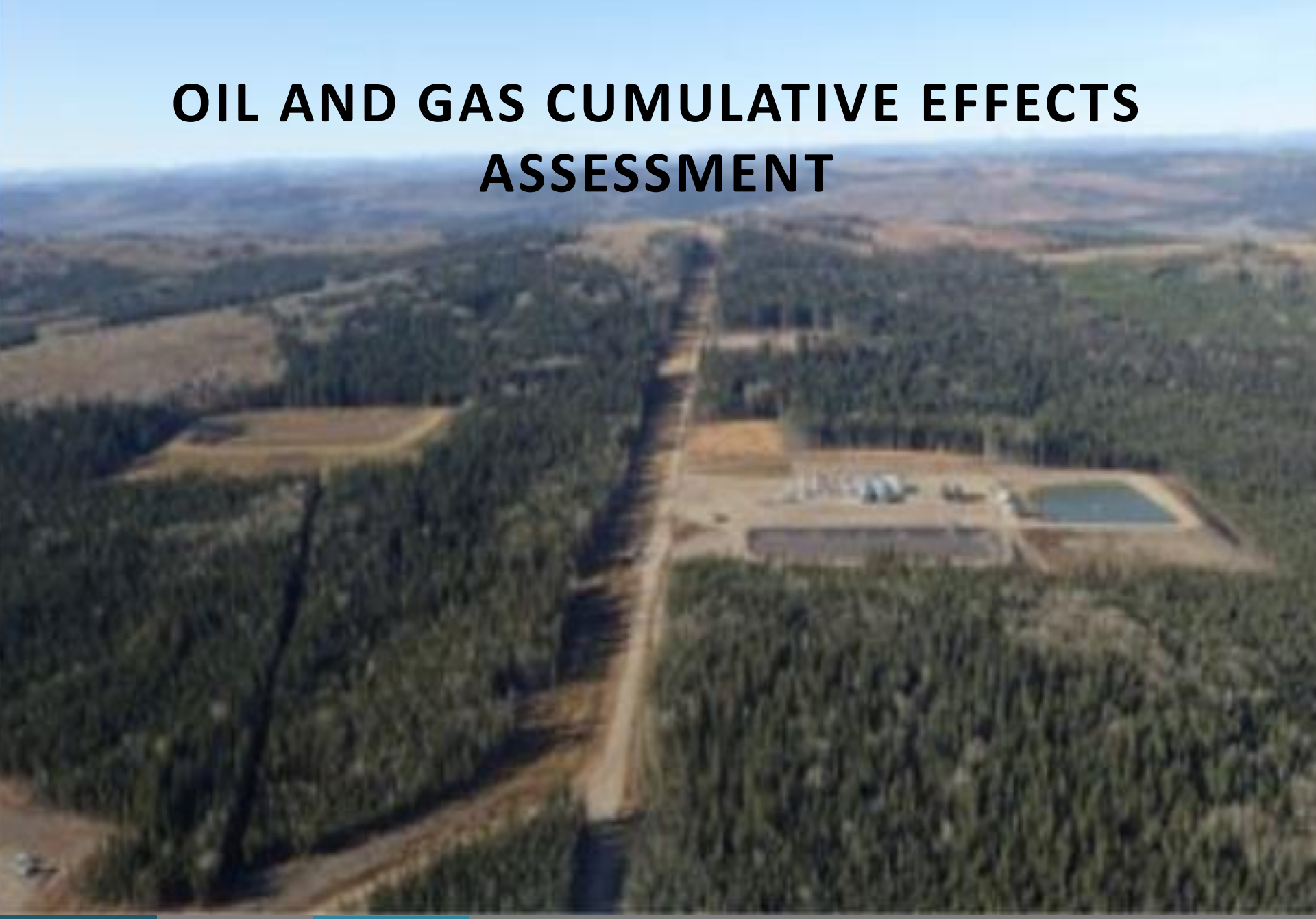
- Permanent rule – monitoring ; suspend fracturing at threshold magnitude
- In-place from time of being deposited and applies to all activities
- Introduction and implementation involves full regulatory process and drafting
- Example: Drilling and Production Regulation (Specifically Sec 21.1)

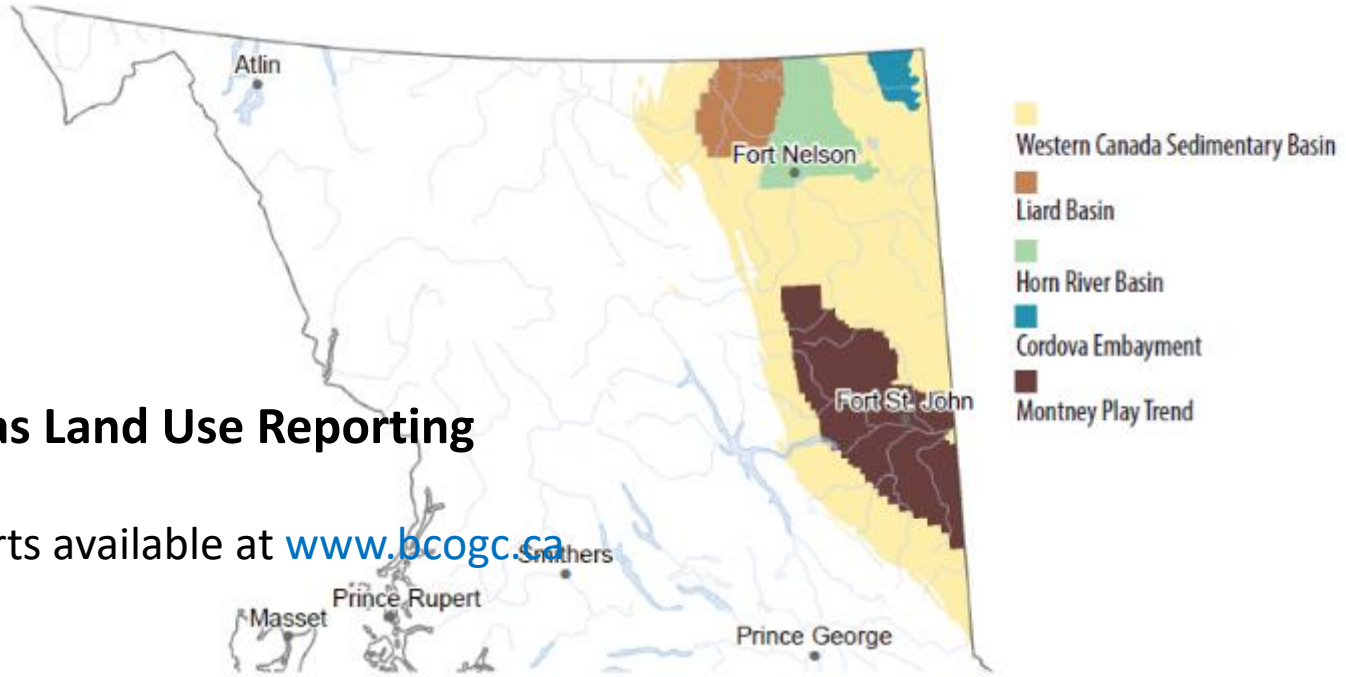
Kiskatinaw Seismic Monitoring and Mitigation Area



- Enhanced communication with residents
- Submission of seismic monitoring and mitigation plan including a seismicity risk assessment
- Notification within 24 to 72 hours of commencement of operations
- Deployment of accelerometer within three km of pad
- Real-time seismicity monitoring
- A reduced magnitude threshold for suspension of operations (3.0 ML)
- Minimum level for activation of mitigation plan
- Requirement to report all events 1.5 ML and greater to the Commission
- Possible shut in resulting from clusters of events

OIL AND GAS CUMULATIVE EFFECTS ASSESSMENT





- **Oil and Gas Land Use Reporting**

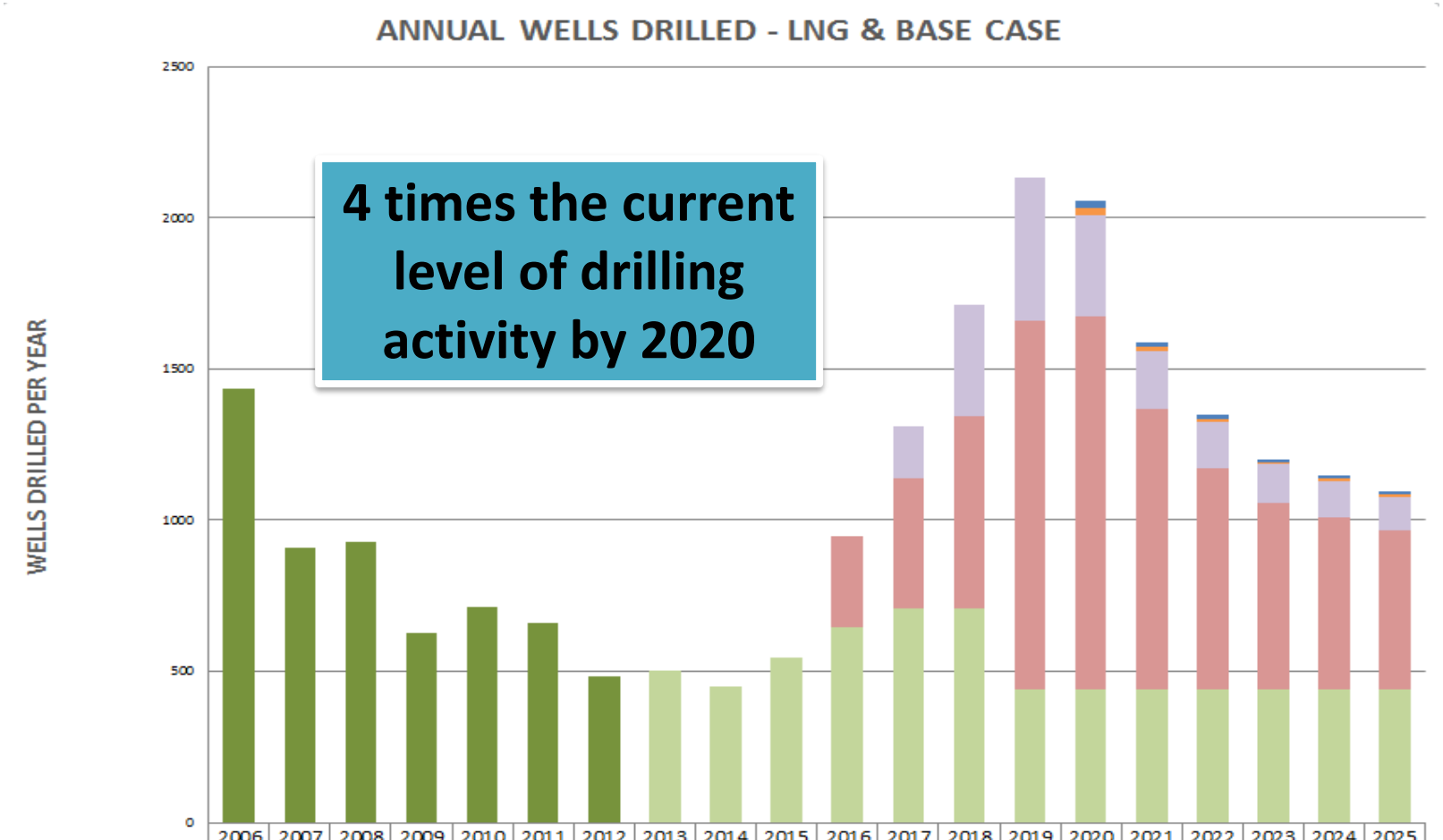
  reports available at www.bcogc.ca

Table 4: Surface Area Used for Oil and Gas Activities by Geological Formation

Activity	Western Canada Sedimentary Basin (ha)	Per cent of Western Canada Sedimentary Basin	Liard Basin (ha)	Per cent of Liard Basin	Horn River Basin (ha)	Per cent of Horn River Basin	Cordova Embayment (ha)	Per cent of Cordova Embayment	Montney Play Trend (ha)	Per cent of Montney Play Trend
Wells **	30,207	0.22	367	0.04	1,240	0.11	499	0.16	13,628	0.46
Roads **	83,454	0.62	3,613	0.39	6,490	0.57	2,974	0.94	25,352	0.85
Facilities **	1,543	0.01	45	0.005	286	0.02	16	0.01	739	0.02
Pipelines **	43,785	0.33	1,177	0.13	2,630	0.23	1,182	0.37	16,749	0.56
Other Oil & Gas Infrastructures **	12,683	0.09	507	0.05	3,838	0.33	347	0.11	5,356	0.18
Geophysical Exploration (seismic lines)	227,497	1.69	7,208	0.78	23,941	2.09	5,634	1.78	67,381	2.26
Basin Area	13,450,458		934,304		1,145,989		315,867		2,985,906	
Total Area Used for Oil and Gas Activities **	399,169	2.97	12,989	1.39	38,425	3.35	10,651	3.37	129,205	4.33
Net Area** Used for Oil and Gas Activities	375,111	2.79	11,939	1.28	36,474	3.18	9,735	3.08	121,950	4.08

* The net area occurs when the area shared by overlapping permit types is removed.
** The total area occurs when the area shared by overlapping permit types is not removed.

LNG Development Forecast - Wells Drilled

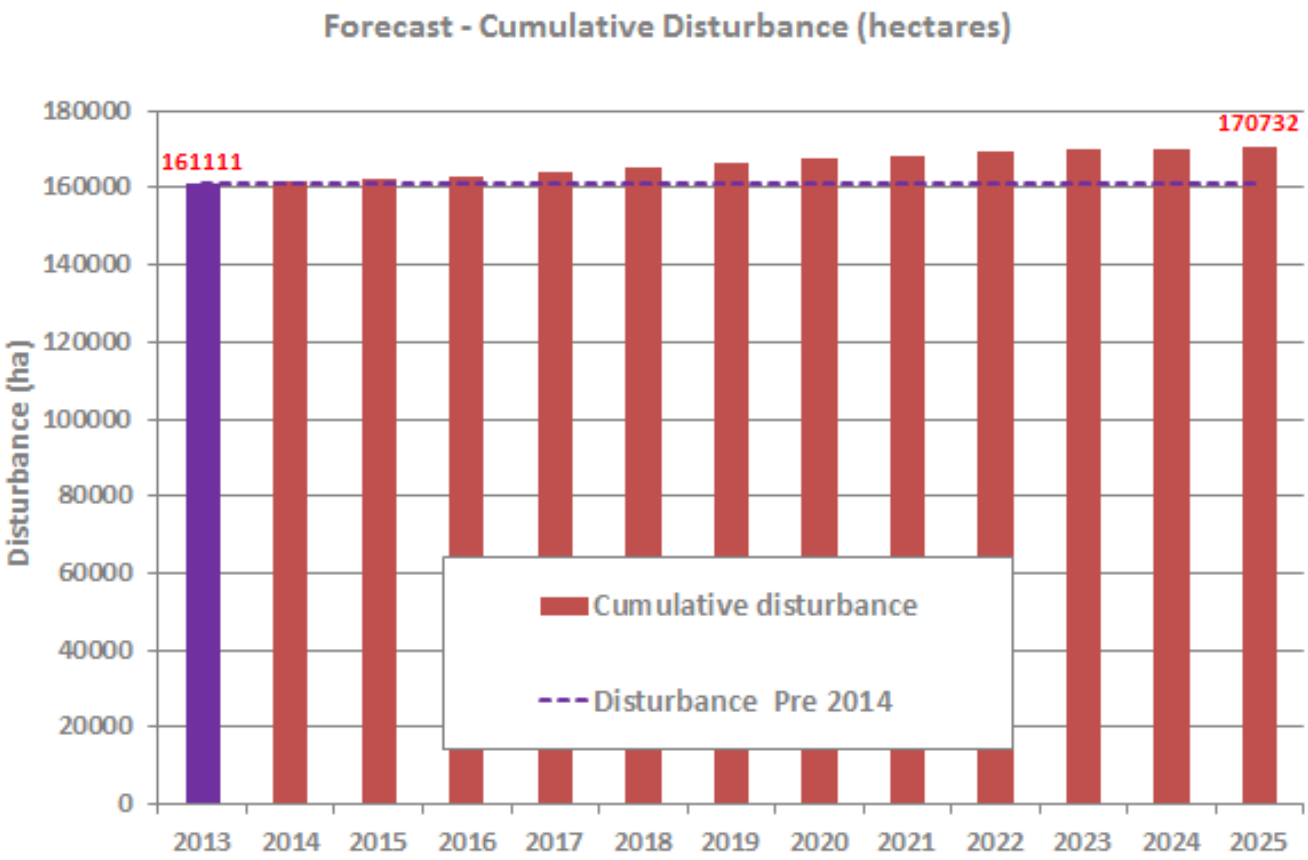


	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
LNG CORDOVA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	14	11	9	9	8
LNG LIARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	14	11	9	8	8
LNG HORN RIVER	0	0	0	0	0	0	0	0	0	0	0	175	365	474	334	191	151	127	119	111
LNG MONTNEY	0	0	0	0	0	0	0	0	0	0	300	429	638	1217	1232	930	734	617	570	526
BASE CASE	1435	908	929	626	713	661	483	503	448	544	645	708	708	440	440	440	440	440	440	440

LNG Development Forecast - Cumulative Disturbance (Wells + Pipelines + Roads)

2013 Base Disturbance Level Up 6% by 2025

NEBC 17.5 million ha

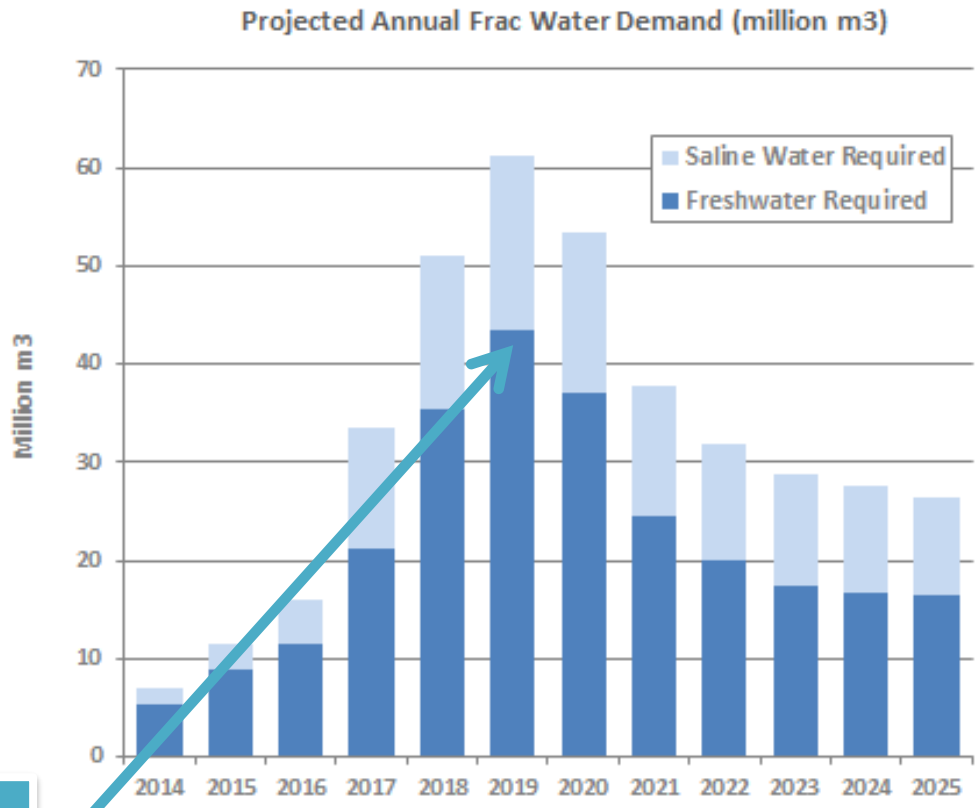


Hydraulic Fracturing Water Needs

Frac Water Source:

9 X current requirement by 2019

20% Saline
60% Fresh
20% Recycled



Maximum annual fresh water requirement Less than
0.1% of mean annual surface discharge

Current Initiatives

- Regional Strategic Environmental Initiative (RSEA)
- Provincial Cumulative Effects Framework
- Regional Assessments including northeast BC
- Area Based Analysis (ABA) – OGC decision support

Questions?