UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CROW BUTTE RESOURCES, INC.	)	Docket No. 40-8943
	)	ASLBP No. 08-867-02-OLA-BD01
(License Renewal for the In Situ	)	
Leach Facility, Crawford, Nebraska)	)	April 29, 2015

EXPERT OPINION TESTIMONY OF MICKEL WIREMAN

I, Mickel Wireman, do hereby swear that the following written testimony is true to the best of my knowledge:

I. Basis for Testimony as Expert in Field.

I have been professionally engaged in hydrogeology and ground-water management issues for more than 35 years. I am recently retired from the US EPA where I served as a National Ground-Water Expert for US EPA Region VIII in Denver, **CO**. In this position I provided scientific and technical support to EPA programs, other Federal agencies, International programs and ground-water protection / management programs in several western states. I have extensive experience in hydrogeology and remediation of hardrock mine sites (fractured rock settings) hydrology of mountain watersheds, DNAPL sites, ground-water monitoring, and ground-water vulnerability assessments. My position involved working closely with policy makers, decision makers and attorneys. I have taught classes for the National Ground -Water Association and Geological Society of America and have developed and taught workshops in Eastern Europe and Middle East. I serve as a consultant to the World Bank and have significant international experience. I have served as an expert witness and in federal court, State court, State Water Quality Control Commission and State Water court.

II. Expert Opinions and Testimony Concerning Contention #_A,C,D,F,6,9,14_.

Opinion: Characterization of the local / regional hydrogeology and groundwater flow flow is inadequate at the Crow Butte ISL facility.

Basis: An appropriate characterization program aimed at determining to what extent the secondary permeability that exists in the rocks that comprise the upper confining unit (UCU) and the overlying aquifer, controls ground water flow in these formations has not been completed. CBR and NRC define the UCU as including the middle & upper members of the Chadron Fm and the lower member (Orella) of the Brule Fm. The overlying aquifer is comprised of the upper member of the Brule (brown siltstone) and the underlying Whitney member. Given the structural setting in which these formations and the uranium ore body occurs, there is a potential for unwanted fluid (lixiviant/ groundwater mixture) migration upward from the ore bearing Basal Chadron (Chamberlain Pass Fm) thru the UCU into the upper Brule aquifer.

The sequence of rocks that comprise the aquifer, the UCU and the ore body occur within the Crawford Basin a synclinal structure that trends E-W and plunges to the west. This basin is about 50 miles long and 25 miles wide at Crawford (CBR-LRA). The basin is bounded on the NW by the Toadstool Park fault, on the E-NE by the NW-SE trending Chadron Arch and Bordeaux fault, and on the south by the E-W trending Cochran Arch and the Pine Ridge fault. The Crawford basin occurs between the Black Hills to the NW and the Pine Ridge escarpment to the S. The Black Hills uplift was tectonically active from the Eocene to middle Miocene and resulted in extensive fracturing, faulting and folding of sedimentary rocks in NW Nebraska and SW South Dakota (LaGarry 2014). A number of NW-SE trending faults have been identified within and near the CBR license area, including the White River fault. Souder (2004) reports that fractures may increase Brule / Chadron permeability in some areas. The NRC Final Environmental Assessment

(2014) reports that structural features sub-parallel to the Cochran Arch have been recognized by CBR drill hole data. CBR reported in the 2007 LRA that there was approximately 200-400 feet of displacement on the White River fault and approximately 60 feet of displacement on the Toadstool Park fault (T33N R53W). These understandings clearly indicate a significant likelihood of extensive secondary porosity. It is clear from the 2007 LRA and the 2014 SER that the nature of the White River fault / fold that occurs about 2 miles north of the CBR facility (and between the current mining area and the proposed North Trend expansion) is very uncertain. The current CBR explanation that the feature is a fold in the post-Pierre Shale rocks is not rigorously supported by data. The modeling analysis completed by the NRC and described in the 2014 SER is a poor substitute for empirical data from drilling and has too much uncertainty.

Because there has been no rigorous, appropriate investigation of the hydraulic properties and groundwater flow in the UCU and the Brule aquifer, there are significant uncertainties that constrain the ability to assess unwanted fluid migration. These uncertainties are evident in the 2007 LRA, the 2014 SER and the 2014 EA.

<u>Regarding the Brule aquifer:</u>

- There is uncertainty regarding direction of groundwater flow – the LR (page 2-140) reports a N-NW flow direction; the LRA (page 2-153) reports an E-NE flow direction; the SER (p22) reports a NW flow direction; Souder (2004) reports a N-NE flow direction.
- Groundwater in the aquifer is hydraulically connected to the White River and likely to Squaw Creek and English Creek. It is important to identify the location of gaining and losing reaches of the White River and the temporal nature base flow and stream loss to the shallow aquifer.
- The four aquifer tests that were reported in the 2007 LRA were clearly focused on characterizing the hydraulic properties of the Basal Chadron

(Chamberlain Pass Fm.). In all four tests the pumping well was in the Basal Chadron ore body. Three of the tests included only one monitoring well in the Brule aquifer and the fourth test included two Brule aquifer monitoring wells. Results and data from these tests are not adequate for assessing the hydraulic properties and groundwater flow in the Brule aquifer. To better estimate hydraulic properties of the Brule aquifer, a series of time-drawdown / distance drawdown aquifer tests should be conducted in areas where well yield is known to be high and in areas that have been mapped as having significant fracturing / faulting.

- SER p 22 – CBR needs to better explain significant (4.5 m) water level rise in the Brule aquifer in the northern part of license area and increase in gradient from 0.012 to 0.043 that occurred between 1983 and 2008. NRCs explanation that this is an artifact of the number of measuring points in 2008 compared to 1983. This is not an acceptable explanation.

Regarding the UCU:

- Only two of the four aquifer tests performed between 1982 and 2002 included an UCU monitoring well. Given the size of the mined area and the spatial heterogeneity of the UCU lithologies, this is not adequate for characterizing hydraulic properties of the UCU rocks.
- Analysis of hydraulic properties for UCU were based on consolidation test on core samples –not time drawdown or distance drawdown data. These types of tests are not representative of field conditions and do not account for secondary permeability.

- CBRs analysis of the risk of fluid migration upward through the UCU was based on properties of the red clay that immediately overlies the BC. However there is no data that indicates if the red clay occurs over the entire extent of the mined ore body and CBR did not adequately assess the possibility for very anisotropic conditions due to secondary permeability

- On page 2-161 of the LRA it is reported that the UCU monitoring well for the aquifer test conducted in 1987 showed a response to barometric pressure during the test. This conclusion needs to be further supported. If this was truly a UCU monitoring well (constructed in the lower Brule / upper Chadron) the hydraulic pressure (potentiometric surface) should not be significantly affected by barometric changes as the groundwater in the UCU is somewhat isolated from surface pressures. Was this monitoring well really in the UCU?

- The LRA (p 2-162) acknowledges some minor leakage from UCU to BC during tests. This indicates that inter-formational flow can occur.

<u>Regarding the Basal Chadron (Chamberlain Pass Fm.):</u>

- CBR has focused their hydrologic investigations on determining the hydraulic properties of the ore bearing portions of the Basal Chadron sandstone. This is obviously necessary for successful mining. However not enough attention has been given to monitoring the magnitude and extent of the lowered potentiometric surface that results from consumptive use of the production bleed water. The pre-mining potentiometric surface is at or above the land surface over most of the area. CBR estimates that the potentiometric surface has been lowered by about 60 feet beneath the mine units. CBR (Page 3-20 LRA) also concludes that the BC potentiometric surface near the City of Crawford could decline by 20 ft due to

consumptive use of BC water. The NRC EA (page 75) indicates a 30-50 ft decline at Crawford. There should be a BC monitoring well located near Chadron to monitor the decline as a lowering of the potentiometric surface will affect well yields. This data should be reported in the EA. There is no discussion of recharge and discharge to the BC. The recharge area for this aquifer should be described and or/ mapped. Pre-mining discharge conditions and locations should also be identified.

Additional hydrogeologic mapping and hydraulic testing needs to be completed to help determine the magnitude and orientation of secondary permeability resulting from the structural deformation of the rocks comprising the Basal Chadron (Chamberlain Pass Fm.), the Chadron and the Brule Formations. The hydraulic properties of the Brule Formation (both the UCU and the overlying aquifer should be estimated based on more appropriate , more empirical methods which use data from outcrops (fracture frequency, orientation, aperture width). It would be useful to introduce a conservative tracer into the lixiviant mixture. Tracing is a highly empirical, recognized tool for characterizing flow in fractured rock settings and, if an appropriate, compatible, conservative tracer can be used, subsurface flow paths could be more clearly identified.

III. Expert Opinions and Testimony Concerning Contention #_6 & 9_.

Opinion: Restoration of groundwater in mine units where mining is complete is inadequate.

Basis: Groundwater restoration efforts at most ISR facilities in the western US have consistently failed to achieve restoration standards for a consistent group of parameters including selected metals, uranium and radium. The geochemical reactions that are induced by the injection of a lixiviant into uranium bearing aquifers result in significant

mobilization of metals, uranium and radium 226. Key reasons for the failure to meet restoration standards include: (a) the mining companies do not conduct restoration activities for a long enough time period and (b) restoration programs do not include sufficient water treatment. Groundwater restoration conducted by CBR pursuant to NRC, EPA and NDEQ regulations has been inadequate to date. Groundwater restoration has been completed and approved for MU 1 and is underway for MUs 2-5. As stated in the LRA (p 6-4) the "primary goal of GW restoration program is to return GW affected by mining operations to pre-injection baseline values on a mine unit average" However, the current CBR license allows for use of secondary restoration goals (State of Nebraska - class of use).

For numerous parameters, the values for the Nebraska Class of Use standards are much higher than baseline values determined by CBR. For eleven parameters the Class of Use standard is an order of magnitude higher than the baseline value and for 5 parameters (mainly metals and radionuclides) the Class of Use standard is two orders of magnitude higher than the baseline value. As such the Class of Use standards are inappropriate. As indicated in Table 6.1-12 (LRA) CBR failed to achieve the restoration standards for seven parameters at MU 1 – radium 226, uranium, cadmium, chloride, manganese, sulfate and TDS. It is assumed that CBR requested ACLs for these parameters.

CBR is currently conducting groundwater restoration at mine units 2-5 which have been in restoration since 1996,1999,2003,2005 respectively. CBR permit conditions require that only 5 mine units can be in production or restoration at any one time. Therefore CBR cannot proceed with MU 11 until production and groundwater restoration is completed at one more mine unit each. As of May 2011 uranium concentration at mine units 2-5 were still well above the restoration standard –even though restoration has been underway for years. CBR reports (SER) that more than 11 pore volumes may need to be removed from a mine unit before restoration is successful. Apparently CBR has significantly increased water treatment at MUs 2-5 in an effort to complete restoration.

Very little information is presented in the LRA or SER as to the details of restoration efforts at mine units 2-5. How many pore volumes have been removed? At which stage of restoration? How much water has been treated? Why have restoration standards not been achieved for all parameters? If all removed pore volumes were subjected to treatment, would standards be met?

NRC has recently determined that the secondary restoration goals (State of Nebraska Class of Use) are not consistent with 10CFR Part 40, Part 40, Appendix A, Criterion 5B(5). CBR has apparently committed to meeting the requirements in Criterion 5B(5); however the potential conflict between State of Nebraska and NRC restoration standards will provide CBR with support for establishment of alternative concentration limits. The CBR permit allows for requesting ACLs if they can demonstrate that they have used best practicable effort. However there is no definition or guidelines for defining and evaluating best practicable effort.

IV. Expert Opinions and Testimony Concerning Contention #_C, D, F_.

Opinion: The groundwater monitoring program intended to detect offsite migration of ISL mining related contaminants is inadequate and poorly reported.

Basis: CBR currently includes 19 domestic water supply wells in the groundwater monitoring program. These wells are reportedly sampled quarterly for uranium and radium 226 only. Neither the LRA nor the SER include any information on the location, depth and screened interval for these wells. Trend data should be presented for these and other monitoring wells and there should be a more complete analyte list that includes metals, TDS and selected anions. (NRC plans to add to this sampling via a condition in renewed license). Most of the background and offsite groundwater sampling has been focused on the basal Chadron. The Brule Fm, especially the lower Brule is under

represented as is the alluvial aquifer along the floodplains of White River. CBR should review the offsite (non-excursion) groundwater and surface water monitoring programs and make modifications necessary to accommodate new understandings and new mining units and satellite ore bodies. This information should be included in license renewal documentation.

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Expert Testimony of _____ [date]

Pursuant to 10 CFR 2.304(d) and 28 USC 1746, I declare under penalty of perjury, that the foregoing is true and correct to the best of my knowledge and belief.

Signed in _____,on April 29, 2015.

[SIGNATURE]