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<p style="text-align: center;">THE ALBERTA ENERGY REGULATOR PROCEEDING ID NO. 436</p> <p style="text-align: center;">IN THE MATTER OF the Regulatory Appeal by Obsidian Energy Ltd. of the Alberta Energy Regulator's decision to issue an Environmental Protection Order to Obsidian Energy Ltd., pursuant to Sections 113 and 24 of the Environmental Protection and Enhancement Act On March 23, 2023 (Regulatory Appeal 1943624)</p> <hr/> <p style="text-align: center;">AER PROCEEDING VOLUME 1</p> <hr/> <p style="text-align: center;">Calgary, Alberta November 28, 2024</p>	<p style="text-align: center;">TABLE OF CONTENTS</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Description</th> <th style="text-align: right;">Page</th> </tr> </thead> <tbody> <tr> <td>November 28, 2024 Morning Session</td> <td style="text-align: right;">3</td> </tr> <tr> <td>Opening Remarks</td> <td style="text-align: right;">4</td> </tr> <tr> <td>AMY FOX, MEHRAN POOLADI-DARVISH, JAMES</td> <td style="text-align: right;">17</td> </tr> <tr> <td>VERDON, STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA MARSHALL, Affirmed</td> <td></td> </tr> <tr> <td>DEREK BOECKX, Sworn</td> <td></td> </tr> <tr> <td>Direct Evidence of the Obsidian Energy Ltd.</td> <td style="text-align: right;">17</td> </tr> <tr> <td>Witnesses</td> <td></td> </tr> <tr> <td>P. Fitzpatrick Cross-examines the Obsidian Energy Ltd. Witnesses</td> <td style="text-align: right;">95</td> </tr> <tr> <td>November 28, 2024 Afternoon Session</td> <td style="text-align: right;">141</td> </tr> <tr> <td>AMY FOX, MEHRAN POOLADI-DARVISH, JAMES</td> <td style="text-align: right;">142</td> </tr> <tr> <td>VERDON, STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA MARSHALL, Previously Affirmed</td> <td></td> </tr> <tr> <td>DEREK BOECKX, Previously Sworn</td> <td></td> </tr> <tr> <td>P. Fitzpatrick Cross-examines the Obsidian Energy Ltd. Witnesses</td> <td style="text-align: right;">142</td> </tr> <tr> <td>Discussion</td> <td style="text-align: right;">184</td> </tr> <tr> <td>Certificate of Transcript</td> <td style="text-align: right;">188</td> </tr> </tbody> </table>	Description	Page	November 28, 2024 Morning Session	3	Opening Remarks	4	AMY FOX, MEHRAN POOLADI-DARVISH, JAMES	17	VERDON, STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA MARSHALL, Affirmed		DEREK BOECKX, Sworn		Direct Evidence of the Obsidian Energy Ltd.	17	Witnesses		P. Fitzpatrick Cross-examines the Obsidian Energy Ltd. Witnesses	95	November 28, 2024 Afternoon Session	141	AMY FOX, MEHRAN POOLADI-DARVISH, JAMES	142	VERDON, STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA MARSHALL, Previously Affirmed		DEREK BOECKX, Previously Sworn		P. Fitzpatrick Cross-examines the Obsidian Energy Ltd. Witnesses	142	Discussion	184	Certificate of Transcript	188
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<p>1 Proceedings taken at the Govier Hall, Calgary, 2 Alberta</p> <hr/> <p>4 November 28, 2024 Morning Session</p> <p>6 A. Bolton The Chair 7 B. Zaitlin Hearing Commissioner 8 T. Stock Hearing Commissioner</p> <p>9</p> <p>10 B. Kapel Holden AER Counsel 11 O. Chijioke AER Counsel 12 A. Huxley AER Counsel 13 (Via Videocast) 14 A. Lung AER Staff 15 A. Stanislavski AER Staff 16 M. Rahimabadi AER Staff</p> <p>17</p> <p>18 P. Fitzpatrick For Regulatory Compliance 19 Branch 20 J. Allison For Regulatory Compliance 21 Branch 22 A. Hall For Regulatory Compliance 23 Branch</p> <p>24</p> <p>25 D.P. Langen For Obsidian Energy Ltd. 26 A. Barrington For Obsidian Energy Ltd.</p>	<p>1 A. Porco, CSR(A) Official Court Reporter</p> <hr/> <p>3 (PROCEEDINGS COMMENCED AT 9:01 AM)</p> <p>4 Opening Remarks</p> <p>5 THE CHAIR: Good morning. 6 Please be seated. Thank you. Oh, now the mic 7 is on. Thanks. 8 Good morning, everyone. Welcome to Govier 9 Hall. Thank you for attending to participate 10 and -- in and observe the hearing for 11 Proceeding 436. 12 My name is Alex Bolton, and I am the 13 Hearing Commissioner chairing this hearing 14 today. The other Panel members are, on my 15 right, Commissioner Tracey Stock, and, on my 16 left, Commissioner Brian Zaitlin. 17 My colleagues and I would like to start by 18 acknowledging that we are holding this 19 proceeding on the traditional territories of 20 the people of the Treaty 7 region of Southern 21 Alberta, which includes the Siksika, the 22 Piikani, the Kainai Nations of the Blackfoot 23 Confederacy; the Tsuut'ina Nation; and the 24 Stoney Nakoda Nation, which includes the 25 Chiniki, the Bearspaw, and the Wesley First 26 Nations. Mohkinstsis, known as the city of</p>																																

5	<p>1 Calgary, is also home to the Métis Nation 2 Alberta Region 3. 3 I'd like to introduce the AER staff 4 assisting the Panel in this proceeding. Please 5 identify yourselves when I read out your names. 6 Barbara Kapel Holden and Oluchi Chijioke, 7 both of the AER law branch. Amanda Huxley, 8 also AER counsel, is observing online and is 9 also supporting the Panel. Andrew Lung is the 10 hearing coordinator for the proceeding. 11 And additional staff supporting the Hearing 12 Panel may change throughout the week, but this 13 morning we have Anastasia Stanislavski and 14 Maryam Rahimabadi and Fahad Hamdan. I'm not 15 sure he's in the room at the moment. Okay. 16 The Hearing Panel and all AER staff in the 17 hearing room are wearing name tags, whether 18 they are assisting with this proceeding or just 19 observing. If you have any questions about 20 this proceeding, please approach the staff 21 providing support for the hearing. 22 Communications with the Hearing Panel must 23 be on the record. Therefore, please don't 24 speak with Panel members unless it is part of 25 the formal hearing process. We're not trying 26 to be unfriendly, but to be fair and</p>	6	<p>1 transparent to all the hearing participants, 2 all communication with us must be on the 3 record. We appreciate everyone's understanding 4 in respect of this request. 5 In addition to AER staff, we also have 6 court reporters to transcribe the proceeding. 7 We ask the parties to be mindful to speak 8 clearly and not too fast -- and I realized a 9 moment ago I was speaking too fast -- and avoid 10 speaking over or interrupting others. And 11 that's for the benefit of the court reporters 12 to make sure we get a clear record. 13 Video of the hearing is also being 14 livestreamed through a link on the AER's 15 website. We do not keep a record of the 16 videocast, and the videocast is not an official 17 transcript of the proceeding. The court 18 reporters will prepare the only official 19 transcript of the proceeding. 20 Recording or transmitting of this hearing, 21 other than via the official transcript and AER 22 videocast, is not permitted. 23 Mr. Lung, can you please tell us about the 24 safety procedures as well as the particulars of 25 this proceeding and the publication of the 26 notice of hearing.</p>
7	<p>1 A. LUNG: Thank you, 2 Commissioner Bolton. 3 So in case there's a building alarm, listen 4 for directions, and if asked to evacuate, turn 5 left as you exit Govier Hall and proceed down 6 the stairs. The muster point will be in the 7 lobby of the Eau Claire Tower, which is 8 directly west of us. 9 In the event of a medical emergency, call 10 911, and then alert an AER employee, who will 11 notify building security. 12 A first aid kit, defibrillator, and a fire 13 extinguisher can be found by the sink in the 14 foyer area. 15 The fire phone on this floor is located 16 next to the elevators that you came in through. 17 An AER employee will present -- will be 18 present to assist anyone who requires support 19 to evacuate should there be an emergency. 20 For any other emergencies, please alert an 21 AER staff member. 22 Please note that Govier Hall is the only 23 AER room on this floor. All other -- all other 24 conference rooms are private and not for use 25 unless a room has been booked for you. 26 The subject of today's proceeding is</p>	8	<p>1 Regulatory Appeal 1943624. On April 21st, 2 2023, the AER received a request for Regulatory 3 Appeal 1942837 of the AER's decision to issue 4 an environmental protection order pursuant to 5 Sections 113 and 241 of the Environmental 6 Protection and Enhancement Act on March 23rd, 7 2023, naming Obsidian Energy Ltd. as the person 8 responsible for seismic events that occurred on 9 November 29th, 2022, and March 16th, 2023, 10 approximately 40 kilometres southeast of 11 Peace River. 12 The AER concluded that Obsidian's disposal 13 operations at Surface Location LSD 14-18-82-17 14 W5M induced the seismic events. The AER 15 granted the request for regulatory appeal on 16 July 18th, 2023. 17 The notice of hearing and notice of 18 scheduling of hearing are Exhibits 8.01 and 19 80.0 respectively and were distributed directly 20 to all parties. 21 The materials filed for the hearings have 22 been marked as exhibits. The parties were sent 23 the most recent exhibit list on November 27th, 24 2024. 25 If parties wish to make a request to file 26 new documentary evidence during the hearing, I</p>

9	<p>1 ask that before you make the requests, you                  2 provide me with an electronic version of the                  3 document via an email to                  4 hearing.services@aer.ca. This will allow us to                  5 proceed quickly if the Panel decides to allow                  6 the document into evidence.                  7 THE CHAIR: Thank you, Mr. Lung.                  8 We will now register the hearing                  9 participants. Please speak clearly, and not                  10 too quickly, into the microphone so the court                  11 reporters can hear you and for the video                  12 webcast. State your name for the record, spell                  13 your surname for the court reporter, and                  14 confirm the party you are representing.                  15 Technical limitations only allow five                  16 microphones to be live at any one time, so                  17 please remember to mute your microphone when                  18 you're finished speaking.                  19 Who is representing Obsidian Energy Ltd.?                  20 D.P. LANGEN: Good morning,                  21 Mr. Chair, Hearing Commissioners. My name is                  22 Langen, L-A-N-G-E-N, initials D.P., for                  23 Obsidian Energy Ltd. Appearing with me is my                  24 colleague, Ms. Barrington, B-A-R-R-I-N-G-T-O-N,                  25 initial A.                  26 THE CHAIR: Okay. Thank you,</p>	10	<p>1 Mr. Langen.                  2 Who is representing the AER's Regulatory                  3 Compliance Branch, formerly called Compliance                  4 and Liability Management?                  5 P. FITZPATRICK: Good morning,                  6 Commissioners. It's Fitzpatrick,                  7 F-I-T-Z-P-A-T-R-I-C-K, initials P.D., from                  8 Miller Thomson; and my colleague Josiah                  9 Allison, last name A-L-L-I-S-O-N. Also with us                  10 is counsel from -- in-house counsel                  11 from -- from the AER, Alana Hall, H A-L-L.                  12 Thank you.                  13 THE CHAIR: Thank you,                  14 Mr. Fitzpatrick.                  15 Mr. Fitzpatrick, I just wanted to confirm                  16 how you would like us to refer to your client.                  17 Although the Compliance and Liability                  18 Management branch, or CLM, was recently renamed                  19 to Regulatory Compliance, "CLM" is the term                  20 used in most of the written submissions on the                  21 record of this proceeding. So I'm just                  22 wondering, to avoid confusion, can we continue                  23 to use "CLM" and the "CLM witness panel" as the                  24 appropriate term?                  25 P. FITZPATRICK: Yes, sir. That                  26 would be fine.</p>
11	<p>1 THE CHAIR: Okay. Thank you.                  2 To our knowledge, that is all the hearing                  3 parties. Is there anyone else in the room who                  4 would like to speak today?                  5 Okay. Seeing none, I will now explain the                  6 procedures for this hearing.                  7 The Panel expects all hearing participants                  8 and observers to be respectful to others                  9 throughout the proceeding.                  10 According to Section 21 of the Alberta                  11 Energy Regulator Rules of Practice, all                  12 witnesses must give evidence under oath or                  13 affirmation. The court reporters will provide                  14 for this when the witnesses come forward to                  15 give their evidence.                  16 Please note that we will not be qualifying                  17 expert witnesses in this hearing. Having said                  18 that, it is open to each party to argue what                  19 weight should -- we should give to a witness's                  20 evidence based on that witness's qualifications                  21 or other relevant factors.                  22 During this hearing, exhibits will be                  23 referred to and displayed on the screens in                  24 this room. To assist all participants, we ask                  25 counsel and witnesses to identify each document                  26 they refer to by its exhibit number, then the</p>	12	<p>1 relevant PDF page number within the document,                  2 and, finally, the paragraph or line number, if                  3 applicable.                  4 Please pause after giving the exhibit                  5 number to provide time for our staff to find                  6 and pull up the relevant exhibit and also to                  7 confirm that the exhibit you requested is the                  8 one being displayed. It is not our staff's                  9 responsibility to guess which exhibit to                  10 display if your reference is not correct.                  11 Regarding the handling of confidential                  12 information in this hearing, the Panel has                  13 scheduled time for in-camera evidence,                  14 cross-examination, and final argument. Any                  15 reference to direct evidence -- sorry -- any                  16 reference in direct evidence,                  17 cross-examination, Panel questioning, or final                  18 argument that could directly or indirectly                  19 reveal the content of the confidential                  20 information will be dealt with in the in-camera                  21 sessions.                  22 General reference to the existence of                  23 confidential information will be acceptable                  24 during the open proceedings.                  25 Prior to the start of an in-camera portion                  26 of the hearing, the Panel will pause the</p>

13	<p>1 hearing in order to stop the video stream and 2 to clear the gallery of anyone who has not 3 signed a confidentiality undertaking. 4 We'll be following the order of 5 presentations set out in the AER Rules of 6 Practice. The general sequence of events will 7 start with Obsidian's direct evidence, followed 8 by cross-examination by CLM, and then Panel 9 questions. Then it will be CLM's direct 10 evidence, followed by cross-examination by 11 Obsidian, and Panel questions. There will then 12 be an opportunity for rebuttal evidence by 13 Obsidian, and then final argument. 14 Obsidian has been allocated until the noon 15 break today to present its direct evidence, 16 following which CLM will then begin 17 cross-examination of Obsidian's witnesses. We 18 plan to wrap up day one of the hearing at 19 approximately 4:35. 20 The full schedule for the hearing is 21 provided as Exhibit 93.1 in the hearing's 22 public record system, which is accessible 23 through the AER's website at aer.ca. 24 The times allocated in the schedule are 25 based on estimates provided by the party and as 26 approved by the Panel. While the Panel expects</p>	14	<p>1 parties to make best efforts to not exceed the 2 allotted times, we will take a flexible 3 approach where necessary. If all goes 4 according to schedule, we'll wrap up the 5 evidentiary portion of the hearing by midday 6 Wednesday and conduct final argument next 7 Friday, subject to how the proceeding unfolds. 8 After the hearing is concluded, we expect 9 to issue the hearing decision within 90 days. 10 Please note that the Panel members may be 11 taking notes during the hearing. Even though 12 we may not be making direct eye contact with 13 you, please understand that we are listening to 14 the evidence and what you are saying. 15 Should any of the parties require a break 16 during the proceedings outside of the scheduled 17 breaks that are planned, please let me or the 18 hearing services staff know. 19 We ask that everyone present ensure that 20 your electronic devices, including telephones 21 and computers, are set to silent mode 22 throughout the hearing. If you must take or 23 make a call and cannot do so at a break, please 24 step outside of Govier Hall to do so. 25 Are there any questions about the hearing's 26 procedures before we commence?</p>
15	<p>1 Okay. Seeing none. Are there any 2 preliminary matters that the parties want to 3 raise before we get to direct evidence? 4 No. Okay. Seeing none. 5 Mr. Langen, are you prepared to seat your 6 witness panel and -- okay. Ms. Barrington. 7 A. BARRINGTON: Good morning, 8 Mr. Chair, and Commissioners Stock and Zaitlin. 9 My name is Amy Barrington, and I'm a lawyer 10 from Stikeman Elliott here in the Calgary. I'm 11 pleased to be appearing today on behalf of 12 Obsidian Energy Ltd., which I will refer to as 13 "Obsidian" going forward. 14 Mr. Chair, I do have one housekeeping item 15 before I present the witnesses. On 16 November 26th, we filed a copy of the slide 17 deck to accompany Obsidian's opening statement. 18 Could we please get an exhibit number for that. 19 THE CHAIR: Thank you. 20 Mr. Lung, do we have an exhibit number? 21 B. KAPEL HOLDEN: The next exhibit 22 number would be 95.0. 23 A. BARRINGTON: Thank you. 24 THE CHAIR: Thank you. 25 A. BARRINGTON: I will now present 26 the witnesses.</p>	16	<p>1 THE COURT REPORTER: Would you like me to 2 swear them in now? 3 A. BARRINGTON: I'll just present 4 them first, and then I think we'll turn to 5 swearing them in, if that works for you. 6 THE COURT REPORTER: Yes. Thank you. 7 A. BARRINGTON: Starting closest to 8 the Panel of Commissioners in the front row, 9 you will see Dr. Amy Fox and Mr. Neil Watson of 10 Enlighten Geoscience Ltd., both independent 11 experts; Dr. Mehran Pooladi-Darvish of MPD 12 Reservoir Engineers Ltd., an independent 13 expert; Dr. James Verdon of Outer Limits 14 Geophysics LLP, an independent expert; 15 Mr. Steve Charbonneau, senior technical 16 advisor, geoscience, at Obsidian; and Mr. Jay 17 McGilvary, senior director, development, at 18 Obsidian. 19 In the row behind them, again starting 20 closest to the Panel, we have Ms. Fiona 21 Marshall of Numbered Company 2228260 Alberta 22 Ltd., an independent expert; and Mr. Derek 23 Boeckx of DAB Energy, also an independent 24 expert. 25 Mr. Chair, if we could now please have the 26 members of Obsidian's witness panel sworn or</p>

<p style="text-align: right;">17</p> <p>1 affirmed at this time.</p> <p>2 THE CHAIR: Thank you.</p> <p>3 AMY FOX, MEHRAN POOLADI-DARVISH, JAMES VERDON,</p> <p>4 STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA</p> <p>5 MARSHALL, Affirmed</p> <p>6 DEREK BOECKX, Sworn</p> <p>7 THE CHAIR: Ms. Barrington, just</p> <p>8 before you do start --</p> <p>9 THE COURT REPORTER: Sorry, sir.</p> <p>10 THE CHAIR: Oh.</p> <p>11 Ms. Barrington, we're scheduled to take our</p> <p>12 first break around 10:30. So I'll just leave</p> <p>13 it to you to find a time that kind of works in</p> <p>14 terms of your direct evidence, and it doesn't</p> <p>15 have to be exactly 10:30. So I'll leave it to</p> <p>16 you to find an appropriate time.</p> <p>17 A. BARRINGTON: Okay. Thank you,</p> <p>18 Mr. Chair.</p> <p>19 Direct Evidence of the Obsidian Energy Ltd.</p> <p>20 Witnesses</p> <p>21 A. BARRINGTON: I will now have the</p> <p>22 witnesses adopt their evidence. Obsidian has</p> <p>23 filed Exhibit Series 50, containing both public</p> <p>24 and confidential evidence-in-chief; Exhibit</p> <p>25 Series 81, containing both public and</p> <p>26 confidential reply evidence; and Exhibit 95, a</p>	<p style="text-align: right;">18</p> <p>1 slide deck filed in support of Obsidian's</p> <p>2 opening statement, containing only public</p> <p>3 information. I will refer to this evidence</p> <p>4 collectively as "the Obsidian evidence".</p> <p>5 I will begin with the independent experts and</p> <p>6 end with Obsidian's company witnesses.</p> <p>7 Q A. BARRINGTON: Dr. Fox, as part of</p> <p>8 the Obsidian evidence, Obsidian filed both</p> <p>9 public and confidential versions of</p> <p>10 Exhibit 50.05, which I will refer to as "the</p> <p>11 Enlighten evidence-in-chief", and Exhibit 95, a</p> <p>12 slide deck to support Obsidian's opening</p> <p>13 statement.</p> <p>14 Dr. Fox, was the Enlighten</p> <p>15 evidence-in-chief prepared by you or under your</p> <p>16 direction and control?</p> <p>17 A A. FOX: Yes.</p> <p>18 Q Can you please confirm that PDF pages 15 to 16</p> <p>19 and 25 and 28 of Exhibit 95 were prepared by</p> <p>20 you or under your direction and control?</p> <p>21 A Yes.</p> <p>22 Q Do you have any changes that you wish to make</p> <p>23 to that evidence?</p> <p>24 A No, I don't.</p> <p>25 Q Is that evidence accurate, to the best of your</p> <p>26 knowledge or belief?</p>
<p style="text-align: right;">19</p> <p>1 A Yes, it is.</p> <p>2 Q Dr. Fox, can you please confirm your CV has</p> <p>3 been filed as Appendix B1 of the Enlighten</p> <p>4 evidence-in-chief?</p> <p>5 A Yes.</p> <p>6 Q Does that CV accurately set out your</p> <p>7 qualifications and experience?</p> <p>8 A Yes, it does.</p> <p>9 Q Do you adopt the Enlighten evidence-in-chief</p> <p>10 and PDF pages 15 to 16, 25, and 28 of</p> <p>11 Exhibit 95 as your evidence in this proceeding?</p> <p>12 A Yes.</p> <p>13 Q Thank you, Dr. Fox.</p> <p>14 Moving now to Mr. Watson. In addition to</p> <p>15 the Enlighten evidence-in-chief, Obsidian has</p> <p>16 filed Exhibits 81.10 and 81.11, which are</p> <p>17 respectively the public and confidential</p> <p>18 versions of what we will refer to as "the</p> <p>19 Enlighten reply evidence". Further, Obsidian</p> <p>20 has filed Exhibit 95, a slide deck to support</p> <p>21 Obsidian's opening statement.</p> <p>22 Mr. Watson, was the Enlighten</p> <p>23 evidence-in-chief and the Enlighten reply</p> <p>24 evidence prepared by you or under your</p> <p>25 direction and control?</p> <p>26 A N. WATSON: Yes.</p>	<p style="text-align: right;">20</p> <p>1 Q Can you please confirm that PDF pages 15 and</p> <p>2 16, 25, and 28 of Exhibit 95 were prepared by</p> <p>3 you or under your direction and control?</p> <p>4 A Yes.</p> <p>5 Q Do you have any changes that you wish to make</p> <p>6 to that evidence?</p> <p>7 A No.</p> <p>8 Q Is that evidence accurate, to the best of your</p> <p>9 knowledge or belief?</p> <p>10 A Yes.</p> <p>11 Q Can you please confirm that your CV has been</p> <p>12 filed as Appendix A3 of the Enlighten</p> <p>13 evidence-in-chief?</p> <p>14 A Yes.</p> <p>15 Q Does that CV accurately set out your</p> <p>16 qualifications and experience?</p> <p>17 A Yes.</p> <p>18 Q Do you adopt the Enlighten evidence-in-chief,</p> <p>19 the Enlighten reply evidence, and PDF pages 15</p> <p>20 to 16, 25, and 28 of Exhibit 95 as part of your</p> <p>21 evidence in this proceeding?</p> <p>22 A Yes.</p> <p>23 Q Thank you, Mr. Watson.</p> <p>24 Moving now to Dr. Pooladi-Darvish.</p> <p>25 Obsidian has filed both a public and</p> <p>26 confidential version of Exhibit 50.03, which we</p>

<p style="text-align: right;">21</p> <p>1 will refer to as "the MPD evidence-in-chief";  2 and Exhibit 81.6, which is public; and  3 Exhibit 81.7, which is confidential. We will  4 refer to these two latter exhibits as "the MPD  5 reply evidence". Further, Obsidian has filed  6 Exhibit 95, which is the slide deck to support  7 Obsidian's opening statement.  8 Dr. Pooladi-Darvish, was the MPD  9 evidence-in-chief and MPD reply evidence  10 prepared by you or under your direction and  11 control?  12 A M. POOLADI-DARVISH: Yes, they were.  13 Q And can you please confirm that PDF pages 29 to  14 37 of Exhibit 95 were prepared by you or under  15 your direction and control?  16 A Yes.  17 Q Do you have any changes that you wish to make  18 to that evidence?  19 A Yes, I do. In the MPD reply evidence, at  20 PDF 10, the last sentence in Footnote 5 should  21 state "Table 2" and not "Table 4".  22 Also in MPD reply evidence, at PDF 12, in  23 the second and fourth bullets, "10-13 well"  24 should be replaced by "13-10 well".  25 Finally, at Exhibit 95.0, on PDF 32, the  26 last bullet should read "06-29 well" and not</p>	<p style="text-align: right;">22</p> <p>1 "16-29".  2 Q With those corrections, is that evidence  3 accurate, to the best of your knowledge or  4 belief?  5 A Yes.  6 Q And can you please confirm that your CV has  7 been filed as Appendix R-IV of the MPD  8 evidence-in-chief?  9 A Yes.  10 Q Does that CV accurately set out your  11 qualifications and experience?  12 A Yes, it does.  13 Q Do you adopt the MPD evidence-in-chief, MPD  14 reply evidence, and PDF pages 29 to 37 of  15 Exhibit 95.0 as part of your evidence in this  16 proceeding?  17 A Yes, I do.  18 Q Thank you, Dr. Pooladi-Darvish.  19 Moving next to Dr. Verdon. Obsidian has  20 filed both a public and confidential version of  21 Exhibit 50.06, which we will refer to as "the  22 Outer Limits evidence-in-chief"; and  23 Exhibit 81.8 and 81.9, which are respectively  24 the public and confidential versions of what we  25 will refer to as "the Outer Limits reply  26 evidence". Further, Obsidian has filed</p>
<p style="text-align: right;">23</p> <p>1 Exhibit 95.0, a slide deck to support  2 Obsidian's opening statement.  3 Dr. Verdon, was the Outer Limits  4 evidence-in-chief and Outer Limits reply  5 evidence prepared by you or under your  6 direction and control?  7 A J. VERDON: Yes.  8 Q Can you please confirm that PDF pages 6 through  9 14, 17 through 24, 26 through 27, and 38  10 through 43 of Exhibit 95.0 were prepared by you  11 or under your direction and control?  12 A Yes.  13 Q Do you have any changes that you wish to make  14 to that evidence?  15 A I have a clarification. In the public version  16 of the Outer Limits reply evidence, which is  17 Exhibit 81.8, Figures 4.2(a), 6.3, and three  18 subfigures from within Figure A3 in the  19 Appendix appear to be missing. This is an  20 error, as these are not confidential figures.  21 The figures in question do appear in the  22 confidential version of the Outer Limits reply  23 evidence, Exhibit 81.9.  24 Q Thank you.  25 With that clarification, is that evidence  26 accurate, to the best of your knowledge or</p>	<p style="text-align: right;">24</p> <p>1 belief?  2 A Yes.  3 Q And can you please confirm that your CV has  4 been filed in Appendix D of the Outer Limits  5 reply evidence?  6 A Yes.  7 Q Does that CV accurately set out your  8 qualifications and experience?  9 A Yes.  10 Q Do you adopt the Outer Limits  11 evidence-in-chief, Outer Limits reply evidence,  12 and PDF pages 6 through 14, 17 through 24, 26  13 through 27, and 38 through 43 of Exhibit 95.0  14 as part of your evidence in this proceeding?  15 A Yes.  16 Q Thank you, Dr. Verdon.  17 Now I will move to the second row of  18 Obsidian's witnesses and begin with  19 Ms. Marshall.  20 Ms. Marshall, Obsidian has filed a public  21 and a confidential version of Exhibit 50.04,  22 which we will refer to as "the Marshall  23 evidence-in-chief".  24 Ms. Marshall, was the Marshall  25 evidence-in-chief prepared by you or under your  26 direction and control?</p>

<p style="text-align: right;">25</p> <p>1 A F. MARSHALL: Yes.</p> <p>2 Q Do you have any changes that you wish to make</p> <p>3 to that evidence?</p> <p>4 A Yes. At PDF 26, in the second line, it states</p> <p>5 "MPD engineers". I would correct this to state</p> <p>6 "MPD reservoir engineers".</p> <p>7 Then at PDF 31 of that document, I would</p> <p>8 like to make a correction to the caption and</p> <p>9 image. The caption currently reads: (as read)</p> <p>10 Figure 25: Image showing geologically</p> <p>11 interpreted faults (brown) and the</p> <p>12 seismic interpreted faults (red) used</p> <p>13 in the coarse faulted model.</p> <p>14 This should read -- or the seismic faults</p> <p>15 indicated in red on the image should be</p> <p>16 discarded, and the caption should read:</p> <p>17 (as read)</p> <p>18 Figure 25: Image showing geologically</p> <p>19 interpreted faults (brown) used in the</p> <p>20 coarse faulted model.</p> <p>21 Q With those corrections, is that evidence</p> <p>22 accurate, to the best of your knowledge or</p> <p>23 belief?</p> <p>24 A Yes.</p> <p>25 Q And can you please confirm that your CV has</p> <p>26 been filed as Appendix 3 to the Marshall</p>	<p style="text-align: right;">26</p> <p>1 evidence-in-chief?</p> <p>2 A Yes.</p> <p>3 Q Does that CV accurately set out your</p> <p>4 qualifications and experience?</p> <p>5 A Yes.</p> <p>6 Q Do you adopt the Marshall evidence-in-chief as</p> <p>7 part of your evidence in this proceeding?</p> <p>8 A Yes.</p> <p>9 Q Thank you, Ms. Marshall.</p> <p>10 Now, for Obsidian's last independent</p> <p>11 expert, I turn to Mr. Boeckx.</p> <p>12 Mr. Boeckx, Obsidian has filed</p> <p>13 Exhibit 81.4, which is public, and 81.5, which</p> <p>14 is confidential, both which we will refer to as</p> <p>15 "the DAB reply evidence".</p> <p>16 Mr. Boeckx, was the DAB reply evidence</p> <p>17 prepared by you or under your direction and</p> <p>18 control?</p> <p>19 A D. BOECKX: It was.</p> <p>20 Q Do you have any changes that you wish to make</p> <p>21 to that evidence?</p> <p>22 A No, I don't.</p> <p>23 Q Is that evidence accurate, to the best of your</p> <p>24 knowledge or belief?</p> <p>25 A Yes.</p> <p>26 Q And can you please confirm that your CV has</p>
<p style="text-align: right;">27</p> <p>1 been filed as appendix to the DAB reply</p> <p>2 evidence?</p> <p>3 A It has.</p> <p>4 Q Does that CV accurately set out your</p> <p>5 qualifications and experience?</p> <p>6 A It does.</p> <p>7 Q Do you adopt the DAB reply evidence as part of</p> <p>8 your evidence in this proceeding?</p> <p>9 A Yes.</p> <p>10 Q Thank you, Mr. Boeckx.</p> <p>11 Finally, I turn to Obsidian's</p> <p>12 representatives, Mr. McGilvary and</p> <p>13 Mr. Charbonneau. These next two questions are</p> <p>14 for you both, perhaps beginning with</p> <p>15 Mr. McGilvary and then to Mr. Charbonneau.</p> <p>16 Was the Obsidian evidence prepared under</p> <p>17 your direction and control?</p> <p>18 A J. MCGILVARY: Yes.</p> <p>19 A S. CHARBONNEAU: Yes.</p> <p>20 Q Do you have any corrections to make to the</p> <p>21 Obsidian evidence?</p> <p>22 A J. MCGILVARY: No.</p> <p>23 A S. CHARBONNEAU: No.</p> <p>24 Q Is the Obsidian evidence accurate, to the best</p> <p>25 of your knowledge or belief?</p> <p>26 A J. MCGILVARY: Yes.</p>	<p style="text-align: right;">28</p> <p>1 A S. CHARBONNEAU: Yes.</p> <p>2 Q Mr. McGilvary, do you adopt the Obsidian</p> <p>3 evidence as evidence of Obsidian in this</p> <p>4 proceeding?</p> <p>5 A J. MCGILVARY: Yes.</p> <p>6 Q And staying with Mr. McGilvary, can you please</p> <p>7 confirm your CV has been filed in this</p> <p>8 proceeding as Exhibit 81.2?</p> <p>9 A Yes.</p> <p>10 Q Does that CV accurately set out your</p> <p>11 qualifications and experience?</p> <p>12 A Yes.</p> <p>13 Q Do you adopt your CV as part of your evidence</p> <p>14 in this proceeding?</p> <p>15 A Yes.</p> <p>16 Q Thank you, Mr. McGilvary.</p> <p>17 Mr. Charbonneau, can you please confirm</p> <p>18 your CV has been filed in this proceeding as</p> <p>19 Exhibit 81.3?</p> <p>20 A S. CHARBONNEAU: Yes.</p> <p>21 Q Does that CV accurately set out your</p> <p>22 qualifications and experience?</p> <p>23 A Yes.</p> <p>24 Q Do you adopt your CV as part of your evidence</p> <p>25 in this proceeding?</p> <p>26 A Yes.</p>

29	<p>1 Q Thank you, Mr. Charbonneau.</p> <p>2 A. BARRINGTON: As we aren't qualifying</p> <p>3 experts today, we will move next to opening</p> <p>4 statements.</p> <p>5 Mr. Chair, Mr. McGilvary and</p> <p>6 Mr. Charbonneau of Obsidian, along with</p> <p>7 Dr. Verdon, Dr. Pooladi-Darvish, Dr. Fox, and</p> <p>8 Mr. Watson have prepared an opening statement,</p> <p>9 which they will present together with reference</p> <p>10 to the slide deck marked as Exhibit 95.0. I</p> <p>11 will now turn it over to Mr. McGilvary.</p> <p>12 A J. MCGILVARY: Thank you very much.</p> <p>13 On behalf of Obsidian Energy, before I</p> <p>14 begin, I'd like to thank the Commissioners, not</p> <p>15 just for your time for this hearing but also</p> <p>16 for the time required to review the evidence</p> <p>17 and get your arms wrapped around what is a very</p> <p>18 wholesome technical case. I appreciate that.</p> <p>19 We'll start this presentation with why we</p> <p>20 are here today. Analysis by the Alberta Energy</p> <p>21 Regulator and the Alberta Geological Survey of</p> <p>22 two seismic events, November 29th, 2022, local</p> <p>23 magnitude 5.59, and March 16th, 2023, local</p> <p>24 magnitude 5.09, collectively referred to as</p> <p>25 "the events", resulted in the Compliance and</p> <p>26 Liability Management branch of the AER, or CLM,</p>	30	<p>1 concluding that these events were induced.</p> <p>2 Additionally, the AER deemed that the</p> <p>3 open-hole Leduc Formation wastewater disposal</p> <p>4 well 14-18-82-17 W5, or "the 14-18 well",</p> <p>5 operated by Obsidian Energy, or "Obsidian", was</p> <p>6 responsible.</p> <p>7 An environmental protection order was</p> <p>8 issued against Obsidian on March 23, 2023,</p> <p>9 citing a release, in this case energy, into the</p> <p>10 environment, and that Obsidian was identified</p> <p>11 as the person responsible.</p> <p>12 In response to the EPO, Obsidian stated</p> <p>13 that, since Obsidian had not seen any data or</p> <p>14 other evidence for the AER's conclusions,</p> <p>15 Obsidian could not agree with the conclusions</p> <p>16 in the EPO.</p> <p>17 Following the EPO being issued, Obsidian</p> <p>18 sought to appeal and gather -- gathered a team</p> <p>19 of independent experts that you see before you</p> <p>20 today to conduct independent analysis and</p> <p>21 derive conclusions regarding the causation of</p> <p>22 the events referred to in the EPO.</p> <p>23 The conclusion of the independent experts</p> <p>24 is that the evidence linking the 14-18 well to</p> <p>25 the events is ambiguous and that other</p> <p>26 industrial activities -- namely, wastewater</p>
31	<p>1 disposal in the area -- are substantially more</p> <p>2 likely to be the cause of the events.</p> <p>3 From a timeline perspective, this -- most</p> <p>4 of this proceeding started on March 22nd, 2023,</p> <p>5 with a courtesy meeting scheduled by CLM. It</p> <p>6 begins again with November 29th, 2022, where a</p> <p>7 seismic event, estimated local magnitude of</p> <p>8 5.59, occurs, and AGS determined that that</p> <p>9 seismic event was of natural occurrence. On</p> <p>10 March 16th, a second -- second seismic event,</p> <p>11 and again, estimated local magnitude 5.09,</p> <p>12 occurs in the Peace River area.</p> <p>13 On March 22nd, 2023, Obsidian attended that</p> <p>14 courtesy meeting with the AER staff. The</p> <p>15 meeting was chaired by Dr. Shipman, who advised</p> <p>16 that it was not necessary to take notes, as the</p> <p>17 technical slide deck would be sent to Obsidian</p> <p>18 after the meeting.</p> <p>19 Dr. Canales of the AER presented a</p> <p>20 PowerPoint deck showing data used by the AER to</p> <p>21 interpret and conclude that the March 16th,</p> <p>22 2023, seismic event was induced and caused by</p> <p>23 wastewater disposal operations at the 14-18</p> <p>24 well.</p> <p>25 Additionally, Dr. Canales also stated that</p> <p>26 the previous November 29th, 2022, seismic event</p>	32	<p>1 had been re-evaluated, and it was now</p> <p>2 determined that this event was also induced by</p> <p>3 wastewater disposal at the 14-18 well. This</p> <p>4 reversed a conclusion that the AER had</p> <p>5 previously stated that the previous -- the</p> <p>6 November event was naturally caused.</p> <p>7 Dr. Shipman indicated to Obsidian that</p> <p>8 there was ongoing academic research on induced</p> <p>9 seismicity in the Peace River area and that a</p> <p>10 paper was to be published in the shorter term</p> <p>11 that would support CLM's conclusions that the</p> <p>12 14-18 well caused the events.</p> <p>13 When asked, Dr. Shipman suggested that the</p> <p>14 research were from -- the researchers were from</p> <p>15 Stanford University and the University of</p> <p>16 Calgary. Dr. Shipman made it clear that an</p> <p>17 official or higher level response or action</p> <p>18 would follow shortly.</p> <p>19 And at the conclusion of the meeting,</p> <p>20 Dr. Shipman indicated that, contrary to the</p> <p>21 messaging at the start of the meeting, the</p> <p>22 AR -- the AER was no longer authorized to share</p> <p>23 the technical slide deck that had been</p> <p>24 presented.</p> <p>25 That followed on March 23rd, 2023, with a</p> <p>26 CLM -- what we call due process meeting. At</p>



33	<p>1 the request of CLM, Obsidian attended with AER 2 staff. The meeting was chaired by Mr. Kuleba, 3 who stated that the AER was going to issue an 4 EPO against Obsidian specific to the operations 5 of the 14-18 well.</p> <p>6 Mr. Kuleba stated through the -- sorry -- 7 stepped through the draft text of the pending 8 EPO. Among the immediate tasks assigned to 9 Obsidian Energy were:</p> <p>10 First, to set up an -- immediately identify 11 actions and an action plan to reduce the 12 frequency and magnitude of induced seismic 13 events;</p> <p>14 Set up a real-time passive seismic 15 monitoring array within a 10-kilometre radius 16 of the disposal operations;</p> <p>17 The implementation of a further mitigation 18 plan to reduce the magnitude and frequency of 19 induced seismic events; and</p> <p>20 The implementation of a reporting protocol 21 to the AER should additional events occur, all 22 within a 7 to 15-day daytime frame, and to the 23 AER's satisfaction.</p> <p>24 Obsidian Energy abided by these 25 requirements of the EPO.</p> <p>26 Mr. Kuleba also noted the right to appeal</p>	34	<p>1 the EPO. Mr. Kuleba asked Obsidian Energy if 2 the company had any evidence to present. In 3 the absence of both time and any data to 4 analyze relied on by the CLM to issue the EPO, 5 Obsidian, at that time, was not in a position 6 to dispute that the 14-18 well was seismogenic 7 or had caused the events. The meeting, 8 therefore, concluded, and the EPO was issued 9 shortly after. That provides a rough timeline 10 of the events preceding. The bulk of the time 11 now will be handed to the independent experts 12 to provide their feedback and findings from 13 their work conducted.</p> <p>14 Thank you.</p> <p>15 A J. VERDON: Thank you.</p> <p>16 And in the following slides, we will 17 present our analysis and conclusions of our 18 assessment of possible induced seismicity 19 causation for the Reno earthquake sequence. 20 I'll be leading this presentation, but I'll be 21 turning to my colleagues on the panel at 22 relevant moments, where they will present their 23 important contributions to this assessment.</p> <p>24 So quick overview: We will begin by 25 describing the seismic observations in the 26 Peace River area. That will include</p>
35	<p>1 observations from the existing regional 2 monitoring networks in the area and additional, 3 what we call, nodal seismic arrays that were 4 deployed in the immediate aftermath of the 5 larger seismic events.</p> <p>6 I will then briefly go on to describe how 7 we judge induced seismicity causation in 8 general, and, specifically, I will describe 9 what we refer to as the "Verdon, Bommer, and 10 Baphtie framework". This is a scheme or 11 framework for assessing induced seismicity 12 causation that was derived by myself and a 13 couple of colleagues in the UK to update 14 quite -- what we viewed as quite outdated 15 methods deriving from the early 1990s that had 16 previously been used to make assessments of 17 induced seismicity causation.</p> <p>18 Having described the scheme, we will go on 19 to apply to the Reno seismicity. And, in 20 particular, we're going to focus on certain 21 aspects, including the character of the 22 seismicity relative to the natural background 23 historical seismicity for the region; we will 24 examine the temporal correlation between 25 injection in different wastewater disposal 26 wells and the seismicity; we will examine the</p>	36	<p>1 potential evidence for transfer of pressure 2 and/or deformation to the depths of the 3 basements where the seismicity occurred; and 4 we'll examine evidence pertaining to the 5 perturbations in pore pressure in the Leduc 6 Formation caused by different disposal wells; 7 and, finally, we'll present our overall 8 conclusions, which is the outcome of this 9 induced seismicity assessment.</p> <p>10 So, firstly, the seismicity in the 11 Peace River area. The seismicity in the area 12 can be broadly divided into three discrete 13 clusters, which are shown in this map image.</p> <p>14 The cyan outlined events we refer to as 15 "the North Peace River cluster". This cluster 16 began at least in 2014, but possibly earlier, 17 given limitations with earthquake monitoring 18 capabilities in the area prior to that time.</p> <p>19 "The North Heart cluster", which I 20 generally outlined in pink here and in pink on 21 the timeline on the -- on the lower plot as 22 well -- I should -- I should add that the North 23 Peace River cluster are outlined in light blue 24 again on this timeline. That cluster initiated 25 from 2016.</p> <p>26 And then "the Reno cluster", which are</p>

<p style="text-align: right;">37</p> <p>1 outlined in green here and, again, green dots  2 on the timeline, which initiated in 2017, with  3 the bulk of the seismicity occurring from late  4 '22 onwards.  5 And it's this Reno cluster in green here  6 that hosted the magnitude 5.6 and magnitude 5.1  7 events that are the focus of this regulatory  8 proceeding.  9 There are a number of wastewater disposal  10 wells in the area. These are marked by grey  11 triangles, and my colleague,  12 Dr. Pooladi-Darvish, will provide more  13 information as to the timings and injection  14 volumes in these different wells during the  15 course of this presentation.  16 Turning now specifically to that Reno  17 seismicity cluster. The sequence began with  18 two small magnitude 2 events in 2017. There  19 was a further small burst of events in mid-2021  20 and a significant increase in the levels of  21 seismicity from late 2022 onwards.  22 There are two nearby disposal wells that  23 are near to this cluster of events. In this  24 map here, WD1, is what we refer to as "the  25 Obsidian well", which is targeting the Leduc  26 Formation; and this well labelled "WD2" here,</p>	<p style="text-align: right;">38</p> <p>1 which is a disposal well that targets the  2 Belloy Formation, and we'll refer to this  3 hereafter as "the Belloy well".  4 The orange curve here shows the monthly  5 disposal rates in the Obsidian well. Injection  6 began in late 2012. Volumes peaked in 2017  7 through 2018 and have been significantly lower  8 since that date.  9 The Belloy well began injection in 2016,  10 and injection rates in the Belloy well have  11 increased substantially since 2022.  12 And note, again, that the -- there are a  13 significant number of disposal wells to the  14 north that have, in combination, disposed a  15 significantly higher total volume of fluid  16 relative to both of these wells. These wells  17 are between 20 and 30 kilometres to the north  18 of the Reno seismicity cluster.  19 So now I'm going to present the mainshock  20 observations. These are seismological  21 observations that describe the main rupture of  22 the magnitude 5.6 events in November 2022.  23 These results are derived from two academic  24 papers that have been published on the topic  25 that are Schultz et al., in 2023; and then  26 Vasyura-Bathke et al., also in 2023.</p>
<p style="text-align: right;">39</p> <p>1 THE COURT REPORTER: Sorry. Excuse me,  2 sir. Can you slow down and repeat the names.  3 J. VERDON: Schultz et al.,  4 2023; and Vasyura-Bathke et al., also 2023.  5 The mainshock observations presented by both of  6 these publications, broadly speaking, are in  7 agreement.  8 The studies use evidence from regional  9 seismic data, so they're kind of background  10 Alberta seismic monitoring network, but know  11 that the regional data for this event is -- is  12 good because the large event has a high  13 signal-to-noise ratio. These studies have also  14 used InSAR observations. That's satellite  15 observations of ground deformation whereby the  16 rupturing of the earthquake creates deformation  17 on the ground, and that information can also be  18 used to infer the nature of the earthquake  19 rupture.  20 So this is a figure from the Schultz et al.  21 paper showing the position and orientation of  22 that mainshock rupture. The -- the kind of  23 orange-brown oval represents the dimensions and  24 orientation of the rupture that were calculated  25 by Schultz et al. So this -- it's -- it's -- I  26 appreciate I'm asking you to understand</p>	<p style="text-align: right;">40</p> <p>1 three-dimensional data when presented into a  2 two-dimensional plot, but the -- the pink that  3 I've added to this plot kind of shows the top  4 of this fault plane. So the strike is roughly  5 northwest/southeast, and it dips to the  6 northeast. So I'm kind of asking you to  7 imagine that this is the top of this plane, and  8 then it dips diagonally downwards to the  9 northeast along this direction.  10 The -- the beachball plots there show the  11 focal mechanisms of the events. I won't go  12 into a detailed explanation of what seismic  13 beachballs are, but I can tell you they  14 represent reverse faultings; that's a thrust or  15 reverse fault mechanism of the earthquake.  16 Note also, again, the position of the two  17 nearby disposal wells are marked. The Belloy  18 well is here, and the Obsidian well is -- is  19 here.  20 Note also the size of this rupture plane.  21 Earthquake magnitude scale with rupture  22 dimensions. A bigger earthquake requires a  23 bigger fault to rupture. A magnitude 5.6 event  24 must have a rupture area of between 10 to  25 100 kilometres squared. Converting an area  26 into a length -- if you assume a circular or</p>

<p style="text-align: right;">41</p> <p>1 rectangular rupture, that corresponds to a 2 rupture length of between 3 to 10 kilometres. 3 So there must be a large, single planar 4 structure on which this earthquake was hosted. 5 Note that the -- the -- the -- the size of this 6 rupture zone as -- as mapped by Schultz et al. 7 meets those requirements, that that -- that 8 that large plane exists in the subsurface. 9 In response to the mainshock, the AER 10 commissioned a -- a -- a nodal array that was 11 deployed in the area to record the aftershocks 12 of these events. The AER initially 13 commissioned an external contractor to process 14 the data from these nodal arrays to detect and 15 locate seismic events. These figures show 16 the -- the initial earthquake locations that 17 were produced by that external contractor. We 18 note there were various errors and issues in 19 the processing workflow that was used by that 20 contractor that generated artifacts in the 21 resulting locations. These artifacts placed 22 events in close proximity to the Obsidian well, 23 but they are not a real subsurface feature. 24 In particular, I draw your attention in the 25 three-dimensional plot to this cluster event 26 that is located immediately proximal to the toe</p>	<p style="text-align: right;">42</p> <p>1 of the Obsidian well. And in map view, that 2 cluster can be most easily seen in this 3 east/west section. Again, you see this line of 4 events that lines up very closely to the bottom 5 of the Obsidian well. We want to be very clear 6 that that is not a real subsurface feature; 7 that is an artifact produced by errors in the 8 geophysical processing. 9 And we note that in their evidence, the AER 10 or the AGS have accepted that those initial 11 results were erroneous and have later produced 12 updated sets of event locations. 13 Outer Limits reprocessed all of the data. 14 We did so with manual picking of all the events 15 by experienced seismologists and using a 16 location algorithm that uses a particular type 17 of inversion that is not sensitive to local 18 minima and, therefore, relatively -- relatively 19 immune to some of the issues that plagued the 20 initial processing done by the external 21 contractor. 22 These maps show our updated results. The 23 green dots show -- sorry. I should start 24 with -- the grey dots show the earthquakes 25 recorded by the initial nodal array that was 26 deployed in response to the November</p>
<p style="text-align: right;">43</p> <p>1 earthquakes, so they were recorded in December 2 and January 2022 through 2023, while the green 3 dots show earthquake locations that were 4 produced by the nodal array that was then 5 deployed by Obsidian in response to the -- the 6 issuing of the EPO. 7 You'll note that the green dots and the 8 grey dots broadly plot in the same position, 9 which is an encouraging sign in terms of event 10 location accuracy, because when you use 11 different arrays -- different nodal arrays, the 12 deployment of the Obsidian array followed a 13 very different footprint to the initial array 14 deployed by the AGS. But producing the same 15 locations is an indicator that there's no 16 artifacts being produced by these locations by 17 the acquisition geometry itself. 18 So let's look in detail at these updated 19 event locations. You'll note that they map out 20 a planar feature in the subsurface. That 21 planar feature reaches up to between 2,000 to 22 3,000 metres below sea level, which is roughly 23 1 kilometre below the depth of the interface 24 between the sedimentary formations in which oil 25 and gas activities are taking place and the 26 underlying crystalline basement rocks.</p>	<p style="text-align: right;">44</p> <p>1 The events can be divided into two 2 subclusters, so western and northwestern 3 cluster, which hosts the bulk of the events; 4 and the eastern cluster or southeastern cluster 5 over here, which I'm highlighting on the 6 screen. But note that the entirety of the 7 events fall on a single planar structure. So 8 you can fit a single plane to all of these 9 event locations. 10 Again, I recognize that I'm requiring you 11 to imagine three-dimensional data in a 12 two-dimensional plot, and I appreciate that 13 that can be a little challenging. I've done my 14 best to address that within the confines of 15 this hearing by producing various kind of 16 rotations of the data in three dimensions to 17 try and give you different angles and different 18 views of the events. 19 So the red dots are showing the event 20 locations from all of the nodal array data that 21 we processed, and then that polygon with the 22 green through to brown colours shaded as a 23 function of depth show the position of that 24 plane. And you can see that plane is actually 25 doing a very good job of matching all of the 26 event locations. So we're satisfied that all</p>

<p style="text-align: right;">45</p> <p>1 of the event locations map onto a single plane 2 within the subsurface that sits within the 3 basement. 4 Note that the orientation of this plane 5 again has a northwest/southeast strike dipping 6 to the northeast. So the size and orientation 7 of this plane provides a very close match with 8 the mainshock regional seismic observations 9 produced by Schultz et al. So we're providing 10 a good match between the nodal data from the 11 aftershocks and the mainshock observations that 12 were published in those academic publications. 13 So there is consistency between these 14 geophysical results. 15 Turning now to the updated AGS or AER nodal 16 array processing. So as I mentioned, having 17 identified the artifacts that were initially in 18 the data used to support the EPO, in 2024, the 19 AGS provided an updated set of locations. 20 They've actually provided a number of 21 different catalogues, created the various 22 different velocity models and processing 23 methods. The data I'm showing here in pink are 24 the AGS locations. These are their locations 25 that have the highest numbers of picks and that 26 have been processed using a program called</p>	<p style="text-align: right;">46</p> <p>1 "HypoDD", which is a -- a type of method called 2 "double differencing", which is generally 3 regarded by the community to produce more 4 accurate locations. So in our view, these are 5 the most accurate of the locations produced by 6 the AGS in their reprocessing work, the highest 7 numbers of picks, and the most precise event 8 location tool. 9 There are some similarities between these 10 data and some differences. You'll note that 11 that's -- artifact of events around the toe of 12 the Obsidian well has been removed by this 13 processing, much as it has been done by our 14 Outer Limits processing as well. So there was 15 agreement there: There are no events around 16 the toe of the Obsidian well, unlike the 17 original data set that was used to issue the 18 EPO. 19 Again, much like our data, the events 20 broadly map out a planar structure with a 21 northwest/southeast strike dipping to the 22 northeast. The AGS events are systematically 23 slightly shallower than our events. So the 24 grey dots here show our events again, and the 25 pink dots are showing the AGS events. If you 26 look at the -- kind of where this plane runs</p>
<p style="text-align: right;">47</p> <p>1 through the subsurface -- again, I'm -- this -- 2 this north/south section is the easiest to 3 envisage it. They're systematically slightly 4 shallower. That is likely a -- a product of 5 different velocity models used to locate the 6 earthquake data. Defining velocity models for 7 earthquake location is -- is a challenging 8 topic and difficult to resolve definitively in 9 terms of exactly where this plane should run. 10 However, the AER locations also show 11 significant vertical smearing at the upper edge 12 of this fault plane. So you see both sets of 13 locations follow a plane, but whereas the 14 Outer Limits events remain within that plane as 15 a tightly focused cluster, within the AGS 16 locations, they start to smear upwards within 17 this zone here. 18 Now, generally, within earthquake location 19 practice, when you start to see that kind of 20 smearing of results, that's often a sign that 21 there are issues remaining in the processing. 22 And in response to the AER's first proceeding, 23 we were able to access the actual raw picking 24 done by the AGS to locate these events. And in 25 the appendix of our reply evidence, 26 particularly within the events within this</p>	<p style="text-align: right;">48</p> <p>1 smeared cloud here, we found a number of issues 2 with the picking. I should note the AGS had 3 used an automated computer-based picking 4 algorithm with manual review rather than fully 5 manual picking by experts and that those 6 picking issues have likely created that 7 smearing at the top of the fault. 8 THE COURT REPORTER: I'm going to ask you 9 to slow down, please. 10 A J. VERDON: Absolutely. 11 So to recap, all of our observations are 12 consistent with a single rupture plane that 13 strikes northwest/southeast dipping to the 14 northeast. Again, I've -- I've -- I've put for 15 your comparison the fault plane mapped by 16 Schultz et al. And now a fault plane below the 17 very similar strike -- very similar position, 18 coming up just to the southwest of the Belloy 19 well in both cases and then dipping down to the 20 northeast. I note again that this is a 21 mainshock rupture that has a reverse faulting 22 mechanism. 23 So the upper ridge of this fault plane is 24 shallowest directly underneath the Belloy well. 25 It is -- also runs underneath the Obsidian 26 well, but in the position it's running under</p>

<p style="text-align: right;">49</p> <p>1 the Obsidian well, this well is dipping away to  2 the northeast, and so it is significantly  3 deeper, as much as 2 to 3 kilometres below the  4 Obsidian well at the position where it is  5 running below the Obsidian well.  6 Further evidence for the position of this  7 faulting plane relative to the sediments and  8 basement interface is provided by our  9 geomechanical analysis. And for that, I turn  10 to my colleague, Dr. Fox.  11 A A. FOX: Thank you,  12 Dr. Verdon.  13 So while the seismological work was  14 ongoing, the work Dr. Verdon just presented,  15 before his work revealed the seismic events to  16 be in the basement, I undertook a geomechanical  17 analysis to evaluate the geomechanics in the  18 Leduc.  19 The goals were to determine stress in the  20 Leduc and then examine the likelihood of fault  21 slip due to a pore pressure increase in that  22 stress state. I relied on public well data and  23 found a very robust dataset. And the  24 techniques I applied were industry standard,  25 and everything is detailed in my evidence.  26 The stress regime in the Leduc was found to</p>	<p style="text-align: right;">50</p> <p>1 be strike-slip, which, as you can see in this  2 figure on the slide here in the middle, that  3 that means that the vertical stress is the  4 intermediate stress, and there's one horizontal  5 stress larger than that and one smaller than  6 that.  7 This finding is consistent with decades of  8 published studies in the Western Canada  9 Sedimentary Basin that show most of it to be in  10 a strike-slip stress state. Several wells in  11 the regime were analyzed to confirm that  12 there's nothing unique about the stress state  13 around the 14-18 well. That would be  14 Obsidian's well as referred to by Dr. Verdon.  15 While the strike-slip stress state in the  16 Leduc is consistent with regional knowledge of  17 the sedimentary column, it is not consistent  18 with the reverse faulting mechanisms of the  19 Reno cluster seismicity.  20 Next slide, please. Thanks.  21 Furthermore, having quantified stresses, I  22 was unable to examine the likelihood of fault  23 slip in the Leduc based on frictional  24 destabilization of faults from an increase in  25 pore pressure at the epicentral location of the  26 November 2022 seismic events. This mechanism</p>
<p style="text-align: right;">51</p> <p>1 has been indicated in many cases of induced  2 seismicity from fluid injection both in Canada  3 and globally.  4 I ran several deterministic models and  5 examined a small range of stress values within  6 the bounds of my stress determination results.  7 I also ran probabilistic models that included  8 ranges of uncertainty in the input parameters.  9 I looked at two cases of initial pore  10 pressure, both the natural pore pressure and  11 also a slightly elevated pore pressure, due to  12 injection into the Leduc that had been  13 occurring before Obsidian began injecting.  14 Two pore pressure increases were also  15 examined for the period following the start of  16 injection at Obsidian's well. The first was an  17 increase in pore pressure due to injection at  18 the 14-18 well alone, and the second was a pore  19 pressure increase from all Leduc injectors in  20 the area, including several high-volume Leduc  21 injection wells to the north.  22 These pressure inputs were based on the  23 results of Dr. Pooladi-Darvish's work, which he  24 will speak to shortly.  25 In total, nine different scenarios were run  26 through both deterministic and the</p>	<p style="text-align: right;">52</p> <p>1 probabilistic analyses.  2 For all of the models, I first looked at  3 the results in general, that is, for all  4 possible fault plane orientations. I then  5 looked specifically at the main rupture for the  6 Reno seismicity cluster, as determined by  7 Dr. Verdon, as well as 11 published plane  8 orientations determined for the events of  9 November 2022; and Dr. Verdon showed those --  10 those were determined from those -- did you  11 call them "beachball diagrams"? I can't --  12 yes -- on one of -- an earlier slide there.  13 In the deterministic models, the pressure  14 increase attributed to the Obsidian well alone  15 was too low to cause any faults to slip in  16 the -- in the Leduc stress state. The only  17 deterministic models that resulted in any  18 unstable or -- I'll call them critically  19 stressed faults or planes included  20 injection-induced pore pressure increases from  21 all the Leduc injectors in the area, and none  22 of the critically stressed planes corresponded  23 to the specific rupture planes examined.  24 In the probabilistic results, the highest  25 probability of any possible plane being  26 critically stressed under a pressure increase</p>

53	<p>1 from the Obsidian well alone was 24 percent.                  2 Without including the slightly elevated initial                  3 pore pressure due to the other Leduc injectors,                  4 this probability was even lower than that.                  5 There was only one probabilistic model where                  6 either the main rupture plane or one of the                  7 November 2022 rupture planes had a nonzero                  8 probability of being critically stressed, and                  9 that, again, was under a pore pressure increase                  10 from all of the area Leduc injectors. These                  11 probabilities were 1 percent and 16.5 percent.                  12 In summary, the fault slip potential                  13 analysis shows that stress conditions are such                  14 that injection activities in the area are very                  15 unlikely to have caused slip on faults in the                  16 Leduc, especially when considering the pore                  17 pressure contribution from Obsidian's well                  18 alone. This conclusion is also consistent with                  19 Dr. Verdon's determination that the events of                  20 the Reno cluster occurred, not in the Leduc but                  21 in the basement. Thank you.                  22 A J. VERDON: Thank you very much.                  23 I will turn now to the question of -- it is                  24 already on -- question of how we judge induced                  25 seismicity causation.                  26 So, firstly, to be clear, there is nothing</p>	54	<p>1 in the seismogram -- so this is an example of                  2 one of the waveforms recorded by the nodal                  3 array showing the arrivals of seismic waves on                  4 the seismogram. There's nothing in these                  5 seismic waveforms that can tell you whether                  6 they're a natural event or an induced event.                  7 The waveforms themselves look the same.                  8 Instead, we judge induced seismicity                  9 causation by assessing various factors that                  10 might indicate that the events are induced.                  11 And these factors might include whether or not                  12 the events are of a different character than                  13 the background natural earthquakes in the                  14 region, whether or not there is spatial                  15 coincidence or correlation between injection                  16 activities and the seismicity, and in                  17 particular whether the earthquakes are -- are                  18 shallow; many earthquakes occur deep within the                  19 crystalline crust far below what any plausible                  20 model could tell you the perturbations from                  21 industrial activities could cause, whether or                  22 not there is temporal coincidence and/or                  23 correlation between the injection activities in                  24 question and the seismicity, and whether or not                  25 there is a plausible mechanism by which                  26 elevated pressures or other perturbations could</p>
55	<p>1 be delivered to the faults.                  2 In 2019, myself and some colleagues                  3 developed an -- an improved framework for                  4 performing this kind of assessment, recognizing                  5 that previous schemes very much struggled to                  6 deal with uncertain data and ambiguous results.                  7 So we developed a scheme that was specifically                  8 designed to incorporate uncertainty in                  9 observations and ambiguity in outcomes. I will                  10 now go on to describe this scheme.                  11 We pose a series of questions, and the                  12 specific questions are provided in -- in my                  13 paper which is attached as an appendix to our                  14 evidence -- to my evidence-in-chief. And for                  15 each of those questions, the answer to that                  16 question can indicate a -- a natural or an                  17 induced cause; for example, there is or there                  18 is not temporal correlation.                  19 The natural causes would score negative                  20 points. So the blue arrows pointing to the                  21 left in this plot with a numbers [sic] of                  22 points listed showing negative numbers here,                  23 meaning you score negative points for answers                  24 that indicated the event was natural.                  25 Conversely, the red arrows here show that                  26 you would score positive points for answers</p>	56	<p>1 that indicated that the events were induced.                  2 And you will note that the arrows have                  3 different lengths. Some questions are more                  4 important than others, and, therefore, we                  5 assign higher weighting to some questions than                  6 others. Also, some questions may have more                  7 than one answer. There might be a -- a strong                  8 answer or a weaker answer that's still positive                  9 but weaker, and so you can see we can score                  10 different numbers of points depending on how                  11 strongly that question is answered.                  12 What we then do is perform our assessments,                  13 answering each question, and we add up the                  14 scores to give our overall induced assessment                  15 ratio. So this is the number that's going to                  16 tell us whether the event was induced by that                  17 particular activity or not.                  18 So you'll see for this particular case,                  19 which was from a natural event, most of the                  20 questions are answered in terms of natural, or                  21 blue, and so we'd add up all the points scored                  22 by the blue arrows and would end up with a                  23 number that is negative. So a negative induced                  24 assessment ratio would tell us that it's                  25 natural.                  26 Note that even for a natural event, some</p>

<p style="text-align: right;">57</p> <p>1 questions might be answered in the positive.  2 Natural earthquakes can also be shallow, for  3 example.  4 This example shows an assessment we did for  5 an induced event. As you can see, the bulk of  6 the answers are positive. Not all the answers,  7 but the bulk of them. And as a result, you'd  8 add up the scores, and these would mostly be  9 positive -- positive numbers being added up,  10 and so you'd end up with an overall strongly  11 positive induced assessment ratio.  12 In some cases, the evidence can be  13 ambiguous. And you can see here in this  14 particular example, I'm answering some  15 questions negative and some questions natural,  16 and some answers indicate induced. Adding up  17 some negative numbers and some positive numbers  18 would lead you to a number that is close to  19 zero. So a low induced assessment ratio,  20 neither negative nor positive but closer to  21 zero, would indicate that the earthquake -- the  22 evidence for the earthquake is ambiguous; it's  23 unclear whether the event is induced or  24 natural.  25 Where multiple potential causes are  26 studied, the relative IAR scores between the --</p>	<p style="text-align: right;">58</p> <p>1 between the different causes can indicate the  2 respective likelihoods of causation. So, for  3 example, if I'd assessed two different causes  4 and ended up with a strongly positive IAR for  5 one cause and a weakly positive IAR for another  6 cause, that would indicate that the cause with  7 the strongly positive -- or the more strongly  8 positive IAR is the more likely to be the cause  9 of the event. It's scoring more points,  10 answering more questions towards being induced  11 than another activity and, therefore, is the  12 more likely cause of the events.  13 Turning now to apply the scheme to the Reno  14 seismicity, and we do so for three potential  15 causes: The Obsidian well and the Belloy well  16 that are relatively close to the Reno  17 seismicity cluster as previously discussed, and  18 then we also consider the combined contribution  19 from the several high-volume Leduc disposal  20 wells that are situated roughly 20 to  21 30 kilometres to the north of the Reno  22 seismicity.  23 And to recap that if the sequence is  24 natural, then we would expect to find a  25 negative induced assessment ratio for each  26 cause. If the sequence is induced, then the</p>
<p style="text-align: right;">59</p> <p>1 relative induced assessment scores between each  2 cause can be used to differentiate which cause  3 is the more likely driving cause of the induced  4 seismicity.  5 Turning now to apply the scheme. The first  6 question is regarding whether there has been  7 previous seismicity at the same site or within  8 the same regional setting. How does this  9 seismicity compare to the natural background  10 earthquakes that the region experiences. Now,  11 there are a number of natural events in the  12 region with magnitudes over the magnitude of 5.  13 So the magnitude of the event itself does not  14 represent something that's substantially  15 different to the background seismicity of the  16 region. However, the Reno seismicity and  17 indeed the North Peace River and North Heart  18 clusters show a substantially increased rate  19 compared to most natural sequences. Most  20 natural earthquakes in the area, you can have a  21 single mainshock, maybe a few aftershocks, and  22 that's it. Whereas, here, this kind of  23 pervasive seismicity continuing over a number  24 of years is -- is not something we typically  25 see in the background regional seismicity.  26 However, this answer does very much depend</p>	<p style="text-align: right;">60</p> <p>1 if the North Peace River cluster is also  2 treated as induced. You'll note that we've got  3 three different clusters of events. They were  4 onset with very similar times; within a few  5 years, they've all onset at the same sort of  6 time. They've all shown that similar kind of  7 pervasive and swarm-like behaviour rather than  8 that kind of single mainshock. It's therefore  9 difficult to support a conclusion that the  10 North Peace River cluster is natural, whereas  11 the north Heart and Reno clusters are induced.  12 However, if the North Peace River cluster  13 is also treated as induced, then that provides  14 a more consistent -- self-consistent  15 conclusion. However, if one were to insist  16 that the North Peace River cluster is  17 natural -- you'll know that it is obviously  18 further away from the nearest disposal wells --  19 then obviously, the rate of the North  20 Peace River cluster is not substantially  21 different to that of the Reno cluster, in which  22 case, the answer to this question would change  23 because we know we have -- the magnitudes are  24 the same as natural earthquakes. If the North  25 Peace River cluster were natural, then that  26 also has a high rate, and so the rate of the</p>

<p style="text-align: right;">61</p> <p>1 Reno cluster is not unusual, and, therefore, 2 the answer to this question would be that the 3 seismicity is not different to the natural -- 4 natural character of the region. 5 However, our view is that all three 6 clusters are likely to be induced, and, 7 therefore, all three are showing behaviours 8 that are different to the background natural 9 seismic character of the region. In which 10 case, our answer to this question was -- was 11 positive or that it -- that it represents a 12 change from the natural background seismic 13 character of the region. It was growing 14 positive points for this question. 15 The next question I'm going to talk about 16 in this presentation is whether the observed 17 seismic events are temporally correlated with 18 the injection activities. Now, to be clear, 19 correlation is more than just coincidence -- 20 something occurring at the same time as 21 something else. Correlation implies a relative 22 scaling and response between two codependent 23 variables: One thing goes up, and the other 24 thing goes up; that thing goes down, the other 25 thing goes down. And in our paper in which 26 this scheme is described, the guidance is very</p>	<p style="text-align: right;">62</p> <p>1 clear: The correlation is to be expressed 2 quantitatively as a correlation coefficient 3 between the two rates. We'll note that the AER 4 did not perform such an assessment of 5 correlation coefficients in their analysis. 6 The upper plot here shows the rates of 7 injection in the Obsidian and the Belloy well 8 and the seismicity. We created disposal rate 9 and seismicity time series and performed 10 cross-correlation analysis. And this is shown 11 in the plot below showing the cross-correlation 12 coefficients as a function of time lag. So 13 within induced seismicity, we often see a time 14 lag between the disposal and the earthquakes, 15 that there is some delay between the start of 16 injection and when the seismicity occurs. And 17 so we're showing the cross-correlation as we 18 lag the rates of seismicity versus the rate of 19 injection. 20 Now, what we find is that there a clear, 21 strong, positive cross-correlation coefficient 22 between disposal in the Belloy well and the 23 rates at which the earthquakes are occurring. 24 And that is statistically significant that 25 there is a relationship between these two time 26 series.</p>
<p style="text-align: right;">63</p> <p>1 Conversely, you'll note that at low time 2 lags, there is a low cross-correlation value 3 between the seismicity and the disposal in the 4 Obsidian well. There is no statistically 5 significant correlation between disposal in the 6 Leduc well, the Obsidian well, and the rates of 7 seismicity. 8 We also performed this analysis for the 9 high-volume Leduc wells. Now, for the 10 high-volume Leduc wells, these wells marked in 11 the -- in the centre of our figure here, our -- 12 our thesis is that all three clusters of 13 seismicity are being driven by pressure pulses 14 expanding out from these wells. Therefore, the 15 appropriate correlation to perform is with the 16 combined disposal rates in all of these wells 17 and the combined earthquake population of all 18 three clusters. And that -- that correlation 19 is shown by the green line in this plot; and, 20 again, we see that at low time lags, we have a 21 high statistically significant correlation 22 between the overall disposal in these 23 high-volume Leduc wells and the overall 24 seismicity in the three clusters across the 25 region. So, again, we're answering that, yes, 26 there's clear correlation between the</p>	<p style="text-align: right;">64</p> <p>1 high-volume Leduc wells and the centre and all 2 three clusters. And to reiterate again, there 3 is no -- no statistically significant 4 correlation between the seismicity and the 5 Obsidian well. 6 Next question pertains to whether the 7 earthquakes occur at similar depths to the 8 industrial activities. And to recap, I'm 9 showing our earthquake locations in this plot 10 relative to the depths of the Leduc well, the 11 Obsidian well, and the Belloy well. And for 12 both cases, the earthquakes are deeper than the 13 disposal. However, this is a common 14 observation for induced seismicity. It's 15 common for induced earthquakes to occur in the 16 basement below the activity that's causing it. 17 So within our assessment scheme, we -- 18 there's a -- there's a rider to this question 19 that means you answer it positively if there 20 are plausible mechanisms by which stress or 21 pressure changes could be transferred from the 22 depth of injection to the depth of which the 23 earthquakes are taking place. And we make it 24 clear that that information may be provided, 25 for example, by geophysical surveys such as 26 reflection seismic data and geological</p>



<p style="text-align: right;">65</p> <p>1 interpretations.</p> <p>2 So for the Leduc -- activities in the</p> <p>3 Leduc -- that includes both the Obsidian well</p> <p>4 and the high-volume Leduc wells to the north.</p> <p>5 The Leduc is only a short distance above the</p> <p>6 basement. The existence of faults extending</p> <p>7 from the Leduc into the basement are certainly</p> <p>8 plausible and reasonable to assume, and,</p> <p>9 therefore, we'd answer that there is a</p> <p>10 plausible mechanism to exist by which the</p> <p>11 perturbations from the Leduc could be</p> <p>12 transferred to the depth of these earthquakes.</p> <p>13 The Belloy situation -- the Belloy is</p> <p>14 substantially shallower, and, therefore, a</p> <p>15 slightly more in-depth analysis was required.</p> <p>16 And for that, I will turn to my colleague,</p> <p>17 Mr. Watson.</p> <p>18 A N. WATSON: Thank you,</p> <p>19 Dr. Verdon.</p> <p>20 As the investigation began to indicate the</p> <p>21 strong potential of Belloy contribution to the</p> <p>22 seismic --</p> <p>23 THE COURT REPORTER: Sorry. Slow down,</p> <p>24 please.</p> <p>25 A N. WATSON: Yes. Thank you for</p> <p>26 reminding me. I'm a bit nervous.</p>	<p style="text-align: right;">66</p> <p>1 As the investigation began to indicate the</p> <p>2 strong potential of Belloy contribution to the</p> <p>3 seismicity, I undertook an evaluation of the</p> <p>4 Belloy at and around the 6-14 well. This</p> <p>5 involved isopach and structural mapping of the</p> <p>6 Belloy Formation and a discussion of the</p> <p>7 regional hydrodynamics -- hydrodynamics of the</p> <p>8 Belloy Formation. This mapping and evaluation</p> <p>9 confirmed the reactivation of basement faulting</p> <p>10 through the Cretaceous as discussed in the</p> <p>11 Geological Atlas of the Western Canada --</p> <p>12 Canada Sedimentary Basin. It also indicated</p> <p>13 that the Belloy reservoir connected to the 6-14</p> <p>14 well is significantly less extensive than shown</p> <p>15 in the application to convert this well to a</p> <p>16 water disposal well.</p> <p>17 The hydrodynamic setting of the region is</p> <p>18 well understood and indicates a strong updip</p> <p>19 flow pattern towards the discharge area to the</p> <p>20 northeast. The disposal fluid has a</p> <p>21 significantly lower salinity and is therefore</p> <p>22 more buoyant. This salinity difference</p> <p>23 combined with the updip flow against the</p> <p>24 subcrop hindered the ability of the Belloy to</p> <p>25 disburse any water disposal related pressure</p> <p>26 increase.</p>
<p style="text-align: right;">67</p> <p>1 Evidence that the 1-1 well intercepted a</p> <p>2 conductive fault was observed during the</p> <p>3 mapping of the Belloy Formation. The presence</p> <p>4 of this fault is consistent with the</p> <p>5 identification of Belloy-level faults through</p> <p>6 seismic interpretation and the evaluation of</p> <p>7 other wellbores.</p> <p>8 The lessened ability of the Belloy to</p> <p>9 disburse any pressure increase due to injection</p> <p>10 and the presence of the pre-Cambrian Belloy</p> <p>11 faulting provides ample evidence for</p> <p>12 transmission of pressure from the Belloy to the</p> <p>13 basement. Thank you.</p> <p>14 A J. VERDON: Thank you.</p> <p>15 So with respect to this question for the</p> <p>16 Belloy, we have evidence for the existence of</p> <p>17 faults that run from the Belloy down into the</p> <p>18 basement.</p> <p>19 The next question is whether these faults</p> <p>20 could provide a plausible means for pressure</p> <p>21 transfer. So in addition to the analysis</p> <p>22 provided by Mr. Watson, we also turn to</p> <p>23 examples of induced seismicity elsewhere in the</p> <p>24 region. This figure here shows an example from</p> <p>25 a study by Pena Castro et al., which was</p> <p>26 examining induced seismicity caused by</p>	<p style="text-align: right;">68</p> <p>1 hydraulic fracturing in the Triassic, so the</p> <p>2 Triassic of -- the Triassic Montney, which sits</p> <p>3 above the Belloy. So in this case, the -- the</p> <p>4 pressure transfer has even further to go in</p> <p>5 terms of depth relative to the Belloy.</p> <p>6 And you can see their interpretation of the</p> <p>7 triggering of the mainshock for this particular</p> <p>8 induced event. They show pressure being</p> <p>9 injected into the Montney and then aseismic</p> <p>10 transfer of pressure down a fracture of fault</p> <p>11 network to intersect with a rupture plane in</p> <p>12 the underlying crystalline basement to trigger</p> <p>13 the mainshock. So similar mechanisms, as we</p> <p>14 are proposing in this case, have been observed</p> <p>15 elsewhere causing induced seismicity in the</p> <p>16 region.</p> <p>17 Another example is -- is this quotation</p> <p>18 from a study by Wang et al., again looking at</p> <p>19 induced seismicity from the overlying Triassic</p> <p>20 strata, and that's the subvertical Graben</p> <p>21 faults that facilitate the downward migration</p> <p>22 of injected fluid and stress preservation to</p> <p>23 reactivate pre-existing faults in the basement.</p> <p>24 And, again, that's -- that's all the way from</p> <p>25 the Triassic formation. And there are other</p> <p>26 similar citations provided, particularly in my</p>

<p style="text-align: right;">69</p> <p>1 reply evidence.  2 So we turn now to the question of whether  3 there's a plausible mechanism for each  4 different activity to have caused this event.  5 And in answering this question, the main focus  6 of our analysis is to consider how each  7 different activity could have delivered  8 pressure change to the top of the mainshock  9 fault.  10 So returning back to our seismological  11 analysis, we know that the rupture plane exists  12 with a northwest-southeast strike dipping to  13 the northeast and, therefore, the top of this  14 fault plane, as demarcated by my pink line that  15 I've added to the image, which is almost  16 directly below the Belloy well, whereas it's  17 roughly 3 kilometres to the west of the  18 Obsidian well.  19 So for the Belloy well, our answer to this  20 question was, yes, the downward pressure  21 transfer on faults is likely. It has been  22 observed elsewhere in region, deriving to  23 induce seismicity in the basement and, as we  24 know, at the top of the mainshock fault plane,  25 and it's directly below the Belloy well.  26 For the Obsidian well, because it's</p>	<p style="text-align: right;">70</p> <p>1 slightly further away from the top of the  2 mainshock fault plane because there are  3 different disposal activities taking place  4 within the Leduc Formation, including those  5 high-volume wells to north, we needed further  6 analysis to understand the different pressure  7 perturbations that we -- would be produced  8 within this formation. And for that, I turn  9 first to my colleague Mr. Watson and then to  10 Dr. Pooladi-Darvish.  11 A N. WATSON: Thank you,  12 Dr. Verdon.  13 In order to provide the inputs to the  14 geomodel, Enlighten correlated the Devonian  15 stratigraphic section in the Reno area. This  16 included isopach mapping of the three primary  17 Leduc sequences, structural -- structure  18 mapping of the pre-Cambrian, Leduc, and Wabamun  19 Formations.  20 Regional models of the hydrodynamics of the  21 Peace River Arch were also included. The thin  22 Ireton and faulting in the area of the Devonian  23 section has led to the establishment of the  24 entire Woodbend through Wabamun section into  25 one continuous hydraulic unit.  26 The mapping was used as inputs into the</p>
<p style="text-align: right;">71</p> <p>1 geomodel and indicated that the reservoir --  2 Leduc reservoir is essentially porous,  3 permeable, and continuous over the study area,  4 a finding that is consistent with industry  5 knowledge about the Leduc.  6 With that, I'll pass it over to  7 Dr. Pooladi-Darvish.  8 A M. POOLADI-DARVISH: Thank you,  9 Mr. Watson.  10 So in this part of the presentation, I'm  11 looking at the effect of pressure -- injection  12 and pressure in the Leduc Formation, and this  13 study basically has two pieces. The first part  14 is based on just observation of pressure  15 measurements in the Leduc and what it indicates  16 about whether these injection activities has  17 caused an increase in pressure. And the second  18 part is a modelling study to integrate the rest  19 of the -- a more convenience of collection of  20 the data to make sure that the conclusions from  21 the first step are -- are consistent with the  22 rest -- with the collection of the data.  23 To start with, I want to describe  24 the -- the Leduc area, the -- our area of study  25 and the injectors that are injecting and the  26 corresponding volumes. The picture to the left</p>	<p style="text-align: right;">72</p> <p>1 shows the study area; the dashed line shows the  2 age of the Leduc reef complex, and the dots  3 under are the water injection wells or water  4 disposal wells that have been drilled in -- in  5 the study area.  6 I have divided them geographically to three  7 areas: northern wells, central wells, and the  8 southern. The northern wells, you can see to  9 the right, there are volume of injection.  10 Northern wells collectively have injected  11 approximately 17 million metre cubed. Huge  12 amount of water, especially as you compare them  13 with a well to the south, which is the 14-18  14 well, the Obsidian well, and that has injected  15 1.3 million metre cubed.  16 Also, the bar charts to the bottom show --  17 it's another depiction of the relative  18 injection volumes, so the actual injection  19 volumes. The two wells to the very left, with  20 the biggest bar, they are the -- two of the  21 northern wells. That -- incidentally, they  22 have started injection the earliest, since  23 1986.  24 So to -- to assess increase in pressure, I  25 needed to first understand what is the initial  26 pressure in that environment and then look at</p>

<p style="text-align: right;">73</p> <p>1 increased levels of pressure if -- if they  2 exist. So to assess initial pressure, as it is  3 customary, I have used the DST data. I looked  4 across this area. I identified 24 various DST  5 pressures. These were typically the -- as you  6 see in here, between 1950s and 1980s when there  7 was exploration for oil and gas going on, but  8 nothing was being found. So wells were being  9 drilled, the access were being done, pressures  10 were being recorded, and then -- but no  11 injection or -- or -- or production activities  12 were happening.</p> <p>13 Upon collection of the data and review of  14 the data, I -- I categorized the quality of  15 this 24 DST pressures into three different  16 categories of good, mediocre, and bad. The  17 assessment that -- criteria that I used is  18 based on pressure transient analysis, the ideas  19 of pressure stabilization. If -- if -- and I  20 have detailed that in my report, but,  21 basically, if the pressures were stabilized, I  22 called them good; if it appeared that they  23 have -- they are slightly underestimating the  24 formation pressure, I called them mediocre; and  25 if there was either lacking data or really  26 clearly far from stabilization, I called them</p>	<p style="text-align: right;">74</p> <p>1 bad data.</p> <p>2 What I have shown in this plot are -- are  3 two. To the left, I'm showing the plot of good  4 pressures, what I've deemed to be good -- good  5 pressures. And about 10 or 11 of the 24  6 datapoints were good.</p> <p>7 If you look at the scatter of the data, you  8 see that they span within 16.1 to 16.5  9 megapascal with a midline of approximately  10 16.3 megapascal, and it's steady over the  11 30 -- more than 30 years of the -- of the  12 drilling activity with no injection or  13 production activities.</p> <p>14 And to the -- to the right, what  15 I'm -- what I have added is the so-called  16 mediocre pressures as well. And, again, with  17 the exception of one datapoint, all of the  18 datapoints combined, the good and mediocre fall  19 within the same range. That gives me more  20 certainty that my assessment of saying that  21 average pressure is 16.3 with an uncertainty of  22 .2 megapascal is - is a good estimation. And,  23 again, I -- I stress that this -- this happens  24 throughout the period of more than three  25 decades, suggesting that the pressure is stable  26 as one would expect from a connected body of</p>
<p style="text-align: right;">75</p> <p>1 water consistent with the hydrogeological model  2 that Mr. Watson presented.</p> <p>3 So that sets the starting point. Until  4 1986, before disposal activities started in  5 Leduc, our pressure is 16.3 megapascal with an  6 arrow bar of about .2 megapascal.</p> <p>7 Now let's look at what do we have  8 afterwards. So in this -- in this slide and  9 the next slide, I'm basically looking at just  10 mid-pressure measurements, and there's no  11 modelling to be done in here. I'll try to  12 describe any noticeably busy plots or explain  13 it here.</p> <p>14 So the map that I'm showing is basically  15 the upper half of the study area, includes  16 northern wells and central wells.</p> <p>17 At -- the time of this date that I'm  18 interested is 2008. It's before the 14-18 well  19 came on, so that's why it's not on this plot.  20 It's not shown.</p> <p>21 So what -- what is happening by 2008? We  22 have been -- we have had a history of 22 years  23 of disposal only from the northern wells, and  24 you will notice that, all of the northern wells  25 in the upper half of this township to the  26 north.</p>	<p style="text-align: right;">76</p> <p>1 But in 2008, the very first well other than  2 the northern wells is being drilled -- has been  3 drilled. That's the 06-29 well, one township  4 to the southeast of the northern well. And  5 before any disposal has happened in this well,  6 there is a measurement of pressure in that  7 well. In the third bullet on the bottom, I  8 have identified that this pressure is  9 significantly higher than the initial pressure.</p> <p>10 This assessment was part of the confidential  11 information; therefore, I have not provided the  12 number for it in here, but I have given the  13 reference for it.</p> <p>14 So by this time -- at this time, we have  15 only injection in the north, significant  16 amount, 43 million metre cubed, and at a  17 distance that is 10 to 12 kilometres away  18 before any -- any other injection in the study  19 area. You have a pressure measurement that's  20 significantly higher than the initial pressure.</p> <p>21 Just -- just an observation that the  22 pressure is higher, and, therefore, water must  23 have moved from the northern wells to the  24 vicinity of 06 -- 06-29 well, suggesting  25 there's communication from north towards the  26 south.</p>

77	<p>1 Next -- on the next line, I'll move from  2 one township further to the east, a farther  3 distance from the 16-20 -- from the northern  4 wells and see what has happened there. So this  5 is at the later time now when we have added  6 more wells. Okay.</p> <p>7 The year is 2013, 27 years after start of  8 disposal. The well of interest is the 13-10  9 well. So we are just -- and that 13-10 well is  10 the first well that is being drilled in  11 Township 84-17 W5, more than two township away  12 from the northern well. Okay.</p> <p>13 What is happening at this time? So we have  14 had, of course, injection from the northern  15 wells, again a significant amount, 15 million  16 metre cubed, and these are at a distance of  17 between 21 and 25 kilometre away from the 13-10  18 well.</p> <p>19 We have also injection from the 06-29 well  20 which we just talked about if -- in the  21 previous slide. That started a few years  22 earlier. Commutative injection by this time in  23 the 06-29 well is 1.3 million metre cubed,  24 significantly less than the northern well. And  25 that well, too, is quite away, 13 kilometre  26 away.</p>	78	<p>1 In addition to these wells, we have slight  2 amount of injection that is in 10-09 well and  3 14-18 well, cumulatively .1 million metre  4 cubed, quite -- quite insignificant as compared  5 to the others, but these too are at significant  6 distances of between 18 and 20 kilometre away  7 from the 13-10 well.</p> <p>8 Again, we have a pressure measurement at  9 13-10 well prior to any injection in that  10 township or at the 13-10 well. That indicates  11 the pressure is significantly higher than the  12 initial pressure.</p> <p>13 This brings in this -- in my study, I have  14 basically two conclusions. The combination of  15 what I just presented leads me to the first  16 conclusion, that there is communication from  17 the north to the south, specifically from the  18 high-volume injection wells, and there is  19 significant pressure increase across distances  20 of more than 20 kilometre.</p> <p>21 The second part of my analysis was done  22 using a modelling workflow. Again, basic  23 analysis of the data is sometimes quite useful,  24 as I presented -- presents big pictures, but  25 to -- to incorporate a larger amount of data  26 and make the -- everything is consistent, they</p>
79	<p>1 will open the models, as commonly done in our  2 workflow in reservoir engineering.</p> <p>3 So for this, I started with the so-called  4 fine-faulted geomodel starting model that  5 Ms. Marshall had -- had developed, which  6 incorporated geology, geophysics, petrophysics  7 and geostatistics. In addition, I needed to  8 provide data for water PVT, basically viscosity  9 and compressibility, rock compressibility, set  10 the initial pressure, as we discussed, and also  11 include the injection -- the disposal wells and  12 their sequence with time of injection.</p> <p>13 So this gives me the starting point. Now  14 what am I going to compare my model with. The  15 data are the measurements of pressure across  16 the region. With exception of only one well,  17 there is pressure measurement for all of the  18 wells. So three of the four northern wells  19 have pressures; all five central wells have  20 pressure information; and the 14-18 well has,  21 too, pressure information, which I -- again,  22 these are confidential; therefore, I am not  23 referring to numbers, but, again, I have  24 provided the reference in here.</p> <p>25 I want to emphasize that, in fact, these  26 pressures are quite useful in determining</p>	80	<p>1 regional flow. Why do I say that? Because  2 most -- 10 of the 12 pressures that we're  3 talking about have been determined before any  4 injection in the corresponding well. So we  5 have drilled the well. It's almost similar to  6 DST, in that sense that there is --</p> <p>7 THE COURT REPORTER: Almost similar to  8 what?</p> <p>9 A M. POOLADI-DARVISH: DST pressure. In  10 that sense that -- the pressure measurement is  11 measured before the well has become active.  12 When the well becomes active, the pressure  13 around the well gets affected by that activity,  14 but these pressures have been measured prior to  15 any injection activity; therefore, they're more  16 representative of flow that has come. It's a  17 more regional flow that affects that pressure.  18 It's not -- it's a longer distance. It's not  19 the activity at the well itself that is  20 affecting it. So in that sense, they are quite  21 useful.</p> <p>22 Okay. So where do I start? I described  23 the starting model within the parameters, and a  24 lot of the data in there have uncertainties.  25 My starting point was the midpoint value of all  26 of the input parameters. Around that case,</p>

<p style="text-align: right;">81</p> <p>1 what do I observe? I'm referring to the second 2 bullet, and then I'll go to the fourth bullet. 3 So what does -- what do I see in the first 4 run that I do? I see the model significantly 5 overpredicts the pressures among the northern 6 wells. As if the model says all of the water 7 or a lot of the water stays in the northern 8 wells the more the pressure goes up, but the 9 measurements do not confirm that. The 10 measurements are quite lower than the model 11 pressure. 12 Also, I see that the model underpredicts 13 the pressure among the southern wells and the 14 central wells as if the model has not allowed 15 the water to move toward the south. So both of 16 these observations leads me to the -- to the 17 conclusion that water must -- moved away from 18 the northern wells for pressures to match, 19 means there's more conductivity, more than 20 the -- the mid-value of mid-value properties 21 that we have assigned in there. 22 I have done an assessment of what is the 23 effect of other uncertain parameters, and I've 24 described parameters like compressibility or 25 pore volume cannot adjust for this difference. 26 If I modify porosity, they either -- pressure</p>	<p style="text-align: right;">82</p> <p>1 would go up everywhere, or it would come down 2 everywhere. It doesn't differentiate between 3 the difference that I'm seeing between the 4 north and the rest. 5 And the matches and mismatches, again I 6 have provided the reference. They were 7 confidential. 8 So what do I do to provide a better match 9 or -- or develop a model that is consistent 10 with the data? We never expect our first run 11 to match the pressure data always. We -- we 12 look into what are done, certain data, and try 13 to -- by adjusting the input data within the 14 range of uncertainty -- constrained by the 15 range of uncertainty, see whether we can obtain 16 a match or not. 17 In this case, I -- I move to our -- our 18 permeability -- permeability porosity 19 cross-plot that we had had a mid-value that I 20 had originally used, but also there are high 21 and low values. I chose the high values in 22 here, and when I ran that case, it led me to a 23 good match for all three groups of wells. No 24 other changes were done for these guys. 25 Now I have a model that has history matched 26 the performance, and I can use it for so-called</p>
<p style="text-align: right;">83</p> <p>1 "what-if studies". One of the what-if studies 2 that I did was that, Okay, what is the pressure 3 rise if only 14-18 well was active? 4 So if I'm -- and when I -- and so when I do 5 that and I compare the pressure rise in the 6 Leduc, at the epicentre of the earthquake, in 7 one scenario 14-18 well being alone and in the 8 other case all wells injecting, I come -- I 9 just observe the results, that the contribution 10 of the 14-18 well in pressure increase is less 11 than 10 percent of the other wells. 12 To test the model and its conclusions, 13 I -- I -- I attempted changing properties 14 within the models while still honouring the 15 measurements, and I developed two other 16 history-matched models, both of which confirm 17 the previous conclusions, leading me to 18 the -- to the overall observation that my 19 conclusions are not dependent on the detail 20 description of permeability on this grid block 21 versus that grid block. 22 Overall conclusions: There is significant 23 pressure increase at distances of more than 10 24 and even 20 kilometre and even 30 kilometre. 25 Therefore, presuming lack of pressure effect 26 from wells that are more than 20 kilometres</p>	<p style="text-align: right;">84</p> <p>1 away, as CLM did, is not justified. My second 2 conclusion is that contribution of the 14-18 3 well is less than 10 percent of other wells. 4 What I just described is all based on the 5 pressure information and the reservoir 6 modelling that I did. But there is another 7 piece of information that is independent of 8 what I just discussed, and what is that? In 9 2023, there was a falloff tests done on the 10 14-18 well and its pressure -- pressure 11 transient behaviour was -- was -- was gathered, 12 and I analyzed that. 13 What it showed is that the 14-18 -- the 14 falloff test of the 14-18 well shows something 15 that we call the "constant pressure boundary", 16 where you see the pressure support from -- from 17 the surrounding wells. Something is pushing 18 against that well. There is a clear signature 19 of a constant pressure boundary in the falloff 20 analysis of that test which I couldn't match it 21 with other models, and that is fully consistent 22 with everything that I just said so far, 23 meaning communication from the north toward the 24 south. 25 With that, I give it back to Dr. Verdon. 26 A. BARRINGTON: Mr. Chair, I note</p>

<p style="text-align: right;">85</p> <p>1 the time, and I would suggest that now might be  2 a good time to pause. We do have seven slides  3 left of the opening statements, and after that,  4 we'll be through all of our direct evidence.  5 So we will not, I don't expect, require all the  6 way up until lunch to complete.  7 If it's your preference to just push  8 through the last seven slides, then we would be  9 through all of our direct evidence, but we're  10 in your hands as to how you'd like to proceed.  11 THE CHAIR: Okay. I think the  12 court reporter would probably benefit from a  13 break. She's been going pretty hard. So let's  14 take a 15-minute break now, and we'll  15 reconvene -- let's say five to 11. So a little  16 longer. So reconvene at five to 11. Thank  17 you.  18 A. BARRINGTON: Okay. Thank you.  19 (ADJOURNMENT)  20 THE CHAIR: Thank you. Please  21 be seated.  22 Okay. Ms. Barrington, your panel can  23 continue.  24 A. BARRINGTON: Thank you.  25 A J. VERDON: Thank you very much.  26 So before the break, Dr. Pooladi-Darvish</p>	<p style="text-align: right;">86</p> <p>1 was describing the evidence for pressure  2 transfer of large distances through the Leduc  3 Formation. There is also independent  4 seismological evidence that speaks to this fact  5 as well, and I've already described the three  6 different clusters of seismicity that have  7 occurred in the region; they've occurred with  8 similar rates and similar onset times, and  9 obviously in the same structural settings,  10 therefore, very difficult to entertain a  11 possibility that one of these clusters is  12 natural, while the other two are induced. And  13 so our -- our belief is that the North  14 Peace River cluster is also likely to be an  15 induced event sequence. And you'll note that  16 it is also a significant distance, over 10  17 kilometres, from the high-volume Leduc wells to  18 the northeast and that there is an absence of  19 what has been referred to as "breadcrumb  20 seismicity", a trail of earthquakes linking the  21 wells to the events.  22 And so the existence of this cluster here  23 provides independent observational evidence  24 supporting the fact that pore pressure  25 transfers from these high-volume wells have  26 extended over significant distances, over</p>
<p style="text-align: right;">87</p> <p>1 20 kilometres, to trigger seismicity without  2 the existence of any, I say, breadcrumb events  3 or trail of seismicity. And, therefore, the  4 same can potentially hold true for the Reno  5 cluster as well and that you don't need to have  6 breadcrumb events linking where the injection  7 is taking place to where the seismicity is  8 occurring.  9 So the next question in the assessment  10 scheme is whether there is a plausible  11 mechanism to have caused the events. We've  12 already described for the Belloy wells the  13 existence of faulting in the proximity to -- of  14 the Belloy well that extends into the basement  15 and that there is evidence elsewhere in the  16 region for these types of features providing  17 pressure transfer down to nucleic seismicity in  18 the basement. So there's clearly a possibility  19 of this mechanism taking place.  20 Note that in answer to this question,  21 the -- the -- the VBB scheme provides stronger  22 and weaker arguments. So some or -- or -- or a  23 clear yes, and obviously we've answered that  24 with a moderate answer, recognizing that it  25 would have -- have to transfer pressure  26 vertically over a significant distance through</p>	<p style="text-align: right;">88</p> <p>1 that fault, but it's clearly a credible  2 mechanism for this induced seismicity in  3 creation.  4 For the high-volume Leduc wells to the  5 north, as described by Dr. Pooladi-Darvish,  6 there are large pressure changes in the Leduc  7 Formation at the position of the mainshock  8 fault driven by the high-volume wells to the  9 north, and so we answer this question with a  10 clear "yes", these wells have produced a large  11 pressure change at the position of the  12 seismicity.  13 For the Obsidian well, we answer this  14 question with "some". There is a small  15 pressure change in Leduc Formation at the  16 position of the mainshock from this well,  17 though, as described by my colleague. It is  18 substantially smaller than the contribution  19 from the high-volume Leduc wells to the north,  20 and, therefore, we've answered that with a  21 qualified "some" but not a hard "yes" answer in  22 response to that question.  23 So turning now to the results, firstly, all  24 the induced assessment ratios are moderately  25 positive. The highest scores are at around or  26 just over 50 percent. This tells us the events</p>

<p style="text-align: right;">89</p> <p>1 are likely induced, though not definitively so.</p> <p>2 And to provide some context for that</p> <p>3 answer, I've worked on other sequences of</p> <p>4 induced seismicity that are very, very clearly</p> <p>5 and obviously induced, and those ones are --</p> <p>6 produced induced assessment ratios of close to</p> <p>7 a hundred percent -- 80, 90, a hundred percent.</p> <p>8 So the scores of 50 percent still indicate an</p> <p>9 induced cause is more likely than -- than being</p> <p>10 natural, but it's not an answer that is</p> <p>11 definitively and incontrovertibly so.</p> <p>12 The highest induced assessment ratio was</p> <p>13 for those high-volume Leduc wells to the north.</p> <p>14 The highest induced assessment ratio means that</p> <p>15 our scheme is rating this as the most likely</p> <p>16 cause of the events. The evidence behind this</p> <p>17 conclusion is that these wells are creating the</p> <p>18 largest pressure change in the Leduc Formation</p> <p>19 at the position of the mainshock faults, as</p> <p>20 indicated by the pressure observations and</p> <p>21 modeling presented by Dr. Pooladi-Darvish and</p> <p>22 that there is overall temporal correlation</p> <p>23 between the high-volume wells and the overall</p> <p>24 growth of seismicity in the region, including</p> <p>25 all three clusters of adjacent seismicity in</p> <p>26 North Peace River, north Heart and Reno</p>	<p style="text-align: right;">90</p> <p>1 clusters combined.</p> <p>2 Our induced assessment ratio for the Belloy</p> <p>3 well is 49 percent. That's a difference of</p> <p>4 6 percent in our scheme. Now, usually the --</p> <p>5 the scheme is not to be taken as, you know,</p> <p>6 every percentage point matters. You know, plus</p> <p>7 or minus 5 to 10 percent points is essentially</p> <p>8 kind of giving you an answer that's essentially</p> <p>9 the same in -- in this case, you know, to kind</p> <p>10 of -- the difference between 49 percent and</p> <p>11 55 percent is not particularly significant. So</p> <p>12 we score a similar likelihood of causation for</p> <p>13 the Belloy well.</p> <p>14 The evidence speaking in favour of that</p> <p>15 conclusion is that the seismicity is showing a</p> <p>16 temporal correlation that's statistically</p> <p>17 significant with the injection of the Belloy</p> <p>18 Formation. The events relocated by the nodal</p> <p>19 array are closest in spatial proximity to the</p> <p>20 Belloy well rather than the Obsidian well and</p> <p>21 that the existence of faults from the Belloy</p> <p>22 and, indeed, above the Belloy have been</p> <p>23 demonstrated to transfer pressure downwards to</p> <p>24 nucleic seismicity in the basement elsewhere in</p> <p>25 the Peace River region.</p> <p>26 Turning down now to the Obsidian well, our</p>
<p style="text-align: right;">91</p> <p>1 induced assessment ratio was 31 percent, so</p> <p>2 significantly lower -- by about 20 percent --</p> <p>3 than the other causes. So clearly lower.</p> <p>4 The nature of the scheme, some of the</p> <p>5 questions that are asked pertain to induced</p> <p>6 seismicity in general rather than the specific</p> <p>7 cause. Example, you know, the seismicity is</p> <p>8 different in character to the regional</p> <p>9 background characteristics. So where you have</p> <p>10 multiple industrial activities in -- in --</p> <p>11 adjacent to each other, other scores can be</p> <p>12 pulled positive by the fact that something is</p> <p>13 being induced by another cause. Some of those</p> <p>14 questions end up being answered yes, but</p> <p>15 they're getting answered yes by the effect of</p> <p>16 another cause.</p> <p>17 So it's not surprising that we still</p> <p>18 produce a positive albeit significantly lower</p> <p>19 induced assessment ratio for this cause, but</p> <p>20 the causation is much more ambiguous because</p> <p>21 it's significantly lower in its induced</p> <p>22 assessment ratio than the other industrial</p> <p>23 activities that we've studied.</p> <p>24 Our conclusion -- that -- that -- that</p> <p>25 assessment is based -- or is evidenced by the</p> <p>26 fact that there's no temporal correlation</p>	<p style="text-align: right;">92</p> <p>1 between the Obsidian injection and the</p> <p>2 seismicity by the fact that the events are</p> <p>3 closer in space to the Belloy well than they</p> <p>4 are to the Obsidian well and that in terms of</p> <p>5 pressure changes in the region, the high-volume</p> <p>6 Leduc wells to the north are dominating the</p> <p>7 pressure perturbations in the Leduc Formation</p> <p>8 at the position at the top of the mainshock</p> <p>9 fault.</p> <p>10 So our overall conclusions is that the Reno</p> <p>11 cluster is likely -- that is to say not</p> <p>12 definitively -- induced; however, there are</p> <p>13 other industrial activities, namely, the Belloy</p> <p>14 well and the high-volume Leduc wells to the</p> <p>15 north, that are the more likely cause of the</p> <p>16 Reno seismicity, and, therefore, the Obsidian</p> <p>17 well is substantially less likely to have</p> <p>18 caused the Reno seismicity. My colleague has a</p> <p>19 few brief words to conclude this talk.</p> <p>20 A M. POOLADI-DARVISH: Thank you,</p> <p>21 Dr. Verdon.</p> <p>22 Mr. Chairman, I would like to address a</p> <p>23 separate issue briefly. In the CLM evidence,</p> <p>24 Mr. Virues accuses me of bias. This</p> <p>25 acquisition -- accusation was copied</p> <p>26 in comments provided by other members of CLM.</p>

<p style="text-align: right;">93</p> <p>1 This accusation is unsubstantiated, and I find 2 it very troubling.</p> <p>3 I take great pride in maintaining the 4 highest level of professionalism and integrity 5 in my work. In the reply evidence that was 6 submitted to this hearing, I have demonstrated 7 that I systematically followed the scientific 8 method. The same scientific method is at the 9 heart of the two reports that I have prepared 10 for these proceedings. These reports are in 11 evidence for review by you, the AER Panel. The 12 accusation of bias is unsubstantiated and 13 inappropriate.</p> <p>14 Thank you.</p> <p>15 A S. CHARBONNEAU: Thank you, 16 Dr. Pooladi-Darvish.</p> <p>17 Obsidian has devoted significant time and 18 resources to appeal the EPO based on the work 19 of the independent experts. The independent 20 experts have prepared a comprehensive suite of 21 evidence that includes reflection seismic, 22 geological interpretation, static geological 23 modelling, dynamic reservoir modelling, 24 geomechanical analysis, and induced seismicity 25 analysis.</p> <p>26 This evidence includes data and analysis</p>	<p style="text-align: right;">94</p> <p>1 that was not completed prior to the issuance of 2 the EPO by CLM, thus providing a much more 3 complete picture of the causes of the events. 4 The work of the multi-disciplined independent 5 expert team covers a comprehensive body of work 6 relating to the induced seismicity conclusion, 7 including technical analysis identified by the 8 AER as required, technical analysis that the 9 AER neglected to pursue.</p> <p>10 The conclusion from this comprehensive 11 suite of evidence is that the events referenced 12 in the EPO are likely, but not definitively, 13 induced and that the evidence linking the 14-18 14 well to the seismic events is ambiguous. Other 15 industrial activities in the area are 16 substantially more likely to have caused the 17 events.</p> <p>18 Obsidian accepts the evidence of the 19 independent experts in this proceeding, 20 including the conclusion of those independent 21 experts. Obsidian respects -- respectfully 22 requests that the EPO be revoked or, in the 23 alternative, be amended in accordance with the 24 AER Panel's findings in this Proceeding 25 Number 436.</p> <p>26 I would also like to, once again, on behalf</p>
<p style="text-align: right;">95</p> <p>1 of Obsidian, the expert team, thank the -- our 2 counsel, thank the AER for allowing us the 3 opportunity to appeal. Mr. Chair -- 4 Mr. Bolton, Dr. Stock, Dr. Zaitlin, we thank 5 each of you for your attention in listening to 6 us, reviewing our data. Mr. Chairman, 7 that's -- we're -- that's it. Thank you.</p> <p>8 THE CHAIR: Okay. Thank you 9 very much.</p> <p>10 Ms. Barrington.</p> <p>11 A. BARRINGTON: Thank you. 12 Mr. Chair, that concludes the direct evidence 13 of Obsidian. The witness panel is available 14 for cross-examination.</p> <p>15 THE CHAIR: Okay. Thank you. 16 Mr. Fitzpatrick, are you ready to proceed, 17 or do you need a short break before we start?</p> <p>18 P. FITZPATRICK: I'm ready to 19 proceed, sir.</p> <p>20 THE CHAIR: Okay. Thank you. 21 P. Fitzpatrick Cross-examines the Obsidian 22 Energy Ltd. Witnesses</p> <p>23 Q P. FITZPATRICK: The first question 24 I'd like to ask --</p> <p>25 THE COURT REPORTER: Sorry. Can you turn 26 your mic on, please.</p>	<p style="text-align: right;">96</p> <p>1 Q P. FITZPATRICK: The first question 2 I'd like to ask is directed to Dr. Verdon. 3 Dr. Verdon, is it your opinion that the 4 seismicity in the Reno cluster is probably 5 induced?</p> <p>6 A J. VERDON: Yes. As I said --</p> <p>7 THE COURT REPORTER: Sorry. Turn on your 8 mic.</p> <p>9 A J. VERDON: I -- my conclusion 10 is that it's more likely than not to be 11 induced.</p> <p>12 Q P. FITZPATRICK: So we're talking 13 here about a "whodunit", to put it 14 colloquially; right?</p> <p>15 A Primarily so, yes.</p> <p>16 Q Yes. Now, if we look at the opening statement, 17 please. If we can pull it back up, the OBE 18 opening -- witness opening statement, please. 19 If you go to page 2. Thank you.</p> <p>20 All right. Now -- now, of course, there's 21 reference here to two seismic events, and those 22 are the -- the two that were most of note, they 23 were the 5.59 and the 5.09. And you're aware, 24 of course, Dr. Verdon, that there were, in 25 fact, hundreds of seismic events that occurred 26 between December of 2022 and March of 2023;</p>



<p style="text-align: right;">97</p> <p>1 right?</p> <p>2 A That's correct, yes.</p> <p>3 Q And you also testified at one point during this</p> <p>4 morning's proceedings that you recognize that</p> <p>5 where you have the -- the increased incidence</p> <p>6 of earthquake activity, of seismic activity,</p> <p>7 and it's not reducing as you would normally see</p> <p>8 after a natural event, that that's something</p> <p>9 that's indicative of an induced event; correct?</p> <p>10 A It can be. Sometimes natural earthquakes do</p> <p>11 also produce that swarm-like behaviour.</p> <p>12 Q Yes. And -- and one way of looking at that</p> <p>13 is -- is it Omori's law, I think?</p> <p>14 A That is correct. Omori's law describes</p> <p>15 behaviour of aftershocks in -- in response to a</p> <p>16 mainshock.</p> <p>17 Q Are there a number of different statistical</p> <p>18 models that are followed for -- for trying to</p> <p>19 look at Omori's law, like looking at the actual</p> <p>20 events and running statistical analysis?</p> <p>21 A There are a number of versions of Omori's law.</p> <p>22 Q Yeah. So -- so, for instance, you've -- you've</p> <p>23 criticized in your -- your submissions -- your</p> <p>24 materials there not being a statistical</p> <p>25 analysis done. Is there one in particular that</p> <p>26 you would have preferred?</p>	<p style="text-align: right;">98</p> <p>1 A I believe I referred to a particular model in</p> <p>2 my -- in -- or a particular model is referred</p> <p>3 to in the IR requests that we made. I can</p> <p>4 bring that up, I believe, if you give me a</p> <p>5 moment.</p> <p>6 Q Sure.</p> <p>7 A Yes. I believe on page 29 of Exhibit 66.1, I</p> <p>8 provide the version of Omori's law that I would</p> <p>9 usually use.</p> <p>10 Q I'm sorry. I didn't catch that.</p> <p>11 A On -- on page 29 of Exhibit 66.1, I provide the</p> <p>12 equation for Omori's law that I would typically</p> <p>13 use.</p> <p>14 Q And did you run that equation to the events at</p> <p>15 issue in this case?</p> <p>16 A I did not because the following or not of</p> <p>17 Omori's law does not provide -- not form part</p> <p>18 of my induced seismicity analysis scheme. I</p> <p>19 consider the overall rates of seismicity, but,</p> <p>20 as I mentioned, sometimes natural earthquakes</p> <p>21 follow Omori's law, and then sometimes they do</p> <p>22 not, and so I -- I have not seen following</p> <p>23 Omori's law as a particularly important</p> <p>24 question when performing induced seismicity</p> <p>25 analysis.</p> <p>26 Q Is it fair to say that you also were of the</p>
<p style="text-align: right;">99</p> <p>1 view that it was not necessary to run any</p> <p>2 statistical analysis because you were already</p> <p>3 satisfied from looking at the data available to</p> <p>4 you that these events were induced?</p> <p>5 A No. I was performing analysis in order to</p> <p>6 assess whether or not the events were induced.</p> <p>7 Q Okay. And you've -- you've now reached that</p> <p>8 conclusion; correct?</p> <p>9 A I've reached the conclusion they're more likely</p> <p>10 than not to be induced.</p> <p>11 Q If we go to page 3 of the opening statement,</p> <p>12 please.</p> <p>13 Now, of course, this was part of the</p> <p>14 presentation that was -- that was addressed</p> <p>15 by -- by the witnesses that were here on behalf</p> <p>16 of Obsidian. The -- but what I did want to</p> <p>17 again address to Dr. Verdon, there is -- one of</p> <p>18 the points here at the -- at the top says that:</p> <p>19 (as read)</p> <p>20 AGS determines that the event is a</p> <p>21 natural occurrence.</p> <p>22 And, Dr. Verdon, I take it you're aware, from</p> <p>23 your review of the facts and materials, that at</p> <p>24 that time, as of November 29 or so of 2022, AGS</p> <p>25 had limited data available to them by way of</p> <p>26 their regional array data; correct?</p>	<p style="text-align: right;">100</p> <p>1 A Their -- the nodal array had not been deployed</p> <p>2 at that time, if that's what your question is</p> <p>3 asking.</p> <p>4 Q Correct. And what they had was the regional</p> <p>5 array data; right?</p> <p>6 A That's correct, I believe. I mean, I obviously</p> <p>7 can't speak to what evidence the AER did or</p> <p>8 didn't have at that time.</p> <p>9 Q In your professional opinion, was it prudent</p> <p>10 for AGS to thereafter gather additional data to</p> <p>11 assess whether the 5.59 seismic event was</p> <p>12 indeed natural as first believed or instead was</p> <p>13 induced?</p> <p>14 A Yes, I believe that would have been a prudent</p> <p>15 step.</p> <p>16 Q And in particular, is it fair to say you'll</p> <p>17 agree it was prudent for AGS to set up the</p> <p>18 nodal array to gather data over the following</p> <p>19 months?</p> <p>20 A Yes.</p> <p>21 Q Do you agree that setting up the nodal array</p> <p>22 and gathering the resulted data -- resulting</p> <p>23 data -- pardon me -- put AGS in a much better</p> <p>24 position to assess whether the 5.59 seismic</p> <p>25 event was natural as -- as initially believed</p> <p>26 or was instead induced?</p>

101	<p>1 A A better position than? Than what? Sorry.</p> <p>2 Q Than what they had originally with the regional</p> <p>3 array.</p> <p>4 A Yes. The nodal array would clearly help.</p> <p>5 Q I do have a couple questions to address to</p> <p>6 Mr. McGilvary and Mr. Charbonneau. And feel</p> <p>7 free, gentlemen, whoever wishes to -- to</p> <p>8 answer.</p> <p>9 On page 3 of -- of the same material of</p> <p>10 the -- of the opening statement -- let me just</p> <p>11 find the right bullet point here, please.</p> <p>12 Sorry. It might be on the next page. Let's</p> <p>13 look at page 4. Okay.</p> <p>14 I'm thinking of the -- of the point that</p> <p>15 says that: (as read)</p> <p>16 In response to the EPO, Obsidian</p> <p>17 stated that Obsidian had not seen any</p> <p>18 data or other evidence.</p> <p>19 And, Mr. McGilvary, Mr. Charbonneau, when there</p> <p>20 was discussion about the -- the EPO, and then</p> <p>21 the EPO was -- was issued, did Obsidian state</p> <p>22 that since Obsidian had not seen any data or</p> <p>23 other evidence, that Obsidian did not agree</p> <p>24 with the conclusions of the EPO?</p> <p>25 D.P. LANGEN: If Mr. Fitzpatrick</p> <p>26 has a reference that he's referring to,</p>	102	<p>1 that -- that'd be helpful, because he seems to</p> <p>2 have pulled the statement from somewhere.</p> <p>3 P. FITZPATRICK: Just a moment,</p> <p>4 please.</p> <p>5 Q P. FITZPATRICK: Apologies. It's on</p> <p>6 page 4. And this is the third-last bullet</p> <p>7 point, the sub-bullet, where it says that:</p> <p>8 (as read)</p> <p>9 In the absence of the data and</p> <p>10 analysis relied on by CLM to issue the</p> <p>11 EPO, Obsidian was not in the position</p> <p>12 to dispute that the 14-18 well was</p> <p>13 seismogenic or it caused the events.</p> <p>14 A J. MCGILVARY: Yes, to be specific,</p> <p>15 that is not a reference to a statement made at</p> <p>16 that meeting. That is Obsidian's position</p> <p>17 following the meeting.</p> <p>18 Q And how long following the meeting was that</p> <p>19 Obsidian's position?</p> <p>20 A I guess at least to the time that we were able</p> <p>21 to sit down and review the conclusions of the</p> <p>22 independent experts.</p> <p>23 Q Now, at that March 22nd meeting, though, the</p> <p>24 day for the EPO, you were shown a slide deck?</p> <p>25 A S. CHARBONNEAU: That is correct.</p> <p>26 Q And the slide deck had data in it?</p>
103	<p>1 A I beg your pardon?</p> <p>2 Q The slide deck showed data?</p> <p>3 A Yes, it did. I was a series -- it was a</p> <p>4 PowerPoint slide deck.</p> <p>5 Q The slide deck that you had requested</p> <p>6 and -- and you say you did not receive at the</p> <p>7 end of that said meeting, did you receive it</p> <p>8 about a week later?</p> <p>9 A We did, after requesting it again.</p> <p>10 Q And you also received with that slide deck data</p> <p>11 that went along with it?</p> <p>12 A That's possible, Mr. Fitzpatrick. I remember</p> <p>13 the slide deck specifically.</p> <p>14 Q Now, you're saying that's -- that -- I take it,</p> <p>15 that at the March 22nd meeting and then</p> <p>16 March 23rd, you didn't have the data; now</p> <p>17 you've got it about a week later. So once you</p> <p>18 had received the slide deck and -- and maybe</p> <p>19 the data -- you weren't quite sure of that --</p> <p>20 was Obsidian then in a position to -- to</p> <p>21 provide any feedback to CLM on -- on whether</p> <p>22 the -- the seismicity was induced by the</p> <p>23 Obsidian well?</p> <p>24 A J. MCGILVARY: At that point, we</p> <p>25 were soliciting the view of independent</p> <p>26 experts.</p>	104	<p>1 Q And is it fair to say that it took, after that,</p> <p>2 approximately 16 months to gather the opinions</p> <p>3 of independent experts, having put into form to</p> <p>4 provide to -- to CLM and then provide them</p> <p>5 through this proceeding?</p> <p>6 A Specifically to what end date are you</p> <p>7 referencing the 16 months?</p> <p>8 Q To when the materials on behalf of Obsidian</p> <p>9 were -- were filed in this proceeding with the</p> <p>10 opinion evidence.</p> <p>11 A No. I -- I wouldn't say that the drafting of</p> <p>12 the material is necessarily when the conclusion</p> <p>13 is reached. Significant technical work was</p> <p>14 done throughout that timeline.</p> <p>15 Q Did Obsidian at any time between March 2023 and</p> <p>16 July 2024 provide CLM with -- with material to</p> <p>17 try to persuade CLM that their conclusions were</p> <p>18 incorrect?</p> <p>19 A Yes. We offered.</p> <p>20 Q Well, did you actually provide it?</p> <p>21 A S. CHARBONNEAU: We offered, and the</p> <p>22 door was closed.</p> <p>23 A J. MCGILVARY: Yeah. We offered</p> <p>24 alternative dispute resolution because we</p> <p>25 thought we had compelling evidence, and that</p> <p>26 offer was rejected.</p>

<p style="text-align: right;">105</p> <p>1 Q Once again, though, could you actually provide 2 any information or evidence? 3 A Yes. They also had continual access to our 4 seismic array throughout -- throughout the 5 timeline. 6 Q And is that the nodal array that was set up 7 pursuant to the order? 8 A Correct. 9 Q Now, still on page 4 of -- of the opening 10 statement, the first bullet point, it is stated 11 that: (as read) 12 The meeting was chaired by Mr. Kuleba, 13 who stated that the AER was going to 14 issue an EPO against Obsidian specific 15 to the operations of the 14-18 well. 16 Do you see that, sir? 17 A We do. 18 Q And did Mr. Kuleba instead say to you that he 19 was considering issuing the EPO, and a decision 20 would be made following the meeting? 21 A S. CHARBONNEAU: I believe, 22 Mr. Fitzpatrick, that Mr. Kuleba walked through 23 all of the clauses of the EPO verbally to us, 24 let -- setting out what was about to transpire, 25 including the necessity of formulating a 26 traffic light system, mitigation system,</p>	<p style="text-align: right;">106</p> <p>1 et cetera. The EPO was publicly issued a few 2 hours after that meeting. 3 Q I do want to ask some further questions of 4 Dr. Verdon at this point. 5 Dr. Verdon, we have discussed the nodal 6 array that was put in place by AGS in December 7 of 2022. And I take it you'll be aware, from 8 your review of materials, that there was some 9 debate or controversy over where those nodal 10 arrays would be placed? 11 A J. VERDON: I wasn't aware of 12 that at the time. I have subsequently become 13 aware through the material on the record in 14 this proceeding. 15 Q Yes. And that's -- there's differing versions 16 of that in terms of -- of what was offered, 17 what was provided. But what I really want to 18 ask you is, in your professional opinion, did 19 any of that make any difference to the data 20 that was gathered? 21 A It would be hard for me to tell without knowing 22 much more information about where else sites 23 may have wanted to be placed or where they 24 could not have been placed. I don't think 25 I'm -- currently have the information needed to 26 answer that question.</p>
<p style="text-align: right;">107</p> <p>1 Q So when you're setting up a nodal array, what 2 are you trying to do in terms of distance away 3 from -- from a particular location? 4 A Well, you need to have the stations spread out. 5 You ideally want to have them kind of circling 6 the -- the focus of where the events are taking 7 place. But then you also have to consider the 8 noise levels at individual stations. So, for 9 instance, placing a seismometer near to a lot 10 of active industrial activity would create a 11 lot of vibration that would cover up any 12 seismic signals. So, ideally, you want a quiet 13 site. 14 Q So, for instance, if you -- if you put a nodal 15 array on a -- on an active drilling site, that 16 would have more noise? 17 A Yes. 18 Q And I didn't see anything in -- in your opinion 19 evidence, sir, that suggested that there was 20 any defect in the nodal array data flowing from 21 any placement of -- of the nodal arrays; is 22 that correct? 23 A From the node -- from the nodal array data 24 correctly processed -- and that's an important 25 step because we know that it wasn't initially 26 correctly processed -- then you're able to</p>	<p style="text-align: right;">108</p> <p>1 obtain sufficient location accuracy to perform 2 the kind of assessment we need for this 3 assessment. 4 Q Well, I'll ask again. Perhaps you 5 misunderstood my question. 6 You haven't suggested in your evidence at 7 all that there is any defect in where these 8 nodal arrays were placed; right? 9 A I think the binary nature of your question is 10 either defective or it's not -- is -- is what's 11 causing me trouble there. There's all -- you 12 know, you can always put more stations out; you 13 can always improve the data, but the data that 14 we had was sufficient to create the event 15 locations that were used. 16 Q Can we pull up Exhibit Number 50.06, please, 17 and we'll look at the PDF page 3. This is a 18 summary. And then looking in the third bullet 19 point -- just give you a moment to read that to 20 yourself, Dr. Verdon. 21 A Yes, I have it. Sorry. 22 Q Now, you say in the last sentence of that 23 bullet point: (as read) 24 Importantly, the recomputed catalogues 25 (both our own and that produced by the 26 AGS) do not show any seismicity in</p>

109	<p>1 proximity to the Obsidian well.</p> <p>2 Do you see that?</p> <p>3 A Yes.</p> <p>4 Q And can we pull up the OBE witness opening</p> <p>5 statement again, please. Go to page 11.</p> <p>6 And you have there, Dr. Verdon, in bold</p> <p>7 print: (as read)</p> <p>8 No events in proximity to the Obsidian</p> <p>9 well.</p> <p>10 A Yes.</p> <p>11 Q And two slides down, page 13, you've also got</p> <p>12 that in bold again; right?</p> <p>13 A Yes.</p> <p>14 Q Now, when you've used that phrase "in</p> <p>15 proximity" in -- in these various materials in</p> <p>16 Exhibit 50.06 and in the OBE witnesses' opening</p> <p>17 statement, what do you consider, sir, to be "in</p> <p>18 proximity"?</p> <p>19 A So these comments were made in reference to</p> <p>20 statements that were made in the record of the</p> <p>21 decision-maker -- and if you'll allow me a</p> <p>22 moment to pull up that -- those statements --</p> <p>23 statements basically saying that there were</p> <p>24 events located -- location and depth at the</p> <p>25 Obsidian -- at the Obsidian well, i.e.,</p> <p>26 implying there are events directly next to, as</p>	110	<p>1 in, like, co-located with the Obsidian well,</p> <p>2 and there were statements saying that the</p> <p>3 events originated at the Obsidian well, again</p> <p>4 "originated" implying the events, you know,</p> <p>5 starting at the Obsidian well.</p> <p>6 And, you know, and -- and images -- so I</p> <p>7 think -- I do think it will be best to pull up</p> <p>8 that particular --</p> <p>9 Q Sure.</p> <p>10 A -- piece of evidence. So I'm just going to try</p> <p>11 and find it. So this would be Reference 6.01,</p> <p>12 page 15. Yeah. So an image such as this, in a</p> <p>13 record of the decision-maker, where it says in</p> <p>14 the line above that image -- you'll see where</p> <p>15 the seismicity seems to originate at the Leduc</p> <p>16 well, i.e., at the red well there.</p> <p>17 As we now know, those event location</p> <p>18 clusters are artifacts and not a real</p> <p>19 subsurface feature, and so my comments of</p> <p>20 proximity in this regard are very clearly</p> <p>21 stating that the existence of events right next</p> <p>22 to the Obsidian well as shown in the record of</p> <p>23 the decision-maker is -- is incorrect and the</p> <p>24 result of an artifact. So that's what I'm</p> <p>25 referring to in that -- with those statements</p> <p>26 of proximity.</p>
111	<p>1 Q So what you're telling us is that when you use</p> <p>2 the words "in proximity", what you meant</p> <p>3 instead was immediately adjacent to or</p> <p>4 something like that?</p> <p>5 A In -- in -- in the context of those particular</p> <p>6 images, yes.</p> <p>7 Q Now, in the context of the reprocessing that</p> <p>8 you and your colleagues did where you mapped</p> <p>9 out where the seismic events occurred, in your</p> <p>10 professional opinion, were there events,</p> <p>11 seismic events, that occurred in proximity to</p> <p>12 the Obsidian well?</p> <p>13 A There were no events that were immediately</p> <p>14 adjacent, to use your words, to the Obsidian</p> <p>15 well.</p> <p>16 Q That's not my question, sir.</p> <p>17 A Sure.</p> <p>18 Q My question is, in your professional opinion,</p> <p>19 sir -- we're talking about when you use the</p> <p>20 term "in proximity", so forget about "adjacent</p> <p>21 to". When you use the term "in proximity to",</p> <p>22 did you observe, in your analysis, seismic</p> <p>23 events in proximity to the Obsidian well?</p> <p>24 A As -- as I mentioned, I'm using "proximity" in</p> <p>25 this term -- in this particular discussion</p> <p>26 because it was in response to the images shown</p>	112	<p>1 by the -- by CLM in the record of the</p> <p>2 decision-maker. I was saying that those events</p> <p>3 that were immediately proximal, in proximity to</p> <p>4 the wells were not -- did not exist.</p> <p>5 Q Once again, Dr. Verdon, that's not my question.</p> <p>6 I'm not asking you to comment on what you're</p> <p>7 saying are artifacts. I'm asking you to</p> <p>8 comment on what you and your team did where you</p> <p>9 reprocessed the information, and you mapped out</p> <p>10 where you -- you determined the seismic events</p> <p>11 to be.</p> <p>12 A M-hm.</p> <p>13 Q Okay. Focus your mind on that, please.</p> <p>14 A Okay.</p> <p>15 Q Were those seismic events, in your professional</p> <p>16 opinion, in proximity to the Obsidian well?</p> <p>17 A Where I'm defining "proximity" to mean within</p> <p>18 the immediate environs of that well, then, no.</p> <p>19 I would like to define my terms. If you</p> <p>20 would -- if you have a definition of</p> <p>21 "proximity", then -- then I would very much</p> <p>22 like for you to expand on it.</p> <p>23 Q Okay. Just a moment.</p> <p>24 A A. FOX: Mr. Fitzpatrick, I'd</p> <p>25 like a moment to confer with Dr. Verdon for</p> <p>26 just one second, please.</p>

113	<p>1 P. FITZPATRICK: I'll take guidance 2 from the Panel. 3 THE CHAIR: We generally allow 4 caucusing, but I also understand you're trying 5 to get a answer from Dr. Verdon. So, you know, 6 perhaps Dr. Verdon should answer the question. 7 P. FITZPATRICK: Yes. Thank you. 8 A DR. VERDON: Would it -- would 9 it -- would it -- my -- my -- my colleague's 10 provided -- it would be more helpful perhaps to 11 define things quantitatively. And when you 12 look at the images, the nearest lateral 13 distance -- so if we go back, perhaps, to the 14 opening statements images to which you're 15 referring to, the nearest events directly below 16 the Obsidian well were -- so those -- these are 17 the grey dots which are our location. So I'd 18 prefer if you went to Slide 11 because these 19 are our actual analysis, which you're referring 20 to. 21 The nearest events -- nearest kind of 22 significant cluster events is roughly -- so the 23 bottom of the well is a -- just over 1,000 24 metres below sea level, and the nearest 25 significant cluster events directly below the 26 well is just above 4,000 metres below sea</p>	114	<p>1 level. So that's a distance of 2-and-a-half to 2 3 kilometres below. And then laterally where 3 the events become shallowest at the top of the 4 fault plane, that's again about 3 kilometres 5 laterally. 6 Q P. FITZPATRICK: Dr. Verdon, 7 when -- when you're actually looking at -- at 8 data, case to case -- 9 A Yeah. 10 Q -- do you use, in your own mind, the term "in 11 proximity"? 12 A Do I? Sorry? 13 Q Do you use that term in your own mind, 14 considering whether events are in proximity? 15 A So when referring to the -- so when I'm 16 performing this kind of analysis, we can refer 17 to the questions in the assessment scheme, and 18 within the assessment scheme for wastewater 19 disposal, we recognize that they can create 20 significant perturbations that are there for a 21 distance of 3 kilometres, is still within a 22 zone that could potentially experience a pore 23 pressure perturbation. 24 THE COURT REPORTER: That can potentially 25 experience what? 26 A J. VERDON: A pore pressure</p>
115	<p>1 perturbation. 2 THE COURT REPORTER: Thank you. 3 Q P. FITZPATRICK: And if we could look 4 at Slide 14, please, in the opening statement. 5 There is content there, of course, about the -- 6 the Obsidian well being 3 kilometres to the 7 west of the Belloy well and the tail of the 8 plane. So that's the tail that -- that you 9 described earlier that's -- that's below the 10 Obsidian well, that's 2 to 3 kilometres below 11 it? 12 A J. VERDON: (NO VERBAL RESPONSE) 13 Q So -- so leaving aside the question of -- of 14 whether there were artifacts, when we look at 15 the data you interpreted, the seismic events 16 were within a distance from the Obsidian well 17 that you consider to be consistent with being 18 induced by the Obsidian well; is that correct? 19 A Yes. And I believe I answered that question in 20 the affirmative in my -- development of the 21 induced assessment scheme within my 22 evidence-in-chief. 23 Q Okay. Can we go to page 23, please. 24 Dr. Verdon, the -- the chart on the top right 25 of Slide 23 of the PowerPoint, that's a chart 26 with respect to injection via the northern and</p>	116	<p>1 central wells, I take it? 2 A That's correct. 3 Q And we see from the -- the bottom of 4 that -- that chart that the dating starts in 5 roughly end of 2005, start of 2006; correct? 6 A That's correct, yes. 7 Q The injection activities in the northern and 8 central wells, have they, in fact, been going 9 on since about 1986? 10 A That is correct. 11 Q And on this chart when we have those -- those 12 little circles, those are all earthquakes; 13 right? 14 A Again, that's correct. 15 Q And we see in -- in this chart that for the 16 period 2006 to 2008, there's -- there's no 17 earthquakes depicted? 18 A Yes. 19 Q And that's after injection had been going on in 20 those areas for about 20 years? 21 A Yes, that's correct. 22 Q Then we see there's a small number of 23 earthquakes that occur in 2009 to 2013. Looks 24 like there's about three of them there; right? 25 A Yes. 26 Q And that's over a period of about -- about five</p>

<p style="text-align: right;">117</p> <p>1 years?</p> <p>2 A Yes.</p> <p>3 Q Now, over that time in this chart,</p> <p>4 we're -- we're seeing that the injection rates,</p> <p>5 they're either staying fairly constant or</p> <p>6 they're, if anything, going up to when we get</p> <p>7 to about 2014; right?</p> <p>8 A Yes.</p> <p>9 Q Then there's a drop in 2014, and it kind of</p> <p>10 levels off to where the peak was before. Do</p> <p>11 you see that in the chart?</p> <p>12 A I do, yes.</p> <p>13 Q Okay. So -- so it's fair to say from</p> <p>14 your -- looking at this chart that when we get</p> <p>15 to 2014, there's not a -- like, a continued</p> <p>16 increase of -- of water injection; in fact, it</p> <p>17 decreases over the following years?</p> <p>18 A Yes. Well, no. I would -- I would say it</p> <p>19 stays fairly stable from 2014 onwards,</p> <p>20 actually.</p> <p>21 Q Yeah. So there's -- there's --</p> <p>22 A There's zigs --</p> <p>23 Q -- ups and downs.</p> <p>24 A -- zigs and zags.</p> <p>25 Q I think you and I are on the same page --</p> <p>26 A Yeah.</p>	<p style="text-align: right;">118</p> <p>1 Q -- that when you kind of level it out, it's --</p> <p>2 it's -- it looks like it's pretty stable</p> <p>3 overall; right?</p> <p>4 A M-hm.</p> <p>5 Q And -- and -- I'm sorry. One of your witnesses</p> <p>6 was saying something to you and --</p> <p>7 A Yes. He was pointing out that obviously this</p> <p>8 is the month-to-month injection rates and that</p> <p>9 cumulatively through the years, the -- the</p> <p>10 amounts of fluid injected is obviously going up</p> <p>11 and up and up.</p> <p>12 Q Absolutely. Absolutely. And -- and I wonder</p> <p>13 if I could ask if any other witness on the</p> <p>14 panel does have something to add, if they could</p> <p>15 turn on their microphone to -- to add so that</p> <p>16 it's in testimony as opposed to between</p> <p>17 witnesses?</p> <p>18 D.P. LANGEN: Mr. Chair, as you</p> <p>19 know -- and you just alluded to it -- the</p> <p>20 witnesses are allowed to caucus, and that's</p> <p>21 what they've been doing. They're not required</p> <p>22 to share what they wish to share with their</p> <p>23 fellow witnesses. So I take issue with my</p> <p>24 friend's request.</p> <p>25 THE CHAIR: Anything else you</p> <p>26 want to add, Mr. Fitzpatrick?</p>
<p style="text-align: right;">119</p> <p>1 P. FITZPATRICK: No, sir. I'm in</p> <p>2 your hands.</p> <p>3 THE CHAIR: Okay. Thank you.</p> <p>4 Yeah, we do allow witness caucusing, but I</p> <p>5 would remind the panel that, you know, if</p> <p>6 you're being asked questions, you need to turn</p> <p>7 on your mic and respond. You can caucus off as</p> <p>8 well.</p> <p>9 P. FITZPATRICK: Thank you, sir.</p> <p>10 Q P. FITZPATRICK: And I think what one</p> <p>11 of your witness colleagues was -- was alluding</p> <p>12 to was that what we appear to be seeing</p> <p>13 reflected here is that there's -- there's water</p> <p>14 injection over many years, and earthquakes</p> <p>15 result, and we can infer that over those many</p> <p>16 years, there was an increase in pressure that</p> <p>17 was gradually building up and up; right?</p> <p>18 A J. VERDON: That's my</p> <p>19 understanding, yes.</p> <p>20 Q Let's go to page 8 of the same material.</p> <p>21 A Before we do, I just want to briefly mention</p> <p>22 that you've talked about the earthquakes. It's</p> <p>23 worth remembering that prior to 2014 the</p> <p>24 monitoring systems in this area were of</p> <p>25 significantly lower quality. So the absence of</p> <p>26 earthquakes prior to 2014 can't be entirely</p>	<p style="text-align: right;">120</p> <p>1 taken as geophysical facts. There may -- you</p> <p>2 know, there may be additional earthquakes.</p> <p>3 Prior to 2014 the monitoring system simply</p> <p>4 wouldn't have been capable of identifying them.</p> <p>5 Q Okay. Let's -- let's unpack that a bit.</p> <p>6 So -- so your understanding is that there</p> <p>7 was some kind of monitoring system in place</p> <p>8 before 2006, but it wasn't as extensive as the</p> <p>9 regional array?</p> <p>10 A Yes. I think there were significant efforts</p> <p>11 made to improve the earthquake monitoring</p> <p>12 across the province through the 2010s.</p> <p>13 Q And is it your understanding that that resulted</p> <p>14 from there being an increase in seismic</p> <p>15 activity in Alberta?</p> <p>16 A I'm not party to how that decision was made.</p> <p>17 Q Okay.</p> <p>18 A But it's a reasonable assumption.</p> <p>19 Q Well, I'd suggest to you is what happened is</p> <p>20 that there were increasing earthquakes, and</p> <p>21 then the decision was made, Well, we've got to</p> <p>22 monitor this stuff; right? Does that make</p> <p>23 sense to you?</p> <p>24 A It makes sense to me. As I say, I'm not party</p> <p>25 to how these decisions are made.</p> <p>26 Q It would also make sense that if there were</p>

121	<p>1 increases in earthquake activities that were</p> <p>2 happening in the '80s or '90s or before 2006,</p> <p>3 then those efforts would have been undertaken</p> <p>4 before they were?</p> <p>5 A I -- I don't know that to be the case.</p> <p>6 Q All right.</p> <p>7 A I'm aware, for example, of other sequences</p> <p>8 where we've looked back and realized that there</p> <p>9 have been sequences of induced seismicity going</p> <p>10 on in areas that were never properly monitored,</p> <p>11 and there was no effort to better monitor them.</p> <p>12 So that's not a given that you can just assume.</p> <p>13 Q As we sit here today, to -- to what extent are</p> <p>14 you aware of -- of any earthquake activity that</p> <p>15 you would say ought to be on this chart that's</p> <p>16 not depicted here?</p> <p>17 A You mean prior to 2014?</p> <p>18 Q Yes.</p> <p>19 A I'm not aware. By definition that data</p> <p>20 wouldn't exist because it wouldn't have been</p> <p>21 recorded by monitoring.</p> <p>22 Q Okay. Let's -- let's now go to Slide 8,</p> <p>23 please. And, in particular, I'd like to look</p> <p>24 at the -- the chart on the top right.</p> <p>25 Now, Dr. Verdon, this is a chart that's</p> <p>26 depicting injection rates of the Obsidian well</p>	122	<p>1 and the Belloy well; correct?</p> <p>2 A Yes.</p> <p>3 Q And like the chart we just looked at on</p> <p>4 page 23, the -- the scale on the left side</p> <p>5 measures the volume of injection per month?</p> <p>6 A Yes.</p> <p>7 Q And, in this case, we've got injection that's</p> <p>8 measured at 2 times 10 to the 4. So that's</p> <p>9 20,000 barrels per month?</p> <p>10 A Yes.</p> <p>11 Q So the one would depict 20,000 barrels, the 2,</p> <p>12 40,000 barrels, and so forth?</p> <p>13 A Yes. I -- I -- used that scale because then</p> <p>14 that scale can also be used to show the</p> <p>15 event --</p> <p>16 THE COURT REPORTER: I can't hear you.</p> <p>17 "Because that scale" what?</p> <p>18 A J. VERDON: Because that scale</p> <p>19 is also useful then to display the event</p> <p>20 magnitude on the same plot which is why I've</p> <p>21 used a slightly odd y-axis scale.</p> <p>22 Q P. FITZPATRICK: Now, this indicates</p> <p>23 that the injection at the Obsidian well started</p> <p>24 in -- in -- sometime in 2012. Do you see that?</p> <p>25 A Yes.</p> <p>26 Q And it wrapped up quite rapidly to -- to</p>
123	<p>1 40,000 barrels a month by the end of 2012?</p> <p>2 A Yes.</p> <p>3 Q Then from the start of 2012 until the end of</p> <p>4 2023, so that's over a period of about</p> <p>5 12 years, you can see on the chart that except</p> <p>6 for three brief periods, the injection rates in</p> <p>7 the Obsidian well were at or above</p> <p>8 40,000 barrels per month; right?</p> <p>9 A I believe that to be the case, yes.</p> <p>10 Q And during about half of that period, the</p> <p>11 injection rates were above 60,000 barrels a</p> <p>12 month?</p> <p>13 A It's hard to judge whether that's exactly half</p> <p>14 or so, but, yeah, there were many periods where</p> <p>15 it's above that rate.</p> <p>16 Q And, in fact, some of the injection rates were</p> <p>17 at times above 80,000, even above a hundred</p> <p>18 thousand a month; right?</p> <p>19 A Yes.</p> <p>20 Q Now, this chart also depicts that the Belloy</p> <p>21 well started injecting in 2016?</p> <p>22 A Yes.</p> <p>23 Q And that's after there's been about four years</p> <p>24 or so of -- of ongoing injection in the</p> <p>25 Obsidian well at 40,000 barrels a month or</p> <p>26 more?</p>	124	<p>1 A Yes.</p> <p>2 Q And you'll agree, 'cause it's clear on</p> <p>3 the -- on the chart, that the injection rates</p> <p>4 in the Belloy well were quite a bit lower than</p> <p>5 they were in the Obsidian well?</p> <p>6 A They appear to be so, yes. Until about 2022.</p> <p>7 Q And you'll also agree that the Belloy well was</p> <p>8 injecting into the Belloy Formation more than</p> <p>9 1,100 metres above the injection depth of the</p> <p>10 Obsidian well?</p> <p>11 A I'm sorry. I'm just trying to remember the</p> <p>12 1,100 metres. That sounds about right, but I</p> <p>13 will check.</p> <p>14 Q Now, you've mentioned that in 2022, the</p> <p>15 injection rates in the Belloy well increased,</p> <p>16 and you see that on the chart?</p> <p>17 A Yes.</p> <p>18 Q And you'll agree, of course, that despite</p> <p>19 that -- that aside from one month that we seen</p> <p>20 on the chart, that the injection rates in the</p> <p>21 Obsidian well were still above or substantially</p> <p>22 above the injection rates in the Belloy well?</p> <p>23 A Yes.</p> <p>24 Q Let's flip back to Slide 23 for a moment. We</p> <p>25 spoke a few moments ago about the -- the</p> <p>26 pattern that we see depicted on the chart in</p>

<p style="text-align: right;">125</p> <p>1 the top right corner. This is injection in the  2 north and central wells. We talked about  3 having a period of years where there's  4 injection of water, and then after that period  5 of years, there's a buildup of pressure, and  6 then we start seeing earthquakes happen. Do  7 you recall that?  8 A Yes.  9 Q Let's go back to Slide 8, please. And I put to  10 you, sir, that that's exactly what we're seeing  11 on Chart Number -- or the Slide 8, the chart in  12 the top right-hand corner, in respect of the  13 injection of the Obsidian well?  14 A No, because our assessment has very clearly  15 indicated that the majority of evidence that  16 would link the Obsidian well to the seismicity  17 is -- is ambiguous.  18 Q Okay. Well, we've got both instances where  19 there's injection of -- of fluid over a number  20 of years; right?  21 A Yes.  22 Q And would you agree that the injection of fluid  23 in the Obsidian well over a number of years  24 would tend to increase pressure?  25 A Yes. I mean, the pressure models have been  26 developed by my -- my colleague, and they're --</p>	<p style="text-align: right;">126</p> <p>1 they're clear as to the amount of pressure that  2 well would have created, and that's obviously  3 in the confidential materials.  4 Q You'll agree as well that the north and the  5 central wells inject into the Leduc Formation?  6 A Yes.  7 Q And the Obsidian well injects into the Leduc  8 Formation?  9 A Yes.  10 Q And in contrast, the Belloy well injects into  11 the Belloy Formation 1,100 metres above?  12 A Yes.  13 Q Now, I'm still looking at the chart on  14 Slide Number 8. Do you see that there's a  15 cluster of earthquakes that occurred in 2021?  16 A I do, yes.  17 Q And if you look, sir, at -- at the pattern  18 of -- of injection in the Belloy well, do you  19 see that after a period of, I guess what we  20 call, its initial peak in 2016 through sometime  21 in 2017, the injection rate then decreased?  22 A Yes. That appears to be the case on the plot.  23 Q And, in fact, thereafter when we get to 2020,  24 it went briefly down to zero?  25 A Yes.  26 Q And it's -- it came back up after that, but it</p>
<p style="text-align: right;">127</p> <p>1 still was -- was nowhere near the -- the --  2 until 2022, the levels of injection that we had  3 seen in the 2016/2017 time period; right?  4 A It is lower, yes.  5 Q And then we see the earthquakes happening in  6 2021 after a period in which the Belloy well  7 injection rate had been decreasing. You  8 understand that, sir?  9 A Yes. I believe -- I believe the  10 overall -- you've asked me specifically in this  11 question to look at the pattern of earthquakes.  12 That's exactly what the cross-correlation  13 coefficient does as shown in -- if we go to  14 Slide 23 or 22 even.  15 Q Yes.  16 A The cross-correlation coefficient is a  17 mathematical quantification of the relationship  18 between the rates and the earthquakes, which is  19 what you're asking me about.  20 Q M-hm.  21 A A high cross-correlation coefficient shows  22 there is dependence in the overall rate of  23 seismicity through time and the overall  24 injection volume through time, and clearly what  25 we've found is that overall -- I mean, I  26 appreciate you wanting to -- to point to</p>	<p style="text-align: right;">128</p> <p>1 different moments in time and different  2 particular earthquakes and injection rates,  3 but, overall, we see a statistically  4 significant correlation coefficient between the  5 injection volumes in the Belloy well and the  6 seismicity, which is absent for the Obsidian  7 well.  8 Q And are you talking about the seismic activity  9 in 2022 and 2023, or are you talking about the  10 seismic activity in 2021?  11 A I'm talking about all of the seismicity taken  12 as a time series from the first event through  13 to the middle of 2023.  14 Q Dr. Verdon, might it be that this is one  15 instance where a score could be pull positive?  16 A Explain what you mean by that.  17 Q What I mean is what you said in your testimony  18 this morning --  19 A M-hm.  20 Q -- that a score could be pull positive --  21 A Yeah.  22 Q -- that was under your method --  23 A Yes. Sure.  24 Q -- if I can call it that.  25 A If there was another well in the area that was  26 following the -- the same pattern of injection</p>



<p style="text-align: right;">129</p> <p>1 as the Belloy well, then that could also be 2 pulled positive, so, by that, a mutual 3 correlation. So, for example, sales of 4 swimming trunks and ice creams go up at the 5 same time. Then you'd have correlation with 6 temperature. And you wouldn't -- wouldn't be 7 causing evidence -- I'm trying to think of the 8 word -- mutual correlation. 9 So if there were another well with the same 10 trend of injection as for the Belloy well, 11 then, yes, it -- and that other well was 12 causing it, then, yes, it could be pulled 13 positive by that particular action, but there's 14 no such other well that I'm aware of that would 15 be able to produce that effect. 16 Q And -- and your issue is -- with respect to the 17 Obsidian well is that in the last several years 18 of 2019 to 2023, that the injection rate was 19 fairly moderate; it wasn't increasing or 20 decreasing? That's why -- 21 A My issue with the Obsidian well is that the 22 cross-correlation shows no significant -- no 23 statistically significant cross-correlation 24 between the rate of seismicity and the 25 injection volumes. 26 Q Dr. Verdon, do you accept the principle that</p>	<p style="text-align: right;">130</p> <p>1 you may have found a false positive or a score 2 being pulled positive for the Belloy well by 3 use of your -- your analysis of what we see now 4 on Slide Number 22? 5 A No, because I'm not aware of another well with 6 the same level of injection as the Belloy well 7 that could create that particular correlation 8 by chance. 9 Q But, Dr. Verdon, aren't we looking on this 10 chart at a well that has more injection, the 11 Obsidian well? 12 A So I'm going to -- there's -- there's two 13 points I want to give to that answer. Firstly, 14 no, it couldn't have been pull positive because 15 there's no positive correlation between the 16 Obsidian well. So it, by definition, can't 17 pull it positive because it's providing a 18 negative answer. 19 In terms of the relative amounts of volume, 20 yes, the Obsidian well has injected more, but 21 the key parameter is -- is -- overall is 22 pressure change, and the amount of pressure 23 change will depend both on the volume and on 24 the geological properties of the formation 25 being targeted. So a lower injection volume 26 doesn't necessarily mean a lower pressure</p>
<p style="text-align: right;">131</p> <p>1 change. 2 Q I'm going to put a hypothetical to you. 3 A Okay. 4 Q If you were incorrect about the Obsidian well 5 inducing seismicity, would you then accept that 6 you may have a -- a pulled-positive result for 7 the Belloy well? 8 A With respect to the temporal correlation, no, 9 because there's nothing else to derive that 10 false positive. 11 Q What about correlation? 12 A Excuse me? 13 Q What about correlation? Simple correlation? 14 Coincidence? 15 A There is coincidence between the Obsidian well 16 and the seismicity, and we've answered as such 17 in our assessment scheme. That's Question 2, 18 which I didn't discuss in these slides for the 19 reason of time because the coincidence question 20 is kind of obvious and a given. They all 21 coincide with the seismicity. 22 Correlation is something more than 23 coincidence. Correlation is a codependence 24 between variables. 25 Q And -- and my apologies. I phrased that 26 question poorly.</p>	<p style="text-align: right;">132</p> <p>1 Might the -- the increase in the injection 2 rate of the Belloy well be coincidental rather 3 than correlative with the seismicity that 4 occurred? 5 A The correlation exists. The existence of the 6 correlation could potentially be coincidental, 7 but it certainly provides evidence linking the 8 well to the activity. 9 Q And -- I'm sorry -- are -- is it your 10 testimony -- 11 A In the sense that, you know, correlation on its 12 own can't -- or correlation does not always 13 equal causation, but it's often a good clue. 14 Q Is it your testimony that as an absolute 15 certainty that the Belloy well induced seismic 16 activity in the Reno? 17 A As before, I -- I believe more likely than not 18 that it did. 19 Q Can we go back to Slide 13, please. Now, we 20 discussed earlier the -- the distances of the 21 Obsidian well to -- to where the seismic events 22 occurred. You recall that? 23 A M-hm. 24 Q And is the hypocentre of an earthquake its 25 latitude, longitude, and depth? 26 A Yes, that's correct. That's the position of</p>

<p style="text-align: right;">133</p> <p>1 the -- the dot within three-dimensional space.  2 Q And then if we go again to page 14 just  3 briefly. We talked earlier about that's what  4 depicts the distances from the Obsidian well to  5 the -- the hypocentres?  6 A Excuse me? Sorry. I didn't catch that.  7 Q The distances from the Obsidian well to the  8 hypocentres?  9 A Yes.  10 Q Yes. Then if we could go to Slide Number 26.  11 Now, Slide 26 says that: (as read)  12 Downward propagation of pressure along  13 faults to cause deeper induced  14 seismicity is common in the  15 Peace River Arch.  16 Right?  17 A Yes.  18 Q Would you agree, sir, in your professional  19 opinion, that that would explain how injection  20 at the depth of the Obsidian well could cause  21 seismic events at deeper depths?  22 A That would explain how injection at any of  23 these levels could cause seismicity at greater  24 depth.  25 Q Okay. Can we call up Exhibit 50.06, please.  26 And if we could go to page 121. This is the</p>	<p style="text-align: right;">134</p> <p>1 paper you spoke of earlier today, sir?  2 A It is, correct.  3 Q And that's yourself and Brian Baptie and  4 Julian Bommer that together wrote that paper?  5 A That's correct.  6 Q You were the lead author?  7 A I was.  8 Q And is it fair to say that you agreed with  9 everything that was said in this paper?  10 A I believe so. Yes.  11 Q Anything that you recall that you disagreed  12 with and that you got outvoted by Baptie and  13 Bommer?  14 A I believe I support everything. Yes, I support  15 everything in this paper. Sorry. Little bit  16 nervous.  17 Q All right. Let's go to page 122 of the PDF.  18 And I'll just take a moment to find where my  19 reference is. There it is, right at the top.  20 Do you see, sir, where -- where it's stated:  21 (as read)  22 We stress that the specific details of  23 the framework are only the suggestion,  24 and others may wish to adapt and  25 adjust those features.  26 A I do, yes.</p>
<p style="text-align: right;">135</p> <p>1 Q Now, if we go to page 127. About -- well,  2 partway down that paragraph that's under the  3 heading "The Proposed Criteria for Fluid  4 Injection and Extraction", there's a sentence  5 that starts "we wish to emphasize". Do you see  6 that?  7 A Thank you.  8 Q (as read)  9 We wish to emphasize two particular  10 points --  11 A Yes.  12 Q (as read)  13 -- the first being that both the  14 criteria and the associated scores  15 presented herein are our own best  16 judgment put forward as a suggestion.  17 These are not intended as a  18 prescription.  19 A That is correct.  20 Q And you go on to say: (as read)  21 We provide these suggestions to  22 illustrate the practical application  23 of a proposed framework, but we would  24 expect users to make their own choices  25 regarding the details, both with  26 regards to questions asked and scores</p>	<p style="text-align: right;">136</p> <p>1 assigned to them.  2 Correct?  3 A Yes.  4 Q So I'm going to suggest to you a number of  5 things that I'll suggest flow from that.  6 Firstly, I'll suggest that the -- the  7 method proposed in your and your colleagues'  8 paper, it's not intended to be cast in stone or  9 followed by rote. Is that fair?  10 A At the time that we were developing this paper,  11 the existing framework had been in place for  12 over -- since 1993, I believe, the Davidson  13 Frolic [phonetic] scheme. So at the time we  14 were developing this paper, which is probably  15 six years ago now, we were still kind  16 of -- there was a lot of open thoughts about  17 how best to generate these frameworks. Since  18 we've written this paper, we've done  19 substantial -- this -- this paper's been used  20 widely. It has been cited over 50 times. I  21 myself have used it on a number of occasions.  22 And we've since found that, actually, as I say,  23 the -- the questions we posed were what we  24 believed to be the most appropriate questions  25 and the most appropriate scoring. And since  26 then, we've found that other users have</p>

137	<p>1 generally chosen to adopt the scheme with the</p> <p>2 questions as they are and -- and haven't seen</p> <p>3 the need to make substantial changes and that</p> <p>4 the -- the framework is actually robust and</p> <p>5 should be used as is and has been used as is</p> <p>6 without significant amendment or change.</p> <p>7 Q So is it your view as of today that this is</p> <p>8 framework that should be followed by rote?</p> <p>9 A Essentially, yes.</p> <p>10 Q Is it fair to say that you and your coauthors</p> <p>11 have attempted to introduce quantitative</p> <p>12 measures into a type of analysis that had</p> <p>13 previously been qualitative in nature?</p> <p>14 A Yes.</p> <p>15 Q The numbers that are in your framework and your</p> <p>16 colleagues' framework --</p> <p>17 A M-hm.</p> <p>18 Q -- is it fair to say that -- that amongst the</p> <p>19 three of you, that was your collective best</p> <p>20 guess at putting together something that you</p> <p>21 could quantify by numbers?</p> <p>22 A I don't like the term "best guess". Best</p> <p>23 judgment based on years of experience analyzing</p> <p>24 cases of induced seismicity.</p> <p>25 Q So you weren't -- weren't creating a new</p> <p>26 yardstick or a tape measure; you were creating</p>	138	<p>1 a different type of measurement that was based</p> <p>2 on judgment that may or may not have been</p> <p>3 completely correct?</p> <p>4 A They were based on judgments derived from years</p> <p>5 of experience looking at these cases as to</p> <p>6 what -- what questions were the most</p> <p>7 appropriate to ask and how important we felt</p> <p>8 the relative questions were, which is the point</p> <p>9 of the scoring system, adding more weight to</p> <p>10 certain questions because we see them as being</p> <p>11 more important.</p> <p>12 Q And does application of your method involve</p> <p>13 qualitative analysis?</p> <p>14 A We've -- the -- the -- the essence of the</p> <p>15 scheme is to introduce as much quantitative</p> <p>16 assessment as is possible and reasonable given</p> <p>17 the inherent nature of induced seismicity</p> <p>18 judgment, which is -- which is often a</p> <p>19 challenging thing to do.</p> <p>20 Q Do you agree that there's still a qualitative</p> <p>21 analysis as part of applying your model?</p> <p>22 A There is a qualitative element, but, as I say,</p> <p>23 wherever possible, we've tried to reduce or</p> <p>24 minimize that, for instance, by providing clear</p> <p>25 guidance as to how the -- how to answer those</p> <p>26 questions so -- so as to minimize that -- that</p>
139	<p>1 subjectivity.</p> <p>2 Q Despite attempts to minimize subjectivity,</p> <p>3 there's also exercises in judgment by anyone</p> <p>4 who's applying this criteria?</p> <p>5 A There may even need to be some degree of</p> <p>6 judgment, but wherever possible we want to</p> <p>7 replace that judgment with clear evidence,</p> <p>8 data, and analysis.</p> <p>9 And I think it's also worth mentioning that</p> <p>10 where that subjective nature of the judgment is</p> <p>11 incorporated, that's the nature of the -- the</p> <p>12 evidence weighting factor. So the key point of</p> <p>13 our scheme is that you have the induced</p> <p>14 assessment ratio, which tells you whether the</p> <p>15 event was induced or natural, but you also have</p> <p>16 the evidence strength ratio, and that describes</p> <p>17 the quality of the evidence used to perform the</p> <p>18 assessment. So the higher the evidence</p> <p>19 strength ratio, the lower the degree of</p> <p>20 subjectivity because you've got more robust</p> <p>21 data, which -- which -- where -- where there</p> <p>22 wouldn't be subjectivity because a high</p> <p>23 evidence strength ratio tells you there's a lot</p> <p>24 of clear evidence that can be used without the</p> <p>25 need for subjective judgment.</p> <p>26 And in -- in this case here, we have</p>	140	<p>1 relatively high evidence strengths ratios for</p> <p>2 our analysis, so that's telling us there's a</p> <p>3 low degree of subjectivity in the assessment.</p> <p>4 P. FITZPATRICK: I wonder if the page</p> <p>5 could be zoomed out just so we can find</p> <p>6 something on the bottom.</p> <p>7 And, actually, I'm about to go into another</p> <p>8 area that may take 10 or 15 minutes. I'm --</p> <p>9 I'm at the Commissioners' hands whether you</p> <p>10 wish to -- me to proceed at this point or to --</p> <p>11 to break early for lunch.</p> <p>12 THE CHAIR: If this is a natural</p> <p>13 break, we could probably take our break now and</p> <p>14 then resume after lunch. So it is five after</p> <p>15 12, so let's resume at ten minutes after 1.</p> <p>16 P. FITZPATRICK: Thank you, sir.</p> <p>17 THE CHAIR: Thank you.</p> <p>18 (WITNESSES STAND DOWN)</p> <p>19</p> <p>20 PROCEEDINGS ADJOURNED UNTIL 1:10 PM</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p> <p>26</p>

141	<p>1 Proceedings taken at the Govier Hall, Calgary, 2 Alberta</p> <hr/> <p>3 4 November 28, 2024 Afternoon Session</p> <p>5</p> <p>6 A. Bolton The Chair 7 B. Zaitlin Hearing Commissioner 8 T. Stock Hearing Commissioner</p> <p>9</p> <p>10 B. Kapel Holden AER Counsel 11 O. Chijioke AER Counsel 12 A. Huxley AER Counsel 13 (Via Videocast) 14 A. Lung AER Staff 15 T. Wheaton AER Staff 16 M. Rahimabadi AER Staff</p> <p>17</p> <p>18 P. Fitzpatrick For Regulatory Compliance 19 Branch 20 J. Allison For Regulatory Compliance 21 Branch 22 A. Hall For Regulatory Compliance 23 Branch</p> <p>24</p> <p>25 D.P. Langen For Obsidian Energy Ltd. 26 A. Barrington For Obsidian Energy Ltd.</p>	142	<p>1 K. Di Rocco, CSR(A) Official Court Reporter</p> <hr/> <p>2 3 (PROCEEDINGS COMMENCED AT 1:11 PM) 4 THE CHAIR: Thank you. Please 5 be seated. 6 Mr. Fitzpatrick, you can continue whenever 7 you're ready. 8 P. FITZPATRICK: Thank you, sir. 9 AMY FOX, MEHRAN POOLADI-DARVISH, JAMES VERDON, 10 STEVE CHARBONNEAU, JOHN MCGILVARY, FIONA 11 MARSHALL, Previously Affirmed 12 DEREK BOECKX, Previously Sworn 13 P. Fitzpatrick Cross-examines the Obsidian 14 Energy Ltd. Witnesses 15 Q P. FITZPATRICK: Can we bring up 16 Exhibit Number 50.06 again, please. 50.06. 17 Page 127. Perfect. 18 Okay. Thank you. 19 So, Dr. Verdon, we're looking back again at 20 your colleague's paper that we were discussing 21 before the lunch break. And at the bottom of 22 the page that we're looking at, page 127 of the 23 PDF, 1598 of the paper and the seismological 24 research letters, you'll see that's the start 25 of your criteria list, if I can call it that, 26 of questions?</p>
143	<p>1 A J. VERDON: Yes. 2 Q And in Question 1(a), it says: (as read) 3 Earthquakes have previously occurred 4 in vicinity to the site with similar 5 rates and magnitudes. 6 Right? 7 A That's right. 8 Q Sir, in this paper, is there any definition of 9 the term "in vicinity"? 10 A I don't believe there's a specific definition 11 of -- of "vicinity" there. It would depend, 12 obviously, on the -- the scheme is designed to 13 apply to a range of different activities. 14 So, for example, for hydraulic fracturing 15 wells, you might be referring in a very 16 localized vicinity, whereas for other 17 activities, you might be interested in a 18 slightly larger vicinity. 19 Q And that's something that someone using this 20 model would have to exercise some judgment to 21 determine what they view to be in the vicinity 22 by terms of an actual measurement. Is that 23 fair? 24 A Yes. 25 Q If we scroll to the next page, please. 26 In Question 1(d), it asks: (as read)</p>	144	<p>1 Past earthquakes occurred at similar 2 depths within the regional setting. 3 And is there anything in your paper that gives 4 guidance on what's a similar depth and what's 5 not? 6 A I believe that that is -- I don't believe 7 there's specific guidance, but, you know, 8 within -- within the context of people who work 9 regularly on induced seismicity, I believe 10 they'd all have a reasonable understanding of 11 what that meant. 12 Q Similarly, in Question 1E, when it refers to: 13 (as read) 14 Earthquakes are significantly 15 shallower. 16 Is that something that someone in the industry 17 would know that without being given any 18 guidance of what the -- what the numerical 19 metrics are? 20 A I believe so, yes. 21 Q Question 1 -- 2B -- pardon me -- where it says: 22 (as read) 23 The earthquake sequence did not begin 24 until a significant period of time 25 after the cessation of industrial 26 activity ends.</p>

145	<p>1 Is there any guidance in your paper as to 2 what's a "significant period of time"?</p> <p>3 A We -- we've published other studies that 4 reviewed extensively the literature and 5 experience on induced seismicity and quantified 6 quite specifically what's -- what levels of 7 time after the cessation of industrial activity 8 you might expect to find induced earthquakes. 9 So that data is out there, yes, though I don't 10 believe it's described in this -- in this 11 paper. And, again, it would very much depend 12 on the nature of the activity.</p> <p>13 I think with all of these questions, it's 14 worth bearing in mind that these were written 15 to be generic because people apply this scheme 16 to lots of different types of activities, such 17 as hydraulic fracturing, geothermal 18 stimulation, wastewater disposal, carbon 19 capture, and storage. And some of the -- some 20 of the quantifications in this will very much 21 depend on the nature of the industry and 22 therefore aren't specified in this paper 23 because they're industry-specific to different 24 industries, but people working within these 25 industries would still have a good idea of 26 what -- what -- what levels of closeness as you</p>	146	<p>1 talk about or depth would be relevant or not 2 relevant to these questions.</p> <p>3 Q Those are judgment calls?</p> <p>4 A I believe there's a fair body of literature 5 that would provide reasonable quantification 6 for those.</p> <p>7 Q Well, and "reasonable quantification", are we 8 talking about a fairly precise number? Like, 9 say, six months, or are we talking about a 10 range, like one to five years? What are we 11 talking about?</p> <p>12 A For -- for example, for hydraulic fracturing, 13 we found that you seldom or ever get induced 14 events after a period longer than about two to 15 three weeks after the stimulation has finished, 16 for example. And we've published a lot of data 17 on that.</p> <p>18 Q And what about for water disposal?</p> <p>19 A For water disposal, we're not aware of any 20 cases where induced seismicity has continued 21 for a significant period of time after the 22 cessation of disposal. That's mostly because 23 in most cases of wastewater disposal, induced 24 seismicity has happened, but wastewater 25 injection hasn't ceased. So we haven't had a 26 chance to observe a significant delayed -- we</p>
147	<p>1 call them "trailing events", events that trail 2 the end of injection.</p> <p>3 But also know in those sequences, those are 4 sequences where the earthquakes are ongoing 5 during injection and then continue for a period 6 afterwards, whereas this question is obviously 7 asking about where the sequence doesn't even 8 begin until after the industrial activity has 9 finished.</p> <p>10 Q Another one of these terms that I want to refer 11 you to is in 3(b). And that's asking whether 12 there's some temporal correlation between the 13 seismicity and the industrial activity. And, 14 again, is there any guidance in your paper as 15 to what --</p> <p>16 A Yes. So we -- with temporal correlation, for 17 example, we discuss how temporal correlation 18 should be done. Where you have injection time 19 series and seismicity time series, you would -- 20 compute a correlation coefficient and the 21 statistical significance thereof, and that 22 would obviously provide you a direct 23 quantitative answer to that question.</p> <p>24 For some activities in other parts of the 25 world, you might not even have injection data 26 available to you. In some areas, that data is</p>	148	<p>1 confidential in trying to perform that 2 assessment.</p> <p>3 Without the data -- without all of the 4 necessary data, you might have some idea of, 5 you know, well, the injection was happening on 6 these days or these months but not these 7 months, but we don't know the exact volumes. 8 And so in those cases, you might have to make a 9 more -- more of a judgment call because you 10 don't have the data, and that's exactly what I 11 was referring to you with the evidence strength 12 ratio. While you have data, you can make more 13 quantitative appraisals, and that was reflected 14 in a high-evidence strength ratio, whereas in 15 some cases -- and, again, bearing in mind, this 16 paper was written to cover all examples of 17 induced seismicity and potential induced 18 seismicity. Some cases, historical that we, 19 again, have very poor data and then more 20 judgment call is required. And that would be 21 reflected in a lower-evidence strength ratio.</p> <p>22 Q In 5(a), it asks whether earthquakes are 23 distant to the activities, given the putative 24 causative mechanism. And is there guidance in 25 your paper as to what is distant or not 26 distant?</p>

<p style="text-align: right;">149</p> <p>1 A I believe there is, and I'm going to try and 2 find it on my text. 3 So I think, for example, I'm struggling to 4 find it. But I say no, that for instance, for 5 hydraulic fracturing, we would say that between 6 1 or 2 kilometres is a reasonable distance, 7 whereas for wastewater disposal, there -- you 8 know, larger distances are possible. 9 But, again, the reason that's -- where it 10 says the putative causative mechanism, that 11 is -- that obviously depended on -- we're 12 applying the scheme to lots of different 13 potential causes. 14 And so we're interested in those different 15 causes. 16 Q And, similarly, the next question below it, 17 5(b), earthquakes are sufficiently close to the 18 activities, again, given the putative causative 19 mechanism -- 20 A Again, that's the inverse of that same 21 question, basically. 22 Q And when there's reference in the -- in 23 question 6 saying is there a plausible 24 mechanism to have caused the events, will you 25 agree that that's fundamentally a judgment 26 call?</p>	<p style="text-align: right;">150</p> <p>1 A There is -- again, in some cases, where you 2 have limited evidence, that question might have 3 to be a judgment call. But referring to our 4 guidance, I believe we -- we say that you'd 5 answer that question with a strong affirmative 6 if you have a large pore pressuring -- if 7 you're able to model a pore pressure increase 8 directly as Dr. Pooladi-Darvish has done, we 9 have a pore pressure change of more than one 10 megapascal. That would constitute a large 11 change in answer to that question. A pore 12 pressure increase of naught .1 MPa or above, 13 that would be the kind of sum pore pressure 14 change in response to that question. 15 Obviously, blow that, then, is the lower level 16 of that question. 17 There are different numbers, by the way, 18 for pore pressure depletion, because you need a 19 larger pore pressure depletion relative to the 20 injection. 21 Q When you and your colleagues wrote this 22 article, developed this criteria -- and I get 23 it that you were trying to improve on the 24 criteria that existed -- you were trying to 25 come up with a better model? 26 A Yes.</p>
<p style="text-align: right;">151</p> <p>1 Q Was it your expectation that you could have two 2 different people experienced in the field 3 looking at the same circumstances applying your 4 model, but they might reach different results? 5 A This is where I come back to the -- the point 6 around the evidence strength ratio and the 7 relative values of. You might find small 8 differences. You'd expect to find some small 9 differences. You would hope they wouldn't come 10 to dramatically different conclusions. 11 Q So there would be some kind of margin of 12 error -- 13 A Yeah. 14 Q -- at least where you might have some variation 15 in the percentages of two different people 16 equally experienced, equally able, but they 17 reach somewhat different conclusions? 18 A As I said, you would expect there to be some 19 degree of uncertainty. You know, the judgment 20 of induced seismicity is a challenging thing to 21 do sometimes. 22 But, as I said, you wouldn't expect it to 23 be dramatic differences in conclusions. 24 Q Now, from there, I want to take you to page a 25 hundred -- well, actually we are on page 128. 26 We can go to the right column. The last</p>	<p style="text-align: right;">152</p> <p>1 paragraph, please. 2 And this is -- again, is part of your and 3 your colleague's paper. Do you see where you 4 said there: (as read) 5 Induced seismicity caused by fluid 6 injection or extraction typically 7 occurs within less than 4 kilometres 8 depth of the industrial activity. 9 A M-hm. 10 Q And you cite an earlier paper by yourself 11 there, sir? 12 A That's correct. 13 Q Did the Reno seismicity occur within less than 14 4 kilometres depth of the Obsidian well? 15 A Yes, I believe it did, or at least the top of 16 the sequences. I would want to just refresh my 17 memory of the figure, but -- yes. 18 Q Can we go to page 129, please. Just take me a 19 moment to find the right place on the page. 20 Actually, we can zoom out for just a 21 moment. I will look a little closer to find 22 the right part. My apologies. 23 There we are. It's the lower left-hand 24 column. Under the heading "Do the Events Occur 25 at Similar Depths to the Activities?" 26 A Yeah.</p>

153	<p>1 Q And then if you scroll down there, please.</p> <p>2 Thank you very much.</p> <p>3 Now, partway through that paragraph, your</p> <p>4 article says: (as read)</p> <p>5 However, this assessment is</p> <p>6 complicated by the fact that many</p> <p>7 cases of induced seismicity have, in</p> <p>8 fact, occurred several kilometres</p> <p>9 deeper than the industrial activity.</p> <p>10 And, again, you cite your 2014 study.</p> <p>11 A Yes.</p> <p>12 Q And you go on to say, (as read)</p> <p>13 These observations are explained by</p> <p>14 the presence of hydraulic or</p> <p>15 geomechanical connections, usually</p> <p>16 faults, from shallow to deeper layers</p> <p>17 [citing Ellsworth 2013]. If events</p> <p>18 occur at the same depth as the</p> <p>19 industrial activity, then we consider</p> <p>20 this to be evidence that they are</p> <p>21 induced. If events are deeper than</p> <p>22 the activity but plausible hydraulic</p> <p>23 or geomechanical connections between</p> <p>24 the two are present, then we also</p> <p>25 consider this as evidence in favour</p> <p>26 that the events are induced. If there</p>	154	<p>1 is a significant difference in depths</p> <p>2 between the events and the industrial</p> <p>3 activity and plausible connections</p> <p>4 between these depths can be ruled out,</p> <p>5 then this represents evidence that the</p> <p>6 events are not induced.</p> <p>7 Right?</p> <p>8 A (NO VERBAL RESPONSE)</p> <p>9 Q And I'm suggesting that that harkens back to a</p> <p>10 point we discussed this morning, that the</p> <p>11 presence of a fault in the Leduc Formation</p> <p>12 could explain how you could have injection in</p> <p>13 the Obsidian well inducing earthquakes several</p> <p>14 kilometres below.</p> <p>15 I see you've been passed a note.</p> <p>16 A Sorry. I missed the last part of that. You</p> <p>17 asked a question at the end. Sorry.</p> <p>18 Q Yeah. So we spoke this morning about it being</p> <p>19 plausible that there is -- there is a fault in</p> <p>20 the -- in the Leduc Formation running down into</p> <p>21 the basement?</p> <p>22 A Yeah.</p> <p>23 Q And that could explain how you could have fluid</p> <p>24 injected in the Obsidian well in the Leduc</p> <p>25 Formation that ends up inducing earthquakes.</p> <p>26 And that's -- that's reflecting the same</p>
155	<p>1 principle you're discussing right in this</p> <p>2 paragraph in the paper, I take it?</p> <p>3 A Yes. But it's worth bearing in mind they're</p> <p>4 the same -- or faults also exist from the</p> <p>5 Belloy down to these depths as well.</p> <p>6 Q Are there any formations between the Belloy and</p> <p>7 the Leduc?</p> <p>8 A I believe so, yes. Yes.</p> <p>9 Q Are any of them aquifers?</p> <p>10 A I would turn to --</p> <p>11 A N. WATSON: Yes, there are</p> <p>12 aquifers between -- oh, sorry. Pardon me,</p> <p>13 slipped my mind.</p> <p>14 Yes, there are aquifers between the Belloy</p> <p>15 and the Leduc. Specifically, the Rundle</p> <p>16 aquifer.</p> <p>17 Q I'm sorry. The which?</p> <p>18 A The Rundle -- Rundle Permian-Triassic aquifer</p> <p>19 is the main aquifer between the Woodbend</p> <p>20 through Wabamun aquifer.</p> <p>21 Q And when you have fluid that goes into an</p> <p>22 aquifer, is it fair to say that the fluid will</p> <p>23 tend to disperse?</p> <p>24 A J. VERDON: That's not necessarily</p> <p>25 true for flow-free faults, no.</p> <p>26 Q Not necessarily true but generally true?</p>	156	<p>1 A We -- we have seen a number of cases around the</p> <p>2 world where the -- you're able to get flow- and</p> <p>3 pressure-free faults even -- and through to</p> <p>4 underlying basement even when there are</p> <p>5 aquifers along the path of that fault.</p> <p>6 Q Well, let's unpack this a bit.</p> <p>7 So -- so you're telling me that there's</p> <p>8 been cases that have been observed. But what</p> <p>9 I'm driving at, would you generally expect when</p> <p>10 you have a fault that goes through an aquifer,</p> <p>11 that there is going to be some fluid dispersion</p> <p>12 in the aquifer?</p> <p>13 A That would very much depend on the properties</p> <p>14 of the fault.</p> <p>15 Q Would it usually be the case, Dr. Verdon?</p> <p>16 A No.</p> <p>17 Q No. So your testimony is that in an aquifer</p> <p>18 that would still just keep on going down</p> <p>19 generally and it wouldn't disperse at all?</p> <p>20 A As I said, it would very much depend on the</p> <p>21 properties of the fault, but it can't be</p> <p>22 assumed that that would be the case, though.</p> <p>23 Q It can't be assumed either way, can it?</p> <p>24 A Yeah, it can't be assumed either way, but we</p> <p>25 have definitely seen examples of this process</p> <p>26 happening.</p>

<p style="text-align: right;">157</p> <p>1 Q Now, in those cases, has there been another 2 nearby well that's also injecting that's a 3 potential candidate for causing the seismicity? 4 A You mean into the deeper aquifer formation? 5 Q Yes. 6 A I'm not sure. I would need to revisit those 7 cases. 8 Q Yes. And what I'm going to suggest is that, of 9 course, in the event that in those cases, 10 there's only one well that's in the area, and 11 there's induced seismicity -- and you can infer 12 that there's that connection -- but if you've 13 got more than one well, then it's more 14 difficult to infer that connection. Isn't that 15 right? 16 A Yes. When you have multiple wells in an area, 17 then obviously the -- the challenge of induced 18 seismicity attribution becomes more 19 complicated. 20 I think it would actually be worth 21 referring back to image -- so this is still on 22 50.06, Figure 3.3 on page 34. 23 Q Yes? 24 A So this is an example from further west within 25 the Peace River Arch, and, again, you see the 26 same process taking place. And there will be</p>	<p style="text-align: right;">158</p> <p>1 aquifers. They're sort of lower Paleozoic 2 layers, the dolostones and limestones. They're 3 light blue sort of stripy-ish layers that would 4 inevitably be layers containing aquifers 5 potentially with wastewater disposal. I would 6 need to, again, review the evidence from this 7 area. 8 But, nevertheless, the conclusion is that 9 the pore pressures were able to propagate down 10 once and reactivate the fault. 11 Q Can we go back to 56.01, please. 12 A Yeah. In fact, my colleague just helpfully 13 reminded me that it's actually the same 14 aquifers in this case that are present here 15 that are present in the Peace River area where 16 we're studying here. So it's the same 17 situation. 18 Q So there's aquifers to the west in the Peace 19 River area? 20 A Yes. So this is for the west, but it's the 21 same geology, the same aquifers. 22 Q And, as I understand it, if we look at the 23 Peace River Arch and the Leduc Formation, that 24 goes a considerable distance to the west and 25 the northwest from the Obsidian well. Is that 26 right?</p>
<p style="text-align: right;">159</p> <p>1 A N. WATSON: Could you repeat 2 that, please, just to make sure I have it. 3 Q Okay. Sorry. Apologies. 4 A Can you repeat that, please. 5 Q So let's start first with the Peace River Arch. 6 That's a formation that goes quite a 7 considerable distance to the southwest from the 8 area that we're talking about? 9 A Which formation within the Peace River Arch? 10 Just to make sure I understand which formation. 11 Q We'll start with the arch first. We'll start 12 with the Peace River Arch first, just itself. 13 A Well, the Peace River Arch isn't a formation, 14 so I just want to be certain I respond to the 15 right formation, this body of rock. 16 Q Okay. Let's just start talking about the Peace 17 River Arch. 18 So the Obsidian well is within the Peace 19 River Arch. Is that right? 20 A Correct. 21 Q How far southwest from the Obsidian well does 22 the Peace River Arch go? 23 A It extends west to the BC-Alberta boundary and 24 further west beyond that until we get to the 25 foothills. 26 Q That's hundreds of kilometres?</p>	<p style="text-align: right;">160</p> <p>1 A Yes, it is. 2 Q And the Leduc Formation, what kind of area in 3 the Peace River Arch does it cover? 4 A The Leduc Formation in this case is what's 5 referred to as the "Peace River Arch fringing 6 reef", "Leduc fringing reef". And so it is -- 7 follows the outline of the Peace River Arch 8 from -- it is found in the foothills, in the 9 mountains of the -- to the west and all the way 10 through on some of the maps that 11 Dr. Pooladi-Darvish had up, for example, you 12 can see as the Peace River Arch starts to 13 circle around and go along the north side of 14 the -- north flank of the arch. 15 Q Thank you. 16 Now, let's go back to 56.01 at page 129. 17 A J. VERDON: 50.06? 18 A N. WATSON: 56.01 is two pages. 19 Q 50.06, my apologies. Page 129. And on the 20 right column, about halfway down the page, 21 there's a paragraph that starts with the words 22 "high volume". If we can zoom in on that. 23 A J. VERDON: Yeah. 24 Q We're still -- or back in your article again, 25 Dr. Verdon. And you'll see there where it 26 says: (as read)</p>



<p style="text-align: right;">161</p> <p>1 High-volume, e.g., greater than 20,000  2 cubic metres per month, wastewater  3 disposal wells can have a large  4 footprint with seismicity occurring  5 tens of kilometres from the injection.  6 And you cite several papers, including one of  7 your own.  8 A M-hm.  9 Q (as read)  10 Inevitably, however, in such instances  11 in which the events extend tens of  12 kilometres from the well, some  13 seismicity is found within  14 5 kilometres of the injection site.  15 Therefore, we suggest that larger  16 distances between events and  17 high-volume injection wells, e.g.,  18 greater than 10 kilometres, are  19 indicative of a natural cause, unless  20 there is also some seismicity located  21 in closer proximity to the well.  22 A Yes.  23 Q You'll recall from the evidence this morning  24 that the Obsidian well was injecting well in  25 excess of 20,000 cubic metres of water per  26 month?</p>	<p style="text-align: right;">162</p> <p>1 A Yes.  2 Q And started around there, and there were  3 periods where it was up to 40,000, 60,000 above  4 that?  5 A Yes.  6 Q You'll agree that by your own definition, that  7 the Obsidian well is a high-volume wastewater  8 disposal well?  9 A Yes. Although there are wells that are  10 significantly higher volume still in the area,  11 there's been a --  12 Q Well, in the area we're talking about 18 or  13 20 kilometres away. Aren't we?  14 A Yes.  15 Q And I do have some questions for  16 Dr. Pooladi-Darvish that relate to  17 Exhibit 81.7. I'm just wondering if we have a  18 filed copy of a public version of 81.7. I  19 think those were just a confidential document.  20 Yeah. So I think those ones I'm going to have  21 to defer until -- until the in-camera session.  22 Can we go back to the slide deck. Slide  23 35, please.  24 Okay. Now, I believe it was Dr. Watson who  25 was mentioning a few moments ago about the vast  26 distance of the Peace River Arch and the</p>
<p style="text-align: right;">163</p> <p>1 Leduc -- sorry.  2 D.P. LANGEN: So, Mr. Chair, I  3 only rise because he used the term "vast", and  4 that's not the term that Mr. Watson used.  5 Q P. FITZPATRICK: Perhaps Dr. Watson  6 could refresh my memory on how he described the  7 distance of the -- the Peace River Arch and the  8 Leduc Formation.  9 A N. WATSON: Could we call up  10 50.05, please, and PDF page 20.  11 Oh, is our mic on? Yes.  12 Thank you. And if you could zoom in a bit.  13 You can -- this map has an outline of  14 Alberta on it, and then the outlines in purple  15 are the various Leduc reef complexes throughout  16 Alberta and British Columbia -- or throughout  17 Alberta. This is out of the Atlas of Western  18 Canada Sedimentary Basin.  19 The uppermost complex is the Peace River  20 Arch Leduc fringing reef. On it in a yellow  21 rectangle is the area that was -- on which we  22 did our report, to give you a sense of scale.  23 Q Yes. And that's actually quite helpful,  24 because we can also see on that page that  25 there's the scale of 100 and 200 kilometres.  26 It's on the lower right-hand corner.</p>	<p style="text-align: right;">164</p> <p>1 A Correct.  2 Q And so looking at the area of interest, and the  3 Peace River Arch that's going southwestern  4 there, just by some quick mental arithmetic,  5 that looks like it's well in excess of 200  6 kilometres, sir?  7 A It's in that range, definitely.  8 Q And it also extends to the -- to the northwest,  9 and that looks like it's close to 200  10 kilometres that direction as well?  11 A Yes. Once you take it into British Columbia as  12 well.  13 Q Of course.  14 P. FITZPATRICK: And my friend and I  15 can debate in closing arguments whether that's  16 a vast distance or not.  17 D.P. LANGEN: We absolutely can.  18 Q P. FITZPATRICK: So let's come back  19 to Slide Number 35, and we can -- in the  20 PowerPoint. And, of course, we can all now  21 take this in perspective that this is a -- just  22 the edge of -- if I can call it that -- of a  23 much larger arch area.  24 So, Dr. Pooladi-Darvish, the question I  25 wanted to ask you is that if -- if you consider  26 injection in the -- the north and the central</p>



<p style="text-align: right;">165</p> <p>1 wells and consider where the water is going to 2 go, will you agree with me that the water is 3 going to tend to go in the path of least 4 resistance? 5 A M. POOLADI-DARVISH: Yes. Water flow is 6 driven by path of least resistance, stability, 7 permeability. That and the value of the 8 pressures. So where the pressures are lower, 9 it would go that way as well. 10 Q Yeah. So would you agree with me that, all 11 things considered, you would expect water 12 injected into the north and central wells to go 13 in any direction in which the resistance is the 14 least? 15 A As I -- as I explained it, water flow -- amount 16 of water flow is determined by two parameters. 17 It's the permeability, which -- you're probably 18 referring to it as the resistance, as well as 19 Delta P, the driving force. 20 Q Now, if we look at the north and the central 21 wells on this side, and we can see that -- that 22 they're -- the nearest ones are close to two 23 townships away from where the 14-18 well is on 24 that diagram. Do you see that? 25 A Sorry. You are referring to the different -- 26 distance between which and 14-18?</p>	<p style="text-align: right;">166</p> <p>1 Q The injections well that are depicted here? 2 A Yes. The central wells? 3 Q I'm sorry? 4 A The central wells you're referring to? 5 Q Yes, central, northern. 6 A Yeah. Central well is about two townships, and 7 northern well is about -- just about three. 8 Yes. 9 Q So would you expect, then, all things being 10 equal, that -- that fluid injected into the 11 north and the central wells today -- somebody 12 is injecting today -- that some amount of that 13 is going to disperse towards the west and the 14 southwest and the northwest? 15 A Yes, unless they are restricted by either -- 16 low permeability regions. That's correct, 17 yeah. 18 Q And are you aware of any features that inhibit 19 the -- the flow of fluid to the northwest or to 20 the southwest from the north and central wells? 21 A I'm told by my geologist friends that, as we go 22 toward the centre of the reef, there is more of 23 a -- a low-quality facies tidal ridge -- no, 24 not tidal ridge -- something else -- some other 25 geological term that would lead to 26 lower-quality rocks, and, therefore, towards</p>
<p style="text-align: right;">167</p> <p>1 the centre of that area, quality is 2 generally -- is expected to be lower. 3 Q And perhaps if we could be pointed to the area 4 on the -- on the diagram, that might help us to 5 understand a bit better. 6 A No, this is not the mouse. 7 So -- 8 A N. WATSON: May I? 9 A M. POOLADI-DARVISH: Yes, please. 10 A N. WATSON: If you were to look 11 in, say, a band starting around Township 82 and 12 paralleling the arch and moving -- parallel to 13 the arch in that direction, you do move away 14 from what are more bank margin deposits in the 15 Leduc, so more the high permeability facies. 16 And as you get into that 82-20-83-19 area, you 17 are into more lagoonal facies that have 18 inherently lower permeability. 19 But the -- and the facies along the edge of 20 the roof -- reef where all the well -- the 21 injectors were drilled are characterized by 22 high permeability. 23 One aspect that Dr. Pooladi-Darvish did not 24 have an opportunity to mention is that, as we 25 outlined in our report, the hydraulic head 26 values are moving in an updip direction towards</p>	<p style="text-align: right;">168</p> <p>1 a discharge area to the northeast, which is 2 consistent -- which is character -- 3 characteristic of all of the aquifers in the 4 area. 5 Q And just to -- to make sure I understand that, 6 I think what you're telling me, sir, is that 7 there's some kind of reduced permeability down 8 towards the southwest of the diagram, if I can 9 call it that, and you haven't commented about 10 there being a reduced permeability to the 11 northwest. 12 A Along the bank margin, in a general sense, the 13 permeability will be of a higher nature than it 14 would be further to the west within the central 15 part of where the reef is -- is present. 16 You'll -- all of those wells are drilled along 17 the edge of the reef, which is characterized by 18 higher permeability. 19 Q So, Dr. Pooladi-Darvish? 20 A M. POOLADI-DARVISH: Yes. 21 Q If you -- if you have an area underground that 22 has pressure in it from -- from fluids, and 23 then the fluid injection is reduced or stopped, 24 would you normally expect that the pressure 25 would reduce over time? 26 A Yes, that's correct. If there has been</p>

<p style="text-align: right;">169</p> <p>1 injection, and then we stop injection and -- it  2 either -- it generally stabilizes. So it  3 becomes more uniform.  4 Q And to put it another way, if there is -- if  5 there is an area of lesser pressure, if I can  6 call it that, that's less adjacent to that area  7 of higher pressure, you're going to have some  8 of that fluid that migrates, and in the area of  9 interest, the pressure is going to drop?  10 A Over very long periods of time, stabilization  11 happens. And that depends on, again, the  12 connectivity or degree of permeability. If  13 there is a lagoonal facie, a lower quality,  14 then it would take much longer. Can be  15 centuries.  16 Q All right. Now, all things being equal, if you  17 inject fluid into a well that's right below our  18 feet here, and you inject fluid into a well  19 that's 20 kilometres away from here, and you  20 inject the same amount of fluid, would you  21 expect the injection right below your feet to  22 have a greater influence on pressure from this  23 day forward than the well that's 20 kilometres  24 away?  25 A Yes. Yes, that is correct. And we do see in  26 this case, as well, around the northern well,</p>	<p style="text-align: right;">170</p> <p>1 pressures are generally higher than as we go --  2 as we -- as we move away from. That's correct.  3 Q Yes. And would you agree, then, that it  4 follows logically that, if we look at the  5 existing pressure in the area of interest, so  6 in the Reno area where there's been the  7 seismicity, and we ask, okay, well, if there's  8 an injection at the Obsidian well, and there's  9 an injection in the north and central wells,  10 it's the injection in the Obsidian well that,  11 as of today and going forward, will be more apt  12 to increase the pressure in the area?  13 A No, sir. In your previous question, when I  14 answered yes, you said "everything else being  15 equal". That includes the amount of injection  16 being equal.  17 In this case, the amount of injection in  18 the northern well is significantly larger to --  19 to the point that it overcomes the -- the --  20 the -- the difference in distance.  21 So we have clearly demonstrated in here  22 that the point of observation that we have  23 considered -- although it's farther away from  24 the northern wells than the 14-18 well, but its  25 pressure impact is -- is largely -- by  26 90 percent of the total -- the 9 times -- 10</p>
<p style="text-align: right;">171</p> <p>1 times more -- more than, the Obsidian well is  2 affected by the northern wells or the rest of  3 the wells. So amount of injection matters  4 extremely.  5 Q But isn't that talking historically rather than  6 today?  7 A I'm sorry?  8 Q Isn't that talking historically about what  9 created the pressure that exists up to -- we'll  10 say up to 2023 versus what's happening from  11 today forward?  12 A So pressure is -- is influenced by the  13 cumulative, by the total amount of injection,  14 if I got your question correctly.  15 Q Because I'm -- I'm thinking you might be  16 misunderstanding what I was asking. I was not  17 asking about historical volumes of injection.  18 I'm asking about injection today, the  19 activities occurring today.  20 A So in this kind of scenario where we have a  21 large area over long periods over time, it's,  22 in fact, historical volumes that matter.  23 Q Well, but isn't what matters to -- what  24 increases pressure today, the fluids that are  25 injected today?  26 A No, not necessarily. There is a</p>	<p style="text-align: right;">172</p> <p>1 relationship -- at short distances -- so when I  2 increase the rate for a very short distance  3 away from the wellbore, the pressure gets  4 affected, and that is a function of the rate  5 that you're referring to, the rate today.  6 But at long distances, and in this case  7 kilometres away, it's more a function of the  8 historical amount, cumulative amount of  9 injection. Because that short-distance effect  10 that is controlled by the rate, that drops up  11 quickly to an -- to an average value, and that  12 average value is determined by the cumulative  13 amount injected into it.  14 Q I understand what you're saying. And, in fact,  15 what you're saying in part is that the  16 injections of water in the north and central  17 wells today and going forward may have less  18 impact than the historical injections into  19 those well?  20 A I'm sorry. Say it again?  21 Q I think what you're saying in part, sir, is  22 that injections into the north and central  23 wells today and going forward have less of an  24 impact than the injections historically in  25 those wells?  26 A To be determined case by case, but are you --</p>

<p style="text-align: right;">173</p> <p>1 yes. And it -- so it -- it depends on the  2 rates of injection as well. Even if today the  3 rates of injection by the northern well is  4 significantly larger than, for example, like,  5 another -- another well, let's say the Obsidian  6 well, then when -- those wells could still  7 impact the pressure more significantly. So it  8 depends, again, on the amount of -- the rates  9 as well as distances.</p> <p>10 Q And is that something you've done a calculation  11 of?</p> <p>12 A So may I ask again, specifically, what are --  13 what is the question? The question --</p> <p>14 Q Have you done a calculation as to the relative  15 impacts of injections of water into the north  16 and central wells on induced seismicity in the  17 Reno area versus the impact of injection in the  18 Obsidian well on seismicity in that same area  19 going forward? And we're only talking about  20 pressure.</p> <p>21 A Yes. So, first of all, I haven't done any  22 assessment of the induced seismicity. I have  23 assessed the effect of injections and the rate.  24 And, yes, when -- when I -- in my opening  25 statement as well as in the evidence, when I  26 referred to the so-called what-if study where I</p>	<p style="text-align: right;">174</p> <p>1 isolate, in one case, the 14-18 well, and I  2 look at the effect of that on pressure only,  3 and in the other case with all wells included,  4 that's -- is exactly looking at the effect of  5 one versus the total on pressure.</p> <p>6 Q But isn't that historical rather than going  7 forward?</p> <p>8 A Yeah. I haven't looked into anything into the  9 future. I have -- my studies come to the end  10 of 2023. So depending on when is your present  11 time, it's about -- my assessment is -- I've  12 looked at the time of the seismicity as well as  13 until end of 2023, which is about a year after  14 the main seismic event.</p> <p>15 Q So is it fair to say that you cannot tell us,  16 as we sit here today, that if there is ongoing  17 water injection in the north and central wells,  18 and there's ongoing water injection in the  19 Obsidian well, you cannot tell us that it is  20 going to be the north and central wells that  21 are causing any further induced seismicity?</p> <p>22 A Again, I make no reference to -- about induced  23 seismicity and the effect of pressure. I can  24 say, if we continue as we are, likely, we see  25 the same trends in pressure.  26 Yes. In fact, pressure effects are</p>
<p style="text-align: right;">175</p> <p>1 quite -- we call them diffusive. They don't  2 jump up and down suddenly, and, therefore,  3 their -- their trends are -- can be  4 extrapolated somewhat.</p> <p>5 Q Now, I do want to address a little bit,  6 Dr. Pooladi-Darvish, the subject of data. And  7 I appreciate your comments earlier that this --  8 I appreciate your comments earlier about --  9 critique. I'm -- I'm not trying to be  10 personal. I'm just asking you questions in  11 terms of the -- the quality of the data.</p> <p>12 A Sure.</p> <p>13 Q So the DST information, you'll agree that  14 that's information that's used to infer  15 pressure rather than being a direct measure?</p> <p>16 A What pressure is -- in DST, pressure is  17 measured, and some analysis can be done on  18 it -- on -- just to find out what is the  19 stabilized pressure.</p> <p>20 And in this case, I have used the pressures  21 that are clearly in the record. They are very  22 close to stabilization within the degree of  23 uncertainty that I have determined.</p> <p>24 So inference, I'm not sure what you meant  25 by that.</p> <p>26 Q Okay. We'll come back to that in a little bit.</p>	<p style="text-align: right;">176</p> <p>1 A Sure.</p> <p>2 Q I do want to visit with Dr. Verdon again for a  3 little while.</p> <p>4 A J. VERDON: Sure.  5 P. FITZPATRICK: If we could have  6 Exhibit 50.06 pulled up again, please. And  7 we're going to go to page 4 of the PDF.</p> <p>8 Q P. FITZPATRICK: All right. So in this  9 part of your report, sir, in the last bullet  10 point, you say: (as read)  11 The record of the decision-maker  12 appears to discount the high volume  13 Leduc WWD wells to the north due to  14 the absence of a breadcrumb trail of  15 events connecting these wells to the  16 cluster that hosted the M 5.6 event.  17 However, the northwestern cluster of  18 seismicity is also located 20  19 kilometres from the nearest disposal  20 wells without the presence of any  21 connecting seismicity.  22 If this cluster is also induced,  23 then it demonstrates observationally  24 that the pressure perturbation from the  25 high-volume Leduc WWD wells has  26 extended more than 20 kilometres</p>

<p style="text-align: right;">177</p> <p>1 through the subsurface to trigger 2 events without the presence of 3 interconnecting breadcrumb trail 4 events. 5 This phenomenon may result from 6 the fact that the Leduc Formation 7 itself is unlikely to be critically 8 stressed, and so seismicity is only 9 able to occur where faults exist that 10 allow pressure perturbations to 11 penetrate into the basement strata. 12 Right? 13 A J. VERDON: Yeah. 14 Q And does it follow from that that the reason 15 that there's seismicity in the Reno area is 16 that there's a fault that exists that 17 penetrates into the basement strata? 18 A Yes. 19 Q Can we go to page 28 of the PDF, please. All 20 right. If we can scroll up one page above. 21 So this is yourself going through, 22 Dr. Verdon, your assessment criteria, looking 23 at the Obsidian well, the Belloy well, and the 24 Leduc -- HV Leduc wells -- high-volume Leduc 25 wells -- wells, I think you called them? 26 A Yeah.</p>	<p style="text-align: right;">178</p> <p>1 Q And then if we scroll down a page and a half or 2 so. Keep going, please. One more page. 3 Perfect. Just right there. Okay. 4 Then we -- we get to the -- the results 5 that you've calculated. And I -- I take it 6 you'll agree that the evidence strength of all 7 the three, you've assessed them to have quite 8 strong evidence strength? 9 A I would -- "quite strong" is probably the wrong 10 word. As I said, it's moderate strength for 11 the two and then significantly lower for the 12 Obsidian well. 13 Q And that's -- you're saying that the evidence 14 strength of -- and -- sorry -- maybe you 15 misunderstood me. I was asking about -- 16 A Oh, sorry. The evidence strength. My -- my 17 mistake. Yeah, the evidence strength ratios 18 are relatively high. 19 Q They're quite high, aren't they? 20 A Yes. 21 Q Close to a hundred percent? 22 A Yes. Yes, they're high. 23 Q And if I understand your model correctly, a 24 negative value is -- is something that says, 25 This looks like it's natural -- 26 A On the induced assessment ratio.</p>
<p style="text-align: right;">179</p> <p>1 Q Right. On the induced assessment ratio? 2 A Yes. 3 Q And a zero value would imply we're not sure? 4 A The -- the evidence is ambiguous. 5 Q A positive value implies that this well likely 6 induced the seismicity? 7 A The -- the higher the -- the positive value, we 8 would conclude the more likely this well is to 9 have caused the seismicity. But, as I 10 mentioned, we get this pull-up effect whereby 11 some of the questions -- so, for example, 12 Question 1, the character of the induced 13 seismicity. Events that are not related to the 14 seismicity but in the general area can get 15 pulled into that positive category through the 16 fact that there is obviously some questions 17 that are just answering whether or not the 18 event is induced and not really looking at the 19 particular cause. 20 And so when we see multiple potential 21 causes where some causes are clearly indicated 22 as higher values, the other causes that have 23 lower but still, you know, small positive 24 values, we conclude the evidence there is 25 ambiguous because the evidence is -- is 26 significantly weaker than for the other causes.</p>	<p style="text-align: right;">180</p> <p>1 Q Sir, I'm going to suggest to you that when I 2 look at these percentages, like on the induced 3 assessment ratio, that the conclusion it ought 4 to lead to is that, in your professional 5 opinion, all three of these wells contributed 6 to the pressure in the seismicity. 7 A No, that is not correct. As I said, you can 8 get draw-up where -- where one cause is 9 significantly weaker than the other. If -- if 10 all three have produced very similar numbers, 11 you know, within 5 or so percent -- 5 to 10 12 percent maybe -- we would say, yes, these are 13 all clearly potentially likely -- equally 14 likely to have contributed or that they were 15 jointly contributing. 16 Where you have other cases in the area that 17 are significantly lower in that situation, even 18 though there's some positive value for the 19 assessment because it's significantly lower 20 than the others, you would say the evidence for 21 that is significantly more unambiguous, and, 22 therefore, you can't conclude that it did cause 23 the seismicity. 24 Q And it's your view that the -- the -- the false 25 positive, if I can call it that, is in respect 26 to the Obsidian well and not in respect to the</p>

181	<p>1 Belloy well?</p> <p>2 A Yes, because there's much stronger evidence</p> <p>3 pointing to the other wells as being the cause.</p> <p>4 As discussed in our opening statement, the much</p> <p>5 higher pressure contribution from the Leduc</p> <p>6 wells, the existence of faulting running very</p> <p>7 close to the Belloy well, connecting to the</p> <p>8 basement, the temporal correlation that we see</p> <p>9 with the Belloy well. All of these are pieces</p> <p>10 of evidence that point towards these other</p> <p>11 causes; then these kind of things are absent</p> <p>12 for the Obsidian well.</p> <p>13 Q I do have some questions, again, for</p> <p>14 Dr. Pooladi-Darvish.</p> <p>15 And I'm going to try to avoid getting into</p> <p>16 any of the confidential material. Certainly,</p> <p>17 sir, if you feel that it would be necessary</p> <p>18 to -- to get into confidential information to</p> <p>19 answer, please let me know.</p> <p>20 A M. POOLADI-DARVISH: I'll try to remember</p> <p>21 which ones are confidential; otherwise, I'll</p> <p>22 answer, yes.</p> <p>23 Q Okay. Would you agree with the statement that</p> <p>24 interpretation of DST results is often regarded</p> <p>25 as an art rather than a science?</p> <p>26 A No.</p>	182	<p>1 Q Would you also agree that pressures based on</p> <p>2 interpretation of DST results must be</p> <p>3 extrapolated?</p> <p>4 A Extrapolation -- if the pressures haven't</p> <p>5 stabilized, then extrapolation is a methodology</p> <p>6 for arriving at that so-called stabilized</p> <p>7 pressure. In my case, I have shown -- I've</p> <p>8 used -- the DSTs that I have qualified as good,</p> <p>9 they are stabilized already too within .1 MPa.</p> <p>10 Q With the DST pressures that you looked at, did</p> <p>11 you do any analysis of -- of how long the tool</p> <p>12 in the hole was shut in?</p> <p>13 A I did look at the record, and there are --</p> <p>14 typically the DSTs have two flow periods of</p> <p>15 varying durations. And, in fact, again, one of</p> <p>16 the criteria that I used to call a DST pressure</p> <p>17 to be a good one was to have both periods and</p> <p>18 both of which would have -- show a stabilized</p> <p>19 behaviour. So I was quite stringent on</p> <p>20 choosing the good ones.</p> <p>21 Q Are you aware of methods other than DST for</p> <p>22 measuring pressure?</p> <p>23 A Yes.</p> <p>24 Q And -- and what are they?</p> <p>25 A So DSTs are typically done on -- on the first</p> <p>26 wells or sometimes called "exploration wells".</p>
183	<p>1 While you're drilling, you're finding the</p> <p>2 formation, you're -- you want to, afterwards,</p> <p>3 log, and, therefore, at the same time, you want</p> <p>4 to assess the pressure.</p> <p>5 But if there are producing wells that have</p> <p>6 been drilled and are producing for periods of</p> <p>7 time, then, of course, you can run a pressure</p> <p>8 bomb into them and -- and -- and -- after</p> <p>9 shut-in and measure pressure. That's one way,</p> <p>10 and there are also other ways.</p> <p>11 Q And if you had your -- your pick of a method</p> <p>12 for measuring pressure, what method would you</p> <p>13 use?</p> <p>14 A For DS -- for initial, depending on what</p> <p>15 pressure you're after. For initial pressure,</p> <p>16 DST is one of the most commonly used methods,</p> <p>17 especially in high permeability formations such</p> <p>18 as Leduc here.</p> <p>19 Q What about after initial pressure?</p> <p>20 A After initial pressure, again, depends. If --</p> <p>21 if the 'C' pressures are available, they can be</p> <p>22 very good value data, but often there is other</p> <p>23 forms of pressure available after -- after the</p> <p>24 wells have been in production. By definition,</p> <p>25 typically nobody runs DST when the well isn't</p> <p>26 producing.</p>	184	<p>1 Q Now, I believe your -- your reports refer to a</p> <p>2 falloff test conducted on the 14-18 well?</p> <p>3 A Yes.</p> <p>4 Q And did you review any information as to how</p> <p>5 long the falloff lasted, whether it was QC'd,</p> <p>6 anything like that?</p> <p>7 A Yes. I did the -- I did that work on the -- on</p> <p>8 the falloff test date.</p> <p>9 P. FITZPATRICK: This might actually</p> <p>10 be an appropriate time to take the afternoon</p> <p>11 break.</p> <p>12 THE CHAIR: Okay. We're a</p> <p>13 little early, but if you'd like to take your</p> <p>14 break now, we'll break for 15 minutes and</p> <p>15 resume at 2:20.</p> <p>16 P. FITZPATRICK: Thank you.</p> <p>17 (ADJOURNMENT)</p> <p>18 THE CHAIR: Thank you. Please</p> <p>19 be seated.</p> <p>20 Whenever you're ready, Mr. Fitzpatrick.</p> <p>21 Discussion</p> <p>22 P. FITZPATRICK: Commissioners,</p> <p>23 during the break, I've been reviewing my notes</p> <p>24 as to whether there are additional</p> <p>25 nonconfidential areas that we'll be questioning</p> <p>26 on. I'm concluding that we're pretty much done</p>

185	<p>1 with the nonconfidential, and, of course, we</p> <p>2 are quite a bit ahead of schedule of where we</p> <p>3 expected to be.</p> <p>4 I'm estimating right now we'll probably be</p> <p>5 an hour or less in the confidential portion.</p> <p>6 What I would propose to do, if it's acceptable</p> <p>7 to the Panel, is to break early today, to start</p> <p>8 immediately in the morning with the -- with an</p> <p>9 in-camera session, and then that would wrap up</p> <p>10 the -- the cross of the -- of the Obsidian</p> <p>11 witness panel.</p> <p>12 THE CHAIR: Mr. Langen, any</p> <p>13 comments on that? Apologies. Mr. Langen, any</p> <p>14 comments on that approach?</p> <p>15 D.P. LANGEN: None at all. The</p> <p>16 only question I would have for Mr. Fitzpatrick</p> <p>17 is whether he has an estimate for how long</p> <p>18 he'll be crossing tomorrow?</p> <p>19 P. FITZPATRICK: Perhaps my friend</p> <p>20 didn't catch that. I said I expected to be an</p> <p>21 hour or less.</p> <p>22 D.P. LANGEN: Thank you.</p> <p>23 THE CHAIR: Okay. Then I think</p> <p>24 that approach works 'cause we're considerably</p> <p>25 ahead of schedule.</p> <p>26 Just a reminder, Mr. Langen and</p>	186	<p>1 Mr. Barrington -- or Ms. Barrington, I know you</p> <p>2 know this, but while your witnesses are in</p> <p>3 cross, of course you can't be having</p> <p>4 discussions with them until their cross is done</p> <p>5 tomorrow.</p> <p>6 D.P. LANGEN: Understood, sir.</p> <p>7 THE CHAIR: Okay. Thank you.</p> <p>8 With that, is there anything else you wanted to</p> <p>9 accomplish before we break, Mr. Fitzpatrick, or</p> <p>10 we can adjourn for the day?</p> <p>11 P. FITZPATRICK: I believe we can</p> <p>12 adjourn for the day, sir, if that's acceptable.</p> <p>13 THE CHAIR: Okay. And,</p> <p>14 Mr. Langen, nothing further from you today?</p> <p>15 D.P. LANGEN: No. The only</p> <p>16 comment is we will have some aids to cross that</p> <p>17 we'll be sending across to my friend. I</p> <p>18 apologize. They might not be 24 hours because</p> <p>19 we were working on the schedule, but they will</p> <p>20 come across as soon as we get to our office.</p> <p>21 THE CHAIR: Okay. Thank you</p> <p>22 very much.</p> <p>23 Okay. I think, with that, if there's</p> <p>24 nothing further, we will adjourn until 9 AM</p> <p>25 tomorrow morning.</p> <p>26 Thank you, everyone, for your participation</p>
187	<p>1 today.</p> <p>2 (WITNESSES STAND DOWN)</p> <p>3</p> <p>4 PROCEEDINGS ADJOURNED UNTIL 9:00 AM,</p> <p>5 NOVEMBER 28, 2024</p> <p>6</p> <p>7</p> <p>8</p> <p>9</p> <p>10</p> <p>11</p> <p>12</p> <p>13</p> <p>14</p> <p>15</p> <p>16</p> <p>17</p> <p>18</p> <p>19</p> <p>20</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p> <p>26</p>	188	<p>1 CERTIFICATE OF TRANSCRIPT:</p> <p>2</p> <p>3 We, A. Porco and K. Di Rocco, certify that</p> <p>4 the foregoing pages are a complete and accurate</p> <p>5 transcript of the proceedings taken down by us</p> <p>6 in shorthand and transcribed from our shorthand</p> <p>7 notes to the best of our skill and ability.</p> <p>8 Dated at the City of Calgary, Province of</p> <p>9 Alberta, this 28th day of November 2024.</p> <p>10</p> <p>11 </p> <p>12 _____</p> <p>13 A. Porco, CSR(A)</p> <p>14 Official Court Reporter</p> <p>15 Commissioner for Oaths Appointee No. 0734405</p> <p>16 ASRA Membership No. 185</p> <p>17</p> <p>18 </p> <p>19 _____</p> <p>20 K. Di Rocco, CSR(A)</p> <p>21 Official Court Reporter</p> <p>22 Commissioner for Oaths Appointee No. 0728318</p> <p>23 ASRA Membership No. 57</p> <p>24</p> <p>25</p> <p>26</p>