CBR-001

May 8, 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)	)	

INITIAL WRITTEN TESTIMONY OF CROW BUTTE RESOURCES WITNESSES WADE BEINS, BRYAN SOLIZ, ROBERT LEWIS, MATT SPURLIN AND LARRY TEAHON ON CONTENTIONS A, C, D, F, AND 14

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EXPERT WITNESSES

A. Wade Beins

Q1. Please state your full name.

A1. Wade Beins (WB)

Q2. By whom are you employed and what is your position?

A2. (WB) I am employed as a Senior Geologist at Crow Butte.

Q3. Please summarize your professional qualifications.

A3. (WB) A copy of my professional qualifications statement is attached to Exhibit CBR-002. I have approximately 20 years of experience at the Crow Butte site as a geologic technician and geologist.

Q4. What is the purpose of your testimony?

A4. (WB) The purpose of my testimony is to address the issues raised in Contentions A, C, D, F, and 14. In particular, I will focus on interpretations of regional and site geology and hydrogeology.

Q5. What documents have you reviewed to prepare your testimony?

A5. (WB) I am fully familiar with the Crow Butte license renewal application and the NRC Staff review documents, including the Environmental Assessment ("EA"), and the final Safety Evaluation Report ("SER"). I have extensive experience in site geology and hydrogeology though my work on thousands of boreholes at the site. Additionally, to prepare this testimony I have reviewed the filings made to date by the Intervenors.

B. Robert Lewis

Q6. Please state your full name.

A6. Robert Lewis (RL)

Q7. By whom are you employed and what is your position?

A7. (RL) I am the owner and Principal Hydrogeologist of AquiferTek LLC, providing specialized hydrogeologic and environmental consulting services.

Q8. Please summarize your professional qualifications.

A8. (RL) A copy of my qualifications statement is attached to Exhibit CBR-003. I have over 27 years of experience as a groundwater scientist and environmental consultant, and am a registered Professional Geologist in Wyoming. I have been involved in more than 300 consulting projects and environmental investigations worldwide. I have expertise in the areas of groundwater flow and transport modeling, mine hydrology, soil and groundwater contamination investigation and remediation, fate and transport of organic, inorganic, and radiological constituents, and water resource development. I also have authored technical papers, peer-reviewed journal articles, and book chapters concerning mine hydrology and water quality, groundwater modeling, and water resource evaluation. I have served as Associate Editor of *Ground Water* journal, and have

been a member of ASTM subcommittees D.18.04 (Determination of Hydrogeological Parameters) and D18.21.10 (Ground Water Modeling).

Q9. What is the purpose of your testimony?

A9. (RL) The purpose of my testimony is to address the issues raised in Contentions A, C, D, F, and 14. In particular, I will focus on interpretations of regional and site geology and hydrogeology.

Q10. What documents have you reviewed to prepare your testimony?

A10. (RL) I am fully familiar with the Crow Butte LRA and the NRC Staff review documents, including the EA, and the final SER. Additionally, to prepare this testimony I have reviewed the filings made to date by the Intervenors.

C. ***Bryan Soliz***

Q11. Please state your full name.

A11. Bryan Soliz (BS)

Q12. By whom are you employed and what is your position?

A12. (BS) I am employed as a Principal Geologist for Cameco Corporation and previously worked as the Director of Exploration and Development for Cameco Resources.

Q13. Please summarize your professional qualifications.

A13. (BS) A copy of my professional qualifications statement is attached to Exhibit CBR-004.

Q14. What is the purpose of your testimony?

A14. (BS) The purpose of my testimony is to address the issues raised in Contentions A, C, D, F, and 14. In particular, I will focus on interpretations of regional and site geology

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

A15. (BS) I am fully familiar with the Crow Butte license renewal application and the NRC Staff review documents, including the EA and SER. Additionally, to prepare this testimony I have reviewed the filings made to date by the Intervenors.

D. Matt Spurlin

Q16. Please state your full name.

A16. Matt Spurlin (MS)

Q17. By whom are you employed and what is your position?

A17. (MS) I am a Senior Hydrogeologist at ARCADIS.

Q18. Please summarize your professional qualifications.

A18. (MS) A copy of my professional qualifications statement is attached to Exhibit CBR-005. I have a M.S. in Geology from UCLA and am a registered professional geologist in the State of Texas. I specialize in applying geological, hydrogeological, geophysical and visualization science techniques to provide high quality hydrogeological data interpretation. I have worked for a variety of clients including the National Science Foundation, oil and gas and mining industry clients, and state agencies, to provide high-quality hydrogeological and visualization expertise on projects ranging from crustal strain analysis of NASA shuttle radar data to interpretation of complex geologic folding and faulting influences on local and regional hydrogeology. My skills include enhanced 3D visualization and data analysis, high-resolution investigation techniques, downhole geophysics investigations, site conceptual model development, water resource assessment, aquifer testing, design and optimization of remediation strategies, field hydrogeology and data collection.

Q19. What is the purpose of your testimony?

A19. (MS) The purpose of my testimony is to address the issues raised in Contentions A, C, D, F, and 14. In particular, I will focus on interpretations of regional and site geology and hydrogeology.

Q20. What documents have you reviewed to prepare your testimony?

A20. (MS) I am fully familiar with the Crow Butte license renewal application and the NRC Staff review documents, including the EA and SER. Additionally, to prepare this testimony, I have reviewed the filings made to date by the Intervenors.

E. <u>Larry Teahon</u>

Q21. Please state your full name.

A21. Larry Teahon (LT)

Q22. By whom are you employed and what is your position?

A22. (LT) I am employed by Crow Butte Resources as the Safety, Health, Environment, and Quality (SHEQ) Manager at the Crow Butte facility. I oversee radiation protection, health and safety, and environmental programs at the site and ensure compliance with all applicable regulatory requirements. I assist in the development and review of radiological and environmental sampling and analysis procedures and am responsible for routine auditing of the programs.

Q23. Please summarize your professional qualifications.

A23. (LT) A copy of my professional qualifications statement is attached to Exhibit CBR-006.

Q24. What is the purpose of your testimony?

A24. (LT) The purpose of my testimony is to address the issues raised in Contentions A, C, D, F, and 14. In particular, I will focus on site operational activities, including water quality sampling, and other environmental data related to site operations.

Q25. What documents have you reviewed to prepare your testimony?

A25. (LT) I am fully familiar with the Crow Butte license renewal application and the NRC Staff review documents, including the EA and SER. Additionally, to prepare this testimony I have reviewed the filings made to date by the Intervenors.

BACKGROUND

Q26. What is your understanding of Contention A?

A26. (All) Contention A asserts that "[t]here is no evidence based science for [the NRC Staff's] conclusion that ISL mining has 'no non radiological health impacts,' or that non radiological impacts for possible excursions or spills are 'small.'" OST claims, based on a 1989 letter to the NRC and a statement by Dr. Hannan LaGarry, that the mined aquifer used by Crow Butte "likely" communicate with aquifers that supply water to the Pine Ridge Indian Reservation and that mining fluid could migrate into the aquifer that supplies drinking water. In effect, the contention challenges Crow Butte's ability to maintain control over underground mining fluids. In addition, based on claims by Dr. Abitz made with the petition to intervene, OST argues that there is no scientific basis for excluding uranium from the monitor well testing and that bi-weekly testing of monitoring wells is insufficient to identify potential contamination.

Q27. What is your understanding of Contention C?

A27. (All) Contention C asserts that "[the NRC Staff's] characterization that the impact of surface waters from an accident is 'minimal since there are no nearby surface water features,' does not accurately address the potential for environmental harm to the White River." OST claims that, because the White River runs through the Pine Ridge Reservation, evidence (in the form of documented excursions/leaks) demonstrates the potential for contamination of the White River from surface spills and subsurface migration. They argue that Crow Butte ignores the White River as a potential surface water that is affected in the event of an accident and claim that the White River alluvium (as a potential pathway) should be evaluated for contamination.

Q28. What is your understanding of Contention D?

A28. (All) Contention D asserts that "[the NRC Staff] incorrectly states there is no communication among the aquifers, when in fact, the Basal Chadron aquifer, where mining occurs, and the aquifer, which provides drinking water to the Pine Ridge Indian Reservation, communicate with each other, resulting in the possibility of contamination of the potable water. Based on this potential communication between the aquifers, the EA's environmental justice analysis, including analysis of cumulative effects, should be expanded to consider potential impacts on the aquifer which provides drinking water to the Pine Ridge Indian Reservation." Based on statements by Dr. LaGarry, OST claims that aquifers in this area are interconnected, and, as a result, there is potential pathway for contamination of the Pine Ridge water supply via faults and fractures. OST also asserts that Crow Butte failed to adequately consider the White River Structural

Feature, which may affect the control of fluid migration outside the mining area. The contention also includes a piece related to the potential for contamination to cause environmental justice impacts outside the immediate vicinity of the site.

Q29. What is your understanding of Contention F?

A29. (All) Contention F is a technical contention entitled "Failure to Include Recent Research." The contention is based on claims by Dr. LaGarry that Crow Butte (as well as the NRC and NDEQ) are relying on old data and old research when there is more recent research. In particular, Dr. LaGarry claims that the recent mapping of the geology of northwestern Nebraska has shown that the simplified, "layer cake" concept applied by pre-1990's workers is incorrect. In addition, CI claims that references in the License Renewal Application (Exh. CBR-011) were to outdated EPA guidance documents for taking groundwater samples from 1974 and 1977 and that the LRA should have cited more recent guidance from 1992 and 2000.

Q30. What is your understanding of Contention 14?

A30. (All) Contention 14 asserts that "[t]he EA violates NEPA in its failure to provide an analysis of the impacts on the project from earthquakes; especially as it concerns secondary porosity and adequate confinement." The only bases for the contention is the claim that the EA omitted two earthquakes near Chadron in 2011 (the LRA was submitted in 2007) and Dr. LaGarry's claim that even small earthquakes can alter the secondary porosity of an aquifer and modify groundwater flow patterns (affecting confinement). In many ways, this contention overlaps with Contention D, which alleges the potential for

contamination via faults and fractures (secondary porosity). The Licensing Board also raised an issue regarding the EA's focus on seismology in Nebraska, rather than other nearby states.

ASSESSMENT OF HYDROGEOLOGY ISSUES

Q31. Can you briefly summarize your approach to responding to the issues raised in the contentions?

A31. (All) Yes. We begin by providing a brief overview of regional geology and hydrogeology to provide background information before focusing on site-specific geology and hydrogeology. We then explain the various ways in which Crow Butte successfully demonstrated the mined aquifer is confined, including borehole log data, laboratory tests of soils and rocks, water level data, water sampling data, aquifer pump tests, and operating experience. We also describe Crow Butte operations, including the steps taken to control underground mining fluid and the monitoring activities associated with site operations. Finally, we address the specific issues raised by OST/CI.

A. Overview of Site Hydrogeology

Q32. Can you briefly summarize the nomenclature that you will use to describe geology of the area surrounding the Crow Butte facility?

A32. (All) Yes, before going into detail regarding the regional geology it is important to provide a context for the nomenclature that we will be using. There have been recent studies of the regional geology that have resulted in the proposal of a new nomenclature for some of the geologic units within the license area, including proposals by Dr. LaGarry, who submitted an opinion earlier in this proceeding. However, in its discussions of site geology, Crow Butte, the NRC Staff, and the

Nebraska Department of Environmental Quality ("NDEQ") continue to use the nomenclature found in the prior license applications for consistency. Stratigraphic nomenclature aside, nothing in the naming conventions for the geologic units in Nebraska or at the Crow Butte facility changes the interpretation of the physical or hydraulic features of the rock units. The differences are a matter of semantics and have no technical relevance to the adequacy of the LRA. Crow Butte therefore will continue to use the naming conventions presented in the LRA.

Q33. Can you briefly describe the geology of the area surrounding Crow Butte/

A33. (WB, MS, RL, BS) Crow Butte provided detailed information regarding the geology at the license area. Figure 2.6-2 of the LRA (Exh. CBR-011) presents a stratigraphic column of the geologic units present within the license and abutting area.

Q34. Can you please describe these units in relation to one another?

A34. (WB, MS, RL, BS) Yes. The Basal Chadron Sandstone is the geologic stratigraphic unit that is host to the uranium mineralization. The Basal Chadron Sandstone is also an aquifer long recognized to have poor water quality due to elevated total dissolved solids ("TDS") (generally above 1,500 milligrams per liter) and a locally strong sulfur odor resulting from reducing conditions associated with the ore body. The unit is bounded above and below by very low permeability strata that form aquicludes (*i.e.*, essentially impermeable rock or sediments that form barriers to groundwater flow). Based on deep oil test holes in Dawes County, the Pierre Shale, which underlies the Basal Chadron Sandstone,

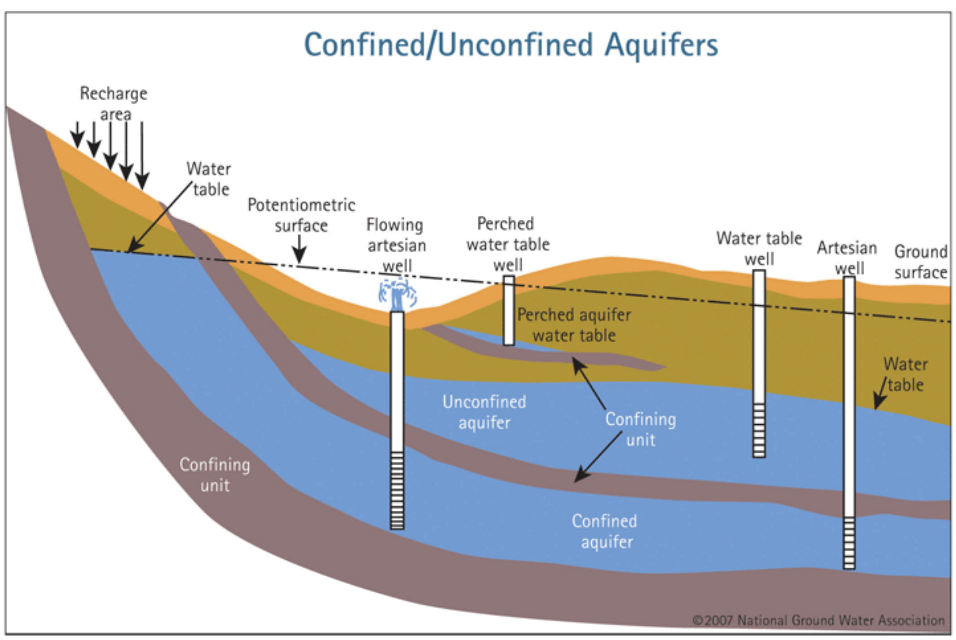
ranges from 1,200 to 1,500 feet thick. It has a very low hydraulic conductivity (consistent with an impermeable shale) and is regionally continuous. The local stratigraphic column indicates that the Basal Chadron Sandstone is locally separated from the overlying Arikaree Group and upper Brule Formation by a thick confining layer that consists of 120-250 ft-thick middle and upper Chadron Formation and 200-300 ft-thick lower Brule Formation. This upper confining layer is regionally continuous. As shown in Figure 2.6-1 of the LRA, the Arikaree Group only occurs on the Pine Ridge Escarpment, which is along the southern portion of the site in Mine Unit 11. A series of seven east-west cross sections have been constructed through the license area to demonstrate the geology of the Basal Chadron Sandstone and its relationship to the confining horizons (LRA Figures 2.6-3 to Figure 2.6-10). One northwest-southeast cross section is included to show the continuity of the geologic units (LRA Figure 2.6-11). *See also* Color Cross Sections (Exh. CBR-024). Crow Butte recognizes that, within these continuous geologic units, lithologic heterogeneities are present; however, the overall interpretation of lateral continuity is not affected by local lithofacies variations.

B. <u>Basis for Conclusions on Confinement</u>

Q35. The intervenors argue that there is inadequate information to demonstrate that adequate confinement exists and that, as a result, mining fluid in the Basal Chadron Sandstone may contaminate other aquifers. First, can you briefly describe what it means to be a "confined" aquifer?

A35. (WB, MS, RL, BS) A "confined" aquifer (also called an "artesian" aquifer) is an aquifer that is overlain by a low permeability or impermeable layer, often made

up of shales or clays. These overlying low permeability materials represent the "confining layer." The groundwater below the confining layer is under pressure greater than atmospheric and, if penetrated by a well, the water level can rise above the top of the aquifer. If the water rises above the ground surface, the well is referred to as a "flowing artesian well." In a confined aquifer, the pores always remain fully saturated. Water is released from storage in response to a drop in head by two mechanisms: (1) expansion of the water in the pores as water pressure is reduced; and (2) compaction of the aquifer as water pressure is reduced and stresses between solid grains of the aquifer matrix increase. An unconfined aquifer (also known as a "surficial" or water table aquifer) is an aquifer where the water table represents its upper boundary. Unconfined aquifers typically occur near the ground surface. In an unconfined aquifer, pumping results in a release of water from storage by an actual dewatering of pores as the water table declines.



Q36. What is the basis for Crow Butte's conclusions regarding confinement?

A36. (WB, MS, RL, BS) As noted above, Dr. LaGarry has proposed alternate nomenclature to describe the geology near Crow Butte, but this does not affect the basis for concluding that mining fluid can be controlled or that the mined aquifer is confined. Crow Butte's conclusions are based on multiple sources of site-specific data, including correlated borehole logs (lithologic and geophysical), laboratory tests of confining zone cores, water quality data, water level data, aquifer pump tests, and operating experience. These data shows that low permeability layers confine the Basal Chadron Sandstone both above and below. This isolates the Basal Chadron Sandstone from overlying and underlying aquifers.

1. Borehole Logs

Q37. What do the borehole logs and laboratory data show regarding confinement?

A37. (WB, MS, RL, BS) As noted above, the Basal Chadron Sandstone, the stratigraphic unit that is host to the uranium mineralization, is bounded above and below by thick sequences of low permeability strata that form aquicludes. This is a favorable situation for in-situ mining of uranium. The lower confining bed is the Pierre Shale, which is over 455 m (1500 feet) thick. The Pierre Shale consists of homogenous black marine shale with very low permeability and is one of the most laterally extensive formations of northwest Nebraska. The shale is an ideal confining bed with measured vertical hydraulic conductivity at the site of less than 2.0×10^{-9} centimeters per second (cm/sec). LRA at 2-127. Regional studies also indicate that there is no observed transmissivity between vertical fractures in the Pierre Shale, which appear to be short and not interconnected. North Trend

Expansion Area ("NTEA"), *Aquifer Exemption Petition*, Section 4.4.1 (Exh. CBR-013).

Upper confinement consists of the middle and upper Chadron Formation and Orella Member of the lower Brule Formation. The middle and upper Chadron Formation is generally composed of impermeable clay grading upward into several hundred feet of siltstones and claystones of the Brule Formation. The middle and upper Chadron Formation represent a distinct and rapid facies change from the underlying Basal Chadron Sandstone (the mined unit). The lowest portions of the middle Chadron Formation are frequently red or green clay, which grade upward to generally light green-gray bentonitic clay. The middle and upper Chadron Formation clays are laterally continuous and distinctive clay marker beds that have been observed in all borings at the Crow Butte site. Within the license area, the Orella Member of the Brule Formation is indistinguishable from the upper Chadron Formation on the basis of drill cuttings or electric logs. The measured vertical hydraulic conductivity of the upper confinement (as measured in the upper Chadron Formation) is less than 1.0×10^{-10} cm/sec within the current license area. LRA at Section 2.6.2.3 (Exh. CBR-011).

Q38. Do X-ray diffraction analyses provide additional support for the existence of confining layers?

A38. (WB, MS, RL, BS) Yes. Table 2.6-2 of the LRA shows that the upper and lower confining units (upper Chadron Formation and Pierre Shale, respectively) contain significant percentages of montmorillonite clay and other clays and/or calcite. Particle size distribution analyses of samples collected within these confining

units indicate mostly silt and clay-sized fractions, which are consistent with observations from pervasive geophysical logging that noted very thick sequences of predominantly fine-grained materials. These two observations indicate that both the upper and lower confinement are significantly less permeable than the ore zone and, given their substantial thickness, are essentially impermeable.

Q39. Are the vertical hydraulic conductivities and XRD data representative for confining layers?

A39. (WB, MS, RL, BS) Yes, the vertical hydraulic conductivities of both the upper and lower confining units are very low. The term "aquiclude" is used to describe strata that are very nearly impermeable and capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for vertical and horizontal hydraulic conductivity of aquicludes are in the range of 10^{-7} to 10^{-10} cm/sec. The Pierre Shale has vertical hydraulic conductivity of 2.0×10^{-9} cm/sec, while the upper Chadron has a vertical hydraulic conductivity of 1.0×10^{-10} cm/sec. As a point of reference, materials with conductivity less than 10^{-6} cm/sec are commonly used as liners in landfills and hazardous waste repositories to protect groundwater from contamination. The Pierre Shale, upper Chadron and Orella Member of the lower Brule Formation, therefore are aquicludes (not aquitards) that provide effective hydraulic isolation of the Basal Chadron Sandstone from other aquifers.

2. Water Sampling

Q40. What does water level data taken from the various aquifers indicate?

A40. (WB, MS, RL, BS) Water level data also support hydrologic isolation of the Basal Chadron Sandstone with respect to the other water-bearing intervals of interest at

Crow Butte. As shown in LRA Tables 2.7-5 and 2.7-6, as well as Figures 2.7-3d and 2.7-4d, the potentiometric surface of the Basal Chadron has historically ranged between approximately 3690-3750 above mean sea level, while the Brule generally varies between approximately 3830-3970 feet above mean sea level. The large differences in hydraulic head (generally in excess of 100 feet) provide an additional line of evidence of hydraulic confinement. If significant hydrologic communication was present, the hydraulic heads of the two aquifers would be expected to be much closer in elevation. In addition, the vertical hydraulic gradient in the permit area is strongly downward. There is therefore no potential for groundwater to flow upward from the production aquifer and into the shallow aquifer, including during mining and restoration.[1]

Q41. What does water quality data taken from the various aquifers reveal?

A41. (WB, MS, RL, BS) The geochemical groundwater characteristics of the Brule Formation and Basal Chadron Sandstone further indicate that the two aquifers are not hydrologically connected. For example, radium levels in the Brule Formation groundwater samples collected within the license area have mean concentrations of 0.7 picoCuries per liter (pCi/L), while the mean concentration of samples collected from the Basal Chadron Sandstone is 53 pCi/L. Significant differences also exist for sodium, chloride, sulfate, conductance, and uranium, as shown in the table below:

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1 Injection of groundwater during mining causes increase in head of less than 50 feet. There is therefore no possibility of upward groundwater movement into the shallow aquifer.

Parameter	Basal Chadron Sandstone (mean value)	Brule Formation (mean value)
Sodium (mg/L)	411	104
Chloride (mg/L)	176	48
Sulfate (mg/L)	407	10
Conductance (µmhos)	1,932	714
Radium-226 (iPi/L)	53	0.7
Uranium (mg/L)	0.092	0.0064

See LRA at Table 2.9-5 (Exh. CBR-011) and Ferret of Nebraska, *Application and Supporting Environmental Report for State of Nebraska Underground Injection Control Program Commercial Permit*, dated November 1987 at Table 4.4-13, "Aquifer Water Quality Summary" (pg. 4.4(62)) (Exh. CBR-014). Hydraulic connection of the Basal Chadron Sandstone to the Brule Formation would result in higher chloride, sodium and sulfate levels that are characteristic of Basal Chadron Sandstone water quality.

3. Aquifer Pump Test

Q42. What are aquifer pump tests?

A42. (WB, MS, RL, BS) Aquifer pump tests are used to estimate hydraulic properties of an aquifer system. An aquifer pumping test evaluates aquifer properties by stimulating (or stressing) the aquifer (*e.g.*, via pumping) and observing the aquifer's response by measuring water levels in observation wells.

Q43. Has Crow Butte performed aquifer pump tests at the Crow Butte site?

A43. (WB, MS, RL, BS) Yes. Crow Butte performed four groundwater pumping tests within the license area boundary between 1982 and 2002 in order to evaluate hydraulic characteristics of the Basal Chadron Sandstone, assess the integrity of

the confining layer above the mining zone, and comply with requirements outlined in the Underground Injection Control ("UIC") permit issued by Nebraska.[2] The pump tests were conducted at four different locations that spanned the northwest to southeast portions of the license area.

Q44. What do the pump tests show?

A44. (WB, MS, RL, BS) All four pumping tests are summarized in the LRA (pages 2-201 to 2-214) (Exh. CBR-011). Results of the pump tests indicate that the Basal Chadron Sandstone has similar hydraulic properties within the license area. Results also demonstrate the integrity of the confining layer above the mining zone throughout the license area. Due to the competency and substantial thickness of the confining layer and the strongly downward vertical hydraulic gradient in the permit area, mining development at the site is very unlikely to significantly impact the shallow aquifer. Analysis of pump test results also indicates the absence of boundary conditions (*i.e.*, breaks in slope in the time-drawdown data) that would indicate faulting or fracturing within the license area that could affect the confinement of the Basal Chadron Sandstone or the in-situ mining of uranium. LRA at 2-136. The pump tests also demonstrate proper plugging and abandonment of all exploration, development, and pilot test holes drilled on the site that could act as a secondary conduit between aquifers.

Q45. Can you describe the results of the most recent pump test?

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[2] The NDEQ approves injections wells, which must be operated and managed in accordance with applicable Nebraska regulations. NDEQ issues and approves UIC permits, conducts inspections, and performs compliance reviews for injection wells to ensure that injection activities comply with State and Federal regulations and to ensure that groundwater is protected from potential contamination sources. NDEQ has authority over Class I, III, and V wells in Nebraska.

A45. (WB, MS, RL, BS) Yes. The results from the most recent aquifer pumping test demonstrate the integrity of the confining layer above the mining zone and indicate that the Basal Chadron Sandstone is relatively homogeneous and isotropic within the southern portion of the permit area. *See* Petrotek Engineering Corporation, *Ground-Water Pumping Test #4 Data Evaluation Report*, dated October 10, 2002 (Exh. CBR-012). The report also notes that no significant response during either the pumping or recovery period was observed in the observation well completed in the overlying Brule Formation, which indicates a lack of hydraulic connection (*i.e.*, no breach in confinement).

4. Operating Experience

Q46. Do you have any operating experience that undermines the conclusions based on the borehole log data, water level data, water quality data, or aquifer pump tests?

A46. (WB, MS, RL, BS) No. Based on more than 20 years of operation at the site, including mining and environmental monitoring, we have not identified any information that would undermine the conclusion that the Basal Chadron Sandstone is confined within the license area. If there were any significant changes in hydrogeological conditions (*e.g.*, newly formed fractures or faults), Crow Butte would detect the change in well-field operations, water levels, and environmental monitoring data. No such conditions have been observed during operations.

C. Potential Contamination Pathways

1. Fluid Movement Through Faults and Fractures

Q47. Do you have any comments regarding the intevenors' allegation of the potential for contamination of the White River or Pine Ridge drinking water supplies through faults and fractures?

A47. (WB, MS, RL, BS) Yes. Crow Butte relies on detailed, site-specific investigation to show that no faults or fractures exist at the site that could provide a pathway for contamination of the White River or drinking water at Pine Ridge. The aquifer pump tests conducted in the Area of Review indicate that there is no faulting or fracturing that affects the confinement of the Basal Chadron Sandstone or that would affect in-situ mining (*see* LRA Section 2.7). Indeed, the thickness of the upper confining layer ranges from approximately 100 feet along the northeast boundary of the Area of Review to over 500 feet. In the immediate vicinity of the wellfield area, the thickness of the upper confining layer ranges from 200 feet on the north to 500 feet on the south. Moreover, water quality samples are regularly collected from private wells located between Crow Butte and the White River with no evidence of contamination to date.

Q48. Is it possible for there to be small faults or fractures in the formation overlying the mine site?

A48. (WB, MS, RL, BS) Dr. LaGarry, in his opinion filed earlier in this proceeding, states that the Brule is generally impermeable except where fractured. Crow Butte recognizes the potential for small faults and fractures to occur in the sediments overlying the mined aquifer (*i.e.*, the Brule formation). Additionally, there may be limited areas of secondary permeability within isolated areas of the

Brule Formation. However, these features typically only develop in materials having a significant silt and sand percentage (*e.g.*, siltstones and sandstones), not the claystones that are common in the upper and lower confining units, which have very low permeability and higher plasticity. And, based on the available data, including thousands of boreholes at the site, any fractures or faults that may be present do not significantly offset confining units. This has been confirmed by the four pump tests, which as noted above demonstrate confinement. Crow Butte has therefore affirmatively demonstrated the absence of fractures affecting confinement in the Brule formation. Moreover, the sediments overlying the mined aquifer have not undergone complete lithification (the process by which sediments are converted into rock), as observed in cores and drill cuttings during drilling investigations. Some sediments also tend to swell rapidly (*i.e.*, higher plasticity) when exposed to water, as evidenced by bridging of borings due to swelling clays. Therefore, any minor faults or fractures that did appear would close up quickly (*i.e.*, be essentially self-sealing) as a result of lithostatic pressure (*i.e.*, overburden pressure) from the weight of overlying materials.

Q49. Do you have comments regarding the inference drawn by Dr. LaGarry in his opinions submitted in this proceeding related to the observation that Chadron Creek went dry in 2007?

A49. (WB, MS, RL) The inference for decreased surface water flow in the distal Chadron Creek as a result of a preferential flow pathway into underlying aquifers through secondary porosity (fracture porosity) features is extrapolated to assert that similar flow pathways may be present between the Basal Chadron Sandstone

and overlying aquifers and the White River. *See* LaGarry 2015 Opinion at 3 (Exh. INT-013). While this is a plausible *hypothetical* scenario, the studies cited by Dr. LaGarry — Balmat, et al. 2008; Bhattacharyya, et al. 2012 (Exhs. CBR-023 and CBR-022) — are conference abstracts that are not supported by publically-available data. Furthermore, on the face of the abstracts, the authors acknowledge that additional research is needed to elucidate the interaction between groundwater, joints, and faults, as well as the potential influence of evapotranspiration and alluvial infiltration within Chadron Creek. Spring discharge rates to Chadron Creek are purported to have remained constant through this time period, but no supporting historical or current data is provided to eliminate the possibility of reduced inflow to the creek as a contributor to overall decreased flow rate. While groundwater flow along faults and joints is a possibility, the research and observations cited in the opinion provide only circumstantial observations with unresolved causes. In contrast, site-specific data from investigations at the Crow Butte site provide multiple lines of evidence and therefore strong support for the interpretation of the lack of hydrologic connectivity between the Basal Chadron Sandstone and overlying aquifers.

Q50. What about the potential for contamination to move through larger, regional features, such as the White River Structural Feature?

A50. (WB, MS, RL, BS) Crow Butte has thoroughly investigated the potential for the White River Structural Feature to be a contaminant pathway. Drilling activities northwest of the Crow Butte site identified a compressional structural feature referred to as the White River Fault/Fold, located between the current facility and

the proposed North Trend Expansion Area ("NTEA") boundary. The White River structure generally follows the drainage of the White River north of Crawford. The White River structure is located approximately one and one half miles northwest of the northern extent of the wellfield area. Evidence of the structure was identified during the exploration drilling phase of the Crow Butte Project in 1984. The feature, which at depth offsets the Pierre Formation, is manifested at shallower depths as a northeast trending, subsurface fold (specifically, a monocline) within the formations of interest near the license areas. The White River structure is not acting as a discharge location for groundwater in the Basal Chadron Sandstone, as evidenced by contoured groundwater levels, which indicate a consistent flow direction across the structure. *See* ARCADIS, *Petition for Aquifer Exemption – North Trend Expansion Area* at Figure 22 (Exh. CBR-013). The increased gradient in the vicinity of the structure is very likely the result of reduced transmissivity due to structural thinning of the Basal Chadron Sandstone along the fold limb. We conclude that the feature does not convey water from the Basal Chadron Formation to the Brule Formation.

More importantly, before any contamination from Crow Butte could even reach the White River feature, it would have to migrate a distance of 1.5 miles without detection by the existing environmental monitoring program. As discussed below, this is highly unlikely.

Q51. How did Crow Butte conclude that the White River Structural Feature will not convey water from the Basal Chadron to the Brule?

A51. (WB, MS, RL, BS) Drilling data suggest that, while a fault may cut the Pierre Formation at depth along with units below the Pierre Formation, there is no evidence that a fault propagates near surface, offsetting the geologic contact with the Pierre Formation and overlying White River Group or individual members of the White River Group (*i.e.*, Brule and Chadron formations). LRA at 2-135 (Exh. CBR-011). The White River structure was evaluated using three-dimensional (3D) geologic modeling software utilizing geologic picks from hundreds of geophysical logs. The 3D modeling indicates that all of the stratigraphic units within the mine area are well-correlated northward across the structure with no apparent offsets or truncated units on the north limb of the fold structure. Results of the geologic modeling provide strong evidence for a revised interpretation of the White River structure as a fold, in lieu of the historic inference of a fault. There are 300-500 vertical feet of structural relief existing across the fold structure, depending on the location. Given all of this information, the observed thinning of individual members of the Chadron Formation is likely related to either a localized reduction in sediment accumulation along the north limb of the fold structure as part of the developing basin (folding at the same time as deposition), localized thinning within the fold limb as a result of flexural bending (post-depositional folding) associated with fault-propagation folding above a blind reverse fault, or highly distributed normal faulting with no apparent fault offsets. *See* Figure F.4-1a from North Trend Expansion Area Class III UIC Permit Application (Exh. CBR-025); see also Figure 2.6-4 showing White River Feature (Exh. CBR-026). Again, there is no evidence that a fault offsets the

geologic contact with the Pierre Formation and overlying White River Group, nor individual members of the White River Group (*i.e.*, Brule and Chadron formations). *See also* Crawford Basis Regional Cross-Sections (Exh. CBR-024). Based on multiple lines of site-specific evidence provided in the *Petition for Aquifer Exemption – North Trend Expansion Area* (August 2008) at Section 4.4 (Exh. CBR-013), we conclude that there is no evidence for a local permeability pathway within the fold structure that permits hydraulic communication between the Basal Chadron Formation and overlying aquifers.

Q52. Does groundwater flow direction data also support this conclusion?

A52. (WB, MS, RL) Yes. An additional line of evidence supporting the low likelihood of groundwater impacts reaching the White River Structure pertains to the observed hydraulic gradients in the Basal Chadron Sandstone within the license area. Historic water level measurements from 1982-1983 and from 2008-2009 for wells within the license area, indicate groundwater flow in the northernmost portion of the area is directed toward the southeast, away from the White River Structure. Groundwater flow across the central and southern portion of the license area is directed to the northeast, parallel with the White River Structure. Therefore, based on hydraulic gradients observed during the period of record, groundwater within the mining zone exiting the license area would not encounter the White River Structure under natural flow conditions in the near vicinity of the license area.

Q53. Does water level data also support this conclusion?

A53. (WB, MS, RL) Yes. As an additional data point, we note that groundwater levels in the Chadron Formation wells at the North Trend site also are different than water levels in wells in the Brule formation. If there were a conduit or hydraulic connection, similar hydraulic head levels would be observed in all wells. The fact that there is a significant difference in head supports the conclusion that the White River Structural Feature does not convey water between the Chadron Formation and the Brule Formation.

Q54. Did the NRC Staff agree with your assessment of the feature as a fold in the formations of interest near the license areas?

A54. (WB, MS, RL, BS) Yes. The NRC Staff concurred with Crow Butte's interpretation, as discussed in SER Section 2.4.3.3 (Exh. NRC-009). To further assess whether or not the structural feature is a fault or a monocline fold, NRC Staff also performed a probabilistic statistics analysis of two sets of five numerical ground water flow models. This analysis is discussed in SER Section 2.4.3.2 (Exh. NRC-009). Based on this analysis, the NRC Staff concluded that the presence of a fault that penetrates the Pierre Shale through the Chadron and Brule formations is not probable, and if one exists, it does not convey water from the Basal Chadron Formation to the Brule Formation. The NRC Staff therefore concluded that no hydraulic connection likely exists to transfer process water between the Basal Chadron Sandstone (the ore zone) and overlying aquifers.

Q55. Do you have any comments regarding the evidence of regional fault structures cited by Dr. LaGarry in his 2008 and 2015 opinions?

A55. (WB, MS, RL, BS) Dr. LaGarry posited the existence of regional fault structures based on the work by researchers, such as Diffendal (1994). However, this research was based primarily on remote sensing techniques. While this technique may be an indicator of offset features and lineaments, it does not provide information about hydraulic aperture or the existence of permeability pathways along faults. Faults are often sealed and do not necessarily represent potential groundwater migration pathways. In addition, the focused deposition of younger geologic units above inferred fault features that occur at depth as a result of preferential erosion of bedrock due to fracturing, also does not indicate a permeability pathway within overlying geologic units. In contrast, site-specific data from investigations at the mine site provide multiple lines of evidence and therefore strong support for the interpretation of the lack of hydrologic connectivity between the Basal Chadron Sandstone and overlying aquifers.

2. Secondary Porosity from Earthquakes

Q56. The intervenors have expressed concern that secondary porosity caused by earthquakes could create potential contaminant pathways from the mined aquifer to the White River or nearby drinking water supplies. Can you first provide an overview of the seismology near the Crow Butte site?

A56. (WB, MS, RL, BS) The Crow Butte permit area in northwest Nebraska is within the Stable Interior of the United States. The project area, along with most of Nebraska, is in seismic risk Zone 1 on the National Seismic Hazard Maps. Most of the central United States is within seismic risk Zone 1 and only minor damage is expected from earthquakes that occur within this area. *See* Marsland Environmental Report at Section 3.3.1.4 (Exh. CBR-021). In general seismic

hazard maps estimate that the LRA and City of Crawford area are at the low end of the USGS's hazard ranking system for earthquake risks. For example, the modeled peak acceleration due to seismic shaking in the City of Crawford area is very low: 6-8%g for the majority of the immediate area and 8-10%g in a much smaller area, meaning that the maximum shaking due to any given earthquake in the region during a 50-year period would be equivalent to only 10 percent or less of the force of gravity at Earth's surface.

Q57. Have earthquakes occurred in the region?

A57. (WB, MS, RL, BS) Yes. Although the License Area is within an area of low seismic risk, occasional earthquakes have been reported and were documented in the LRA and in subsequent documents. *See, e.g.*, Marsland Environmental Report at Section 3.3.1.4 (Exh. CBR-021). We also note that references made to Modified Mercalli intensities of earthquakes in the region in the LRA (*see* LRA Table 2.6-3) may not be representative of earthquake intensity at the license area because intensities are typically reported for sites near the earthquake epicenter. Therefore, reported intensities, which range from II (weak) to VII (very strong) must be considered *maximum* intensities, which generally decrease with distance. In any event, the LRA notes that all but two of these earthquakes range from not felt (Intensity I) to light (Intensity IV).

Q58. What information does Crow Butte have to demonstrate the absence of secondary porosity at the license area?

A58. (WB, MS, RL, BS) As noted above (¶35-¶46), Crow Butte confirmed confinement prior to the start of operations. To date, CBR has performed four

pumping tests with overlapping radii of influence that spanned the length of the license area, all of which confirmed adequate isolation between the Brule Formation and the Basal Chadron Sandstone (*i.e.*, no fractures exist that could transmit a significant amount of water between the two aquifers). Similar conclusions were reached pertaining to adequate confinement between these two aquifer zones as a result of multiple aquifer tests at other CBR expansion areas around Crawford, suggesting regional competency of the upper confining units. In addition, significant historical differences exist in geochemical groundwater characteristics between the confined Basal Chadron Sandstone and the Brule Formation, further suggesting that inferred preferential flow pathways associated with secondary porosity features are not present. Importantly, regardless of how the formations may have been or may be affected by seismic events, Crow Butte must maintain hydraulic control over the site in accordance with its UIC permits.

Q59. Has Crow Butte observed faults or fractures during the development of the mine site?

A59. (WB, MS, RL, BS) No. Close spaced drill data throughout the license area indicate that no significant faulting is present in the wellfield area.

Q60. Have there been any operational impacts from earthquakes in the past?

A60. (WB, BS, LT) Crow Butte has not observed operational impacts from prior earthquakes within the region. For example, Crow Butte did not observe any effects at the site from the two earthquakes in 2011 that were noted by the intervenors.

Q61. The Licensing Board pointed out that the LRA and the EA focused on seismology in Nebraska and did not expressly consider seismology in other nearby States. Does consideration of regional seismology (beyond Nebraska) change any of your conclusions?

A61. (WB, MS, RL, BS) No. Subsequent CBR documents have expanded upon the LRA seismology discussion — *see, e.g.*, Marsland ER, Section 3.3.1.4 (Exh. CBR-021) — to evaluate earthquakes across a wider geographic range, recent earthquakes, and updated USGS seismic hazard data. Inclusion of additional data has not changed overall interpretations of seismicity or seismic risks within the general Crow Butte mining area. Although the region is tectonically active (as evidenced by the continued Black Hills Uplift), there is no evidence of significant regional seismic activity that could generate a new fault, fracture, or contaminant pathway *at the license area*. In the unlikely event that such a fault or fracture capable of generating a contaminant pathway were to occur in a location that affected confinement of the mined aquifer, it would be likely to have an observable impact on wellfield operations and would trigger corrective or remedial actions. As noted above, Crow Butte must maintain hydraulic control over the site in accordance with its UIC permits.

D. <u>Use of Recent Research</u>

Q62. CI's Technical Contention F asserts that Crow Butte failed to use recent research. Do you have any comments regarding that claim?

A62. (WB, MS, RL, BS) Yes. First, there is no requirement that an applicant consider the research or opinions of any particular expert in preparing its application. Instead, it is the applicant's obligation to describe the site geology and

hydrogeology at a sufficient level of detail to enable an assessment of the applicant's ability to control mining fluids. Crow Butte has done that as part of its initial application, as well as for its first license renewal in 1998. Second, the 2008 LaGarry "opinion" was, at its core, nothing more than an overview of the regional geology. A generalized overview of the regional geology is no substitute for the detailed, site-specific geological and hydrogeoglogical studies performed at the mine site. As detailed above, those studies conclusively demonstrate that the Basal Chadron Sandstone, which is the mined aquifer, is hydraulically isolated from other aquifers by continuous confining layers of very low permeability in the license area.

Q63. That said, can you please discuss the stratigraphic issues raised by LaGarry?

A63. (WB, MS, RL, BS) Yes. The history of stratigraphic nomenclature for the White River Group of Nebraska and South Dakota has had various interpretations. For example, the stratigraphic nomenclature of the White River Group has been revised by Terry and LaGarry (1998), Terry (1998), LaGarry (1998), and Hoganson et al. (1998). Crow Butte, as well as NDEQ and others, recognize these recent interpretations of the stratigraphic nomenclature for the White River Group. However, to be consistent with historical permitting and to prevent confusion as to where mining is occurring (for both the public and regulators), Crow Butte is continuing to use the term "Basal Chadron Sandstone" to describe the mined formation.

Q64. Can you correlate the nomenclature among various sources?

A64. (WB, MS, RL, BS) A table provided with the Marsland Expansion Area application correlates the nomenclature for the various units. *See* MEA Technical Report, Table 2.6-2, *Representative Stratigraphic Section* (Exh. CBR-015).[3] The description of the regional geology in the Marsland Technical Report also correlates the nomenclature used by Crow Butte, NDEQ, and NRC to more recent interpretations. *See* MEA Technical Report, Section 2.6, *Geology and Seismology* (Exh. CBR-016). For example, the Brule Formation was originally subdivided by Swinehart, et al. (1985) and later revised by LaGarry (1998) into three members, from youngest to oldest: the "brown siltstone" member, the Whitney Member, and underlying Orella Member. Additionally, the Basal Chadron Sandstone is referred to as the Chamberlain Pass Formation in the revised nomenclature. The primary concern raised regarding the use of "Chamberlain Pass Formation" rather than "basal Chadron sandstone" in the LaGarry's 2008 opinion was that the thickness of the Basal Chadron Sandstone was assumed by previous researchers to have a distribution equal to that of the overlying Chadron Formation. This assumption has since been shown to be incorrect, as the distribution of the Basal Chadron Sandstone is determined by the paleotopography of the eroded surface of the underlying Pierre Shale where exposed prior to deposition of the Basal Chadron Sandstone. Crow Butte determined the thickness of the Basal Chadron Sandstone at the mine site based on lithologic and geophysical characteristics (see LRA Section 2.6.2.2). These determinations are independent of any assumptions regarding the thickness of the unit based on overlying units. Variations in

[3] Correlation with more recent nomenclature was also provided in the NTEA and Three Crow Expansion Area documents.

thickness of the Basal Chadron Sandstone due to paleotopographic and depositional variations are clearly depicted in isopach maps and cross-sections (LRA Figures 2.6-4 through 2.6-11). So again, the nomenclature used to describe the formations does not affect the conclusions regarding hydrogeologic conditions at Crow Butte, which are based on detailed, site-specific evaluations.

Q65. Did the NRC Staff agree with this approach?

A65. (WB, MS, RL, BS) Yes. The NRC Staff observed that recent studies of the regional geology have resulted in the proposal of a new nomenclature for some of the geologic units within the license area. SER at 15 (citing LaGarry, 2010) (Exh. NRC-009). The NRC Staff, for example, noted differences in characterization of the basal portion of the Chadron Formation and a Chamberlain Pass Formation, as well differences in terminology used by the USGS, Crow Butte, LaGarry, and NDEQ. Nevertheless, the NRC Staff acknowledged that Crow Butte was using consistent terminology relative to that used in the past. The NRC Staff also concluded that, stratigraphic nomenclature aside, nothing in the naming conventions for the geologic units in Nebraska or at the Crow Butte facility changes the interpretation of the physical or hydraulic features of the geologic units. As a result, the NRC Staff concluded that it was appropriate to continue to use the current naming conventions presented in the LRA. SER at 15 (Section 2.3.3.2, *Site Geology*). We concur with the NRC Staff's approach.

Q66. Does the research cited by the intervenors call into question the adequacy of the application or the site?

A66. (WB, MS, RL, BS) No. As noted above, the conclusions regarding the suitability of the Crow Butte site for in situ mining were based on site-specific data, tests, and conclusions. The recent research cited by the intervenors was not focused on the Crow Butte site, nor does it directly dispute any of the site-specific data or other information that underlies Crow Butte's application.

E. Leaks and Spills During Operations

Q67. How do leaks or spills typically occur at an *in situ* uranium recovery facility?

A67. (WB, LT) Spills generally can take two forms within an in situ recovery facility: subsurface releases such as an excursion, in which mining fluids threaten to migrate beyond the wellfield; or surface spills, such as pond leaks or piping ruptures, that result in a release of waste solutions. At Crow Butte, engineering and administrative controls are in place to prevent both subsurface and surface releases to the environment and also to mitigate the effects should a release occur.

1. Underground Leaks and Spills

Q68. Can you briefly summarize your groundwater monitoring program?

A68. (WB, RL, MS, LT) Crow Butte maintains an extensive water sampling program to identify any potential impacts to water resources in the area. The groundwater monitoring program is designed to establish baseline water quality prior to mining at each mine site; detect excursions of lixiviant either horizontally or vertically outside of the production zone; and determine when the production zone aquifer has been adequately restored following mining. The program includes sampling of monitoring wells and private wells within and surrounding the license area to establish pre-mining baseline water quality. Water quality sampling continues throughout the operational phase of mining for detection of excursions. Water

quality sampling will also be conducted during restoration, including stabilization monitoring at the end of restoration activities, to determine when baseline or otherwise acceptable water quality has been achieved. The monitoring requirements (parameters, monitoring well spacing, location of shallow monitoring wells) are established by the Class III permit issued by the State of Nebraska. This permit authorizes the underground injection and mineral production wells at Crow Butte. *See* Class III UIC Permit No. NE0122611 (Exh. CBR-017).

Q69. What has Crow Butte done to minimize the risk of subsurface leaks or spills?

A69. (WB, RL, MS, LT) Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring is to detect any mining solutions that may migrate away from the production area due to fluid pressure imbalance. The monitoring well ring is located well inside the permit area. This system has functioned satisfactorily over many years of operating experience with in-situ mining at Crow Butte and elsewhere. Crow Butte has undertaken other measures to prevent migration of fluids to overlying aquifers. First, Crow Butte has plugged all exploration and development holes to prevent co-mingling of Brule and Chadron aquifers and to isolate the mineralized zone. Successful plugging was confirmed by conducting four successful hydrologic tests prior to mining. Results indicated that no leakage or communication exists between the mineralized zone and overlying aquifers. In addition, prior to placing a well in service, a well mechanical integrity test ("MIT") is performed. Wells are re-tested every five

years. This requirement of the NDEQ UIC Program ensures that all wells are constructed properly and are capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer are also sampled on a regular basis for the presence of leach solution.

Q70. Can you provide more information about the wellfield monitoring program?

A70. (WB, RL, MS, LT) During operation, the primary purpose of the wellfield monitoring program is to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed include monitoring of production and injection rates and volumes, wellhead pressure, water levels, and water quality. According to Crow Butte's Class III UIC permit, production zone monitor wells shall be spaced no greater than 300 feet from a mine unit and no greater than 400 feet between the wells and located so as to detect excursions. NE Permit NE0122611 at 16 (Exh. CBR-017). Shallow monitor wells are completed in the first continuous and water-bearing sandstone unit overlying the production zone. The shallow monitor wells are equally distributed throughout the mine unit, with one well for every four acres included in the mine unit.

Q71. Do you monitor parameters other than water quality?

A71. (WB, RL, MS, LT) Yes. We also monitor production (extraction) and injection rates. Monitoring of production and injection rates and volumes enable an accurate assessment of water balance for the wellfields. A "bleed" system results in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5-1.5 percent is typically

maintained during production. Maintenance of the bleed causes an inflow of groundwater into the production area and prevents loss of leach solution. In addition, wellhead pressure is monitored at all injection wells. Pressure gauges are installed on the injection manifold and read once daily per the Class III UIC permit.

Q72. What parameters do you rely on to detect excursions in monitoring wells?

A72. (WB, RL, MS, LT) The parameters and constituents chosen for indicators of lixiviant migration and for which upper control limits ("UCLs") are set are chloride, conductivity, and total alkalinity. Upper control limits are set at 20 percent above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/L, the UCL may be determined by adding 5 standard deviations or 15 mg/L to the baseline average for the indicator. *See* NE Permit NE0122611 at 9 (Exh. CBR-017).

Q73. The intervenors argue that there is no scientific basis for excluding uranium from the monitor well testing. Do you agree?

A73. (WB, RL, MS, LT) No. To the contrary, Crow Butte has explained its choice of excursion parameters as follows:

> The parameters and constituents chosen for indicators of lixiviant migration and for which [upper control limits] are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a highly mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion, as

bicarbonate is the major constituent added to the lixiviant during mining.[4]

Q74. Why did Crow Butte not include uranium?

A74. (WB, RL, MS, LT) Uranium is not a good excursion indicator because, although it is mobilized during mining, it may be retarded by reducing conditions in the aquifer — that is, the rate of uranium transport in the aquifer could be slowed by adsorption and precipitation, which would render it a poor leading indicator of an excursion. *See* WorleyParsons, "Response to NDEQ Excursion Monitoring Issues," dated August 26, 2010, at 3 (noting that, under the conditions encountered at Crow Butte, the total distance uranium could be expected to travel would be 0.5 to 15% of the distance traveled by a conservative parameter such as chloride) (Exh. CBR-020). The amount that the uranium is slowed by adsorption and precipitation is less important than the fact that it is slowed by these processes, whereas the approved excursion indicators (chloride, alkalinity and TDS) are not. Observations of historical data associated with site operations have confirmed that uranium movement is much slower than movement of other indicator parameters. For this reason, uranium is not as effective a tool for providing a timely alert regarding a lixiviant excursion from an ISR facility as the other parameters used by Crow Butte.

Q75. Do you consider bi-weekly testing to be adequate?

A75. (WB, RL, MS, LT) Yes. The horizontal flow rates at the edges of the mining area are relatively slow. Based on our experience, as well as on groundwater modeling of the site, the movement of fluids at the edges of the operating wellfields

4 LRA at 5-123 (Exh. CBR-011).

typically ranges from 5-15 feet per month. *See* WorleyParsons Report at 3 (concluding that, based on a conservative maximum groundwater velocity, indicator parameters would move less than 14 feet beyond the monitor well ring once detected) (Exh. CBR-020). This means that there is more than ample time with biweekly testing to detect a potential excursion and take corrective action prior to there being any movement of mining fluids beyond the permit area. In fact, prior to detecting an "excursion," Crow Butte commonly sees an increase in indicator parameter concentration in monitor ring wells. This serves as early warning. Crow Butte is then able to take preemptive corrective actions to further reduce the rate of groundwater movement and reverse the flow direction back toward the wellfield. Moreover, as noted above, once a potential excursion is identified, the sampling frequency is increased to weekly.

Q76. Any other comments regarding the intervenors' concern?

A76. (WB, RL, MS, LT) Yes. It is important to understand that the indicator is selected specifically to provide early indications of potential excursions of mining fluid. There is no evidence that Crow Butte's choice of parameters is inadequate to detect any excursions. In fact, other ISR facilities also rely on parameters other than uranium.

Q77. How is an excursion identified?

A77. (WB, RL, MS, LT) During routine sampling, if two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20 percent, the well is resampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample is taken within 48

hours. If neither the second nor third sample results exceeded the UCLs, the first sample is considered in error. If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the NRC Project Manager is notified by telephone within 48 hours and notified in writing within 30 days. The Class III UIC permit also has re-sampling and notification (within 24 hours) requirements.

Q78. What actions does Crow Butte take if an excursion is verified?

A78. (WB, RL, MS, LT) If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given and depending on the particular circumstances):

- A preliminary investigation is completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over-recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells are pumped to enhance recovery of mining solutions.
- Injection into the well field area adjacent to the monitor well may be suspended.

Recovery operations continue as necessary, thus increasing the overall bleed rate and the recovery of wellfield solutions. In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to weekly. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive 1-week samples.

Q79. Have there been any excursions at Crow Butte?

A79. (WB, RL, MS, LT) There have been several confirmed horizontal “excursions” in the Basal Chadron Sandstone. However, these excursions were quickly detected

and recovered through overproduction in the immediate vicinity of the excursion. In no case did excursions threaten the water quality of an underground source of drinking water since the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. In all but one case, the reported vertical "excursions" were due to natural seasonal fluctuations in Brule groundwater quality and very stringent UCLs (typically the result of abnormal spring rains). The one exception involved a spill (not an excursion) that was corrected and remediated. Crow Butte has never had a vertical excursion of mining solution.

Q80. Do you have any comments regarding the intervenors claim that there is a risk that an undetected excursion could occur, leading to contamination of the White River?

A80. (WB, RL, MS, LT) An undetected excursion is highly unlikely. All wellfields are surrounded by the ring of production zone monitor wells located no further than 300 feet from the wellfield and screened in the orebearing Chadron aquifer. Shallow monitor wells are placed in the first overlying aquifer above each wellfield segment every four acres. Sampling of these wells is done on a biweekly basis. Past experience at in-situ leach mining facilities has shown that this monitoring system is effective in detecting leachate migration. The use of an injection well and production well pattern creates a "spot" in which local flow is toward production wells and therefore relatively little flow across the mined area or toward the monitoring well ring. As noted above, Crow Butte also maintains a production "bleed" to create an inward gradient within the mined aquifer. The

total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and overproduction of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote. Moreover, the current Nebraska permit for in-situ recovery (Permit Number NE0122611) requires corrective action for any lixiviant movement that may impact waters of the State, including groundwater. And, as noted above, bore holes must be properly plugged and wells are subject to MIT.

Q81. Beyond the monitoring well ring, is there water quality data from nearby wells to support the conclusion that there are no undetected excursions?

A81. (WB, RL, MS, LT) Yes. Crow Butte conducts quarterly radiological sampling of all private wells within 1 km of the mine unit. These wells were also sampled prior to the start of operations. These wells are screened for the most part in the Brule, though one well is screened in the Basal Chadron. The one well that is screened in the Basal Chadron is along the hydraulic gradient between the mine site and the White River. The data do not show any indications that mining fluid has migrated beyond the mine site.

Q82. The intervenors have asserted that the Chamberlain Pass Formation provides a potential pathway for water to be transported to the White River. Can you comment on this?

A82. (WB, RL, MS, LT) The Chamberlain Pass Formation is equivalent to the Basal Chadron Sandstone (mining unit) and the overlying "red clay horizon." *See* MEA Technical Report, Table 2.6-2, *Representative Stratigraphic Section* (Exh. CBR-015). As discussed above, Crow Butte has demonstrated that the Basal Chadron

Sandstone is confined such that there is no upward migration of mining fluid into the Brule aquifer. Crow Butte also maintains an inward gradient within the wellfield to minimize the potential for lateral excursions. The effectiveness of these measures has been confirmed by monitoring well data, as well as by samples of nearby private wells. More broadly, the issue of whether the Basal Chadron Sandstone discharges to the White River at some distant location from Crow Butte is beside the point.[5] The key is that Crow Butte has demonstrated its ability to control mining fluid such that contamination outside of the permit area does not occur.

As a final note on this point, Dr. LaGarry references research documenting uranium-contaminated artesian springs along the Sandoz Ranch-White clay Fault in Fall River and Shannon counties (Bhattacharyya, et al. 2008) (Exh. CBR-022) as evidence supporting hydrologic connectivity between the Chamberlain Pass Formation and the surface. However, this conference abstract only vaguely describes wells and springs that may be completed in or discharge from the Chamberlain Pass Formation. If wells are completed in this formation or springs discharge directly from this formation, the noted uranium concentrations are likely representative of the natural water quality of the aquifer (*i.e.*, regionally-elevated radiological levels) and would not have any bearing on the hydrologic function of nearby faults.[6] We are aware of no available evidence by which we

5 Based on the flow direction and evaluation of bedrock geology maps, it is likely that groundwater discharges somewhere in eastern Dawes County.

6 As noted in the LRA and other licensing documents, groundwater in the Basal Chadron Sandstone is of poor water quality because it is mineral-bearing with high levels of naturally-occurring radionuclides. *See, e.g.*, LRA at 7-14, 8-5 (Exh. CBR-011).

can definitively judge what aquifer this data represents. And, in any event, the vertical hydraulic gradient is downward at the main Crow Butte site.

2. Surface Leaks and Spills

Q83. Can you provide an overview of measures in place to prevent or mitigate surface leaks or spills?

A83. (WB, RL, MS, LT) The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids between the process plant and the wellfield. These are generally small releases due to engineering controls that detect pressure changes in the piping systems and alert the plant operators through system alarms. In general, piping from the plant to and within the wellfield is constructed of PVC, high-density polyethylene pipe with butt-welded joints or equivalent. All pipelines are pressure tested at operating pressures prior to operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines are protected from a major cause of potential failure: vehicles driving over the lines causing breaks. The only exposed pipes are at the process plant, the wellheads, at temporary transfer lines and in the control house in the wellfield. Trunkline flows and wellhead pressures are monitored each shift for process control. One section of underground piping that passes beneath Squaw Creek is double contained for additional protection. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of EHSMS Program Volume VIII, *Emergency Manual.*

Q84. Have these programs been effective?

A84. (WB, LT) Yes. Crow Butte's spill control programs have been very effective at limiting surface releases from mining operations. Crow Butte has never had a spill that was reportable under 10 C.F.R. Part 20. All spills are analyzed for root causes and contributing factors. Periodically, the Crow Butte Safety and Environmental Review Panel ("SERP") meets to analyze recent spill events and to determine whether engineering or administrative improvements are indicated to reduce the frequency and magnitude of spills.

Q85. The intervenors have asserted that the risk of accident involving Crow Butte's operations affecting surface waters is more than minimal. Can you comment?

A85. (WB, RL, MS, LT) Crow Butte has taken affirmative steps to protect surface water quality in the event of a wellfield accident. Crow Butte installs protective berms and dams around Squaw Creek and English Creek to minimize the potential for a spill of mining, process, or restoration solutions from impacting the creeks. These berms and dams are routinely maintained and inspected to ensure their integrity and protect the surface water in the permit area. Crow Butte also has installed instrumentation to detect wet berms, wet valve stations, and wet wellhouses. Moreover, the current Nebraska permit for in-situ recovery — Permit Number NE0122611 (Exh. CBR-017) — requires corrective action for any lixiviant movement that may impact waters of the State, including surface waters.

Q86. Do you have data on water quality in Squaw and English Creeks?

A86. (WB, LT) Yes, Crow Butte performed preoperational water quality sampling and conducts quarterly sampling of Squaw and English Creeks both upstream

(background) and downstream of the mine site. This data does not indicate impacts from Crow Butte's operations on water quality in either water body. Crow Butte also takes quarterly water quality samples of impoundments located within the permit boundary, as well as annual sediment samples. These data also do not indicate impacts from Crow Butte's operations. All of these data are provided in our semi-annual effluent monitoring reports that are submitted to the NRC. *See, e.g.*, Section 3.3 and Appendix H of 2013 *Semiannual Radiological Effluent and Environmental Monitoring Report for the Crow Butte Uranium Project* (ADAMS Accession No. ML14071A019) (Exh. CBR-018).

Q87. Does Crow Butte conduct water quality sampling in the White River?

A87. (WB, LT) No. NDEQ, however, does conduct sampling of the White River. To our knowledge, the data do not indicate that there have been any impacts associated with Crow Butte's operations.

Q88. Is there any need for Crow Butte to conduct monitoring in the White River alluvium, as claimed by intervenors?

A88. (WB, RL, MS, LT) No. As noted above, Crow Butte maintains a comprehensive environmental monitoring program that includes surface water and groundwater sampling, and sediment sampling, at the mine site and at background locations in the surrounding area. Crow Butte also conducts its operations in a manner to minimize the potential movement of mining fluid outside the mining area and takes corrective actions as necessary. There are no data to suggest a need for additional sampling beyond that already being conducted.

Q89. Has Crow Butte taken other measures to minimize the risk of a leak or spill that could affect surface waters?

A89. (WB, RL, MS, LT) Yes. Process buildings are constructed with secondary containment, and a regular program of inspections and preventive maintenance is in place. LRA at 7-11 (Exh. CBR-011). Crow Butte also implements measures to protect against contamination of the surficial aquifer, which is referred to in the LRA (at 2-28) as "Brule Alluvium" and in the intervenors' petition to intervene as "White River alluvium." These measures include use of high density polyethylene with butt welded joints and leak testing before entering new lines into service. LRA at 7-15 to 7-16. There is also ongoing monitoring of wellfield conditions that can be used to detect upset or accident conditions, and trigger appropriate responses, prior to any contamination of surface water or groundwater.

Q90. What is your overall assessment of the potential risks to surface waters from Crow Butte's operations?

A90. (WB, RL, MS, LT) Crow Butte has taken comprehensive steps to prevent significant impacts to surface water features at the Crow Butte site. In light of the protection measures in place, ongoing monitoring, and requirement to take corrective actions, the risk of contamination of nearby surface water features is minimal.

Q91. Has the State of Nebraska weighed in on the issues raised by the intervenors in these contentions?

A91. (WB, LT, MS, RL, BS) Yes. In addressing Crow Butte's petition for an aquifer exemption at the North Trend Expansion Area, NDEQ addressed the concerns raised by the intervenors in Contentions A, C, D, and F. NDEQ Aquifer Exemption Order, dated April 7, 2001 (Exh. CBR-019). Specifically, Attachment C contains NDEQ's responses to comments from members of the public on the exemption petition that closely track the language of the admitted contentions in this proceeding. For example, NDEQ addresses the potential for contamination of aquifers via faults, fractures, or the White River Structural Feature (Questions 1, 8, and 48), the effect of nomenclature changes (Questions 2, 11, 12, and 50), confinement of the mining unit (Questions 3, 6, 7, 15, 35, and 39), potential for contamination of the White River or other surface waters (Questions 5, 9, 14, 26, and 31), and spill contingency plans (Questions 13 and 31). NDEQ found the concerns to be without merit or otherwise addressed by information provided by Crow Butte.

F. Other Intervenor Concerns

1. Environmental Justice

Q92. A portion of Contention D alleges that potential contamination outside the immediate vicinity of the site could have environmental justice impacts. Can you comment please?

A92. (WB, RL, MS, LT) First, there is no evidence that Crow Butte's operations have had any effect on water quality outside of the permit area. All of the detailed, site-specific evidence, including borehole logs, water level data, water quality data, pumping tests, as well as the measures in place to control and monitor mining operations, such as maintaining an inward hydraulic gradient and

performing comprehensive monitoring program, supports confinement of mining fluids within the mined aquifer. In addition, the vertical hydraulic gradient is strongly downward within the permit area. It is therefore highly unlikely that mining operations will impact groundwater or surface water outside the permit area.

In the absence of any "off-site" impacts that could contaminate the White River or drinking water supplies at Pine Ridge, there would be no environmental justice impacts from Crow Butte's operations. Moreover, if any off-site impacts were detected that could threaten to contaminate water supplies, Crow Butte would be obligated to take remedial measures and therefore there would be no environmental justice impacts.

Q93. Based on this assessment, was it appropriate for the NRC's environmental justice review to focus on the immediate vicinity of the site?

A93. (WB, LT) Yes. The NRC's environmental justice review was appropriately focused on area immediately surrounding the site. *See* EA at 89-92 (Exh. NRC-010). Given the distance to the Pine Ridge Reservation (approximately 30 miles "as the crow flies") and the absence of any indications of potential impacts from Crow Butte's operations at the Pine Ridge Reservation, there was no reason for the NRC Staff to include the Pine Ridge Reservation in its environmental justice analysis.

2. Baseline Water Quality

Q94. Can you please explain how Crow Butte establishes baseline groundwater quality?

A94. (WB, RL, MS, LT) Crow Butte followed the requirements of its Class III UIC permit for calculating baseline groundwater quality. As explained in the LRA (at 6-5), before mining in each mine unit, the baseline groundwater quality is determined. The data are established in each mine unit by assigning and evaluating groundwater quality in "baseline restoration wells." A minimum of one baseline restoration well for each four acres is sampled to establish the mine unit baseline water quality. A minimum of three samples is collected from each well. The samples are collected at least 14 days apart. The samples are analyzed for the parameters listed in Table 6.1-1 and on page 5-251. The baseline water quality indicators include physical indicators (*e.g.*, pH, conductivity), common constituents (*e.g.*, sulfate, chloride), trace and minor elements (*e.g.*, arsenic, lead, iron), and radionuclides.

Q95. How does Crow Butte ensure that it is getting a representative sample of groundwater in a baseline restoration well?

A95. (WB, RL, MS, LT) As discussed in Section 3.1.2.3 of the LRA, the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer following well construction (and before baseline water quality samples are taken). All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing and borehole walls along the screened interval. During the final stages of initial development, water samples will be collected in a transparent or translucent

container and visually examined for turbidity (*i.e.*, cloudiness and visual suspended solids). Development is continued until clear, sediment-free formation water is produced. When the water begins to become clear, the development will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will be continued. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete. Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. Monitoring for pH and conductivity is performed during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling begins.

Q96. The intervenors have argued that Crow Butte is using outdated guidance documents to calculate baseline groundwater quality. Can you comment?

A96. (WB, RL, MS, LT) As noted above, Crow Butte followed the requirements of its UIC permit in establishing baseline data. Moreover, no additional wellfields are slated for development within the permit area. The well fields and monitoring well ring are fully "built out" and all baseline data have already been collected. Because there is no additional baseline groundwater data collection and because it is not possible to re-sample for baseline once mining has started, this issue is moot. In addition, the monitoring frequency and methodology used to establish existing baseline values for mine units at Crow Butte cannot be used to "revise"

baseline values using more recent statistical methods due to the differences in sampling methodology and frequency.

Q97. Does the renewed NRC license include requirements related to establishment of background water quality?

A97. (WB, RL, MS, LT) Yes. The renewed license includes specific license conditions relating establishment of background water quality should there be additional wellfield development. Specifically, LC 11.3 requires Crow Butte, prior to injection of lixiviant for each mine unit, to establish background ground water quality data for the ore zone and overlying aquifers. The background water quality will be used to define the background ground water protection standards required to be met in 10 C.F.R. Part 40, Appendix A, Criterion 5B(5), for the ore zone aquifer and surrounding aquifers. Water quality sampling shall provide representative background ground water quality data and restoration criteria as described in Sections 5.8.8 and 6.1.3 of the LRA. The data shall consist, at a minimum, of the following sampling and analyses: (1) four samples collected from production and injection wells at a minimum density of one production or injection well per four acres at least 14 days apart; (2) four samples collected from each designated monitoring well at a minimum density of one upper aquifer monitoring well per five acres of mine unit area and all perimeter monitoring wells;[7] (3) sample analysis for ammonia, arsenic, barium, cadmium, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, pH, potassium, radium-226, selenium, sodium,

[7] These samples must collected at least 14 days apart. The results of these analyses shall constitute the baseline for each designated well.

sulfate, total carbonate, total dissolved solids, uranium, vanadium, and zinc; and (4) prior to operation of a mine unit, representative background concentrations shall be established on a parameter-by-parameter basis using either the mine unit or well-specific mean value. Crow Butte also must submit all mine unit hydrologic test packages to the NRC for review.

CONCLUSIONS

Q98. What are your overall conclusions regarding the concerns by the intervenors in Contention A?

A98. (All) All of the data and evidence available to Crow Butte indicate that the non-radiological (as well as the radiological) impacts of Crow Butte's operations are small. Crow Butte has established through multiple lines of evidence — borehole logs, laboratory tests, water quality, water levels, aquifer pump tests, operational experience — that the Basal Chadron aquifer, where mining occurs, is isolated from overlying aquifers. In addition, Crow Butte conducts its operations to maintain hydraulic control over mining fluids and maintains an extensive environmental monitoring network to confirm control over mining fluids. In short, mining fluid from Crow Butte's operations will not migrate beyond the license area or contaminate the aquifers that supply drinking water to the Pine Ridge Reservation. In addition, Crow Butte has established that other parameters provide better indications of potential excursions and also that biweekly monitoring is adequate to detect potential excursions. Most importantly, Crow Butte's operations have not contaminated the drinking water at the Pine Ridge Reservation, nor has it contaminated any drinking water between the site and the

Pine Ridge Reservation. For these reasons, Contention A should be resolved in Crow Butte's favor.

Q99. What are your overall conclusions regarding the concerns by the intervenors in Contention C?

A99. (All) Crow Butte has taken active steps to minimize the potential for either surface or subsurface leaks or spills to cause environmental harm to the White River, including use of berms or dikes to protect these waterbodies. Regular monitoring of Squaw and English Creeks shows that Crow Butte's operations are not adversely impacting surface waters in the mine area. If leaks and spills were to occur, Crow Butte is required to take immediate corrective actions, including restoration of the environment. Moreover, Crow Butte maintains an extensive environmental monitoring network that would detect any migration of mining fluids beyond the license area, including testing of water quality in private wells outside the mining area. At bottom, there are no data to indicate impacts to the White River from Crow Butte's operations. For these reasons, Contention C should be resolved in Crow Butte's favor.

Q100. What are your overall conclusions regarding the concerns by the intervenors in Contention D?

A100. (All) Crow Butte has established through multiple lines of evidence — borehole logs, laboratory tests of cores, water quality, water levels, aquifer pump tests, operational experience — that the Basal Chadron aquifer, where mining occurs, is hydraulically isolated from overlying aquifers. In addition, Crow Butte conducts its operations to maintain hydraulic control over mining fluids and maintains an

extensive environmental monitoring network to confirm control over mining fluids. All of the testing and operational experience to date confirms the absence of faults or fractures that could transmit mining fluid into aquifers that provide drinking water to the Pine Ridge Reservation. Crow Butte's analysis of the White River Structural Feature, as supported by NRC Staff numerical modeling, indicates that it is a structural fold in the formations of interest and does not create a hydraulic connection between the Basal Chadron Sandstone and the Brule Formation. Because of the absence of any impacts beyond the mining area, much less impacts over 30 miles away at the Pine Ridge Reservation,[8] there was no need for the NRC Staff to include the Pine Ridge Reservation in the environmental justice analysis. For these reasons, Contention D should be resolved in Crow Butte's favor.

Q101. What are your overall conclusions regarding the concerns by the intervenors in Contention F?

A101. (All) While there have been recent studies of the regional geology that have resulted in the proposal of a new nomenclature for some of the geologic units within the license area, including proposals by Dr. LaGarry, these studies do not indicate that any portion of the application was inadequate. In discussing regional geology, Crow Butte, the NRC Staff, and NDEQ continue to use the nomenclature found in the prior license applications for consistency and to facilitate public review and comparison. Most importantly, stratigraphic nomenclature aside, nothing in the naming conventions for the geologic units in

[8] (MS) To the best of my knowledge, I am aware of no contaminant plume in history that has migrated that distance.

Nebraska or at the Crow Butte facility changes the interpretation of the physical or hydraulic features of the geologic units presented by Crow Butte. For these reasons, Contention F should be resolved in Crow Butte's favor.

Q102. What are your overall conclusions regarding the concerns by the intervenors in Contention 14?

A102. (All) Crow Butte considered the potential impacts of earthquakes at the site prior to beginning operations. Crow Butte also recognizes the potential for small faults and fractures to occur in the sediments overlying the mined aquifer. Additionally, there may be limited areas of secondary permeability within isolated areas of the Brule Formation. However, aquifer pump tests confirmed adequate upper confinement due to the thick sequence of overlying low permeability silt and clay and the absence of any faults or fractures that would permit a preferential permeability pathway for impacted groundwater to migrate into overlying aquifers. All of the testing and operational experience to date confirms the absence of faults or fractures that could transmit mining fluid into aquifers outside the mined area. If there were any significant changes in hydrogeological conditions (*e.g.*, newly formed fractures or faults), Crow Butte would detect the change in well-field operations and monitoring activities. No such conditions have been observed during operations. Further, based on the available data, including thousands of boreholes, any fractures or faults that did occur would be of very limited extent. This has been confirmed by the four pump tests, which as noted above demonstrate confinement. Moreover, the sediments overlying the mined aquifer are not consolidated rock and tend to swell rapidly when exposed

to water. Any minor faults or fractures that did appear would close up quickly (*i.e.*, be essentially self-sealing) due to lithostatic pressure. For these reasons, Contention 14 should be resolved in Crow Butte's favor.