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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7815

Report on the monitoring of micro-earthquakes during the hydraulic fracturing conducted in New Brunswick in August and September 2014

M. Lamontagne and D. Lavoie

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Abstract

This report examines whether the hydraulic fracturing of August and September 2014 in the McCully gas field and adjacent area produced any induced events that could be detected by the six-station seismograph array of southeastern New Brunswick. After verifying the automatic triggers of each individual station and visually scanning the nearest station to the wells where hydraulic fracturing occurred, it was found that no induced micro-earthquake occurred within the few hours during and following hydraulic fracturing operations.

Introduction

The potential for induced seismicity associated with hydraulic fracturing (HF) of shales has been studied by the Geological Survey of Canada since 2012. Most of the initial research activities were carried out in the Horn River Basin of north-eastern British Columbia where the research indicates that indeed HF was responsible for an increase in number of shallow low magnitude earthquakes (Farahbod et al, 2015). In 2012-2013, the Geological Survey of Canada installed 5 field seismographs to initiate the study of natural seismicity in the area of Sussex in southern New Brunswick and gather seismicity data at time of limited HF in the McCully gas field area.

This report examines if the hydraulic fracturing (HF) of August and September 2014 in the McCully gas field and adjacent area produced any induced events that could be detected by the six-station seismograph array of southeastern New Brunswick. This activity if part of a project on the monitoring of earthquakes potentially induced by oil and gas operations, part of the Environmental Geoscience Program of the Geological Survey of Canada. This Open File Report documents that no event [1] induced by HF was detected by the seismograph stations at the surface.

[1] In this report, we will use the following definitions (as defined in Table 2 of BC Oil and Gas Commission, 2012; p. 7):

- Micro-seismicity: Micro events of magnitude -3.0 to 0.5 (Richter magnitude scale) created when hydraulic fracturing breaks rock, including micro shear movement and tensile fracturing, not felt.
- Micro earthquake: Very small earthquakes of magnitude 0.5- 2.0 (Richter magnitude scale), not felt.

Context

During August and September 2014, HF was conducted at five wells located in the Moncton sub-basin of the Maritimes basin in southeastern New Brunswick (Figure 1 and Table 1). Fracking operations aim at stimulating natural gas production from the Hiram Brook sandstones of the McCully gas field and further testing of the potential of the Frederick Brook shale to produce natural gas. Four of the five wells had HF operations with liquid petroleum gel and one with slickwater; all the stimulations were single stage with low volume of proppant emplacement (Corridor Resources, 2014).

Corridor Resources currently produces natural gas at the McCully field near Sussex, New Brunswick (Figure 1); production is primarily from tight sandstones of the Hiram Brook Member (Albert Formation) and one well is producing from the shale of the Frederick Brook Member (Albert Formation). These wells are considered unconventional because the Hiram Brook sandstone and the Frederick Brook shale at the McCully field require HF stimulation to promote economic production. The production at McCully field is from vertical wells that were subjected to few stages – low water volume HF operations, recently propane gel was used for proppant carrying fluid (Corridor Resources, 2014).

This Induced Seismicity Research Activity, part of the Shale Gas Project of the Environmental Geoscience Program, focuses on (1) the establishment of sound scientific observations and lists of earthquakes (pre-HF to post-HF) upon which any potential links between the practice of HF and induced earthquakes, if they exist, can be assessed and studied in detail; and (2) a systematic evaluation of major shale gas basins to quantitatively characterize the likelihood of large/major earthquakes being induced by HF. New Brunswick is one area that is studied in more detail, along with other ongoing activities in British Columbia, Alberta, Northwest Territories and Quebec.

The monitoring of earthquakes potentially-induced by shale gas exploration in southeastern New Brunswick has four main objectives. The first is to document the

naturally-occurring seismicity in this area in the absence of any significant, high-volume and high-pressure HF. The second is to document the earthquake activity or absence of activity above a certain magnitude in areas where HF is performed in New Brunswick. Thirdly, the information thus obtained may guide policies related to earthquake activity induced by HF in New Brunswick and elsewhere in Canada. The fourth goal is to develop scientific methods to actively monitor the regional seismic activity, to describe the activity in space and in time and to interpret its possible connections with causative factors. This short report examines only one aspect of the whole project: can HF-related seismic events, if any, be detected with the currently-deployed seismographs in New Brunswick? Other aspects of the monitoring and of the geological and seismological context are described in Lamontagne et al. (2015).

Seismograph Network

In collaboration with the Energy Institute of New Brunswick and the New Brunswick Department of Energy and Mines, Natural Resources Canada has been operating a total of six digital broadband seismograph stations in the Moncton-Sussex sub-basin in New Brunswick (Fig. 2). In this area, seismograph station LMN (Caledonia Mountain) has been in operation since October 1981. This station is part of the Canadian National Seismograph Network (CNSN) which comprises three other stations in New Brunswick (one near Fredericton in collaboration with the University of New Brunswick (HANN), one near St. George (GGN), and one near Bathurst (BATG)). To improve the capacity to detect and locate earthquakes in the area with potential for future significant HF, it was decided to add few broadband stations to complement the CNSN. In September 2012, a station was installed at Elgin (ELNB). In October 2013, four additional broadband stations were installed (WCNB, SRNB, HKNB, SVNB). Finally, one more station near Sussex (SUSY) is operated by the Imperial College of London. That station is not located on bedrock and for this reason is not as sensitive to high-frequency ground motions in the bedrock. There, recording is only done on- site and this implies that the site must be

visited to retrieve the data. We can obtain the data following a request for specific dates/times made to Dr. Ian Bastow of the Imperial College of London.

The six-station local network encloses most of the Moncton Sub-Basin (Figure 2). Data from the array are telemetered in real time via cell phone communications and archived at the Geological Survey of Canada Centre in Ottawa. The data from these stations are publicly available via autodrm (see Appendix 1). These stations significantly enhance the monitoring capacity of seismic events possibly induced (or triggered) by local HF for shale gas exploration. Currently, in the absence of large HF program in the area, this capacity helps determine the focal depth and the magnitude of natural (tectonic) events (background seismicity). Focal depths and time variations of regional/local seismic activity are central to the analysis of a possible link between HF and seismicity. In addition to defining characteristics of the naturally occurring and potentially induced seismicity, the network could eventually be used for a scientific investigation of seismicity (3-D location, migration in space and time, relationship with injection parameters, etc).

All stations of the NRCan local network are located on bedrock at the surface and have shown to be capable of detecting small local earthquakes (events as small as Nuttli magnitude m_N 0.4 were detected) in the surroundings of the Moncton Sub-Basin. Some stations are located within a few kilometres of the wells that were recently subject to HF (Figure 2). The HF program of August-September 2014 was an ideal opportunity to verify if the HF was producing micro- to small-scale earthquakes that were sufficiently strong to be detected by one or more stations of the network.

Geological Setting

The Maritimes Basin unconformably overlies diverse Appalachian crustal zones of varying ages and composition, deformed during the Middle to Late Ordovician Taconian and Early to Mid-Devonian Acadian orogens (Calder, 1998). In Late Devonian, small

fault-bounded basins opened from the continued oblique convergence of Gondwana after the Middle Devonian Acadian Orogen (Gibling et al., 2008). These basins were either isolated or poorly connected initially; these individual basins are collectively known as the Maritimes Basin. The Moncton Sub-Basin is one of these many sub-basins within which the Horton Group (host of the McCully gas field and the shale gas target) is found in the lower part of the late Devonian-early Permian succession, near the basal unconformity over the Precambrian-early Devonian basement (St. Peter and Johnson, 2009).

Analysis

Logs of the HF experiments were provided by the New Brunswick Department of Energy and Mines (Appendix 2). The five logs provide a description of the HF (volume of proppant, pressures, etc) in addition to the dates and times of the tests (Table 1). Later on, a table with the dates and times of eight fracking operations were provided by Corridor Resources. These dates and times were used to evaluate whether any seismic activity was detected by our network following two approaches. Firstly, the automatic event detector used for routine processing of the data of the Canadian National Seismograph Network (CNSN) is applied (Wetmiller, 1998). The detector uses a conventional STA/LTA algorithm to detect seismic events in the data stream of the CNSN. The detector is implemented in the frequency domain in four spectral bands simultaneously (typically 1-3 hz, 3-6 hz, 6-12 hz and 12-15 hz) and applied to vertical-component signals from all stations. Additional criteria are applied to identify and classify local seismic events and produce plots of the triggers. Secondly, the seismograms of specific time windows were visually examined by the first author. For the time periods of the HF, he visually scanned the seismic traces of the corresponding time periods of HF to make sure that no event went undetected.

In the days around each test, the routine processing of CNSN data did not detect any signal that could correspond to a local event. In fact, no seismic event was detected by the local network during the period of the fracturing tests plus three weeks afterwards (i.e., from August 1st to October 1st, 2015). Figure 2 shows an example of triggers on individual stations that are produced daily. The first author could distinguish between a local or regional earthquake, a blast or some local noise source (Figures 3 and 4). To show that no event was detected, we also include the trigger plots for the days and times when hydraulic fracturing was done (Figures 5-12). Some triggers that raised questions were looked at in more details but all were found to be noise (Table 1).

To ensure that the automatic detector did not miss any event, we also visually scanned the traces of the seismograph closest to the wells where HF was conducted. Using Antelope[2], individual traces were scanned for a period of a few hours before and after the times of HF (Table 1). Although some bursts of background noise were noticed, nothing could be interpreted as being an earthquake or a blast. For some of these noise events, we checked the records of nearby stations and found nothing that could be correlated between stations. In general, it can be then assumed that the noise bursts were from sources close to the seismograph stations (wind, walkers, machinery, etc).

Conclusions and recommendations

In conclusion, the HF stimulation of 5 wells in the McCully gas field area in August and September 2014 did not produce any induced micro-earthquake that could be detected by our seismograph stations located at the surface on bedrock. Careful scanning of the traces did not show any events that could be linked to the HF of rocks that occurred within a few kilometre hypocentral distances.

[2] Antelope is an integrated collection of programs for data collection and seismic data analysis. It was developed by Boulder Real Time Technologies.

Most stations of our local network have a relatively low background noise level and, during the period September 2013 to January 2015, the network proved that it is capable to detect earthquakes above magnitude 1.0 in this general area. Additional stations could detect smaller earthquakes and the additional data could help the analysis of the earthquakes.

The six-station network is designed to detect micro-earthquakes which are defined as events between magnitude 0.5-2.0 (BC Oil and Gas Commission, 2012). For this reason, it cannot detect microseismic events (magnitude smaller than 0.5) caused by HF. HF events are extremely small releases of energy and our stations at the surface are located at a few kilometre distance from the sources. It is likely that the little energy that is released gets attenuated before it reaches our stations. For HF events, magnitudes are typically in the negative magnitude range. As a consequence of the complicated local geology, seismic velocities vary dramatically in this region which could contribute to the scattering of the seismic energy. Second, the source mechanism of hydraulic fracturing events (extension of a fracture) is known to produce high P and small S amplitudes. It is not certain that we could recognize such events, especially if they are of small amplitudes, barely above the background noise. Finally, our broad band stations may not have the ideal band width to monitor microseismicity which have very high frequency seismic events. The network, however, is very well capable of detecting micro-earthquakes (magnitude ≥ 1.0) in the area.

Acknowledgments

We thank Honn Kao of GSC-Pacific for his review of the initial manuscript. We extend our gratitude to Veronika Peci, seismological analyst at the GSC, for her dedicated work at analyzing New Brunswick earthquakes; Tim Côté of the GSC for his help in analysing seismograph data; the members of the New Brunswick Energy Institute and the New Brunswick Department of Energy and Mines for their support; the technologists Canadian

Hazards Information Service (CHIS); and the owners and employees of the properties where our stations are located.

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Wetmiller, R.J. 1998. ULF--The Unlocated Local Seismic Event Filter. Abstracts of the 1997 Eastern Section of the Seismological Society of America, Seismological Research Letters, 69: 86.

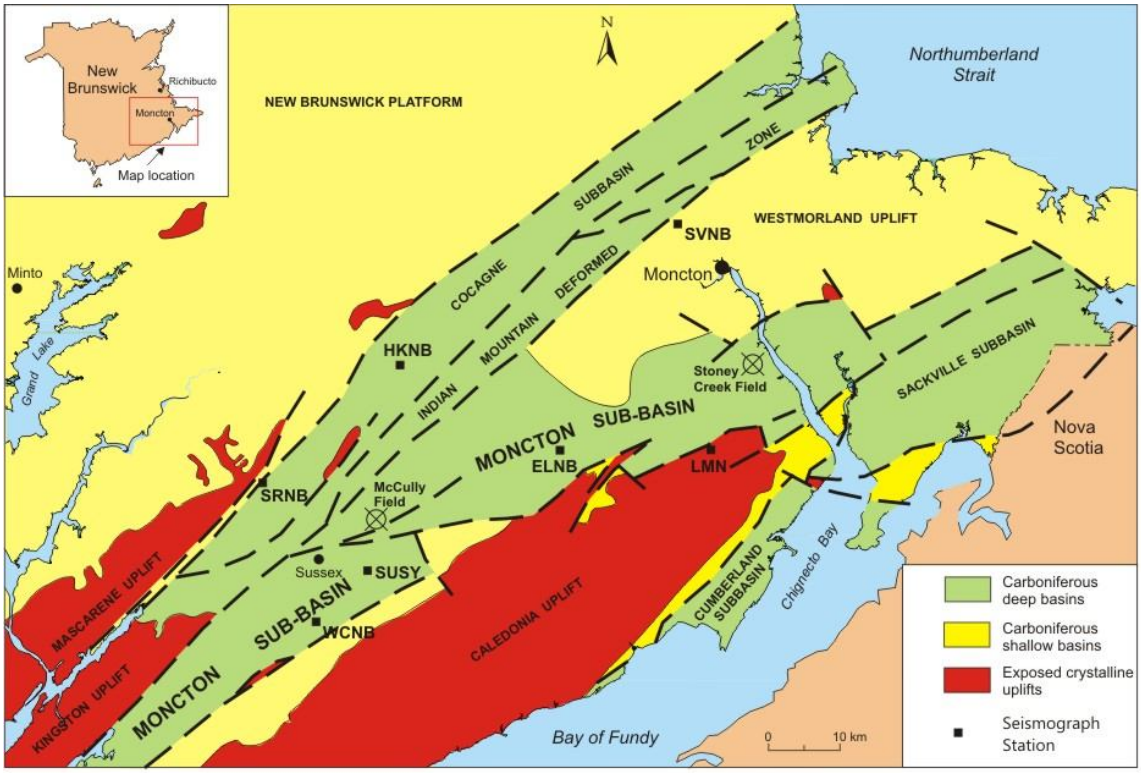


Figure 1. Simplified geological map of the Moncton Sub-Basin in southern New Brunswick. The map illustrates the complex relationships between the late Devonian-early Permian succession and the crystalline basement uplifts. The Stoney Creek (oil) and McCully (gas) fields are shown. Locations of the SE NB seismograph stations are also shown. Modified from St. Peter and Johnson (2009).

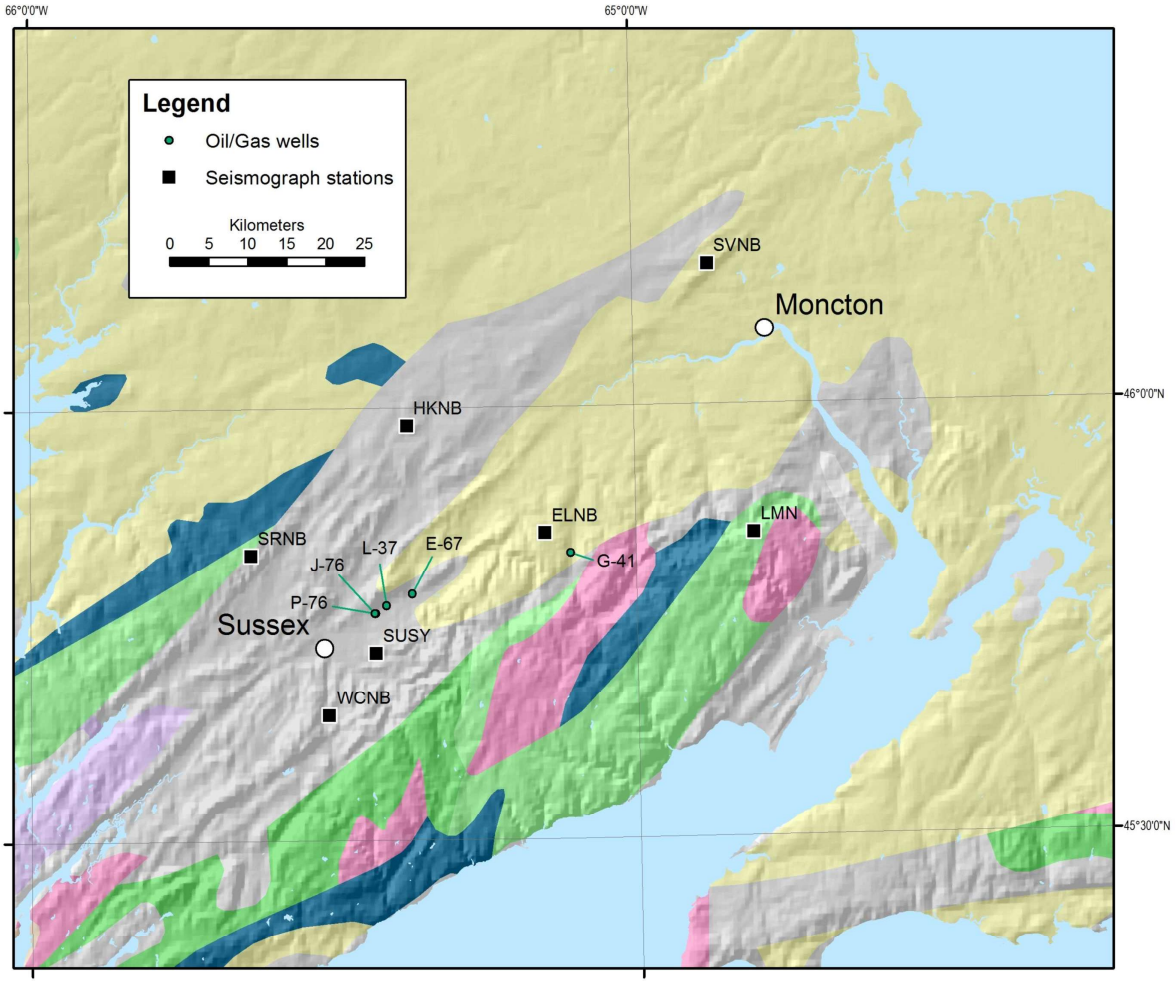


Figure 2: Location of the Moncton sub-basin, the seismograph stations mentioned in text and the wells listed in Table 1.

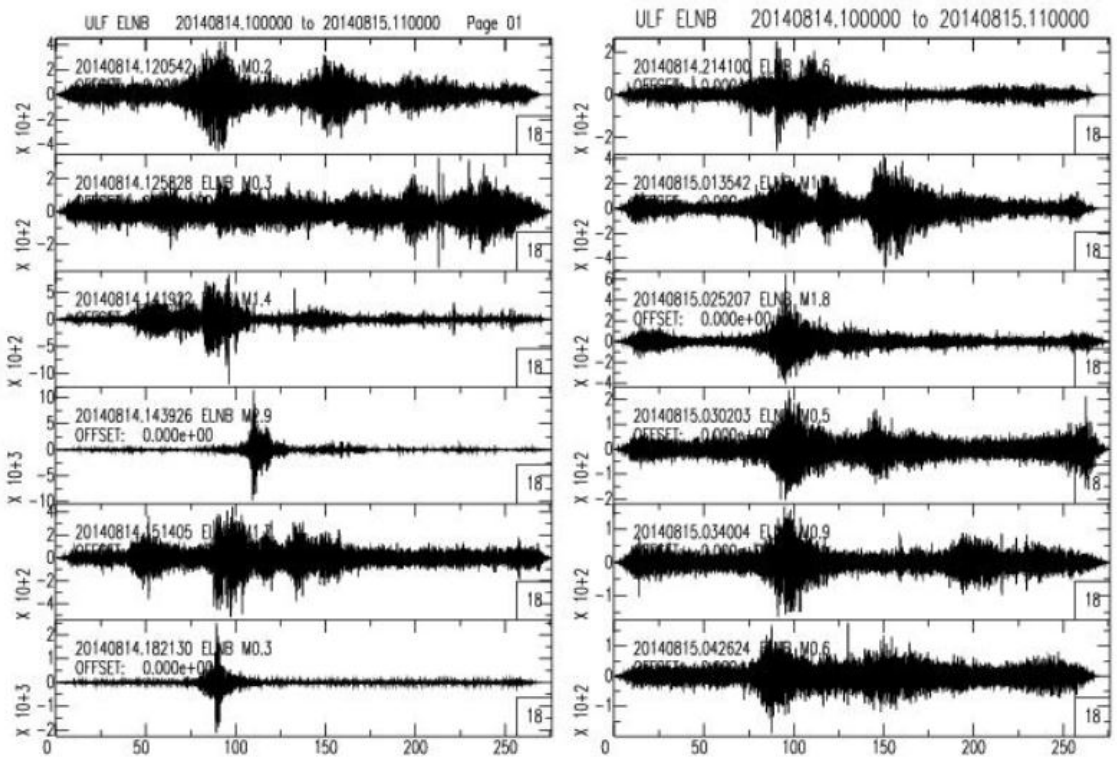


Figure 3: Example of a plot of the triggers at station ELNB for the time period 20140814.1000 UT to 20140815.0426 during which HF was done (Table 1). For each plot, the time of the trigger is shown in the top left corner. These plots are created daily. All of the triggers above are noise bursts. The X axis represents the time in seconds from a given starting time that attempts to put the trigger at about 80 seconds. The Y axis is the number of counts but each trace will be scaled to occupy the maximum height of the window.

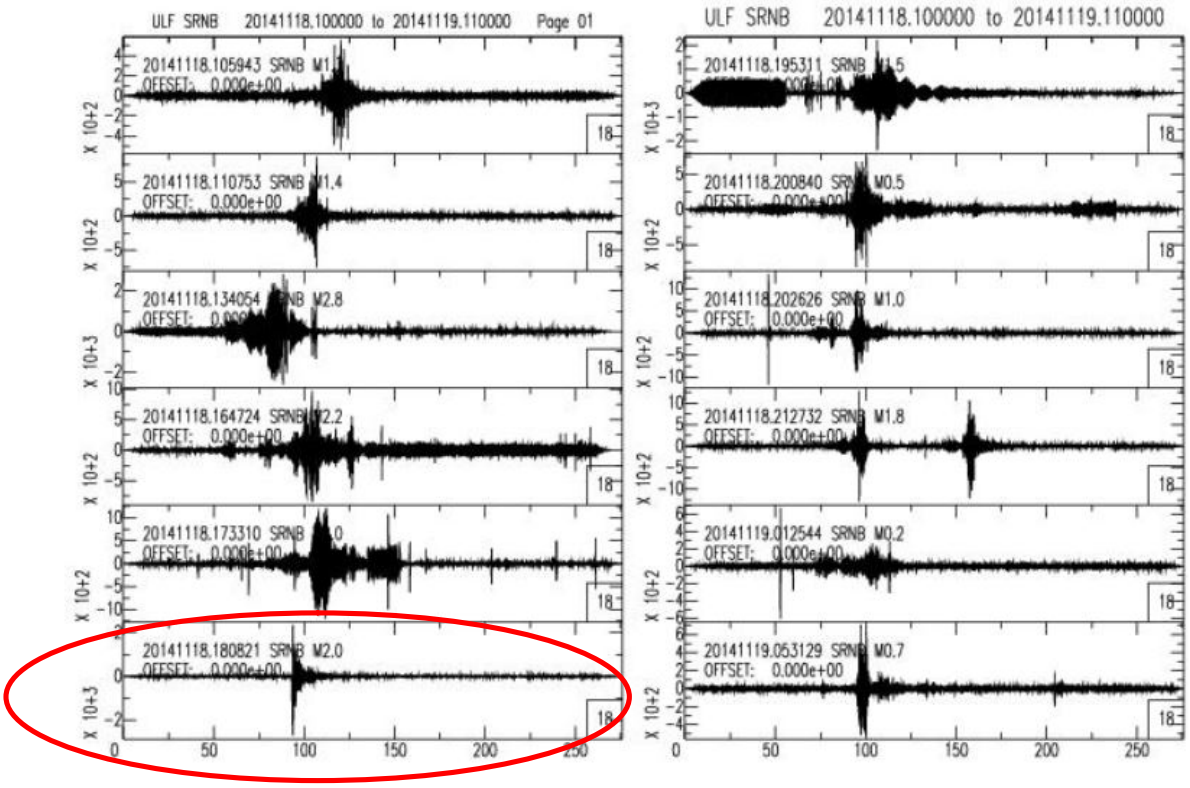


Figure 4: Example of a plot of the triggers at station SRNB for the time period 20141118.1000 UT to 20141119.0531. A real event can be seen for the trace 20141118.180821. This magnitude 1.4 event in November 2014 located some 14 km N of Sussex was also detected by the other nearby stations. All other triggers are noise bursts. See Figure 3 for a description of the trigger times and of the X and Y scales.

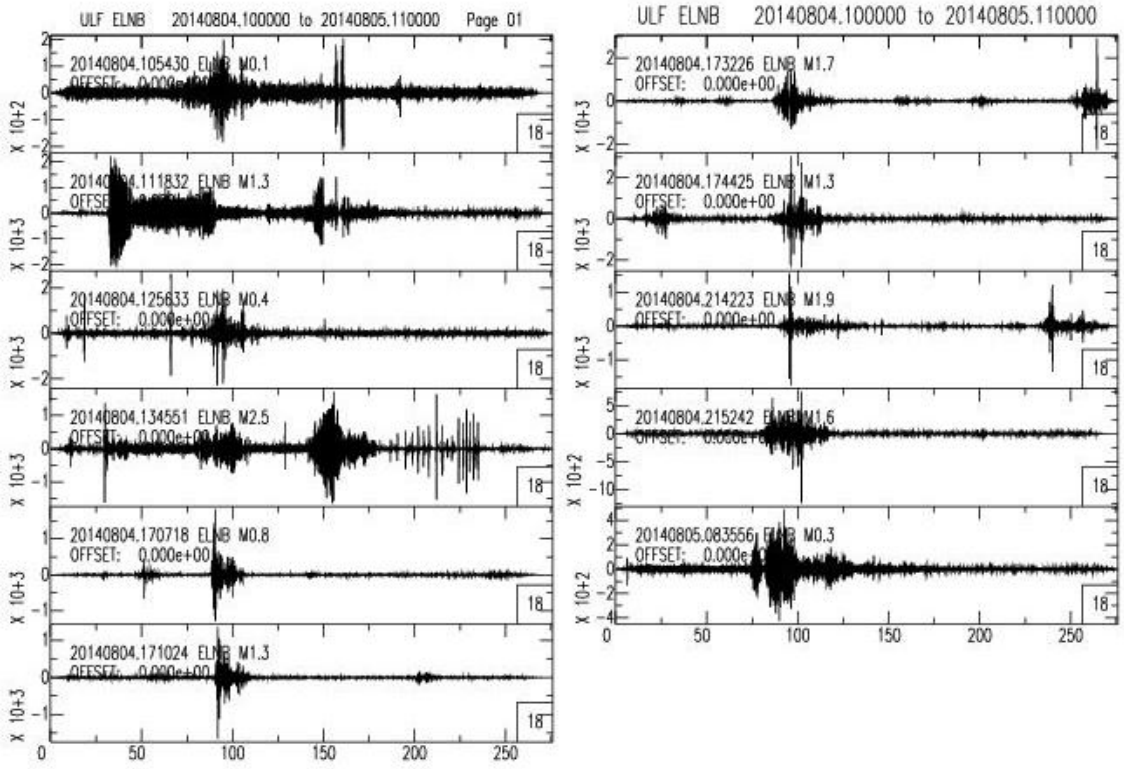


Figure 5: Trigger plot for station ELNB for the period 20140804.1000 to 20140805.1100. All triggers are noise bursts. See Figure 3 for a description of the trigger times and of the X and Y scales.

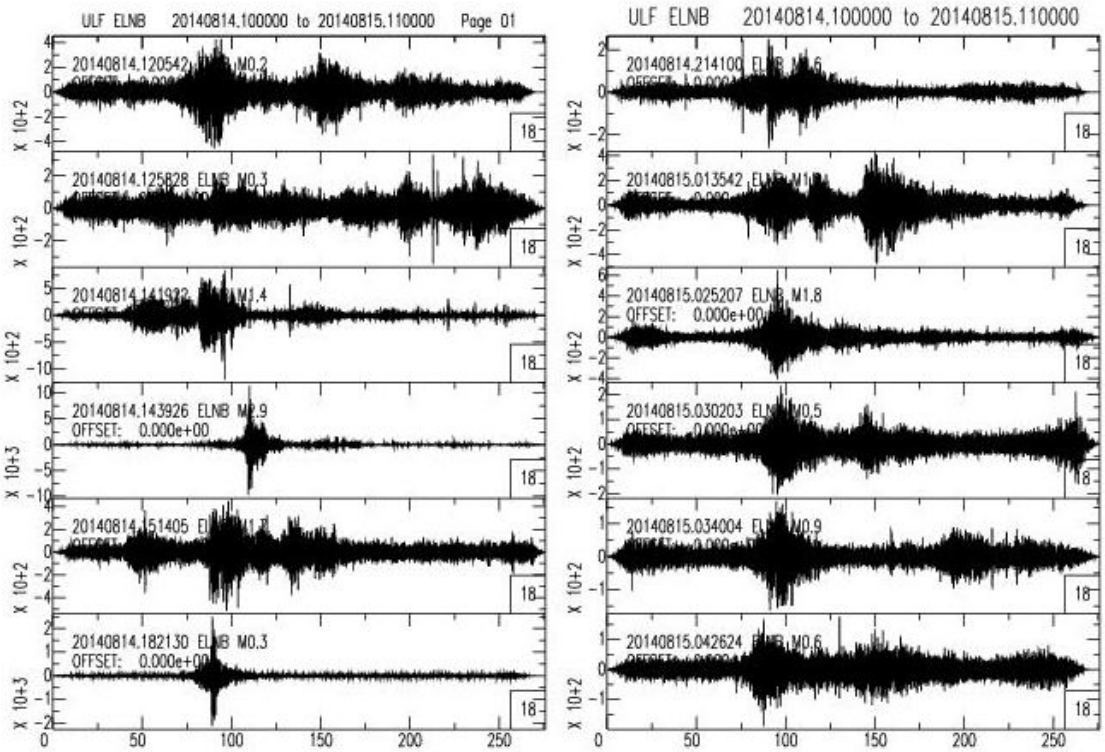
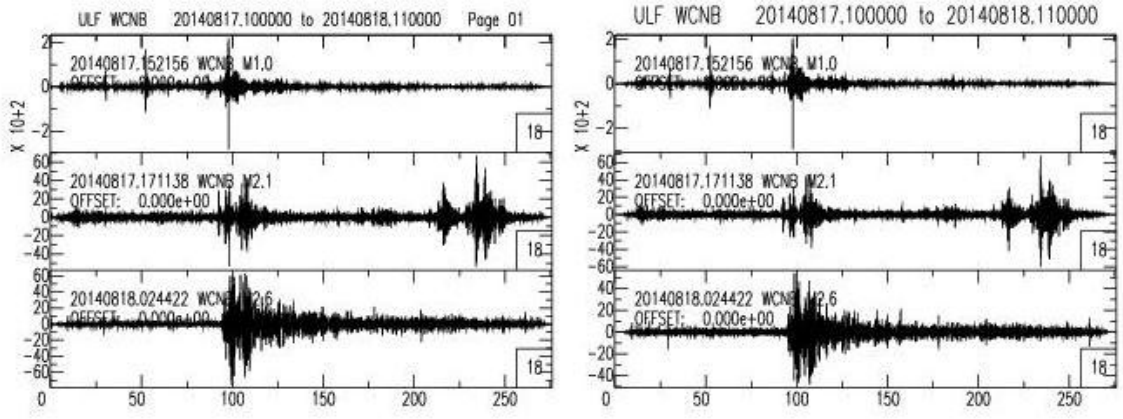


Figure 6: Trigger plot for station ELNB for the period 20140814.1000 to 20140815.1100. All triggers are noise bursts. See Figure 3 for a description of the trigger times and of the X and Y scales.




```
XV  20140817.100000 WCNB   407 30 3 NB
```

```
ULF 20140817.152156 WCNB 1.0 sei34
ULF 20140817.171138 WCNB 2.1 sei17
ULF 20140818.024422 WCNB 2.6 sei35
```

Figure 7: Trigger plot for station WCNB for the period 20140817.1000 to 20140818.1100. All triggers are noise bursts. The trigger at 02:44 wqas caused by a magnitude 6.2 earthquake in Iran. See Figure 3 for a description of the trigger times and of the X and Y scales.

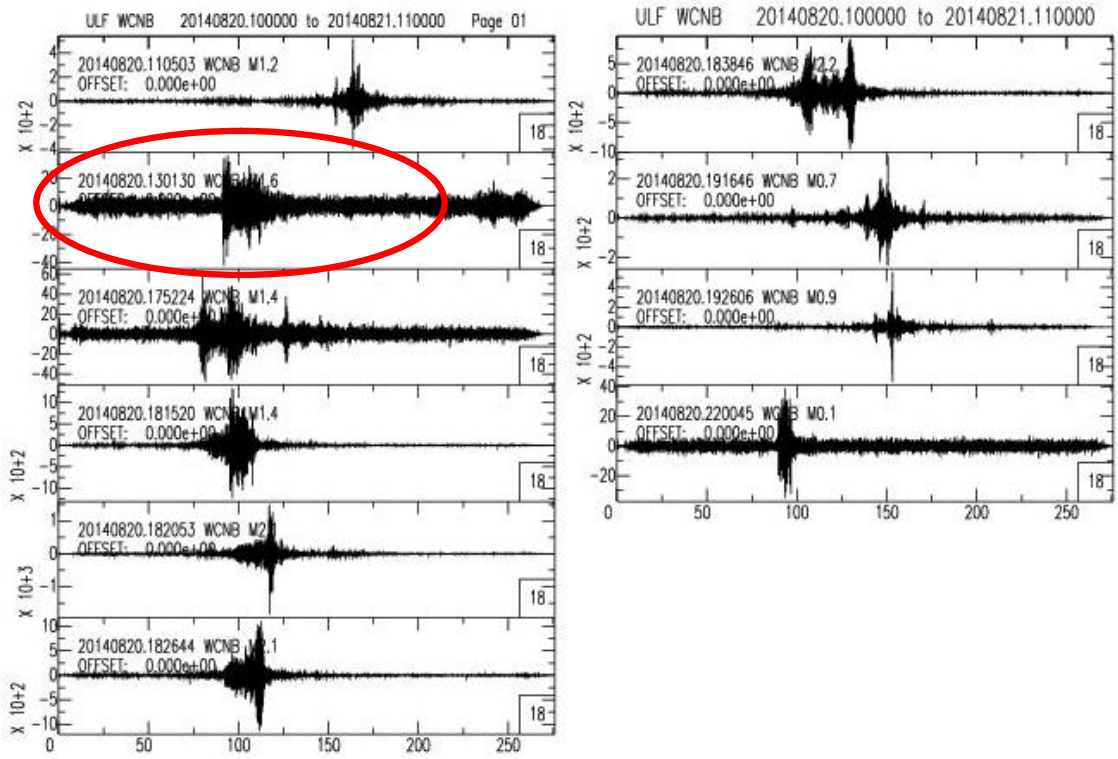
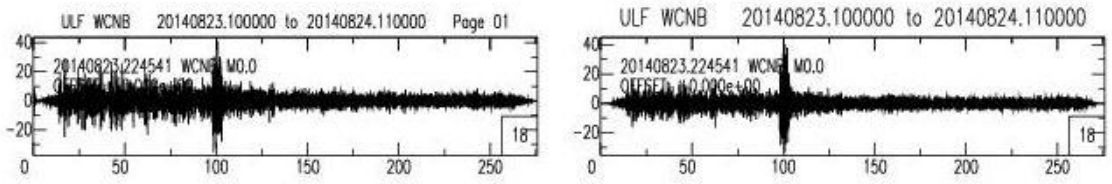


Figure 8: Trigger plot for station WCNB for the period 20140820.1000 to 20140821.1100. All triggers are noise bursts except the trigger at 13:01 which was caused by a blast near Moncton. See Figure 3 for a description of the trigger times and of the X and Y scales.




```
XV  20140823.100000 WCNB   174 5 1 NB

ULF 20140823.224541 WCNB 0.0 sei20
```

Figure 9: Trigger plot for station WCNB for the period 20140823.1000 to 20140824.1100. The trigger is a noise burst. See Figure 3 for a description of the trigger times and of the X and Y scales.

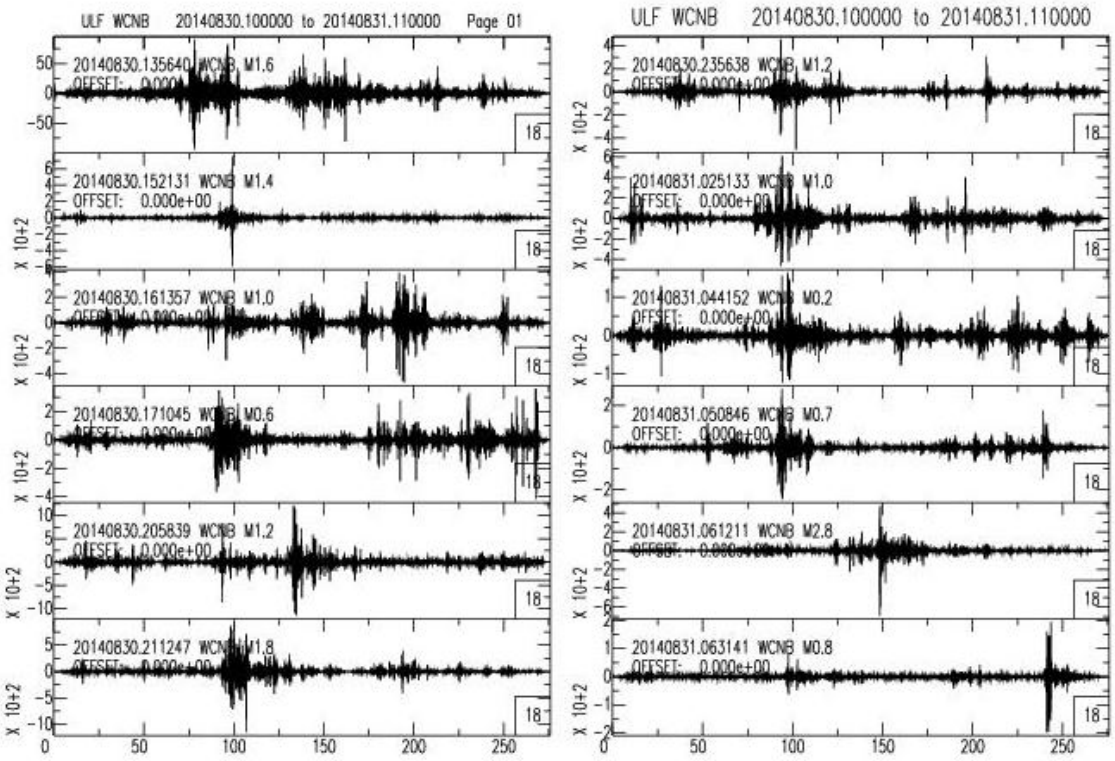


Figure 10: Trigger plot for station WCNB for the period 20140830.1000 to 20140831.1100. All triggers are noise bursts. See Figure 3 for a description of the trigger times and of the X and Y scales.

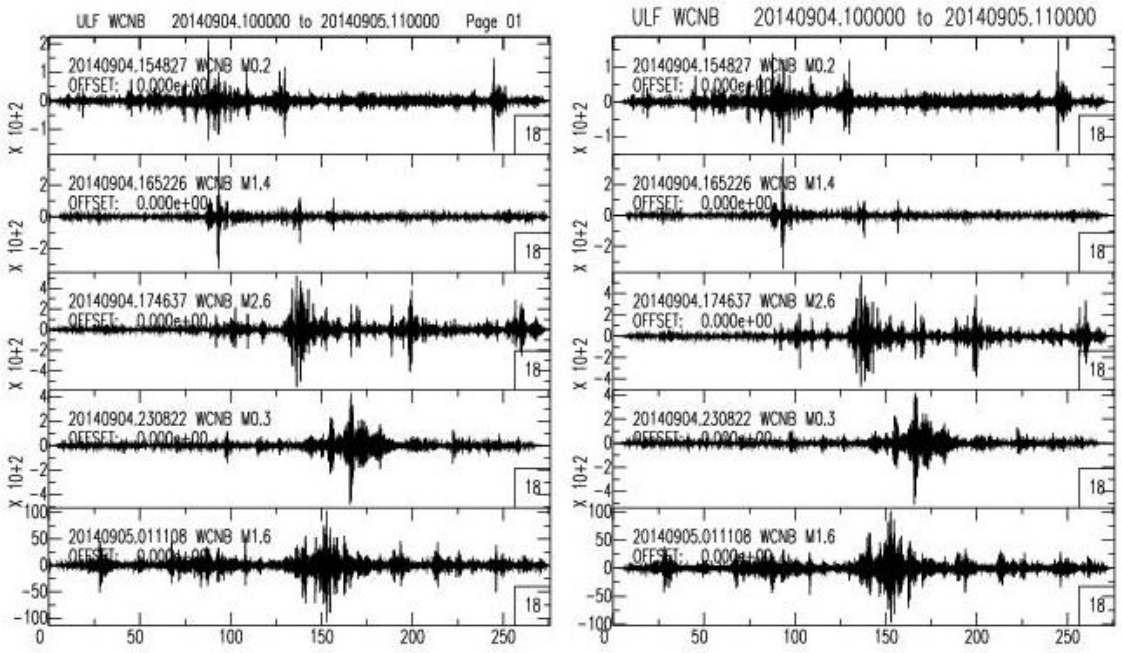


Figure 11: Trigger plot for station WCNB for the period 20140904.1000 to 20140905.1100. All triggers are noise bursts. See Figure 3 for a description of the trigger times and of the X and Y scales.

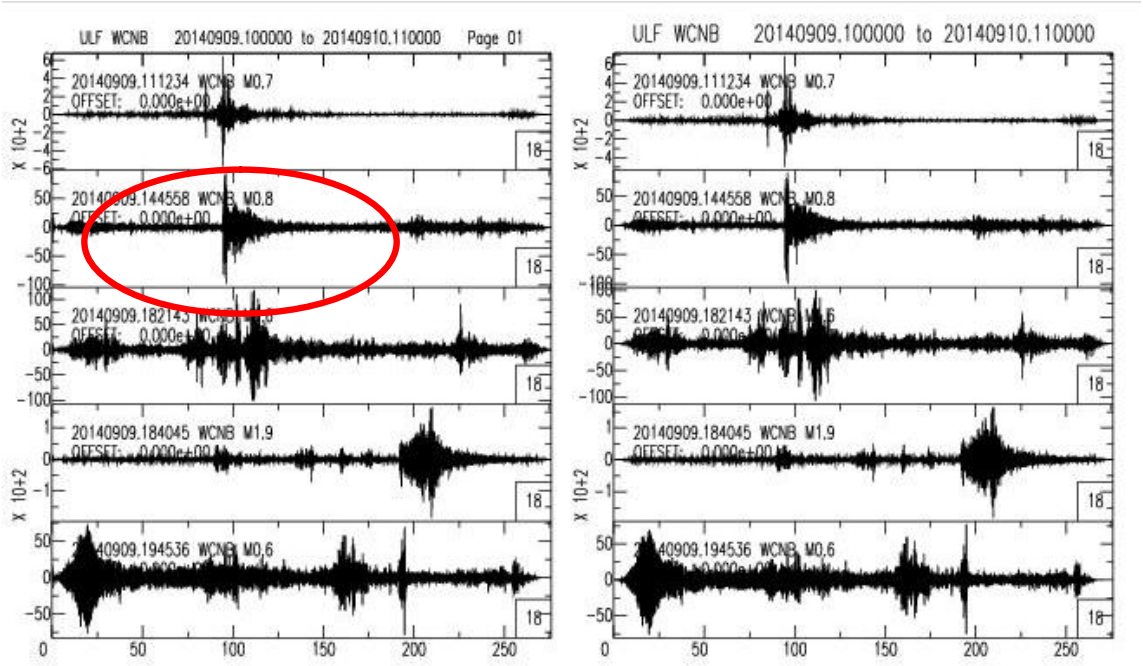


Figure 12: Trigger plot for station WCNB for the period 20140909.1000 to 20140910.1100. The event at 14:45 is a blast located at Havelock Quarry. All other triggers are noise bursts. The left and right columns are the same events. See Figure 3 for a description of the trigger times and of the X and Y scales.

No.	Log	Well/Pad	Depth (m)	Fluid type	Start Date (AST)	Start time (AST)	Fracturing Start – End Times (AST)	End Date (AST)	End time (AST)	Nearest station	Approximate Distance (km)	Search Start Julian Day-Time (UT)	Search End Julian Day-Time (UT)
1	No	B41/Elgin G41	1956	--	2014-08-04	00:00	17:16-17:46 (20:16-20:46 UT)	--	--	ELNB (no triggers; Figure 5) 20:20:30-20:23:30 no signal on ELNB (nothing on WCNB)	3	216-20:00	216-22:00
2	Yes	B41/Elgin G41	1833	LPG	2014-08-14	00:00	14:57-15:36 (17:57-18:36 UT)	2014-08-14	24:00	ELNB (no triggers; Figure 6)	3	195-00:00	196-12:00
3	No	L-37/D48		--	2014-08-17	?	11:18-15:07 (14:18-18:07 UT)	2014-08-17	?	WCNB + ELNB (No triggers; Figure 7) WCNB: nothing when looked at with Antelope;	19	229-15:00	229-19:00

4	Yes	P-67		Gas (propane)	2014-08-20		14:00-16:00 (17:00-19:00 UT) 17:00-19:00 (20:00-22:00 UT)			WCNB (No triggers; Figure 8) Checked: ULF 20140820.192606 WCNB 0.9 sei17 **Noise**. ULF 20140820.220045 WCNB 0.1 sei18 Looks like a noise burst with low frequencies; nothing on other stations			P-67
5	Yes	L-37/D48	2099	LPG	2014-08-23	00:00	13:05-14:22 (16:05-17:22 UT)	2014-08-23	23:59	WCNB+ELNB (No triggers; Figure 9) WCNB down	19	235-16:00	236-17:30

										16:09-16:40 ELNB: electronic noise 16:39-17:58			
6	No	J-76/O76	2940	---	2014-08-30	06:00	08:00-18:00 (11:00-19:00 UT)	2014-08-30	24:00	WCNB (No triggers; Figure 10)	17	242-11:00	243-19:00
7	Yes	E-67B	2880	LPG	2014-09-04	00:01	15:50-17:04 (18:50-20:04 UT)	2014-09-04	22:20	WCNB (No triggers; Figure 11)	16	247-00:00 (2014-09-04)	248-12:00
8	Yes	J-76/O76	2838	Gas	2014-09-09	06:00	11:48-13:45 (14:48-16:45 UT)	2014-09-09	24:00	WCNB (No triggers; Figure 12) (blast located at Havelock Quarry at 14:45 UT)	17	252-00:00	253-12:00

Table 1: Some basic information on the five wells where HF was conducted in August and September 2014 and the time periods for the search for possible induced earthquakes.

Appendix 1: Simple command to extract seismographic data in seed format using autodrm

The autodrm instructions are available at:
www.earthquakescanada.nrcan.gc.ca/stndon/AutoDRM/index-eng.php

Example of a message to request data:

From: Lamontagne, Maurice
Sent: January-30-15 16:15
To: autodrm@seismo.nrcan.gc.ca
Subject: TR : New Brunswick

BEGIN
EMAIL EMAIL@domain > confirm email message
START_TIME 2014/08/01.01.01:00 > Enter start time
DURATION 300 > Duration in seconds
NET_LIST CNSN SL > CNSN and temporary network SL
STA_LIST GGN,WCNB,SRNB,ELNB,HKNB,SVNB,LMN > station codes
CHAN_LIST * > all components
FORMAT SEED > seed format
WAVEFORM > waveforms
STOP

An email confirmation message of this type will be sent to : EMAIL@domain
BEGIN
MSG_TYPE data
MSG_ID 20150130.211518 CAN_NDC
DATA_TYPE LOG
Your SEED-format output file is now available via FTP.

FTP_FILE line below provides FTP site address, username (anonymous) output directory, and filename.

DATA_TYPE FTP_LOG

FTP_FILE ftp.seismo.NRCan.gc.ca anonymous /pub/autodrm CNDC_20150130.211531

*** NOTE: If you use RDSEED to remove instrument response from CNSN data ***

*** in SAC, only RDSEED versions <= 4.12 or >= 4.6 do this correctly. ***

The data is available on the ftp site: ftp.seismo.NRCan.gc.ca

User name: anonymous

Data in: /pub/autodrm

Appendix 2: Logs of the wells in accompanying pdfs

A. B-41 Daily Report Aug 14, 2014

B. P-67 Daily Report Aug 20 2014

C. L-37 Daily Report 2014-08-23

D. E-67B Daily Report Sept 04 – 2014

E. J-76 Daily Report for Sept 9 2014

CORRIDOR RESOURCES INC

Well Name:	**B - 41**	**Date:**	**Aug 14/2014**
Purpose of Job:	LPG Frac	**Completion Days:**	
Current Operation:	Perforate Frederick Brook	**PBTD:**	**2895m**
Contractor:	SLB,Essential, Gasfrac	**CSG SIZE:**	**139.7mm**
Formation:	Fredrick Brooke shale	**TBG SIZE:**	**73mm**
Completion Fluid Type:	LPG		

Perforations: (1875m-1877m) (2027m-2032m) (2130m - 2132m, 2208m - 2210m) (2274m - 2276m, 2314.5m - 2316.5m) (2408m - 2410m, 2463m - 2465m) (2578m - 2580m, 2638m - 2640m) (2778m - 2780m, 2838m - 2840m)

Directions to Location: Coming from Moncton on Highway #1, take turnoff to Petitcodiac / Elgin , Go left or south on Highway 905, Go 14.2 km, Turn right on to green road, go .5 km, right into location, Civic # 40

TIME	ACTIVITY
00:00	Continue to pressure test lubricator. Good low pressure test to 3 Mpa.
	High pressure test to 24.5 Mpa. Hold for 10 minutes. Good test. Bleed off to testers.
01:15	Hold safety meeting. Arm gun and record gun data. 93mm ERHSC loaded on 2.0m interval, 20 spm, total 40 shots
	29 gram Power Jet charges 72o phasing. **CCL to TS - 4.5m, CCL to BS - 6.5m, overall gun length, CCL to**
	bullnose, 10.9m. Pickup and stab lubricator onto well.
02:15	Equalize lubricator to wellbore pressure and open master valve. RIH with perforating gun to 1935m. Log on depth
	to marker joint at 1928 mKB. Correlate log and depth correct 2.7m. Log into position. SICP: 19.37 Mpa.
04:50	**Perforate the Frederick Brook from 1875.0 - 1877.0 mKB.** Light gun response at surface. 10# weight change.
	No pressure change. Log up and POH.
06:00	Out of hole. Shut in master valve and bleed down lubricator. Layout gun. Confirm all shots fired and properly
	directed.
	Rig out Schlumberger and support services and equipment.
09:00	Continue moving out Schlumberger, Gas Frac on location for pending stimulation.
12:45	Held general pre-frac safety meeting. Covered planned frac operations.
14:00	Conduct "mock" evacuation drill as per regulatory requirements
14:10	Prime and pressure test surface treating lines and equipment.
14:50	Completed HIGH pressure 30 minute test to 94 Mpa - Good test signed off.
14:56	Open well - SICP = 19.0 Mpa
14:57	Start LPG Pumping Operations
15:10	Start scour @ 75 kg/m3 / Treating pressure 46.0 Mpa / 74.9 m3 LPG away
15:12	Pump LPG Pad / 100.4 m3 LPG away
15:15	Start Proppant @ 90 Kg / m3 / 136.7m3 LPG Cum
15:19	Sand @ 150 Kg / CP = 44.4 Mpa
15:23	Sand @ 200 Kg / CP = 44.4 Mpa
15:26	Sand @ 250 Kg / CP - 42.2 Mpa
15:29	Sand @ 300 Kg / CP = 41.5 Mpa
15:30	Sand @ 350 Kg / CP= 41.3 Mpa

FLUID VOLUMES	LPG				FLUID SHIPMENTS		Water		
1700 HRS	m^3	m^3	m^3	Total	To Loc.			m^3	m^3
Total Load Fluid Today	12.0				**Daily**				
Daily Fluid Recovered	0.0				**Total**		30.0		
Recovered to Date	86.4			86.4	**From Loc.**				
New Fluid Produced	0.0				**Daily**				
Load to Recover	266.2				**Total**				

Weather / Temp	Cloudy, 18C	**Lease Condition:**	Dry	**Road Condition:**	Good
Report From:	Terry Gallant	**Cell Ph.:**	403-651-4201	**Reporting To:**	P. Nash
Daily Rig Hours:		**Rig Hours to Date**:		**AFE:**	18 – 33 – 02

CORRIDOR RESOURCES INC

Well Name:	**B - 41**	**Date:**	**Aug 14/2014**
Purpose of Job:	LPG Frac	**Completion Days:**	
Current Operation:	Perforate Frederick Brook	**PBTD:**	**2895m**
Contractor:	SLB,Essential, Gasfrac	**CSG SIZE:**	**139.7mm**
Formation:	Fredrick Brooke shale	**TBG SIZE:**	**73mm**
Completion Fluid Type:	LPG		

Perforations: (1875m-1877m) (2027m-2032m) (2130m - 2132m, 2208m - 2210m) (2274m - 2276m, 2314.5m - 2316.5m) (2408m - 2410m, 2463m - 2465m) (2578m - 2580m, 2638m - 2640m) (2778m - 2780m, 2838m - 2840m)

Directions to Location: Coming from Moncton on Highway #1, take turnoff to Petitcodiac / Elgin , Go left or south on Highway 905, Go 14.2 km, Turn right on to green road, go .5 km, right into location, Civic # 40

TIME	ACTIVITY
15:31	Sand @ 400 Kg/m3 / CP = 40.8 m3 / 251.3 m3 LPG away
15:36	FLUSH - Total LPG 22.8 m3
	FRAC DETAILS
	Opening wellhead Pressure - 19,000 Kpa
	Total LPG Pumped - 262.3 M3 (Gas Volume 70,821.0 m3)
	Total Proppant Placed - 30.0 Tonnes
	ISIP - 40.0 Mpa
	Average Pumping Rate 8.0 m3/min
	Average Pressure 43.4 Mpa
	Formation Break - 48.5 Mpa
	Frac Gradient - 25.75 Kpa /m
	5 minute - SICP = 38.4 Mpa
	10 Minute - SICP = 36.1 Mpa
	15 Minute - SICP = 34.0 Mpa
	Pumped 1000 scm N2 down well / Secure and Locked wellhead
18:00	Gasfrac rigging out equipment; mechanic team rebuilding pumps.
	Testers continue to read and record shut in wellbore pressure.
20:00	SICP: 30,884 Kpa
21:00	Move in AIC vacuum truck. Complete Corridor orientation (1). Clean all water from drip trays and unload in water
	tank. Clean all contaminated drip trays and offload into test vessel for subsequent sampling.
22:00	SICP: 30,350 Kpa
24:00	SICP: 30,020 Kpa
	Release vac truck services.

FLUID VOLUMES	LPG				FLUID SHIPMENTS		Water		
1700 HRS	m^3	m^3	m^3	Total	To Loc.			m^3	m^3
Total Load Fluid Today	12.0				Daily				
Daily Fluid Recovered	0.0				Total		30.0		
Recovered to Date	86.4			86.4	From Loc.				
New Fluid Produced	0.0				Daily				
Load to Recover	266.2				Total				

Weather / Temp	Cloudy, 18C	**Lease Condition:**	Dry	**Road Condition:**	Good
Report From:	Terry Gallant	**Cell Ph.:**	403-651-4201	**Reporting To:**	P. Nash
Daily Rig Hours:		**Rig Hours to Date**:		**AFE:**	18 – 33 – 02

McCully P-67
Daily Completions Report

Date:	Aug 20,2014	**Completion Days:**	
Daily Objective:	fracture treatment	**PBTD:**	2761.7mKB (float collar)
Contractor(s):	Cameron/Essential crane/Gasfrac	**Effective Depth**	2772.75mKB (Coil Aug 2)
Formation:	Hiram Brook "A" "Lower & Upper B"	**Slickline Depth**	2767.0mKB
Completion Fluid:			
Summary of Daily Activity:	install frachead and pressure test	mobilize Gasfrac	

QHSE	Incident	Hazards	Safety	Corridor	Gov't Inspection?
(Y/N)	N	N	Y	N	N

Hiram Brook "A" : 2714.5 - 2715.5, 2720.5 - 2721, 2732 - 2732.5, 2737.5 - 2738, 2741.5 -
Hiram Brook "Lower B" : 2630.5-2631, 2636-2636.5, 2640.5-2641, 2645-2646, 2650-2650.5, 2660-
Hiram Brook "Lower B" : 2643.5-2646.5, 2649.5-2651, 2658.5-2661.5, 2666.8-2667.8 mKB (172
Hiram Brook "Upper B" : 2579-2579.5, 2583.5-2584, 2590-2591, 2612-2614mKB (53 shots total)
Hiram Brook "Upper B" : 2610.5-2616.9, 2587.0-2591.5, 2577.0- 2578.0 mKB (120 + 111 shots)

TP (kPa)	SICp 0 kPa		SICP/FCP	

TIME	DAILY ACTIVITY
00:00	receive LPG through out the day
07:00	review daily operations and safety meeting discuss ERP
	define roles and responsibilities, as per Corridor policies and procedures
	discuss hazards and barriers, drug and alcohol policy, communication
	security and reiterate tight hole conditions
07:45	Gasfrac frac team on location, load remaining sand and LPG bulkers
08:00	fill line heater 6m3 fresh water
	mobilize and spot remaining bulkers
10:00	mobilize fire crews into position
11:00	Testers propane tank in spotted for line heater, rigged up
12:00	spotted AWI incinerator, rigged in
13:00	hold pre pump meeting with Gasfrac,fire and medical crews
	head count 33, environmental, drilling consultants on location as observers
14:00	Gasfrac begin treatment
	well treating at 53.2 Mpa, 56.9m3 away, HP manifold developed leak
	shut down, secure well bleed off, muster, purge, repair leak
17:00	start up,pressure test, and prime pumps, bring onliquid and pressure test
	well treating at 200 conc, 4 tonnes away, 2.5 Tonne to formation
19:00	Gasfrac HP quinn pump developed a leak on head, shut down treatment
	secure well, bleed off to testers and purge out equipment
19:00	33.4 Mpa on well, well secured, monitor well,Rig Gasfrac off wellhead
20:00	observe Casing pressures overnight

	Frac 1	Frac 2	Frac 3	Frac 4	Frac 5	Total	Fluids	H_2O	MeOH
Load Fluid (m3) @ 06:00 hrs									
13							To Loc.	0.0	
Well Notes: *(Does this well contain downhole*									

Weather/Temp :	partly cloudy 24'c	**Lease Condition :**	good	**Road Condition :**	good
Report From :	Frank Gardener	**Daily Rig Hours :**	12	**Reporting To :**	Phil Nash
Cell Phone :	403-837-6055	**Cum Rig Hours :**	48	**AFE :**	30 – 33 – 09

McCully L-37
Daily Completions Report

Date:	Aug 23,2014	**TD:**	3915.50m
Daily Objective:	Pump LPG Frac	**10K B-Plug**	2800mKB
Contractor(s):	AWS/Gasfrac	**12K Comp B-Plug**	2770 mKB (10 Mpa below plug)
Formation:	Hiram Brook G Sand	**Perfs:**	2733-2738 mKB
Completion Fluid:	LPG	**Perfs :**	2446.5 - 2448.5 mKB
Summary of Daily Activity:			

QHSE	Incident (Injury/Spill)?	Hazards Identified?	Safety Orientations?	Corridor Inspection?	Gov't Inspection?
(Y/N)	N	Y	N	N	N

TIME	DAILY ACTIVITY
00:01	SICP: 8788Kpa
01:00	SICP: 8841Kpa
02:00	SICP: 8891Kpa
03:00	SICP: 8946Kpa
04:00	SICP: 8999Kpa
05:00	SICP: 9053Kpa
06:00	SICP: 9110Kpa / RST continues transferring in LPG from P67
07:00	SICP: 9167Kpa / Gas Frac crew arrive on location.
07:30	Held pre -job safety meeting,
08:00	SICP: 9218Kpa - Cameron install and torque down top blanking flange on frac tree
09:00	SICP: 9277Kpa - Called & notified Fire Department regarding pending intermitent flaring
10:00	SICP: 9324Kpa
10:30	Assembled ALL personnel on location (35) for pre-frac safety meeting. Covered associated hazards, assigned
	responsibilities.
11:20	Start Low pressure N2 pressure test
12:22	Start HP LPG pressure test with 10 pumpers
12:52	Successful 30 minute pressure test - charted and signed off / depressure to flare / unlock master valve
13:00	Pressure up to master valve - 15.0 Mpa
13:04	Initial opening pressure 9.1 Mpa
13:05	Start LPG Treatment
14:22	End LPG Fracture stimulation
	Frac Details
	Initial opening pressure 9.1 Mpa
	Formation Break Pressure - 60.0 Mpa @ 18.5 m3
	Maximum Pressure recorded 90.0 Mpa / Screen out
	Average pumping pressure 48.8 Mpa
	Total LPG pumped 282.6 m3
	Total Ftec 30/50 Proppant pumped - 49.5 Tonne /
	Total Proppant placed 41.7 Tonne
	Estimated Sand in pipe - 7.8 Tonne / Sand top 1900 m
	GelIP-10 - 1112 L
	ACTXL-46D - 1112 L
	BRKLP-10 - 2150 L
	Frac Gradient - 48.22 Kpa/m
	1 minute 75.8 Mpa
	5 Minute 50.9 Mpa
	10 Minute 47.5 Mpa
	15 Minute 44.2 Mpa
16:00	Pumped 650 scm N2 down casing / Opening pressure 32.7 mpa building to 46.6 Mpa

Load Fluid (m3) @ 06:00 hrs							Fluids	H_2O	KCl Water / Glycol
Total Load Fluid:									
Recovered Last 24hrs:							To Loc.		
Cumulative Recovery to 0600hrs:							Well	3m3	
Fluid Left to Recover at 0600hrs :									

Well Notes: *(Does this well contain downhole equipment or behavior that should be noted?)*

444.5 m3 LPG to recover

From Loc.		

Weather/Temp :	Sunny + 24	**Lease Condition :**	good	**Road Condition :**	good
Report From :	T. Gallant / J.Farion	**Daily Rig Hours :**	0	**Reporting To :**	Phil Nash
Cell Phone :	403-651-4201	**Cum Rig Hours :**		**AFE# :**	06-33-09

McCully L-37
Daily Completions Report

Date:	Aug 23,2014	**TD:**	3915.50m
Daily Objective:	Pump LPG Frac	**10K B-Plug**	2800mKB
Contractor(s):	AWS/Gasfrac	**12K Comp B-Plug**	2770 mKB (10 Mpa below plug)
Formation:	Hiram Brook G Sand	**Perfs:**	2733-2738 mKB
Completion Fluid:	LPG	**Perfs :**	2446.5 - 2448.5 mKB
Summary of Daily Activity:			

QHSE	Incident (Injury/Spill)?	Hazards Identified?	Safety Orientations?	Corridor Inspection?	Gov't Inspection?
(Y/N)	N	Y	N	N	N

TIME	DAILY ACTIVITY
17:00	Gas frac purged out / start rigging out equipment
18:30	Cross shift safety meeting w/all personnel Discussed hazards and mitigation. Signed off on safety meeting document
19:00	SICP: 30400Kpa
20:00	All GFS pumpers, iron truck, manifold, data van etc off location - moving to J76 location / AWS monitor well pressures
20:01	SICP: 29720Kpa
21:00	SICP: 28534Kpa
22:00	SICP: 28321Kpa
23:00	SICP: 28175Kpa
23:59	SICP: 28087Kpa

Load Fluid (m3) @ 06:00 hrs							**Fluids**	**H_2O**	**KCl Water / Glycol**
Total Load Fluid:									
Recovered Last 24hrs:							**To Loc.**		
Cumulative Recovery to 0600hrs:							Well	3m3	
Fluid Left to Recover at 0600hrs :									
Well Notes: *(Does this well contain downhole equipment or behavior that should be noted?)*							**From Loc.**		
444.5 m3 LPG to recover									

Weather/Temp :	Sunny + 24	**Lease Condition :**	good	**Road Condition :**	good
Report From :	T. Gallant / J.Farion	**Daily Rig Hours :**	0	**Reporting To :**	Phil Nash
Cell Phone :	403-651-4201	**Cum Rig Hours :**		**AFE# :**	06-33-09

CORRIDOR RESOURCES INC

Well Name:	**E-67B**	**Date:**	**September 4, 2014**
Purpose of Job:	Frac with LPG	**Completion Days:**	
Current Operation:	Prep for frac	**PBTD:**	2939mKB
Contractor:	Gasfrac/AWS/Essential/Cameron	**TBG Size:**	
Formation:		**Effective PBTD**	**2939 mKB**
Completion Fluid Type:	LPG		

Perforations : 2920 - 2925mKB

TIME	
00:01	Continue to monitor equipment & site
03:00	J. Farion off location to travel to Moncton for days off reset (AWS testers & security on site)
05:00	T. Gallant & Essential fluid pump on site to pre-mix 2% KCL.
06:00	Essential rigged in and mixing KCL
06:45	Gas Frac, Fire Master crews on location
07:00	Assemebled personnel for pre shift safety meeting - covered plans for the day, hazards and mitigation
	Gave Corridor orientation to 8 new crew members of Gas frac (3) and Fire Master (5)
08:00	Continue to roll KCL tank, rig in gas frac iron. Refuel all equipment as required
09:00	Rigging up to pump 1.0 m3 15% acid / 2% KCL 15% methanol mixed and ready
10:30	Held pre pumping safety meeting with all personel on location
10:50	Master valve open start pumping acid
10:53	1.0 m3 acid pumped / start pumping KCL @ 0.500 m3 /min
11:15	14.0 m3 pumped / 0 pressure
11:21	19.6 m3 pumped starting to see pressure
11:27	21.5 m3 pumped - pump rate at 150 L /min casing pressure at 65 Mpa
11:30	Pump rate steady at 150 L / min - total volume pumped 22.7 m3
11:30	Shut down - shut in wellhead / rig down Essential pumper - reposition for pressure testing
12:45	Held pre-frac safety meeting with ALL personnel on location
	Covered plans for pumping , associated hazards, assigned responsibilities
13:00	Conducted "mock evacuation drill as required
13:30	Start 280 psi low pressure N2 test
15:26	Successfully pressure tested treating iron to 94 Mpa
15:38	Open well for LPG Frac
17:03	Frac successfully completed as programmed
	FRAC DETAILS - as follows
	continued on next page……..

FLUID VOLUMES	Zone	Today m³	Prior m³	Total m³
Total Load Fluid	LPG			
	glycol/water			
	water/meth		0.44	0.44
Recovered to Date	LPG			
	glycol/water			
	water/meth			
Load to Recover	LPG			
	glycol/water			
	water/meth			0.44

FLUID SHIPMENTS		Glycol / KCl	H_2O (m3)	
To Loc.			110.0	0.0
From Loc.				0.0

Weather / Temp		**Lease Condition:**	Good	**Road Condition:**	Good
Report From:	T. Gallant / F Gardener	**Phone**	403-837-6055	**Reporting To:**	P. Nash
Daily Rig Hours:		**Rig Hours to Date**:		**AFE**	06-33-08

CORRIDOR RESOURCES INC

Well Name:	**E-67B**	**Date:**	**September 4, 2014**
Purpose of Job:	Frac with LPG	**Completion Days:**	
Current Operation:	Pump frac treatment	**PBTD:**	2939mKB
Contractor:	Gasfrac/AWS/Essential/Cameron	**TBG Size:**	
Formation:		**Effective PBTD**	**2939 mKB**
Completion Fluid Type:	LPG		

Perforations : 2920 - 2925mKB

TIME	
17:03	Frac completed as programmed
	Opening well pressure = 22.5 Mpa / after acid and KCL pumped
	Formation Break Pressure = 67 Mpa
	Maximum Pressure = 83 Mpa
	Average pump pressure = 74.0 Mpa
	Maximum Pump Rate = 6.5 m3/min
	Average Pump Rate = 6.0 m3 /min
	LPG pumped = 393.2 m3
	Sand Placed into formation - 5.0 Tonne Canadian White 50/140 / 50.0 Tonne Ftec 40/70
	1 minute 66.2MPa
	5 minute 63.2MPa
	10 minute 61.4MPa
	15 Minute
	ISIP = 68.0 Mpa
17:25	Shut in master valves, depressure to flare / purge system with N2
18:25	Continue to purge Gas Frac equipment
18:30	Cross shift handover -
19:00	Gas Frac equipment is purged. Rig in N2 pump. Objective iswellhead to pump 1000scm N2 blanket into wellbore.
	Pressure test N2 line to 60MPa. Unlock and open master on wellhead.
	SICP is +/- 54MPa. Pump 25 scm of N2 and pressured up to 60MPa. Found a closed valve on N2 unit.
	Valve was installed backwards. Remedy valve issue and ask Gas Frac to write it up.
21:30	Pump 1000 scm N2 blanket into wellbore. SICP is 56.5MPa. Shut in wellhead, chain and lock.
21:30	4 Gas Frac mechanics on site to tear down heads on pumps.
	Testers are rigging out their iron for move to Elgin tomorrow.
	No other activity on wellsite tonight.
22:20	Data logger is installed on wing valve. Testers will monitor pressure and download data tomorrow morning.
	End of todays report

FLUID VOLUMES	**Zone**	Today m^3	Prior m^3	**Total m^3**	**FLUID SHIPMENTS**		Glycol / KCl	H_20 (m3)	
Total Load Fluid	LPG	392	0	392	**To Loc.**			110.0	0.0
	KCl water/meth	22.7	0	22.7					
	water/meth		0.44	0.44					
Recovered to Date	LPG				**From Loc.**				0.0
	KCl water/meth								
	water/meth								
Load to Recover	LPG	392	0	392					
	KCl water/meth	22.7	0	22.7					
	water/meth		0.44	0.44					

Weather / Temp		**Lease Condition:**	Good	**Road Condition:**	Good
Report From:	T. Gallant / F Gardener	**Phone**	403-837-6055	**Reporting To:**	P. Nash
Daily Rig Hours:		**Rig Hours to Date**:		**AFE**	06-33-08

CORRIDOR RESOURCES INC

Well Name:	**J – 76**	**Date:**	**September 9, 2014**
Purpose of Job:	Fracture stimulation on uppper interval	**Completion Days:**	
Current Operation:	Rig up Gas Frac equipment	**PBTD:**	3072.25mKB
Contractor:	AWS, Gas Frac	**TBG Size:**	
Formation:	Frederick Brook Shale	**Effective PBTD**	**3050 mKB**
Completion Fluid Type:	2% KCl 20% methanol, LPG		

Perforations : Frederick Brook Shale: 2905-2910mKB & 3010-3015mKB

TIME	
06:00	WSS arrive on location
07:00	Gas Frac, AWS, Fire Master, Essential, crews on location
07:15	Assembled all personnel for general preshift safety meeting, discussed planned operations to complete rig up, pressure up casing
	to 30 Mpa. Associated hazards and mitigation.
08:00	LPG pressure in frachead, rigged up testers flow line to bleed off pressure to flare stack.
09:00	Pressure up intermediate casing to 35 Mpa. Set PSV to 40 Mpa. Tie in testers flowline
09:05	**Notification given to local fire department about intermittent flaring**
09:15	Held pre-frac safety meeting with ALL personnel (33) on location. Discussed plans going forward, pressure testing and stimulation
	Covered associated risks and mitigation.
09:45	Start pressure testing system with 2% KCl methanol water mix to 94 Mpa
10:20	Successful 30 minute test with water mix - Charted
10:30	Checked torque on ALL 10 GFS pumpers prior to taking on LPG. Found non out of torque spec.
11:10	Completed LOW pressure N2 test to 280 Psi
11:38	Unlocked and opened master valve on frachead for LPG frac / Pressure up to remote valve to 30.0 Mpa
11:46	Open hydraulic remote - **Initial well pressure - 23.6 Mpa**
11:48	Start LPG fracture stimulation
13:27	End of LPG Frac
	LPG Frac Details
	Initial Opening well pressure - 23.6 Mpa
	Formation Break 74.5 Mpa @ 1.5 m3/min / 1.8 m3 pumped
	Pumped 352.5 m3 LPG c/w 1,350 L GellP10 / 1,350 L ACTXL-46D / 1,400 L BRKLP-10
	Placed 26.4 Tonnes sand - (5.4 Tonne 50/140 mesh and 21.0 Tonne Ftec Lite 40/70
	Average pump Rate - 5.7 m3 /min @ 84.0 Mpa
	Frac Gradient - 32.68 Kpa / m
	ISIP- 77.7 Mpa
	1 Minute SICP - 73.6 Mpa
	5 Minute SICP - 67.5 Mpa
	10 Minute SICP - 65.1 Mpa
	15 Minute SICP - 63.5 Mpa

FLUID VOLUMES	Upper Zone	Today m³	Prior m³	**Total m³**	**FLUID SHIPMENTS**		Glycol / KCl	Brine	
					To Loc.				
Total Load Fluid	LPG	352.5	151.4	503.9					
	Glycol H2O		43.3	43.3					
Recovered to Date	LPG	0	142.02		**From Loc.**		7.0		
	Glyclol H2O		6.97	7.56				22.0	
Load to Recover	LPG		9.38						
	Glycol H2O		36.33	**35.74**					

Weather / Temp	24°C Sunny	**Lease Condition:**	Good	**Road Condition:**	Good
Report From:	B. Dillabough / T Gallant	**Phone**	403-968-4333	**Reporting To:**	P. Nash
Daily Rig Hours:		**Rig Hours to Date**:		**AFE**	06-33-09

CORRIDOR RESOURCES INC

Well Name:	**J – 76**	**Date:**	**September 9, 2014**
Purpose of Job:	Fracture stimulation on uppper interval	**Completion Days:**	
Current Operation:	Rig up Gas Frac equipment	**PBTD:**	3072.25mKB
Contractor:	AWS, Gas Frac	**TBG Size:**	
Formation:	Frederick Brook Shale	**Effective PBTD**	**3050 mKB**
Completion Fluid Type:	2% KCl 20% methanol, LPG		

Perforations : Frederick Brook Shale: 2905-2910mKB & 3010-3015mKB

TIME	
13:45	Closed Hydraulic remote valve - depressure treating lines and purge with N2
16:00	ALL GFS equipment purged out . Start rigging down standing iron. / SICP - 53,180 Kpa
17:00	GFS equipment being rigged out - Testers rigged back and recording Shut in casing pressures - 51,656 Kpa
18:00	SICP - 50,421 Kpa
18:30	Cross shift handover / conduct walk around lease inspection
19:00	SICP: 49,555 Kpa
20:00	SICP: 48,724 Kpa
21:00	SICP: 48,016 Kpa
22:00	SICP: 47,544 Kpa
23:00	SICP: 47,452 Kpa
24:00	SICP: 46,627 Kpa
	Continue to monitor SICP leakoff pressures through night with testers.

FLUID VOLUMES	Upper Zone	Today m³	Prior m³	Total m³	FLUID SHIPMENTS		Glycol / KCl	Brine	
					To Loc.				
Total Load Fluid	LPG	352.5	151.4	503.9					
	Glycol H2O		43.3	43.3					
Recovered to Date	LPG	0	142.02		From Loc.		7.0		
	Glyclol H2O		6.97	7.56				22.0	
Load to Recover	LPG		9.38						
	Glycol H2O		36.33	**35.74**					

Weather / Temp	24°C Sunny	**Lease Condition:**	Good	**Road Condition:**	Good
Report From:	B. Dillabough / T Gallant	**Phone**	403-968-4333	**Reporting To:**	P. Nash
Daily Rig Hours:		**Rig Hours to Date**:		**AFE**	06-33-09