INT-069

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)	)	June 8, 2015

REBUTTAL STATEMENT OF DR. DAVID K. KREAMER

The following points comprise my statement:

(a) In my opinion there is a potential for impact on surface waters from an accident, and the statement that, the risk is "minimal since there are no nearby surface water features", does not accurately address the potential harm to surface water. There has been inadequate characterization of surface water sources near the facility (e.g. reservoirs, springs and ephemeral flows). Within a few miles radius of the CBR facility there are several creeks and reservoirs, including Squaw Creek, Saw Log Creek, White Clay Creek, English Creek, Squaw Creek Reservoir, and McDowell Number 1 Reservoir. The LRA lists eight reservoirs in the area as locations for livestock watering. No limnologic information is provided on these reservoirs, nor is water quality or sediment analysis provided in the LRA. The progressive changes in the nearby reservoirs are unexplained in the LRA. Google earth satellite images from the dates: 5/2/1993, 7/6/1993, 5/11/1999, 7/23/2003, 8/26/2005, 8/14/2006, 8/11/2009, 12/20/2010, and 9/25/2013 show a general, progressive reduction in the areal extent of the down gradient Squaw Creek Reservoir through the course of CBR operations, and in the latest image in this series, noticeable discoloration occurs in the small reservoir close to the CBR operation, just upgradient of McDowell Number 1 Reservoir and downgradient from surface impoundments at CBR.

The creeks in this area are described as follows: "southern tributaries originate in the Pine Ridge escarpment, and flow primarily over forest, range, and agricultural

land. These streams are generally ephemeral except where they are spring-fed." No information is provided on the location, flow or water quality of springs in the LRA. The LRA does not identify White Clay Creek or Saw Log Creek which run through or adjacent to the property, although it identifies a reservoirs associated with these creeks. There are additional unnamed southern tributaries to the White River in close proximity to the CBR property. In flood events, sediments in creek beds are typically mobilized and would flow downgradient, likely to these small reservoirs, if not to the White River. Sediments in these flows can potentially sorb and retain pollutants, and become a possible avenue of lateral surface translation of spills or leaks. There is inadequate information provided on the existence or methods of sediment retention on the CBR site, such as silt fences, which would inhibit offsite movement. In ephemeral reaches of creeks, small surface water impoundments and springs in these water courses with more dependable water can serve as a focus of local wildlife, and sustain diversity. There is inadequate information provided on local springs, incomplete analyses of reservoirs, and inadequate reporting of creek sediment quality when dry, and creek water quality when flowing. There is no accounting for impacts on wildlife and livestock which use water resources down gradient of the CBR site. The flood potential of southern tributaries of the White River, e.g. Squaw Creek, Saw Log Creek and White Clay Creek, were not reported in the LRA, and a 1995 FEMA flood plain was analyzed solely for the White River, which is several miles distant. NUREG-1623 does not preclude erosion modeling when sites are not in 100 year floodplains of distant rivers, particularly when there are nearby creeks that have been reported to periodically flood and flow.

(b) There is an incorrect assumption of lack of vertical communication of water between aquifers in the Chamberlain Formation (Basal Chadron) and the Overlying Brule Formation. Attempts to characterize the vertical hydraulic connectivity at the CBR site as "low" or essentially "impermeable" have generally been inadequate. Analysis of aquifer tests have in many cases relied on inappropriate assumptions, and the design of the many field tests at CBR are deficient, resulting in an inability to confirm that they reliably test vertical communication. In some cases, only selected data were used in evaluating aquifer tests, effectively ignoring contradictory data which could indicate vertical communication of groundwater.

The basic assumptions about the site that were used to complete aquifer test analysis are not acceptable. CBR and NRC generally make the case that the

geology at the site can be considered "layer cake", that is, horizontal strata of uniform thickness, with each layer being homogeneous and isotropic or slightly anisotropic in the Chamberlain Formation (Basal Chadron). NRC reports that this assumption can be supported by examinations of the site's geologic cross-sections. The reported analyses of the hydraulic properties of these formations, from aquifer testing, has utilized simplified equations that assume, *a priori* "layer-cake" geology. Specifically, aquifer test equations in the LRA, used to analyze hydrogeologic properties, contain presumptions about the geological setting that include: all the geologic layers are horizontal, of uniform thickness, of infinite horizontal extent, these layers contain homogeneous and isotropic material, and the geological setting contains no fractures or secondary porosity that would affect analysis of vertical groundwater movement. Conversely, geologic cross-sections show layers with tilted contacts, varying thicknesses, and profound heterogeneity is reported in some strata. Where hydraulically tested, some anisotropy is reported in the production zone. Particularly, the Chamberlain Pass Formation varies in thickness throughout the site and is reported as pinching out to the northwest, while the Brule Formation is reported to have significant heterogeneity. Regionally, the contact between the Chamberlain Pass and the underlying Pierre Shale varies many hundreds of feet, and the thickness of many formations more than doubles.

Importantly, the documentation largely ignores the possibility of secondary porosity, faults, fractures, heterogeneity, or preferential pathways. The Chamberlain formation is referred to, in different parts of CBR documentation, as both as "sandstone" (consolidated) and "sand" (unconsolidated). It is difficult to tell if the descriptive differences in the reported consolidation of the Chamberlain ("sand" or "sandstone") is a reporting error in CBR documentation, but if the reported variability is real, and the sandstones are fissile in some locations but not others, this would support the existence of secondary porosity and heterogeneity. Further, the *a priori* assumption, that the "sand" or "sandstone" in the Chamberlain Pass (Basal Chadron) has no secondary porosity (fractures), is inconsistent with its reported directional anisotropy. It therefore is likely, based on the reported information of hydraulic conductivity directional variation, that there is some evidence of fracturing and/or preferred pathways of groundwater flow in the sandstone. Aquifer test analysis in the Chamberlain has reported permeability variations of approximately 3 times, which is inconsistent with assumptions of homogeneity in the production zone; rather it supports the idea of preferred pathways for groundwater flow. Further, restoration efforts from mining activities in the Chamberlain Pass Formation have been difficult, with a reported need for localized "spot treatment". This uneven distribution of contamination is also an indicator of heterogeneity, secondary porosity, and preferred groundwater

pathways. The existence of secondary porosity and heterogeneity is supported on a large scale by observed areal changes in hydraulic gradient as well. A homogeneous system as assumed by CBR and NRC should show constant regional groundwater gradients. The overlying Brule Formation is reported to have even greater heterogeneity than the Chamberlain Pass formation, but is treated in mathematical analysis as being homogeneous.

Much of the efforts by CBR and their consultants to show hydrologic isolation and lack of potential for vertical groundwater migration from the Chamberlain Pass Formation, were on the basis of aquifer (pumping) tests that were conducted through years. These tests used analyses based on simplified and inappropriate assumptions, and were not set up optimally to yield usable results. Reported aquifer testing in the CBR and Crawford area include tests in 1982, 1987, 1992, 2002, throughout 2004 and 2005 (five tests), and 2006. The aquifer tests are entirely insufficient and potentially misleading, as typically only one observation well was placed in the overlying Brule Formation to determine vertical migration. The Brule is documented to be extremely heterogeneous, making the selection and placement of only a single well not advantageous for producing usable results, and embodying a nonstandard and questionable practice. If the sole observation well in the heterogeneous Brule Formation happened to be in placed in a localized low permeability zone, the responses of this well would not be representative of the Brule aquifer, and would artificially and inaccurately show a lack of or reduced vertical connectivity. Somewhat surprisingly, not all aquifer test information was reported and some entire tests were entirely invalidated. The five aquifer tests in 2004 and 2005 were invalidated on the basis reported as follows: "*Results from the initial testing activities conducted in 2004 to 2005 (Tests #1 through #5) were not definitive as a result of such problems including improperly abandoned old exploration holes, equipment problems, insufficient stress (drawdown) to provide usable data and infiltration of surface water into observation wells*." The data from these tests which were "*not definitive"* were not widely reported or available for this external analysis. Many of the reasons given, for labeling these tests as not definitive, actually support the idea of vertical communication of water. For example, the mention of "*improperly old abandoned explorations holes"* implies vertical groundwater movement. Hundreds of exploratory holes have been drilled in the region, with 686 exploration/ development boreholes reported in the NTEA alone, and hundreds of wells of several types in the CBR region. Importantly, no supportive information is supplied to assess whether this implied vertical groundwater movement was indeed from improperly abandoned wells, or adjacent secondary porosity and fractures/ faults. Further, one potential cause of the reported lack of a definitive aquifer test was: "*insufficient stress (drawdown) to provide usable data*".

Insufficient stress could be symptom of unexpected vertical groundwater replenishment and subsequent reduction in the drawdown of piezometric surfaces. Reasons are not specified why drawdown was considered insufficient, or if vertical groundwater replenishment was a suspected cause. Finally, the reasoning to draw the conclusion, that the tests were not definitive, because there might have been vertical flow of "*surface water into observation wells"* in the 2004 and 2005 tests, was not supported. Accompanying supporting data, demonstrating temporal variation in observation well water levels, was not available for this external review.

Some analysis and discussion of aquifer test data is potentially misleading. For example, Petrotek's analysis of the 2002 aquifer testing is insufficient, in that only the first 700 or 800 minutes of a 3,780 minute drawdown fully matched a Cooper-Jacob straight line approach for several observation wells, and observation well response beyond that time was not fully discussed. As mentioned above, the data analysis was based on equations that assume grossly simplified assumptions of the geologic strata, specifically, that the geologic media is homogeneous, isotropic, of uniform thickness, and there is infinite horizontal extent of geologic strata. A fuller analysis of the Petrotek data, even using these inappropriate assumptions, shows that drawdown rates in several wells significantly slowed or momentarily stopped at times in several wells after 700 minutes, reflecting increased groundwater inflow into the Chamberlain Pass Formation, and the potential existence of a recharge boundary. Likely recharge boundaries would include vertical influx of water into the Chamberlain Pass (Basal Chadron). Full description of the reasons for omitting the analysis and complete discussion of late drawdown data by Petrotek is not available.

Petrotek's data show another possible relationship that supports vertical hydraulic connectivity between the Chamberlain Pass Formation and the overlying Brule Formation. The first figure in Appendix A shows background water levels of wells, before pumping, in the Chamberlain Pass and Brule Formations, CPW2002 and SM9-10, respectively, along with barometric pressure changes. This figure shows a response of water levels in the Brule observation well to barometric pressure changes, indicating a connection between the Brule and the land surface. Importantly, what is not articulated in the report, is that there is also is apparently a muted and lagged response in the Chamberlain to pressure changes in the Brule. This would indicate a hydraulic response of piezometric level changes in the Chamberlain to water level fluctuations in the Brule, and suggest a level of vertical communication between the two, even if the well in the Brule were not optimally placed to show complete, representative response. Additionally, no

groundwater age dating is presented to support that these two aquifers are in different and distinct hydrologic systems.

(c) Monitoring and restoration efforts, as detailed in the LRA, are inadequate. A monitoring period that is restricted to only six months after restoration and stabilization does not account for rebound effects, common at many contaminated sites. Several factors can produce the sequestering of long term contaminant sources that can later release pollutants into groundwater systems. Examples include: localized entrapment in low permeability zones, and oxidation of contamination zones after artificially emplaced reductant is replaced with natural groundwater. Regarding these two examples, uneven distribution of subsurface contamination found at CBR lends credence to the existence of low permeability zones in the Chamberlain Pass Formation (Basal Chadron) and the potential for delayed release, and the planned addition of reductants for stabilization opens up the same possibility. The exhibited heterogeneity of the Chamberlain Pass Formation makes addition of reductants for stabilization potentially ineffective, as there may only be treatment of the well bore and immediate surrounding environment and not the larger aquifer. Monitoring for selected parameters only, (e.g. excluding uranium), profoundly inhibits discovery of rebound effects, as the release of sequestered contaminant and indicator parameters would not be expected to occur simultaneously.

Monitoring locations and well screened intervals at CBR are not optimally located and could miss contaminant excursion. Monitoring in geologic strata overlying the Chamberlain Pass Formation is deficient. Additionally, screened intervals of monitoring wells are not optimally protective of human and ecosystem health. NUREG 1569 does not prohibit many short vertically displaced screened intervals. Particularly, NUREG 1569 guidance misstates, in my opinion, prior EPA guidance on optimal monitoring well screened intervals. Screening entire thicknesses of aquifers is not standard practice in the environmental industry, and is highly non-optimal in the CBR situation where there is an apparent uneven distribution of contamination. Wells that are screened throughout the entire aquifer thickness have a great propensity for diluting contaminant events, causing false negatives, inducing vertical spread of contamination, and not allowing focused spot remediation and overall restoration, among other non-optimal consequences. Apparent heterogeneity in the Chamberlain Pass production zone also makes the pore volume calculations mute, as preferential flow paths could bypass lower permeability areas that need to be remediated. Further, basing

cleanup requirements on mine-based averages is also non standard in the environmental industry, and is not a conservative practice for protecting human or ecosystem health. This non-standard practice adds another possibility of concealing a contaminant excursion, particularly from a thin plume.

Restoration at CBR is now guided by a new, Model-based Restoration Plan (MBRP) instituted in 2009. The modeling approach is based on MODFLOW2000, which is a USGS model that was developed for flow in porous, unfractured media. Documentation states that the MBRP model is derived from a generalized lumped parameter ground-water model, which was developed based on simultaneous water and solute balances for a phreatic aquifer. It is stated that this model is based on the batch mixing model of Gelhar and Wilson (1974) which was designed for unconfined aquifers, not confined systems such as the Chamberlain. Also referenced is Zheng et al. (1991, 1992) who used the simplifying concept of the mixed linear reservoir (MLR). Particle tracking along the lines of Zheng et al.'s work with PATH3D is shown in the WorleyParsons (2009) documentation, but the detailed model parameter estimations and conditions which justify these particle tracks are not fully detailed. Several more recent models claim significant improvements in PATH3D. Likewise, Zheng et al.'s work on MT3D has been updated since the early 1990s but their second-generation work MT3D MS (1998) and later work is not fully referenced in the LRA. The MBRP has been "*continually updated and improved since it was originally developed*", indicating that initial use of the MBRP, as originally conceived and on which restoration procedures were based, was not optimal and required continual updating. Complete details of the model were not available for review such as the model domain; detailed boundary conditions; grid spacing; details of model calibration, recalibration and validation; and sensitivity analysis. The model domain must be large enough to encompass the area of interest, be large enough so that the selected boundary conditions don't affect results, and also be large enough to account for periodic stresses outside of the model boundaries. Grid spacing and distribution is dependent on the thickness and variation of geologic media, hydraulic conductivity variations, head, contaminant concentrations, wells, drains, and vertical flow. Model properties which should undergo external evaluation and review include chosen values for: hydraulic conductivity (or permeability), storativity, porosity, dispersion/diffusion, sorption, reaction rates (Chemical, Biological, Physical), and initial heads and concentrations. Documentation should be made available for calibration and recalibration of such additional factors such as recharge rates, boundary conditions, aquitard conditions (leakage), pumping variation, source location, source configuration, source strength, and initial heads. The mathematical uniqueness of model solutions should be checked and documented. The changes

and updates of the model, central to the MBRP, are not well documented in the LRA and supporting materials.

(d) Complete water balance for the region is not well reported to substantiate that consumptive use of groundwater by CBR will not impact the surrounding regions long-term. In the absence of a detailed regional water balance evaluation, the short term justification, that the impact will be SMALL because "*the aquifer is expected to recover relatively quickly once restoration is complete and natural flow patterns are re-established*", does not adequately address the complete long-term picture and impact on surrounding communities and ecosystems. Some presented documentation indicates that at a minimum, flowing wells in surrounding area would cease to flow to the surface by some CBR activities. The stated impact of this is minimized in the documentation, indicating that shallow submersible pumps could installed, despite the added energy costs associated with this change.

(e) The monitoring of pipes would only account for large leaks. Regarding the possibility of leaking pipes, pressure monitoring is the primary monitoring technique. The documentation states, "*Accordingly, as described in the LRA (Exh. CBR-011), Section 3.3, Crow Butte maintains continuous real-time monitoring and control systems to detect and mitigate potential spills and leaks that would impact groundwater.*" Also, "*As previously discussed, all piping is leak checked prior to operation. Piping from the wellfields is generally buried, minimizing the possibility of an accident. Large leaks in the pipe would quickly become apparent to the plant operators due to a decrease in flow and pressure, thus any release could be mitigated rapidly*." With this system, chronic leaks in pipes would not be caught. These could be quite sizable in the long term.

Pursuant to 10 C.F.R. § 22.304(d) and 28 U.S.C. § 1746, I declare, under penalty of perjury, that the foregoing is true and correct to the best of my knowledge and belief.

Dated this 8th day of June, 2015.

Respectfully submitted,

David K. Kreamer