
From: Schubak, Bob
Sent: 2018, November 30 7:04 AM
To: Addo, Kofi
Subject: EQ last night in Fort St John

Good morning Kofi,

I somehow suspect that you already know more about this than I do (☺) but just in case I thought I'd let you know that there was a M4.2 earthquake near FSJ yesterday evening.

Data:

Latitude	56.1685
Longitude	-120.5234
Depth	10 km

It was felt at the Site C construction site and work on the tunnels was shut down as a precaution until first light this morning.

The earthquake estimator (I know; these numbers won't be very good because the GMMs are wrong) suggested $pga = 0.01g$ at Site C and $0.001g$ at PCN.

I'm not sure how rich or available the data will be from this event, but whatever you can get will be valuable, I think.

With the shallow depth, can we take the leap of logic to suggest this was likely the result of fracking or injection? If you have an opinion, let me know, okay?

In any case, have a good and productive day.
See you next week.

Cheers,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

BC Hydro
6911 Southpoint Drive, 10th Floor
Burnaby, BC V3N 4X8

P 604 528 1680
M (22)
E rob.schubak@bchydro.com

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Smart about power in all we do.

From: Schubak, Bob
Sent: 2018, October 22 8:37 AM
To: O'Riley, Christopher; Daschuk, Maureen
Subject: FW: DC Initial and Final Report - M6.6, M6.8, M6.5 and M4.9 earthquakes off Vancouver Island - no impacts to BCH

Hi Chris and Maureen,

As a follow-up on last night's earthquakes off the coast of Vancouver Island, we've run the earthquake acceleration estimator (actually Eric Mainprize did so last night) and found that the closest affected dam was Strathcona with an estimated peak ground acceleration of 0.003g, which is far below any ground motions that would cause any concerns or spur any non-routine inspections. See below.

No alarms were tripped in our ADAS system and no instrumentation is showing any notable change.

Thanks,
Bob

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Earthquake Acceleration Estimator

MENU INSPECTION REQUIREMENT CALCULATION

Decimal Degrees

Degrees Minutes Seconds

Latitude 49.3468

Longitude -129.2135

Magnitude

6.8

Moment

Depth

10

KMs

Calculate

Clear

Override

BC Hydro Facilities

Towns and Cities

Recent Earthquakes

Search:

Facility	Component	Consequence	Est. Acc (g)	Est. Acc + 1SD	Withstand PGA (g)
Salmon River Dam	Rockfill Timber Crib Dam	Low	0.003		0.32
Salmon River Dam	Sluiceway	Low	0.003		0.32
Strathcona Dam	Earthfill Dam	Extreme	0.003		0.2
Strathcona Dam	Spillway Gates	Extreme	0.003		0.3
Strathcona Dam	Spillway U/S Retaining Wall	Extreme	0.003		0.6
Strathcona Dam	Spillway gate hoist towers	Extreme	0.003		0.55
Strathcona Dam	Intake Tower	Extreme	0.003		0.26
Strathcona Dam	Intake Tower Access Bridge Abutment Fill	Extreme	0.003		0.1
Strathcona Dam	Intake Wing Walls	Extreme	0.003		0.26
Strathcona Dam	Penstock Conduit	Extreme	0.003		0.26
Strathcona Dam	Low Level Outlet Area	Extreme	0.003		0.26
Quinsam R Stge Dam	Storage dam spillway	Significant	0.003		0.32
Quinsam R Stge Dam	Storage dam sluiceway	Significant	0.003		0.32
Quinsam R Diver Dam	Diversion dam	Significant	0.003		0.32
Ladore Falls Dam	Ladore Dam	Extreme	0.003		0.53
Ladore Falls Dam	Surge Tank	Extreme	0.003		0.4
Ladore Falls Dam	Spillway gates	Extreme	0.003		0.3
Ladore Falls Dam	Spillway Hoist Structure	Extreme	0.003		0.1
Ladore Falls Dam	Loveland Bay Saddle Dam	Significant	0.003		0.6
Ladore Falls Dam	Big Slide Saddle Dam	Extreme	0.003		0.55
John Hart Dam	Main Dam	Extreme	0.002		0.3
John Hart Dam	North Earthfill Dam	Extreme	0.002		0.23
John Hart Dam	Middle Earthfill Dam	Extreme	0.002		0.09
John Hart Dam	South Earthfill Dam	Extreme	0.002		0.23
John Hart Dam	Intake Structure (dam)	Extreme	0.002		0.23
John Hart Dam	Spillway hoist structure	Extreme	0.002		0.55
John Hart Dam	Spillway Gates	Extreme	0.002		0.3
John Hart Dam	Spillway training wall	Extreme	0.002		0.74
John Hart Dam	Woodstave Penstocks	Extreme	0.002		0.05
John Hart PH	Powerhouse		0.002		
Elsie Dam	Main Earthfill Dam	Extreme	0.002		0.55
Elsie Dam	Saddle Dam 1 (EX)	Extreme	0.002		0.55
Elsie Dam	Spillway	Extreme	0.002		0.55
Elsie Dam	Low Level Outlet Intake Tower	Extreme	0.002		0.55
Elsie Dam	Low Level Outlet Conduit	Extreme	0.002		0.55
Elsie Dam	Low Level Outlet Structure	Extreme	0.002		0.55
Comox Dam	Concrete Dam	Extreme	0.002		0.65

From: Schubak, Bob

Sent: Monday, October 22, 2018 5:57 AM

To: O'Riley, Christopher

Subject: Re: DC Initial and Final Report - M6.6, M6.8, M6.5 and M4.9 earthquakes off Vancouver Island - no impacts to BCH

Good morning Chris.

They are indeed on the larger end of things and my eyes opened wide when I saw the first numbers without the epicentres.

They will as a matter of course be followed up on to be certain they don't fall outside our expectations vis a vis the PSHA Model.

Because of that we'll be looking at these events in the broader sense too.

Maybe we can chat briefly at this afternoon's Navigant workshop if you'll be attending.

We can take Salmon River off, as you suggest.

Bob

Robert B. Schubak, Ph.D., P.Eng.

Director, Dam Safety

BC Hydro

P | 604-528-1680

M | (22)

E | bob.schubak@bchydro.com

On Oct 22, 2018, at 5:35 AM, O'Riley, Christopher <Chris.Oriley@bchydro.com> wrote:

Bob, these earthquakes are quite large compared to what we've frequently experienced off the coast. Fortunately a good distance away. Do they merit any further follow up or study?

It's a small thing but could we remove the Salmon River Dam from the consequence table below?

Sent from my iPhone

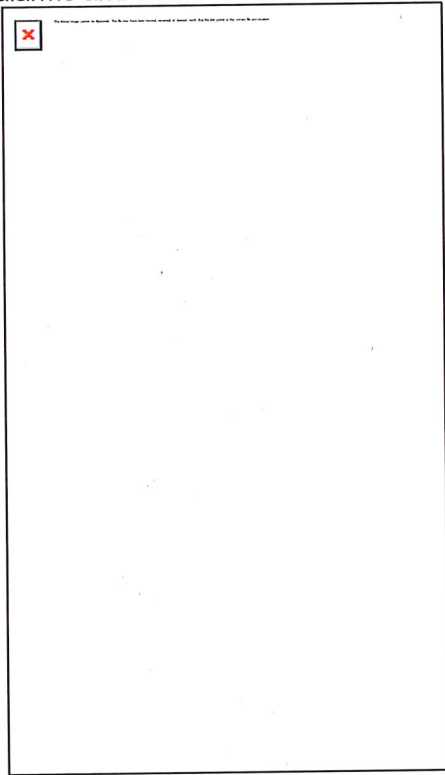
Begin forwarded message:

From: Duty Coordinator <DutyCoordinator@bchydro.com>
Date: October 22, 2018 at 12:33:32 AM PDT
To: "O'Riley, Christopher" <Chris.Oriley@bchydro.com>, "Lebeter, David" <david.lebeter@bchydro.com>, "Wong, David" <David.Wong@bchydro.com>, "Fraser, Janet" <Janet.Fraser@bchydro.com>, "Bechard, Thomas" <Tom.Bechard@powerex.com>, "Leonard, Allan" <Allan.Leonard@bchydro.com>, "Daschuk, Maureen" <Maureen.Daschuk@bchydro.com>, "Lings, Raymond" <Raymond.Lings@powertechlabs.com>, "Sauer, Darwin" <Darwin.Sauer@bchydro.com>, "Clarke, Gareth" <Gareth.Clarke@bchydro.com>, "Poweska, Mark" <Mark.Poweska@bchydro.com>, "Young, Brandon" <Brandon.Young@bchydro.com>
Cc: Duty Coordinator <DutyCoordinator@bchydro.com>, "Schubak, Bob" <Bob.Schubak@bchydro.com>, "BC Hydro, Restoration Centre" <BCHydro.RestorationCentre@bchydro.com>, "FVO, System Control Manager" <SystemControlManager@bchydro.com>
Subject: DC Initial and Final Report - M6.6, M6.8, M6.5 and M4.9 earthquakes off Vancouver Island - no impacts to BCH

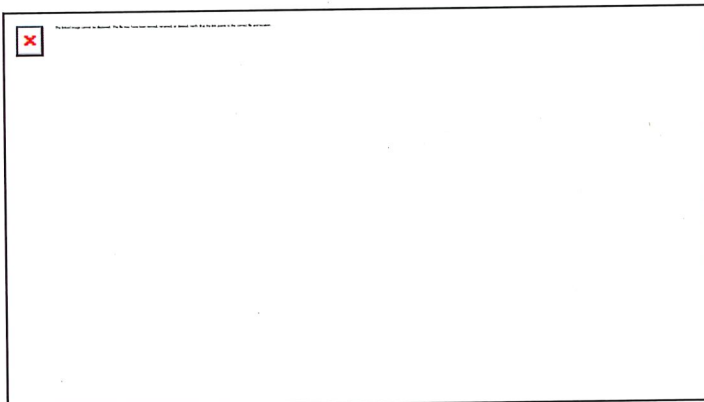
Four earthquakes of 6.6M, 6.8M, 6.5M, and 4.9M occurred this evening at 22:39pm, 23:16pm, 23:22pm, and 23:36pm off the coast of Vancouver Island. Distances ranged from ~127km-156km SW from the Brooks Peninsula and 197km- 223km SW of Port Hardy. The closest one to the coast was the M6.8.

No Tsunami alerts have been issued. The above earthquakes are being reported in the media.

Emergency protocols were followed and key internal stakeholders have confirmed no alarms and cause for concern.



(Red pins show BCH Dams)



Epicentres of Earthquakes

[USGS Interactive Map](#) for M6.8

Information on BC Hydro infrastructure from the Earthquake Estimator App below (Report for the M6.8 earthquake).

Closest Dams, shaking felt, and potential damage:

Dam	Consequence	Potential Damage	Perceived Shaking	Distance to EPI (km)	Latitude	L
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Salmon River Dam	Low	None	Weak	268.4	50.0975
Strathcona Dam	Extreme	None	Weak	270.9	49.9965
Quinsam R Stge Dam	Significant	None	Weak	271.6	49.9113
Quinsam R Diver Dam	Significant	None	Weak	273.7	49.9298
Ladore Falls Dam	Extreme	None	Weak	284.9	50.0126
John Hart Dam	Extreme	None	Weak	289.3	50.0416
John Hart PH		None	Weak	291.3	50.0439
Elsie Dam	Extreme	None	Weak	297.5	49.4656
Comox Dam	Extreme	None	Weak	299.3	49.6439
Puntledge Dam	Very High	None	Weak	299.6	49.6642
Puntledge PH		None	Weak	304.1	49.6885
Clayton Falls Dam	Significant	None	Not Felt	375.7	52.3654
Clayton Falls PH		None	Not Felt	376.0	52.3707
Jordan River PH		None	Not Felt	390.9	48.4297
Jordan River Dam	High	None	Not Felt	392.9	48.4966
Elliott Dam	Low	None	Not Felt	393.3	48.4770
Bear Creek Dam	Low	None	Not Felt	398.2	48.5037
Clowhom Dam	Significant	None	Not Felt	411.7	49.7122
Cheakamus PH		None	Not Felt	431.5	49.9339

Cheakamus Dam	Extreme	None	Not Felt	442.7	49.9769
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Closest Towns and Cities:

Town or City	Potential Damage	Perceived Shaking	Distance to EPI (km)	Latitude	Longitude
Winter Harbour	None	Light	155.1	50.5167	-128.03
Port Alice	None	Weak	171.0	50.3833	-127.45
Quatsino	None	Weak	173.0	50.5333	-127.65
Zeballos	None	Weak	184.2	49.9833	-126.85
Estevan Point	None	Weak	192.9	49.3833	-126.55
Tahsis	None	Weak	194.0	49.9167	-126.60
Port Hardy	None	Weak	197.8	50.7000	-127.41
Alert Bay	None	Weak	213.3	50.5833	-126.95
Gold River	None	Weak	227.8	49.6833	-126.10
Tofino	None	Weak	240.3	49.1500	-125.91
Sayward	None	Weak	262.1	50.3667	-125.91
Ucluelet	None	Weak	270.1	48.9500	-125.55
Rivers Inlet	None	Weak	294.5	51.6833	-127.25
Campbell River	None	Weak	295.0	49.9833	-125.25
Bamfield	None	Weak	302.5	48.8333	-125.15
Puntledge	None	Weak	302.7	49.6667	-125.05
Cumberland	None	Weak	303.4	49.6167	-125.05
Courtenay	None	Weak	307.6	49.6833	-124.95
Royston	None	Weak	309.7	49.6500	-124.95
Sproat Lake	None	Weak	311.5	49.2833	-124.91

Closest Substations:

Substation	Component	Potential Damage	Perceived Shaking	Distance to EPI (km)	Latitude	L
JUL	JEUNE LANDING SUB	None	Weak	173.0	50.4391	
CSS	CAPE SCOTT WIND IPP	None	Weak	180.6	50.7652	
MRH	MARBLE RIVER HATCHERY SUB	None	Weak	182.7	50.5234	
ZBL	ZEBALLOS LAKE IPP	None	Weak	191.8	50.0533	
PHY	PORT HARDY SUB	None	Weak	195.2	50.7139	
ZBT	ZEBALLOS TERMINAL	None	Weak	195.3	49.9233	
TSV	TAHSIS VILLAGE SUB	None	Weak	195.3	49.9233	
KGT	KEOGH GAS TURBINE	None	Weak	195.5	50.6029	
KGH	KEOGH SUBSTATION	None	Weak	196.0	50.6043	
PML	PORT MCNEILL SUB	None	Weak	204.7	50.5723	
CMH	CONUMA HATCHERY SUB	None	Weak	207.7	49.8009	
WOS	WOSS SUB	None	Weak	211.5	50.2176	
BVC	BEAVER COVE SUB	None	Weak	211.8	50.5196	
KTS	KOKISH TERMINAL SUB	None	Weak	211.9	50.5206	
KKS	KOKISH RIVER IPP	None	Weak	212.2	50.5203	
GRP	MUCHALAT INDUSTRIES (GOLD RIVER PULP) SUB	None	Weak	226.0	49.6840	
UCN	UCONA RIVER IPP	None	Weak	226.2	49.6868	

GLD	GOLD RIVER SUB	None	Weak	232.4	49.7891
LBH	LONG BEACH SUB	None	Weak	266.8	48.9965
SCA	STRATHCONA GS	None	Weak	270.9	49.9979

Closest Buildings:

BCH Number	Building	Potential Damage	Perceived Shaking	Distance to EPI (km)	Latitude	Longitude	M E
BCH071	Quatsino	None	Weak	174.6	50.5400	-127.6280	
BCH069	Tahsis	None	Weak	195.5	49.9330	-126.6540	
BCH052	Port Hardy	None	Weak	198.1	50.6870	-127.3860	
BCH057	Tofino	None	Weak	266.8	48.9960	-125.5830	
BCH126	Campbell River	None	Weak	292.2	50.0150	-125.2850	
BCH048	Courtenay	None	Weak	309.2	49.7130	-124.9660	
BCH072	Cortes	None	Weak	312.8	50.1020	-125.0210	
BCH051	Port Alberni Tebo Ave	None	Not Felt	320.7	49.2620	-124.7910	
BCH066	Texada	None	Not Felt	339.2	49.7580	-124.5540	
BCH011	Powell River	None	Not Felt	343.2	49.8360	-124.5110	
BCH053	Qualicum	None	Not Felt	346.0	49.3460	-124.4360	
BCH129	Nanaimo	None	Not Felt	380.0	49.1790	-123.9820	
BCH073	Pender	None	Not Felt	380.5	49.6400	-123.9640	

BCH012	Sechelt	None	Not Felt	398.3	49.4540	-123.7110
BCH049	Duncan	None	Not Felt	404.8	48.8060	-123.7160
BCH058	Keats	None	Not Felt	415.2	49.3960	-123.4780
BCH050	Ganges	None	Not Felt	417.9	48.8630	-123.5190
BCH059	Gambier	None	Not Felt	418.1	49.4610	-123.4360
BCH061	Mayne	None	Not Felt	434.8	48.8490	-123.2890
BCH054	Victoria Operations and Warehouse - DECOMMISSIONED	None	Not Felt	436.0	48.4900	-123.3890

This is the final report.

Jorge Hollman (Duty Coordinator)
Karinya Kosh (Emergency Manager)

Duty Coordinator

BC Hydro

T 1 877 311 8611

E dutycoordinator@bchydro.com

bchydro.com

Smart about power in all we do.

<image001.png>

<image002.jpg>

From: Schubak, Bob
Sent: 2018, October 22 5:57 AM
To: O'Riley, Christopher
Subject: Re: DC Initial and Final Report - M6.6, M6.8, M6.5 and M4.9 earthquakes off Vancouver Island - no impacts to BCH
Attachments: image001.png; image002.jpg

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Date: October 22, 2018 at 12:33:32 AM PDT
To: "O'Riley, Christopher" <Chris.Oriley@bchydro.com>, "Lebeter, David" <david.lebeter@bchydro.com>, "Wong, David" <David.Wong@bchydro.com>, "Fraser, Janet" <Janet.Fraser@bchydro.com>, "Bechard, Thomas" <Tom.Bechard@powerex.com>, "Leonard, Allan" <Allan.Leonard@bchydro.com>, "Daschuk, Maureen" <Maureen.Daschuk@bchydro.com>, "Lings, Raymond" <Raymond.Lings@powertechlabs.com>, "Sauer, Darwin" <Darwin.Sauer@bchydro.com>, "Clarke, Gareth" <Gareth.Clarke@bchydro.com>, "Poweska, Mark" <Mark.Poweska@bchydro.com>, "Young, Brandon" <Brandon.Young@bchydro.com>

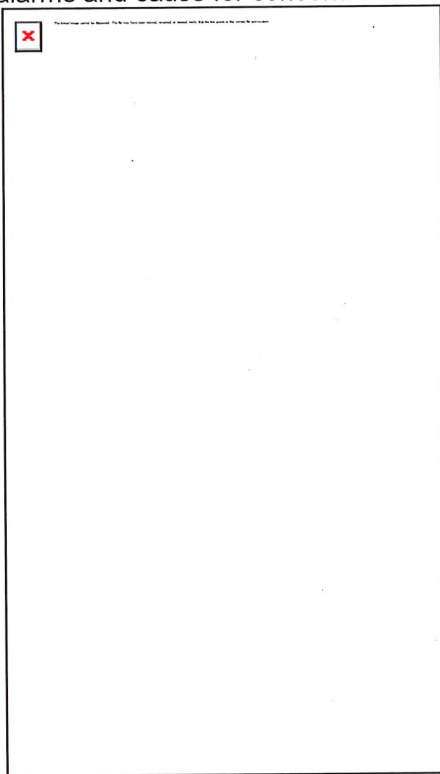
Cc: Duty Coordinator <DutyCoordinator@bchydro.com>, "Schubak, Bob"
<Bob.Schubak@bchydro.com>, "BC Hydro, Restoration Centre"
<BCHydro.RestorationCentre@bchydro.com>, "FVO, System Control Manager"
<SystemControlManager@bchydro.com>

Subject: DC Initial and Final Report - M6.6, M6.8, M6.5 and M4.9 earthquakes off Vancouver Island - no impacts to BCH

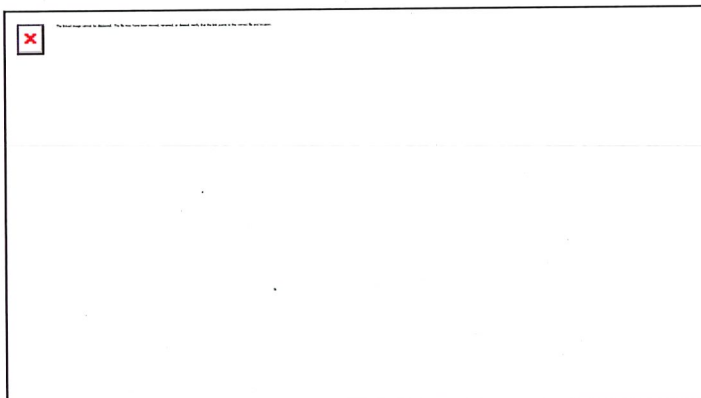
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Tahsis	None	Weak	194.0	49.9167	-126.66
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KTS	KOKISH TERMINAL SUB	None	Weak	211.9	50.5206	
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BCH069	Tahsis	None	Weak	195.5	49.9330	-126.6540	
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BCH057	Tofino	None	Weak	266.8	48.9960	-125.5830	
BCH126	Campbell River	None	Weak	292.2	50.0150	-125.2850	
BCH048	Courtenay	None	Weak	309.2	49.7130	-124.9660	
BCH072	Cortes	None	Weak	312.8	50.1020	-125.0210	
BCH051	Port Alberni Tebo Ave	None	Not Felt	320.7	49.2620	-124.7910	
BCH066	Texada	None	Not Felt	339.2	49.7580	-124.5540	
BCH011	Powell River	None	Not Felt	343.2	49.8360	-124.5110	

BCH053	Qualicum	None	Not Felt	346.0	49.3460	-124.4360
BCH129	Nanaimo	None	Not Felt	380.0	49.1790	-123.9820
BCH073	Pender	None	Not Felt	380.5	49.6400	-123.9640
BCH012	Sechelt	None	Not Felt	398.3	49.4540	-123.7110
BCH049	Duncan	None	Not Felt	404.8	48.8060	-123.7160
BCH058	Keats	None	Not Felt	415.2	49.3960	-123.4780
BCH050	Ganges	None	Not Felt	417.9	48.8630	-123.5190
BCH059	Gambier	None	Not Felt	418.1	49.4610	-123.4360
BCH061	Mayne	None	Not Felt	434.8	48.8490	-123.2890
BCH054	Victoria Operations and Warehouse - DECOMISSIONED	None	Not Felt	436.0	48.4900	-123.3890

This is the final report.

Jorge Hollman (Duty Coordinator)
Karinya Kosh (Emergency Manager)

Duty Coordinator

BC Hydro

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<image001.png>

<image002.jpg>

Spatial
Plateau
Wilderness Park

Northern Rocky
Mountains Park

B.C.

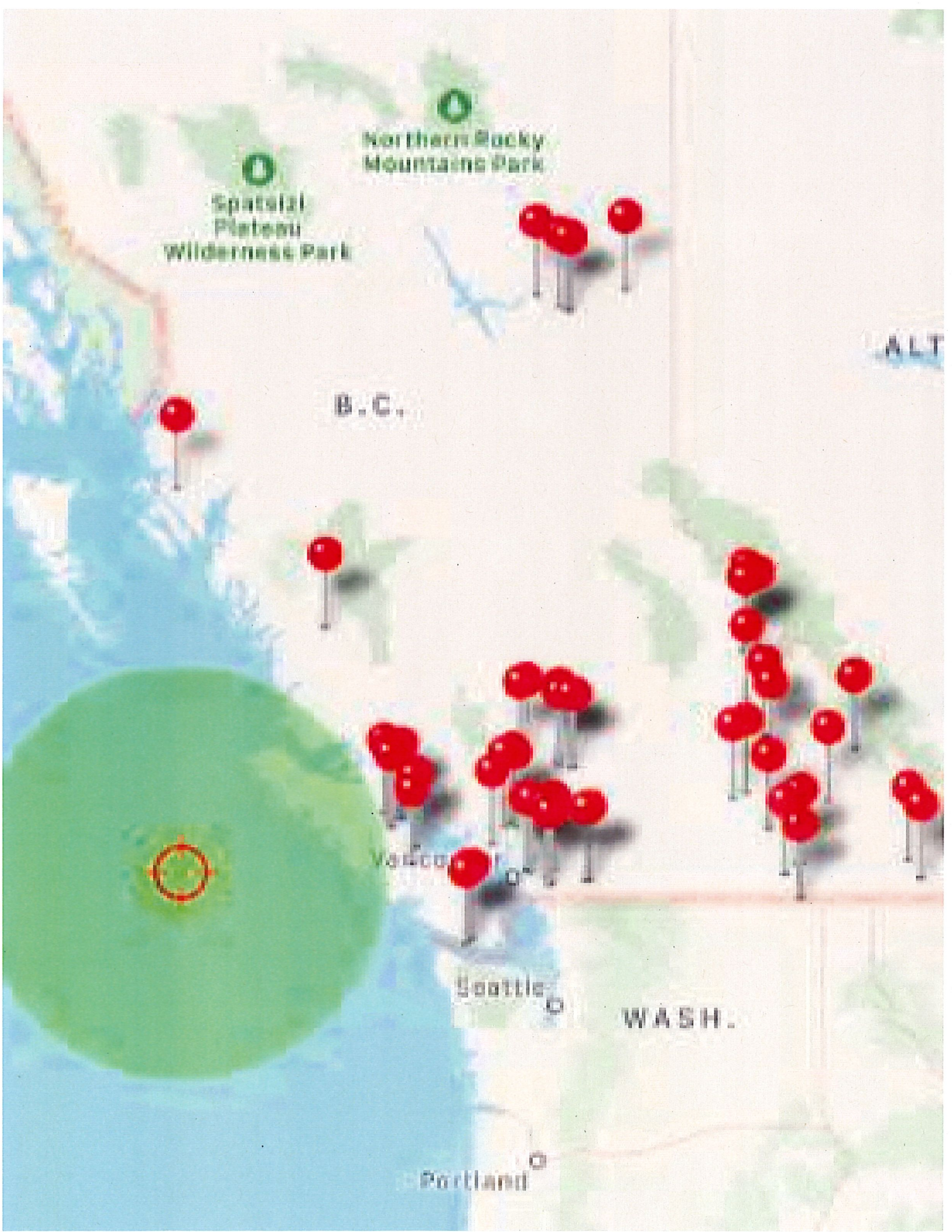
ALT

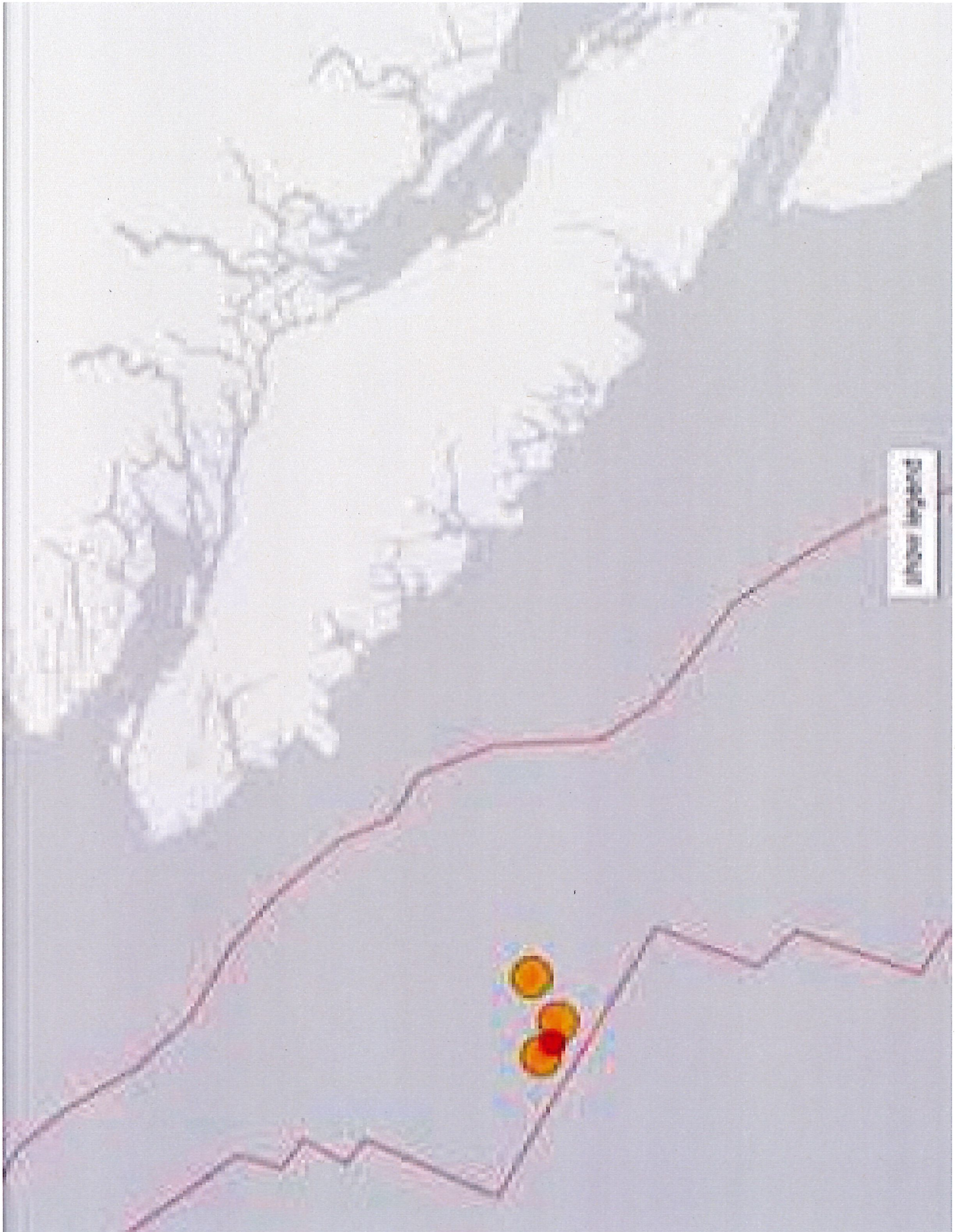
WASH.

Seattle

Portland

Vancouver





From: Schubak, Bob
Sent: 2019, February 21 12:15 PM
To: Aquino, Kevin
Subject: RE: Media request: November Peace River Region earthquake

Meeting with Crew Energy in the Site C project team office in Vancouver

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

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From: Aquino, Kevin
Sent: 2019, February 21 10:09 AM
To: Schubak, Bob
Subject: RE: Media request: November Peace River Region earthquake

Hi Bob – hope all is well.

We received one follow up question on this request. The reporter was hoping to find out where meetings were held between BC Hydro, and the OGC and Crew Energy. The meeting between BC Hydro and the OGC was over a telephone conference, but are you able to tell me where the meeting was held with Crew Energy?

Thanks in advance,
Kevin

From: Schubak, Bob
Sent: 2019, January 29 12:23 PM
To: Aquino, Kevin
Subject: FW: Media request: November Peace River Region earthquake

Kevin,
Here's the response that was prepared by Dam Safety and Site C and vetted for accuracy by the OGC.
Now it's time for media relations to do it's thing, I guess.
Thanks,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

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From: Venables, Stuart [mailto:Stuart.Venables@BCOGC.ca]
Sent: 2019, January 29 11:13 AM
To: Schubak, Bob; Johnson, Jeff
Cc: Watson, Andrew; Oswell, Terry
Subject: RE: Media request: November Peace River Region earthquake

Morning Bob,

We made one (very) minor change to the answer in question 4. Otherwise, everyone felt that BC Hydro did a great job with the responses. Thank you for providing this information to us to review, it's really appreciated. Lannea Parfitt from our Communications team may reach out to Kevin Aquino from your Communications team to get more background details.

Thanks again and have a great day,

-Stu



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From: Schubak, Bob <Bob.Schubak@bchydro.com>
Sent: Monday, January 28, 2019 4:54 PM
To: Venables, Stuart <Stuart.Venables@BCOGC.ca>; Johnson, Jeff <Jeff.Johnson@bcogc.ca>
Cc: Watson, Andrew <Andrew.Watson@bchydro.com>; Oswell, Terry <Terry.Oswell@bchydro.com>
Subject: FW: Media request: November Peace River Region earthquake

Good evening Stuart and Jeff,
I hope you are both well.

BC Hydro has recently received a request from a person in the media for answers to questions regarding the November 29, 2018 earthquake near Fort St. John. The reporter is writing his piece following the provincial Oil and Gas Commission ordering the natural gas company suspected of triggering that earthquake to cease operations, along with other natural gas companies.

We've drafted a response to those questions, attached, but as a number of them pertain to directives that have been established by the OGC we were hoping that you might look at our responses and correct any factual errors we may

have inadvertently made. If this is not something for which you have the time or inclination, please don't hesitate to respond to that effect and we'll respond with what we have.

Thanks gents. I look forward to future meetings and discussions.

Regards,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

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From: Aquino, Kevin
Sent: 2019, January 24 4:10 PM
To: Schubak, Bob; Ahlfield, Kay
Subject: Media request: November Peace River Region earthquake

Hi Bob, Kay – hope all is well. We received a media request about the late November earthquake that was felt in the Peace River region and subsequently at Site C. The reporter is writing his piece following the provincial Oil and Gas Commission ordering the natural gas company suspected of triggering that earthquake to cease operations, along with other natural gas companies.

Here are his list of questions verbatim. He wanted to know if BC Hydro:

1. Was in contact with the Oil and Gas Commission following the incident in late November and if so, what concerns it may have raised at that time?
2. Expressed concerns to the Commission, the company or any provincial government Ministry about the earthquake and its possible impacts on the Site C project or added costs that could be incurred at the project?
3. Conducted any site inspections at the Site C site following the earthquake to determine whether any damage may have occurred?
4. Has a clear understanding of what the precise location of the fracking operation or deep well disposal operation was that is suspected of causing the quake, and if so how many kilometres away it is from the Site C dam site?
5. Considers the 5-kilometre no-fracking/no liquids disposal zone agreed to between BC Hydro and the Oil and Gas Commission to be all that is needed to ensure that no damage occurs to hydro infrastructure or whether the zone, in Hydro's estimation, should be extended out further still?
6. Has its own network of seismographs in place to monitor earthquake activity, and if so how many seismographs it has in place in the Peace region.
7. Regularly receives information from third parties (for example natural gas companies) about what their seismographs detect by way of ground motion?

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