

September 18, 2015

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	
	)	Docket No. 40-8943
CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 08-867-02-OLA-BD01
(License Renewal)	)	

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SUPPLEMENTAL DIRECT TESTIMONY OF CROW BUTTE RESOURCES

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**EXPERT WITNESSES**

**A. Wade Beins**

**Q1. Please state your full name, your employer, and your position.**

A1. Wade Beins (WB). I am employed as a Senior Geologist at Crow Butte. A statement of my professional qualifications and work experience were provided previously.

**Q2. What is the purpose of your testimony?**

A2. (WB) The purpose of my testimony is to respond to the issues and new exhibits raised at the recent oral evidentiary hearing.

**Q3. What documents have you reviewed to prepare your testimony?**

A3. (WB) I am fully familiar with the Crow Butte license renewal application ("LRA") and the NRC Staff review documents, including the Environmental Assessment ("EA") and the final Safety Evaluation Report ("SER"). I also have reviewed the testimony and exhibits in this proceeding.

**B. Robert Lewis**

**Q4. Please state your full name, your employer, and your position.**

A4. Robert Lewis (RL). I am the owner and Principal Hydrogeologist of AquiferTek LLC, providing specialized hydrogeologic and environmental consulting services. A statement of my professional qualifications and work experience were provided previously.

**Q5. What is the purpose of your testimony?**

A5. (RL) The purpose of my testimony is to respond to the issues and new exhibits raised at the recent oral evidentiary hearing.

**Q6. What documents have you reviewed to prepare your testimony?**

A6. (RL) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits in this proceeding.

***C. Doug Pavlick***

**Q7. Please state your full name, your employer, and your position.**

A7. Doug Pavlick (DP). I am employed by Cameco Resources as General Manager for U.S. Operations. A statement of my professional qualifications and work experience were provided previously.

**Q8. What is the purpose of your testimony?**

A8. (DP) The purpose of my testimony is to respond to the issues and new exhibits raised at the recent oral evidentiary hearing.

**Q9. What documents have you reviewed to prepare your testimony?**

A9. (DP) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits in this proceeding.

***D. Matt Spurlin***

**Q10. Please state your full name.**

A10. Matt Spurlin (MS). I am a Senior Hydrogeologist at ARCADIS. A statement of my professional qualifications and work experience were provided previously.

**Q11. What is the purpose of your testimony?**

A11. (MS) The purpose of my testimony is to respond to the issues and new exhibits raised at the recent oral evidentiary hearing.

**Q12. What documents have you reviewed to prepare your testimony?**

A12. (MS) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits in this proceeding.

***E. Larry Teahon***

**Q13. Please state your full name, employer, and position.**

A13. Larry Teahon (LT). I am employed by Crow Butte Resources as the Safety, Health, Environment, and Quality (SHEQ) Manager at the Crow Butte facility. A statement of my professional qualifications and work experience were provided previously.

**Q14. What is the purpose of your testimony?**

A14. (LT) The purpose of my testimony is to respond to the issues and new exhibits raised at the recent oral evidentiary hearing.

**Q15. What documents have you reviewed to prepare your testimony?**

A15. (LT) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the Environmental Assessment EA and the final SER. I also have reviewed the testimony and exhibits in this proceeding.

## **SUPPLEMENTAL TESTIMONY**

**Q16. Can you briefly summarize your approach to the supplemental testimony?**

A16. (All) Yes. In an Order, dated September 4, 2015, the Board directed that the parties limit their supplemental testimony to the following topics:

- Topic 1: Whether the water levels in the Brule aquifer have lowered due to mining activities;
- Topic 2: What is the available head in the Basal Chadron/Chamberlain Pass formation and the maximum anticipated drawdown during Crow Butte's operation and restoration of its mining facility;
- Topic 3: Whether the results from the four pump tests demonstrate a hydraulic connection between the Brule and Basal Chadron/Chamberlain Pass formations;
- Topic 4: Whether the Basal Chadron/Chamberlain Pass formation exists beneath the Pine Ridge reservation and its connection (if any) to the Basal Chadron/Chamberlain Pass formation beneath the license renewal area;
- Topic 5: To what degree (if any) do the additional exhibits affect the conclusions regarding the structure of the White River feature and the NRC Staff's maximum likelihood modeling; and
- Topic 6: To what degree (if any) do the additional exhibits illustrate the groundwater flow directions in the Arikaree and Brule aquifers underlying the Pine Ridge reservation and the license renewal area.

Each of these topics are addressed in turn below.

### ***A. Brule Water Levels***

**Q17. Have the water levels in the Brule aquifer been lowered as a result of mining activities?**

A17. (WB, LT, MS, BL) No. There is no indication that water levels in the Brule aquifer have been lowered due to mining activities in the Basal Chadron Sandstone or inadequate confinement. As an aquifer that recharges, in part, through the direct infiltration of precipitation at the mine site, the Brule aquifer is

subject to seasonal water levels changes, as well as changes due to drought or periods of wet weather. There is no sustained downward trend in water levels or correlation to mine activities within the underlying Basal Chadron Sandstone that would suggest mining is having an effect on Brule water levels.

**Q18. Are there exhibits that demonstrate the absence of Brule drawdown from mining activities?**

A18. (WB, LT, MS, BL) Yes. Crow Butte provided two exhibits during the hearing (CBR-063 and CBR-064) that show long-term water level trends (1999-present) for two shallow (Brule) monitoring wells, SM7-17 and SM7-22.<sup>1</sup> Data is collected every two weeks. Neither exhibit shows a long-term decline in water levels that would suggest an impact from Crow Butte's mining operations. Instead, the relatively narrow band of water levels (+/- several feet) are consistent with seasonal and annual weather patterns (*e.g.*, droughts and wet years) in the area.

**Q19. Is this data consistent with that at other monitoring wells?**

A19. (WB, LT, MS, BL) Yes. The data is representative of and similar to data taken in other shallow monitoring wells across the site. *See* CBR-065 (water level data for 8 additional shallow monitoring wells) and CBR-066 (locations of shallow monitoring well water level data). At the hearing, there also was discussion comparing water levels in the pre-mining period to the 2008 time period based on contour maps in the LRA Figures 2.7-3 a-d (Exh. CBR-011 at 2-172 to 2-179).

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<sup>1</sup> Crow Butte filed revised versions of the exhibits (Exhs. CBR-063R and CBR-064R) with this supplemental testimony. The revised exhibits fill in the short data gap that existed in the prior version of each exhibit.

Those contour maps were prepared primarily to show groundwater flow direction across the mine site. The pre-mining contour maps also were based on a limited data set from regionals private wells, some of which have limited information regarding the depth of the well and the screened interval that can affect the water level measurements. For example, deeper screened private wells can have heads that are significantly different than heads measured in shallow wells. These differences in water levels should not be misinterpreted to represent significant changes in head over time when compared with more recent water levels from shallow wells screened in consistent locations. Our conclusion that water levels in the Brule have not been affected by mining activities is based on much more detailed monitoring well water level data — both in terms of the number of wells and the frequency of data collection — collected for the duration of mine activities. As indicated at the oral evidentiary hearing (Tr. at 1795), information regarding the screened interval in a private well also can influence the water level. For this reason, Crow Butte’s monitoring well water level data, which is collected every two weeks and is the most reliable data, enables an “apples to apples” comparison of water levels at a particular point over time.

***B. Available Head and Drawdown***

**Q20. Do you agree with the NRC Staff’s calculations regarding maximum drawdown at the site?**

A20. (WB, LT, MS, BL) We agree that the methodology used by the NRC Staff to evaluate maximum drawdown in the EA is technically appropriate. And, we generally agree with the results of the calculations performed by the NRC Staff regarding the maximum drawdown across the site, though we note that drawdown



may be slightly greater than predicted by the NRC Staff if actual flow rates are greater than that used by the NRC Staff. Importantly, there are no new mine units to be commissioned at the current license area. As a result, pumping rates are presently at or near their projected maximum. As production ends in the current mine units and restoration is completed in mine units, pumping rates will decline.

**Q21. What is the current available head at the mine site?**

A21. (WB, LT, MS, BL) Exhibit CBR-062 shows the available head at a number of points throughout the various mine units at the license renewal area. The available head ranges from 435 feet to 147 feet (based on August 2015 data).

**Q22. Will Crow Butte's mining activities cause drawdown in the Basal Chadron Sandstone aquifer below the top of the Basal Chadron Sandstone formation?**

A22. (WB, LT, MS, BL, DP) No. Licensed flow rates for operations are insufficient to lower the water level to that point. There is more than ample available head to accommodate the remaining wellfield production and restoration activities, particularly since consumption/pumping will only be reduced going forward as mine unit operations are sequentially shut down.

**C. Aquifer Pump Test Results**

**Q23. Has Crow Butte performed aquifer pumping tests?**

A23. (WB, LT, MS, BL) Yes. The Nebraska Department of Environmental Quality ("NDEQ") authorized Crow Butte to operate in Underground Injection Control ("UIC") Permit Number NE 0122611 (Exh. CBR-017). The permit required aquifer pumping tests to demonstrate the integrity of the confining layer above the mining zone prior to mine development. Data collected and analyzed as part of these aquifer pumping tests included pumping rate, test duration, formation

characteristics, transmissivity, hydraulic conductivity, storativity, and radius of influence. The purpose of the testing was to evaluate the properties of the aquifer and the integrity of the confining layer at the site. Crow Butte performed four groundwater pumping tests between 1982 and 2002 in order to comply with the requirements of the UIC permit. The aquifer testing involved overlapping areas of influence across the length of the site. The tests were performed in accordance with regulatory requirements (and reviewed and approved by NDEQ in advance).

**Q24. Are those tests documented?**

A24. (WB, LT, MS, BL) Yes. The aquifer testing reports are Exhs. BRD-010A, BRD-010BR, BRD-010C, and CBR-012.

**Q25. Can you please briefly summarize the tests?**

A25. (WB, LT, MS, BL) Yes. The pump tests are briefly described in the LRA. The resulting pumping rates for each test were based on sustainable drawdown rates for the individual pumping wells. Key data is summarized in the following table:

	<b>Test #1</b>	<b>Test #2</b>	<b>Test #3</b>	<b>Test #4</b>
Exhibit	BRD-002A	BRD-002BR	BRD-002C	CBR-012
Date	Nov. 1982	June/July 1987	Sept. 1996	August 2002
Pumping Period	50.75 hours	72 hours	55 hours	64.5 hours
Recovery Period	27.6 hours	72.5 hours	44 hours	> 64.5 hours
Pump Rate	24 gpm	47.74 gpm	51.2 gpm	50.2 gpm
Max. Drawdown		36.86 feet	65 feet	45.3 feet
Monitoring Wells	Four Basal Chadron wells; two Brule wells (upper and lower)	Three Basal Chadron wells; one Brule well; Upper and Lower Confining Piezometers	Three Basal Chadron wells; one Brule well	Four Basal Chadron wells; one Brule well

**Q26. What did those tests conclude?**

A26. (WB, LT, MS, BL) All four pump tests conclude that there is no hydraulic connection between the Brule and the Basal Chadron Sandstone/Chamberlain Pass Formation. Results from Test #1 imply that the aquicludes over- and underlying the Basal Chadron Sandstone probably yielded some small amount of water as recharge (or leakage) to the aquifer during the pump test. However, close examination of the time-drawdown responses indicate the observed aquifer response is indicative of a fully confined aquifer (*e.g.*, time drawdown responses fit the Theis confined aquifer type curves very well). In any case, the amount of this recharge or leakage calculated by the authors was extremely small, equivalent to 947 gallons spread out over 50,268,240 square feet (1154 acres) over a period of nearly 51 hours, or 0.00001884 gallons/square foot. These extremely small leakage rates are consistent with a fully confined aquifer response. This conclusion is further supported by the results of the laboratory test of the core samples. According to the test results, the time needed for a water molecule to travel through a thickness of the aquiclude is calculated as the hydraulic resistance times the effective porosity. Authors of the aquifer test report calculate that it would take more than 12,000 years for water to move through a 15-foot thick section of the Red Clay. The time for water to move through the entire Upper Confining Unit is obviously much longer. During Test #2, the overlying confining layer piezometer showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. The overlying aquifer monitor well also showed no response to the pumping from the Basal Chadron Sandstone

during the aquifer test, demonstrating that the overlying aquifer is not in hydraulic communication with the Basal Chadron Sandstone. The authors of the aquifer test report estimate it would take more than 2.8 million years for a molecule of water to move through the upper confining aquiclude. Aquifer Test #3 results also demonstrate the integrity of the confining layer above the mining zone and the homogeneity and isotropy of the Chadron Sandstone in the northern portion of the license area, confirming the integrity of the confining layer between the Chadron Sandstone and the Brule Formation. The results for Test #4 also demonstrate the integrity of the confining layer above the mining zone, and indicate that the Chadron Sandstone is relatively homogeneous and isotropic within the southern portion of the permit area.

**Q27. Overall, do the results from the four pump tests demonstrate a hydraulic connection between the Brule and Basal Chadron/Chamberlain Pass formations?**

A27. (WB, LT, MS, BL) No. All four pump tests conclude that that there is no hydraulic connection between the Brule and the Basal Chadron Sandstone/Chamberlain Pass Formation. Overall, there is strong evidence for hydraulic isolation and a competent upper confining unit at the site, indicating that groundwater flow pathways between the production zone and overlying aquifers are not present.

***D. Basal Chadron at Pine Ridge Reservation***

**Q28. The intervenors presented several new exhibits during the hearing that purport to show the existence of the Chamberlain Pass Formation at the Pine Ridge Reservation. Have you reviewed those documents?**

A28. (WB, MS, BL) Yes. The Chamberlain Pass Formation is being defined, at least in part, as a chronostratigraphic unit — that is, a group of sediments that were deposited during the same time interval, regardless of the lithology (*e.g.*, grain type and size) or depositional environment of the sediments. So, while the Chamberlain Pass Formation may be present on the reservation, the distribution of specific lithofacies within the Pine Ridge Reservation is not conclusively demonstrated in exhibits INT-073, INT-074, INT-076, and INT-077.<sup>2</sup> For example, exhibit INT-073 describes the Chamberlain Pass Formation as consisting of silty claystone and thin ribbons of diagenically altered sandstone. It is unclear from these documents whether, on a regional basis, these thin ribbon sandstones correlate to the channel-sandstone lithofacies or if they represent other ribbon-like deposits commonly associated with overbank deposits (*e.g.*, avulsion or crevasse-splay deposits). As illustrated in Exhibit INT-076, channel sandstone deposits at the base of the Chamberlain Pass Formation that appear similar to those within the license area are present regionally. However, as Dr. LaGarry indicated at the hearing (Tr. at 2019), the multiple occurrences of this lithologic unit likely represent deposition by river systems within separate synclines. The distribution of these individual deposits are not defined in these documents. As such, review of these documents does not conclusively indicate that the channel sandstone lithofacies of the Chamberlain Pass Formation — that is, the Basal Chadron Sandstone — is present on the reservation. More importantly, these documents do not present evidence that the specific deposits of channel sandstone

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<sup>2</sup> Although there may be additional relevant data associated with INT-073, INT-074, and INT-075 (*e.g.*, in poster presentations), such data was not included in the abstract form.

mined within the license renewal area can be correlated to similar sandstones that may be present on the reservation.

**Q29. Is there a hydraulic connection between the Chamberlain Pass Formation that exists beneath the Pine Ridge reservation and the Basal Chadron Sandstone beneath the license renewal area?**

A29. (WB, MS, BL) Overall, there is no evidence of hydrologic connectivity between the channel sandstone lithofacies of the Chamberlain Pass Formation (Basal Chadron Sandstone) within the license renewal area and the Chamberlain Pass Formation at the Pine Ridge Reservation. The Basal Chadron Sandstone present within the license renewal area pinches out (*i.e.*, is not present) beyond a few miles to the east of the license area and is not hydraulically connected to the Chamberlain Pass Formation on the reservation. Dr. Striz for the NRC Staff also recognized at the hearing (Tr. at 1224) that there is “no pathway in the southern portion of the license area for water to get in the Arikaree and to be transported 30 miles all the way up to the Pine Ridge Reservation” because the Basal Chadron Sandstone pinches out and then “you have all the siltstones and mudstones for 27 miles that a particle of water would have to pass through.” Dr. LaGarry also acknowledged at the oral hearing that there is no direct connection via the Chamberlain Pass formation (Tr. at 1220). Instead, he posited (*id.*) that the faults could allow “transmissivity of fluids connecting these little isolated pod[s] to Chamberlain Pass formation, then water could migrate through Chamberlain Pass, through a fault, through Chamberlain Pass, through a fault, through Chamberlain Pass, through a fault, through Chamberlain Pass to the reservation.” This is pure

speculation (upon speculation) and is not supported by any hydrogeologic evidence. Crow Butte, in contrast, presented relevant site-specific data demonstrating the absence of faulting or fracturing at the site that affects confinement or secondary porosity. In any event, even if, hypothetically, there were faults or fractures connecting the Basal Chadron to the Brule at the Crow Butte site (which there are not), the vertical hydraulic gradient in the permit area during operations is strongly downward, which precludes upward migration of mining fluids into the Brule aquifer.

**Q30. Do the new exhibits shed any light on the source of uranium in groundwater at the Pine Ridge Reservation?**

A30. (WB, MS, RL) Yes. The references (*e.g.*, INT-072 and 074) identify the Chamberlain Pass Formation as the source of naturally-occurring uranium contamination of groundwater at the Pine Ridge Reservation. Exhibit INT-074 also proposes that “Cretaceous sandstones” are a likely source of groundwater contamination near the community of Red Shirt on the Pine Ridge Reservation. The publications note uranium contamination in locations so far distant from the Crow Butte site that they could not possibly be from mining fluids — due to both dilution effects over that distance and the slow travel times for uranium. This undercuts the claim, which, in any event, was not based on evidence or data, that Crow Butte’s operations are the source of uranium found in groundwater at Pine Ridge. As we have stated previously, there is no evidence to suggest that any mining fluids have migrated beyond the license area, much less are the source of uranium contamination at the far-off locations in South Dakota cited by Ms.

White Face during the hearing. Crow Butte maintains an extensive monitoring network precisely to identify any such issues, and take appropriate corrective actions, long before there would be any offsite impacts.

***E. White River Structural Feature***

**Q31. To what degree (if any) do the additional exhibits affect the conclusions regarding the structure of the White River feature and the NRC Staff's maximum likelihood modeling?**

A31. (WB, MS, RL) The additional exhibits do not affect the conclusions in the NRC Staff's EA and SER. Crow Butte has not relied on the NRC Staff's modeling results for its conclusions in the license renewal application regarding the White River Structural Feature. The NRC Staff's independent assessments simply confirm what Crow Butte had already demonstrated. While further refinements and additional modeling runs can also always be made, there is no reason to believe that the NRC Staff's modeling efforts were unreasonable given the stated limited purpose of the model.

**Q32. With respect to the capability of the White River Structural Feature to transmit fluids, Mr. Wireman testified that older faults tend to be less permeable (if not impermeable), while younger faults are more likely to be permeable. Does Crow Butte have any information or data regarding the age of the White River Structural Feature and its relationship to the depositional history in the area?**

A32. (WB, MS, RL) Yes. Regarding the White River Structural Feature discussion at the oral hearing, the age of the structure is a strong argument for the lack of a transmissive pathway, such as a fault. This follows on Mr. Wireman's testimony



(Tr. at 1186-1187) regarding the process by which a fault becomes less transmissive with age. In this case, we know the fold structure is very old, between 30-32 million years old, which is tightly constrained by regional dating (paleo fauna and flora) of the age of the Chamberlain Pass, Chadron, and Brule formations. The tightly-spaced network of borehole picks for the top of the Basal Chadron Sandstone and the top of Pierre Shale indicate continuous geologic surfaces across the entire fold structure. In addition, from a geometric standpoint, the orientation of the northward-dipping fold limb precludes any structural offset of the Basal Chadron Sandstone. The thickness of the sandstone is greatly reduced on the north-dipping limb of the fold and ranges from 6-20 feet thick (average 10 feet thick), which is the result of flexural bending and a common type of deformation related to this type of folding. If structural offset had occurred, the observed hydraulic connectivity and consistent gradient direction within the sandstone from north to south across the fold structure would not be possible.

***F. Groundwater Flow Directions***

**Q33. To what degree (if any) do the additional exhibits illustrate the groundwater flow directions in the Arikaree and Brule aquifers underlying the Pine Ridge reservation and the license renewal area?**

A33. (WB, LT, MS, RL) Whether or not the exhibits, such as the Arikaree flow directions in BRD-006, accurately represent flow directions underlying the Pine Ridge reservation, is not relevant to resolution of the admitted contentions. There is no hydraulic connection between the Basal Chadron Sandstone and the Arikaree or Brule aquifers at the mine site, much less the potential for mining

fluids to travel the many 10s of miles from Crow Butte's mine to the Pine Ridge Reservation.