RAS B-20 Perrong & P INT-011 Pending answer

STATE OF NEBRASKA

Dave Heineman
Governor

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DOCKETED
USNRC
April 16, 2008 (3:00pm)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

NOV 0 8 2007

Mr. Stephen P. Collings
President
Crow Butte Resources, Inc.
141 Union Blvd, Suite 330
Lakewood, CO 80228

RE: Technical Review of Aquifer Exemption Petition for North Trend Expansion

Dear Mr. Collings:

The Nebraska Department of Environmental Quality (NDEQ) has completed a preliminary review of the Crow Butte Resources (CBR) "Petition for Aquifer Exemption North Trend Expansion Area" received by this office on August 20, 2007. The document was reviewed by Mr. Dave Carlson of NDEQ, Mr. Dave Miesbach of NDEQ, Professor Jim Swinehart of the University of Nebraska-Lincoln, Conservation and Survey Division, and myself.

NDEQ evaluates a petition for an aquifer exemption on the merits of site specific data collected, the incorporation of historical and contemporary research from the study area and vicinity, and the synthesis of that information to support scientific interpretations presented. As a general statement, the document provided for review by CBR lacks site specific data, inclusion of recent research, and the presentation of well supported scientific interpretations to be considered acceptable. This specifically applies to the repeated reference in the document to data collected from the original Crow Butte Study Area (CSA), and the application of that data to interpretations of subsurface conditions within the North Trend Expansion Area (NTEA). Site specific data from the NTEA including sedimentologic and petrophysical studies of cores as well as aquifer tests (heretofore not provided to NDEQ) will be required. In addition, the most recent geologic and hydrogeologic research of the area must be incorporated and referenced, and subsurface interpretations within the NTEA must utilize the most recent stratigraphic nomenclature and subdivisions. Finally, the subsurface structural anomaly (the White River Fault/Fold) that is present in the southern portion of the NTEA is inadequately defined and must be accurately delineated for consideration of this petition.

Template Secy-028 DS-03

U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of Crowe Butte Resources, Inc.

Docket No. 40-8943-MLA Official Exhibit No. B

OFFERED by: Applicant/Licensee Intervenor

NRC Staff Other

IDENTIFIED on 1-16-08 Witness/Panel N/A

Action Taken: ADMITTED REJECTED WITHDRAWN

Reporter/Clerk Thibault

Crow Butte Resources
Petition for Aquifer Exemption: North Trend Expansion Area
Technical Review of Aquifer Exemption Petition Dated August 15, 2007

NDEQ Detailed Technical Review Comments

General comment on nomenclature: Within these comments, NDEQ has followed CBR's nomenclature used in the reviewed document to provide relational consistency between the document and the comments. However, these comments should in no way reflect an acceptance by NDEQ of the nomenclature utilized by CBR. The nomenclature utilized by CBR is outdated and does not conform to widely accepted and published geologic literature from the area. Specific comments on, and references for nomenclature are provided within the body of the following text.

Page 1: CBR states that North Trend is comparable to the original Crow Butte Study Area (CSA). Other than on a gross formational level scale, there is no evidence collected at North Trend to support this claim. This is a recurring theme throughout the document.

Page 5: CBR states that the Basal Chadron Aquifer does not currently serve as a source of drinking water and will not in the future serve as a source of drinking water, with supporting evidence purported to be contained in Section 5 of the document. As elaborated on later in this review, this statement may not be accurate.

Page 6: Figure 1 Reference; Figure 1 should show the position of the site relative to the State of Nebraska. A county level statewide map would be useful in this instance as there are many county references in this document, but no maps showing county boundaries.

Page 7, CBR states that regional deposition between North Trend and the existing CBR mine are similar. Therefore the expectation is that the ore and chemistry will be similar, as well as groundwater characteristics. However, they fail to discuss the differences between the two areas which are significant in that the Basal Chadron at North Trend was deposited into a basin that may have been actively subsiding at the time of deposition; that North Trend is dominated by an artesian groundwater system, significantly different from the existing mine site; and that overlying aquitards or aquicludes may be significantly different texturally due to basin subsidence. No site specific evidence is presented, such as core data from the NTEA highlighting mineralogy and chemistry to support such a position.

Page 8: Section 3.2 – A sample portion of an elog should be shown in this section. The elog should be from the Pierre, Basal Chadron and above to show how the elogs are interpreted to generate the cross-sections. These interpretive

figures and associated text should explain the log traces, and their relationship to lithology. The public has no way to understand the context in which the data is presented and should be shown what it means.

Page 8: Section 3.2 – Reference to Figure 4; Figure 4 or another map should show all borehole locations for the North Trend prospect. Only very limited borehole data is shown on figure 4, leading the reader to assume that little subsurface investigation has been completed. This is misleading, and should either be shown on this or another map, along with the total number of boreholes drilled and logged within the North Trend area. This should also be summarized in the text.

Page 8: Section 3.3 – Nomenclature and descriptions are important here. The statement that *"the interior paleosol has been scoured away by the overlying Chadron Sandstone"* is incorrect. The erosional event that preceded the deposition of the Basal Chadron Sandstone is the control on the removal/erosion of the interior paleosol, and should be stated as such. Also, see comments on the use of "interior paleosol" in the following paragraphs.

Page 8: Section 3.3 – The document refers to two deep wells either within or near to the proposed aquifer exemption area (Heckman #1 and Soester #1). This citation is used to delimit the thickness of the Pierre Shale in the vicinity of the site. These well locations should be shown on a figure in the context to the position of the existing mine site and North Trend. The logs for these wells should be shown on a separate cross section to display the thickness of the Pierre relative to overlying strata and the mining zone, and the potential for deformation within and below the Pierre. An interpretation of structure in the study area from these deep holes, coupled with data from shallow holes would be appropriate here. It will likely show how little is known about the exact nature and origin of the structure.

Page 9: Second paragraph; The nomenclature of the "Interior Paleosol" is no longer accepted within the literature. As early as 1983, Retallack showed that this unit was composed of two separate paleosols. The two units are the "Yellow Mounds Paleosol" that developed on the Pierre Shale and the "Upper Interior Paleosol" developed on top of the overlying fluvial sediments. It is unclear in the last sentence of this paragraph what eroded the surface of the Pierre. We all know sandstones don't erode things. It is the erosive event prior to the deposition of the sandstones that controls the magnitude and extent of incision, and that sandstones are what are deposited on that eroded surface. This needs to be cleared up before public notice.

Page 9: Paragraph 3; Again, the interpretation of log curves will be crucial to display to the general public in way that is informative and easy to understand. Not only should a blow-up section of an interpreted elog be shown, but also the cross sections should be presented at such a scale that the scale on each log

can be easily read. This should likely be as a fold out plate at 36 x 48 dimensions. Additionally, not only should the cross-section show the A-A' or B-B' designation, but the sections should also be clearly labeled on each end "north" or "south", "east" or "west".

Page 9: Paragraph 4 - The Chadron Formation; The absence of reference to Terry's (1998) lithostratigraphic revision of the White River Group is unacceptable. This was published as GSA Special Paper 328 and established revisions of the stratigraphy now used by the Nebraska Conservation and Survey Division - Geological Survey and most other geologists working in Nebraska and South Dakota. All stratigraphic interpretations must be revised to reflect this now accepted lithostratigraphic framework (this includes all cross-sections).

Page 9: Basal Chadron Sandstone; Using the most recent and widely accepted nomenclature, the "Basal Chadron Sandstone" is actually the channel sandstone facies of the Chamberlin Pass Formation. Additionally, an interpretation regarding the depositional environment for the Upper/Middle Chadron sand has been placed in the last sentence of the paragraph on page 9. This does not belong in this section, and should be moved to the next section of the document.

Page 10: Paragraph 1; The Basal Chadron Sandstone at North Trend is described as being overlain by "*a persistent clay horizon, typically brick red in color generally marks the upper limit of the Basal Chadron Sandstone*". However, reports from Dave Carlson, as well as meetings between NDEQ and CBR indicate that observed borehole cuttings at North Trend do not contain the "red clay"; there is no "red clay" zone picked on any logs shown; and that it is in fact missing completely in the North Trend area. This change is depositional in nature, likely relates to structure, and requires a detailed review and explanation. Further, this distinctive and persistent red clay or mudstone horizon is the overbank mudstone lithofacies of the Chamberlin Pass Formation (Terry, 1998, pg 26) and typically ranges from 0.8 to 1.8 m thick in outcrop.

Page 10: Paragraph 2; Basal Chadron Sandstone is reported to thicken to 170 feet west of the "North Trend Property Boundary". However, at what point on the western boundary does this occur? Only one east-west cross section was presented in the document, and it is at the very southern boundary of the North Trend Expansion Area. Why does this thickening happen? What is the relationship of sediment thickness to the local structure? What is the change in associated stratigraphic architecture, and how will that play a role in hydraulic control of the site?

Page 10: Paragraph 4; Text in this paragraph references thin section mineralogy of the Basal Chadron Sandstone for the original Crow Butte Study Area (CSA) and implies that the mineralogy of the Basal Chadron at North Trend is exactly the same. This data is not site specific for North Trend and is therefore unacceptable. This is especially true when it appears likely that the deposition of

the Basal Chadron Sandstone at North Trend may have been contemporaneous with deformation of the Pierre. Therefore, there may be significant textural changes in the Basal Chadron as well as mineralogical changes that would be related to deformation along the Crawford/White River Structural Uplift. Core samples will need to be collected from North Trend at a variety of locations (i.e., spatially representative) and analyzed for mineralogy and petrologic characteristics, as well as fundamental petrophysical characteristics to describe North Trend-local textural, mineralogical, porosity and permeability parameters.

Page 10: Section on Middle Chadron and Upper Middle Chadron Sand (first paragraph); The Middle Chadron" would appear to be the revised Peanut Peak Member of the Chadron Formation (Terry, 1998; Terry and LaGarry, 1998) and the Upper/Middle Chadron Sandstone appears to be the Big Cottonwood Creek member of the Chadron Formation (Terry, 1998; Terry and LaGarry, 1998).

This section begins discussion by stating the Middle Chadron is a confining layer above the Basal Chadron Sandstone, that ranges in North Trend from 200 to 300 feet thick. However, no supporting evidence is provided to establish the permeability of the Middle Chadron within North Trend, or where this unit thickens and thins. Bentonitic interbeds are referenced as being present, however no reference to how bentonitic mineralogy has been determined is mentioned. This is something that can only be substantiated through x-ray diffraction or microprobe analysis, so where is the data to support this claim? The authors claim that the "light green-gray sticky clay of the Chadron serves as an excellent marker bed in drill cuttings and has been observed in "virtually all' drill holes within the Crow Butte area, including North Trend." If this is the case, then where has it not been observed, since "virtually all" implies that it is not present at some locations. Where are the lithologic logs to back this claim? One thing that is conspicuously missing from this document are ANY lithologic logs. Further, the hydraulic conductivity of the "Middle Chadron" at North Trend is inferred from vertical hydraulic conductivity data collected from the original Crow Butte Study Area (CSA). Again, as previous, why is this data not site specific? Additionally, how is it possible that the mineralogical, petrologic, and petrophysical character of the Middle Chadron at North Trend is the same as the CSA when it is clear (from the data presented in this document) that the "Middle Chadron" at North Trend has been deposited into an actively subsiding basin. This depositional environment is completely different than that to the south of the Crawford/White River Structure, which is where the original CSA is located. The structural and stratigraphic data presented in this document indicates that, at a minimum, a textural change should be evident in samples collected from south to north across the structure (i.e., from the highland into the basin). As such, a textural change is likely across this boundary, and that textural change will likely impact potential vertical and horizontal hydraulic conductivities. These textural changes may also be coincident with mineralogical changes that ultimately correspond to significant facies shifts across the Crawford/White River Structure and into the associated Crawford Basin.

Page 10: Section on Middle Chadron and Upper-Middle Chadron (second paragraph); This paragraph is obtuse, difficult to read, and needs substantial revision to convey whatever message it is aimed at communicating. Is the Upper/Middle Chadron a sand or a sandstone? Data in this document indicates a sandstone. Therefore, call it sandstone, and make sure it is noted as an informally named unit. If it is detailed within more recent revisions of the stratigraphic nomenclature, then you must utilize that terminology, and again, if it would appear to be an informal unit within the most recent nomenclature then it must be referenced as such. Additionally, a reference is made to a "regional depositional model", without a citation as to what or whose model it is. Also, if this model has validity, does it apply to the Basal Chadron as well as the purported Middle Chadron? If a model is referenced, it must be substantiated. This document forms the foundation for any future discussion for an aquifer exemption. Each claim made within the document must be substantiated and appropriately referenced and based on sound science. If the claim is made out of original research, from original unpublished data collected, then the data set must be shown, along with the associated interpretation. Anyone reading this document, who decides to research the referenced claims, must be able to reach the same conclusions. If it is new data presented, then the interpretation of this data must be supported by the data. At this point in the document, there is a lack of ANY supporting evidence that has been collected and analyzed directly from the North Trend prospect.

Page 11: First Paragraph; The Upper Middle Chadron sandstone is described as being very "*similar in appearance to the Basal Chadron Sandstone, and is typically very fine-to-fine grained, well sorted, poorly cemented sandstone. At other locations it is of poor quality*." Does this refer to the Basal Chadron or to the Upper Middle Chadron? If this is the Upper/Middle Chadron Sandstone, then it is not at all similar to the Basal Chadron as described previously in this document. On page 10 of this document the Basal Chadron is described as a coarse-grained arkosic sandstone with varying amounts of clay interbeds that grades vertically into a fine grained sandstone with varying amounts of interstitial clay and persistent clay interbeds. Additionally, what does a "poor quality" mean? The inference is that the sandstone is of "poor quality", however this meets no known geologic textural or mineralogical description that we are aware of. Is it of "poor quality" as compared to some property of another sandstone? Please define or remove. Provide an appropriate stand-alone description of the Upper Middle Chadron Sandstone that is representative of the unit when found within boreholes. This description should be inclusive of observations obtained from both cuttings and cores.

Page 11: Second Paragraph; CBR states in this paragraph that the Upper-Middle Chadron Sandstone be included in the Aquifer Exemption due to its potential for commercial grade uranium deposits. However, CBR has presented no evidence that this unit contains ANY concentrations of uranium that may be

considered to be of commercial value. This request may be denied unless it can be supported with widespread evidence within the proposed exemption boundary that it may be a viable production target.

Page 11: Third Paragraph; The "Upper Chadron" unit would appear to be within the Big Cottonwood Creek Member of the Chadron Formation (Terry and LaGarry, 1998). Therefore, some of the stratal inconsistencies highlighted below may be resolved utilizing the accepted lithostratigraphic revision. CBR states that the Upper Chadron represents a major facies shift from stratigraphically lower units in the Chadron Formation, and that this "Upper Chadron" is continuous, but of varying thickness through the North Trend prospect area. Stratal thicknesses within this zone change by over 150 ft. Are these thickness changes explained by facies variations, stratigraphic architecture, or post-depositional modifications (or all of these), or by lithostratigraphic revision? What effect might these factors play in overall hydraulic conductivity? It is not clear where the lithologic characteristics referenced in this paragraph come from. It is likely these data are from the original Crow Butte Study Area (CSA) and therefore are not acceptable as local descriptors for the Upper Chadron at North Trend. Again, changes in structural accommodation for sediment storage also likely plays a key role in stratigraphic architecture and sediment dispersal patterns. North Trend specific data for this unit that is spatially representative is required for this petition.

Page 11: Paragraph 4; Terry and LaGarry (1998) state that the Brule/Chadron contact is intertounging except where the channel sandstone of the Orella Member of the Brule incise into the Big cottonwood Creek Member. CBR states that the contact between the Brule and Chadron is conformable, but is also gradational and not easily distinguished. As stated above, others would argue that this is not the case and that there is a lithologic break between the two formations that is identifiable. As such, it is inappropriate to lump the Brule and Chadron together as a single confining interval for the purpose of this discussion. Additionally, siltstones and claystones of the Lower Brule may be fractured due to the structural modification on the Crawford/White River Structure, and thus may be more permeable than other locales. This coupled with the widely dispersed or intermittent channel sandstones of the lower Brule may create permeability pathways that are heretofore uncharacterized. Again, site specific core data will be required to proceed with the aquifer exemption.

Page 11: Paragraph 5; CBR states that Upper Brule siltstones "*have a larger grain size than the lower part of the Brule Formation*". Where is the sieve data to support this grain size differentiation? How was this determined? What is the criteria that was used to make this statement? Also, Terry and LaGarry (1998) should be reviewed and referenced in this section.

Page 11: Paragraph 5; CBR states that small sandstone units of limited lateral continuity and water bearing capacity are found in the upper part of the Brule.

They also state that "*These sandstones have been included in the upper part of the Brule Formation and are illustrated on the series of cross-sections as overlying the upper confinement (Figures 5a and 5b).*". However, in reviewing the cross-sections presented on Figures 5a and 5b, there is no differentiation of units or interpretation of internal architecture for the Brule, and only a formational rank break is shown as the contact between the Chadron and Brule. It is unclear if this formational pick is as implied in the preceding Paragraph 4, and that the Lower Brule is lumped in with the Upper Chadron, and therefore the actual formation break shown between the Chadron/Brule is somewhere below that shown on the cross-sections. The above underlined passage is thus misleading, as the reader anticipates architectural information to be presented on the cross-section showing the relative positions and geometry of sandstone bodies within the Brule. Instead the reader finds a single formational level break between the two formations, and that break may in fact, not be representative of the base of the Brule. Cross-sections must be reworked to show accurate formation level breaks and as much 2D internal architecture as possible. Confining unit interpretations should be shown using a different symbology, so that cross-sections do not become over-simplified representations. Therefore, cross-sections should ultimately show 1) accurate depth scaling; 2) formational breaks; 3) member breaks; 4) bed or unit level breaks; 5) 2D architectural information at all levels of stratigraphic hierarchy; 6) separate, but overprinted symbology for interpreted hydrogeologic characteristics (this should include confined water table elevations, direction of groundwater gradient, position of confining unit placement especially if these are not coincident with formational level boundaries, placement of multiple aquifers, potentiometric surfaces and multiple confining units, etc..). This will allow the end user to immediately relate the text to the cross-section, and find the data to support the interpretations proposed.

Page 12: Paragraph 1; Alluvium is described in this section, and is noted as covering the North Trend area in variable thickness from 0 to 30 ft. The alluvium is reported as being potentially water bearing, but not reliable water source due to the discontinuous nature of the deposits. The relative stratigraphic position and location of the alluvial deposits are not shown on the cross sections. Cross sections should be modified to show the alluvial units. If the cross-section scale needs to be modified to achieve this goal, then it should be done. These cross-sections suffer in general from being to small, and thus scales on actual electric logs or nuances in elog curves cannot be visualized. If cross-sections were provided on 36 by 48 fold-out plates, scales could easily be shown, as well as the basic occurrence and geometry of alluvial units as well as other architectural elements within specific formations. These data will allow the user to gain a greater understanding of the details that are currently missing in the existing oversimplified cross-sections.

Page 12: Paragraph 2; Site Stratigraphy; This section is NOT the site stratigraphy section. The preceding section detailed the site stratigraphy. This section interprets the 3D geometry of planar surfaces at formation, member, or

subunit rank, as well as provides a visualization of the interpreted structural deformation, especially along the top of the Pierre. It is not correct to state that the figures referenced (Figures 10A through D) within this section provide evidence for showing the hydraulic isolation of the proposed Aquifer Exemption interval from any underlying or overlying units. These figures clearly do not display ANY hydrogeologic data, or provide a visualization of the total thickness of any single unit. Rather, basal or top surfaces are picked to display the geometry of the bounding plane. What would very useful in aiding in any interpretations would be the 3D geometry of the thickness of each unit of interest, and the position of the unit relative to the interpreted structure on the Pierre. What would also be very useful is this same technique applied to the thickness of the Pierre, to help interpret fault or fold status.

Page 12: Section 3.4: Structural Geology; Is figure 11 the most up-to-date structural interpretation of the area? Based on the most recent interpretations, is a new structure map needed?

Page 12: Structure- Paragraph 2; CBR has drilled hundreds of holes in the area and has a huge data set available for interpretation, yet is relying on a 1969 interpretation of a limited regional data set to interpret localized structure. This does not seem reasonable. Additionally, why is there no reference to more recent data, such as Figure 4 from LaGarry (1998) or Figure 3 from Terry and LaGarry (1998) which shows details of faulting in the Toadstool Park area.

Page 12: Structure – Paragraph 3; CBR states that the bedrock geologic map indicates that the Brule subcrops below the NT expansion area . However, upon examination of Figure 12, the geologic map, the Brule is not shown as an individual unit but rather the White River Group is shown in total (map symbology Tw). In addition, map symbology for the White River (Tw) is missing from the enlarged view of the study area. The text in this section should accurately reflect the data shown on the map. The faults discussed in the text are not shown on the State geologic map because DeGraw did not have them mapped accurately. See Hunt (1990) GSA Special Paper 244 for a more accurate map of faults in northwest Nebraska. Also see A. Lisenbee, 1985, Tectonic map of the black Hills uplift, Montana, Wyoming and South Dakota: Geological Map Series 13, scale 1:250,000; and Lisenbee, A.L., 1988; Tectonic history of the Black Hills uplift, in Diedrich, R.P. and others, Wyoming Geological Association Annual Field Conference Guidebook, pp. 45-52.

Page 13: Paragraph 1; The descriptions of formation dips in this paragraph are misleading. CBR states that "*As a result of structural uplifts (Figure 11), formations in the North Trend Expansion Area generally dip gently to the south...*". This is not an accurate statement after reviewing the data that has been presented herein. In general, units within the northern portion of the North Trend Expansion Area (NTEA) dip steeply to the south (see figure 5a) and units in the southern portion of the NTEA deep very steeply to gently to the north (see

figure 5a). In addition, dips depicted on figure 5b indicate that there is also a pronounced westerly dip component. A complete analysis of all available borehole data may yield very steep dips to the northwest in the southern NTEA and steep to moderate dips to the southwest in the northern NTEA. This may also be substantiated using the 3D surface models generated and shown on Figures 10a – d, which represent a larger proportion of the available borehole dataset. Structure contour maps generated shown on Figures 13 and 14 also do not support the concept of "gentle southerly dips".

Further, it is apparent on the cross-sections presented that there is likely an evolution of dips as the Crawford Basin filled. Basal fill in the basin was more profoundly influenced by basinal subsidence than were later fill components. It is likely, as previously commented on in the stratigraphy section, that this change in accommodation for the fill has impacted the stratigraphic architecture of the units overlying the Basal Chadron Sandstone. Changes in accommodation, potentially related to deformational events likely control the influx and distribution of the Middle Chadron Sandstone as well as the facies changes (and again, stratigraphic architecture) of all fill above the basal member. This is very apparent when comparing the data presented on the Brule Formation as compared to the Chadron. The contact between the Brule and the Chadron is generally flat lying or gently dipping rather than steeply dipping into the basin. This would indicate that accommodation within the Crawford Basin was very limited by the time Brule sediments were being deposited and the basin was close to full.

Page 13: Paragraph 2; CBR indicates that previous exploration efforts yielded data to support the interpretation of a fault (known as the White River Fault) immediately northeast of Crawford. CBR states that throw along this fault is interpreted to be approximately 200 ft to the south-southeast. However, data presented on the cross-sections (Figure 5a-b) indicate more than 400 ft of offset along this structure (~2980 to 3420 along the base of the Basal Chadron Sandstone). The structure contour map shown on Figure 6 also indicates more than 400 feet of elevation change in the Pierre within less than ½ mile horizontal distance (see southeast quarter of section 34, Figure 6). A more accurate accounting of relief along this structure is required.

CBR also states at the end of this paragraph that they are now interpreting this structure to be a deep seated fault that does not penetrate the Pierre, but rather deforms the Pierre as a monocline. CBR goes on in the following paragraphs on page 13 (paragraphs 3 and 4) to attempt to justify this interpretation. However, no hard evidence is presented for either argument (that is, fault or fold) but rather that a fold interpretation is equally as justified given the current data set as is a fault interpretation.

CBR states that "*cross-sections show that the Basal Chadron Sandstone is pervasive and correlatable throughout the area and does not appear to exhibit*

thickness changes across the White River fault/fold, suggesting that movement along this feature did not impact deposition of the Basal Chadron Sandstone". However cross-section 5a and isopach maps of the Basal Chadron Sandstone show some subtle thickening of the Basal Chadron Sandstone into the basin depocenter. This thickening may have been the result of contemporaneous subsidence with the deposition of the Basal Chadron Sandstone. Clearly this basal unit is deformed over the structure shown on the top of the Pierre, but stratigraphically up section, units reflect less deformation (or structural influence) over unit thickness, and thus may reflect architecture related to infilling of accommodation within the basin. Multiple views of the 3D geometry of the full thickness of individual basin fill units, rotated to differing views would aide significantly in interpreting these data.

Page 14: Paragraph 1; CBR states that the "*Upper and Middle Chadron/Lower Brule thin across the mapped fault suggesting that movement along the monocline/fold may have impacted deposition of the Upper/Middle Chadron*". However, is this unit thinning over the structural high or is it thickening into the adjacent basin as part of the composite fill? As previously stated in this review, the gross architecture of units appear to be that of a basin filling in response to initial subsidence, but not one that is necessarily continuously subsiding. Episodes of pulsed uplift along the structure may be reflected in the distribution of the Middle Chadron Sandstone. More data and detailed subsurface mapping on both sides of the Crawford/White River Structure are required to resolve this question. Mapping should be generally widespread, and be inclusive of data collected to the south at the existing mine site, as well as data collected to the north at NTEA. Conspicuously missing is the gap represented by the town of Crawford, and exploration efforts should include this area to appropriately define the subsurface structure and the impact it may have on the distribution of the mining zone and overlying and underlying confining units.

In addition, how would this interpretation change if the revised stratigraphy of Terry and LaGarry (1998) had been used? As they demonstrated, faults clearly offset the Peanut Peak and Big Cottonwood Creek Members of the Chadron Formation in Toadstool Park (see Fig 3 of Terry and LaGarry (1998) and Fig 4 of LaGarry (1998)). How is the offset of these units at Toadstool related to the structure at Crawford? Is it related at all? If there have been a series of deformational events, how does this effect the hydrogeology of the area.

Page 14: Paragraph 2; As previously stated, there is not enough evidence presented to support the interpretation suggested in this paragraph. Additional exploration and mapping are required to adequately define this structure.

Page 14: Summary of Site Geology; There is a discrepancy in the summary between the first and second paragraphs regarding the thickness of the confining unit above the Basal Chadron Sandstone. CBR states in paragraph 1 in this section that "*The Basal Chadron is overlain by over 500 feet of the impermeable*

to low permeability Upper and Middle Chadron and Brule Formations". In the second paragraph in this section, CBR states that "*The thickness of the upper confinement ranges from 150 to 250 feet within the North Trend Area.*" Therefore there seems to be a fundamental discrepancy regarding the purported thickness of the "confining" unit.

Page 14 and 15: Summary of Geology; last paragraph on page 14 and first paragraph on page 15; CBR states that "*Based on core analysis from the CSA, it is evident that the upper and lower confining beds (the Upper Chadron through Brule and Pierre Shale, respectively) contain significant percentages of montmorillonite clay and other clays and/or calcite. Those would indicate the presence of clay minerals with very fine grain sizes. Core and hydrologic data from the CSA indicate that the vertical hydraulic conductivity of the confining shales and clays overlying and underlying the Basal Chadron Sandstone are on the order of 10^{-10} cm/sec, or lower. The geologic information presented in this application clearly demonstrates the lateral continuity of the overlying and underlying confining zones on both regional and local scales, as well as the lateral occurrence and distribution of the Basal Chadron Sandstone.*"

As stated previously, these types of statements are unsupported and misleading. Other than on a gross, formational level scale, no sedimentologic evidence has been presented to indicate textural, petrographic, or hydraulic characteristics are continuous across the area from the existing Crow Butte Mine to the North Trend Expansion Area. No site specific sedimentologic or hydrogeologic data has been collected from NTEA, and this must be corrected. An aquifer exemption cannot be predicated on core data collected from another location. Data presented for discussion or to support technical arguments must be site specific. Data from the CSA will not be accepted in lieu of data from NTEA. In addition, the statement that "*Those would indicate the presence of clay minerals with very fine grain sizes.*" is a misleading statement. Is CBR really suggesting that they are differentiating between clay particle sizes? If so where is the supporting evidence?

Page 16: Section 4.2.1; CBR states that "*Alluvial deposits occur intermittently in ephemeral drainages...*". This statement is confusing. That alluvial deposits occur in ephemeral drainages, is correct, as all drainages by definition will contain alluvial sediments. However, it is unlikely the "sediments" are intermittent, but rather the "ephemeral" drainage is what is intermittent.

Page 17: Paragraph 3; CBR states that "*The Upper/Middle Chadron Sand occurs intermittently*". There is no clear evidence presented in this document to support this statement. Previous data shown on Figures 5 and 10 clearly indicate the Upper/Middle Chadron Sandstone is a pervasive feature within the Crawford Basin. If CBR is implying that the Upper/Middle Chadron Sandstone is not found as a regionally extensive unit (that is, outside the Crawford Basin), then

they should state that. However, the Upper/Middle Chadron Sandstone is likely an important unit within the basin.
CBR is presenting conflicting information for review with regards to the Upper/Middle Chadron Sandstone. On page 11 of this document CBR states they want this unit exempted as part of the aquifer exemption due to the potential for mining, however here CBR is stating there was limited groundwater production, and no samples collected. Therefore, based on the data presented, it is unlikely that this unit has any potential for future mining efforts.

Page 17: Paragraph 4; CBR states that "*On a regional basis...Because of limited data density, no potentiometric interpretation is presented...However the available data suggest a regional hydraulic gradient to the north.*". How can an aquifer exemption be granted on the basis of a suggested hydraulic gradient? Why is there limited regional groundwater monitoring data? CBR should install wells and collect the requisite data to provide an accurate and repeatable determination of regional groundwater gradient. Further, data referenced from the CSA for this purpose, are misleading, and have little value in assisting in the interpretation of regional gradient inclusive of the NTEA. These data are collected on the south side of a major structural feature, and represent water levels collected where the aquifer is in a position some 400 feet higher in base elevation than in the NTEA. In this case, regional data is lacking and must be collected for an exemption to be appropriately evaluated.

Page 17: Paragraph 5; In contrast to the above, CBR states that groundwater gradient in the Basal Chadron within the NTEA is to the east (Figure 21). This by itself seems in question, as this gradient is directed, at least in part, towards the uplift on the Crawford/White River Structure. Although this data is placed within the caveat that it is only four data points, it is clear this gradient would be contrary to what would be expected. Again, this analysis suffers from lack of information, and more site specific data would be aid significantly in resolving such discrepancies. More than four data points will be required to provide an accurate estimate of gradient for the purpose of an aquifer exemption.

Page 18; Section 4.2.2- Groundwater Quality Data; Well locations shown on Figures 18 and 19 are unacceptable. This particularly applies to wells that are referenced as sample locations. The proposed aquifer exemption boundary is drawn through well numbers shown on the map and thus obscures the symbols and makes identification of well locations difficult. Additionally, the abandoned well that was previously used for sample collection is not shown. This well location needs to be placed on the map showing as an abandoned well.

All wells identified in the "water user survey" need to be included on a table within this document. A large number of wells are shown on Figures 18 and 19, but there is no summary of well information (other than that provided in Appendix A, that is not referenced in this section). As on the map, where wells have been broken down by stratigraphic position, this also needs to be shown on a table to

include: sorting by: owner, registration and number, or document as unregistered; stratigraphic position; well number; legal description; gps location; total depth, depth of screen interval(s), primary seal interval(s); secondary seal interval(s); production flow rate. If this is the data that is supposed to be in Appendix A, then it needs a "call out", and Appendix A data needs to be modified to meet these requirements.

On page 19, paragraph 1, CBR states that "*These data establish the groundwater conditions associated with the mineralized Basal Chadron Sandstone and Brule in the North Trend Area, at a location immediately outside and northeast of the proposed expansion area*". As CBR has stated, these data do not represent groundwater conditions within the aquifer exemption boundary. This is particularly true with regards to the Basal Chadron Sandstone as samples collected are not from within the major mineralized portion of the ore zone. In general, the number and location of wells within the NTEA are few, and not widely distributed or necessarily representative of NTEA. Groundwater monitoring wells should be installed in both the Chadron and Brule formations that are spatially distributed so that the most representative groundwater data can be presented. The Current NRC permit (SUA-1534, Section 10.3) establishes a *minimum* criteria for determination of baseline as three biweekly sampling events from monitoring wells within proposed mine units, and this condition was incorporated into the Class III permit for the current CBR mine site. However, another approach to consider is to compile an accurate pre-mining data set by sampling strategically located, spatially representative wells on a monthly basis for a period of 12 to 24 months to show natural (background) data from at least one or two complete seasonal cycles. The current data presented is spatially limited and temporally disconnected, and does not provide an accurate assessment of the groundwater quality within the Chadron or Brule within the extent of the proposed aquifer exemption boundary.

Page 19: Section 4.3 – Aquifer Testing and Hydraulic Parameter Identification; ***This section is has no validity as pump test results referenced in this section were never reported to NDEQ.*** Pump test data for the referenced aquifer testing must be included in whole with this document as an appendix, or must be submitted under a separate cover. While the technical data from this section is completely unsupported due to the lack of the required documentation, the following comments can be provided:

Page 19, Paragraph 2 under section 4.3; CBR states that the aquifer behaves as an isotropic and homogeneous media. How can this be when this document clearly states that clay discontinuities are widely prevalent within the Basal Chadron Sandstone? As stratigraphic architecture is complex, with many permeability boundaries, how does CBR explain the homogeneous and isotropic behavior?

Page 20, Paragraph 1 – bullets; There is to much mixed and inconsistent nomenclature in this document. There is no Basal Chadron Production Zone, but rather only the Basal Chadron Sandstone. If you want an abbreviation for this, then use a callout such as BCSS. Also, there is no value in now lumping all water bearing units overlying the Basal Chadron Sandstone as "overlying aquifers". Spell out what these units are so that the reader can follow what water bearing zones you are specifically identifying as being isolated from the Basal Chadron Sandstone.

Again, the same applies in Paragraph 3. The generalities of talking about the "production zone" does not fit with the specific stratigraphic identification that has been included to this point in the document. Also, you are talking about rocks here, so the use of the word "sands" is not appropriate. Use either "sandstone" or "aquifer" to make the intended points. The above comments apply to the remainder of this section. It should be completely rewritten to remove the nomenclature issues.

Page 21: Paragraph 2; As stated in the first paragraph for the review of this section of the document, the "North Trend Hydrologic Testing Report" as referenced in this paragraph was never provided to the NDEQ for review or approval. Therefore results claimed within this section of the document and referenced from that report cannot be substantiated. Given that the fundamental aquifer characterization data is missing, Section 4.4 of the document cannot be adequately reviewed at this time. However a few comments can be provided:

Page 21: Section 4.4, Paragraph 3; Please specify on Table 7 the wells from which these data were collected, and from what time period. If the data is collected from multiple, but temporally disconnected time periods, then clearly display that information.

Page 21; Paragraph 4: CBR states that the water bearing zone within the Brule is likely dissected, and is in communication with the White River. Given that this one possible, but important interpretation, wouldn't it be appropriate to provide monitoring data from the White River and from wells set into the Brule aquifer adjacent to sampling locations in the White River? This could be especially important information with regards to future potential failure of injection or production wells through the Brule that may result in communication with surface water. The exact nature of the relationship between groundwater and surface water within the proposed exemption area should be established as part of the exemption process.

Page 22, Paragraph 1; CBR states that the upper contact of the Basal Chadron Sandstone dip to the east, and is concurrent with an easterly groundwater gradient direction within this unit. However data presented in this document contradicts this interpretation, and Figures 10a-d show that both basal and upper surfaces of the Basal Chadron Sandstone dip to the north and west, especially in

close proximity to the Crawford/White River Structure. As a side question related to this paragraph, are there any studies that show the change in water quality from what is believed to be the "recharge area" to that of the ore bodies? Is there any sense of transport timing from the recharge area to the mining area?

Page 22: Paragraph 2; CBR states that no hydraulic communication has been identified between the Basal Chadron Sandstone and the White River. Has CBR conducted any surface water monitoring during any aquifer testing programs to verify this statement? What has CBR done to "identify" this possible connection?

Further, CBR states that a monocline or fold is present within the Pierre, Chadron and Brule. There is no clear evidence presented in this document to support this statement. In fact, as previously identified elsewhere in this review, there appears to be more evidence of architectural elements of basin infilling such that by Brule time, contacts entering the basin are relatively flat and uniform, and thus unaffected by folding. Evidence for deeper structural expression is evident at the top of the Pierre and within the Basal Chadron Sandstone but above that unit, structural expression appears subdued, and basin fill architecture may predominate. The statement that groundwater flow does not appear to be defined by the Crawford/White River Structure is not supported. Data needs to be collected on top of, and immediately adjacent to the structure, as well as spatially removed from the structure so that groundwater flow in this region can be appropriately defined. It is not appropriate to wait to collect this information after the aquifer exemption, but rather these data should be part of the aquifer exemption petition. For instance, one contradiction to the current interpretation would be the presence of the artesian wells north of the Crawford/White River Structure. As an example, one possible hypothesis for the explanation of artesian wells to the north would be the large elevation change in the Basal Chadron to the north of the structure coupled with land surface elevation decrease to the north of the structure. Thus, if the potentiometric surface from the existing mine site south of the structure to the NTEA north of the structure are truly connected, then the potentiometric surface across this 400 ft structural divide would provide the head required for artesian flow to the north.

Clearly, as stated elsewhere in this review, this is an area that lacks appropriate site specific data collection. More detailed data will be required to be collected in the vicinity of the Crawford/White River structure to verify hypotheses that are being used to justify the proposed aquifer exemption before the aquifer exemption petition can be appropriately reviewed.

Page 23: Section 4.6 – Lateral and Vertical Extent of the Exempt Aquifer; CBR states that the "Upper/Middle Chadron Sand" should be included in the aquifer exemption, even though it is part of the confining unit, because possible uranium reserves may be present within the "Upper/Middle Chadron Sand". CBR has presented no evidence to support this statement. There have been no reported ore grade uranium discoveries within the "Upper/Middle Chadron Sand" and

therefore this premise is wholly unsubstantiated. Unless CBR can show that ore grade deposits exist within this unit within the proposed exemption area, it may not be included in the exemption.

Page 24: Paragraph 3; CBR states that "*In some areas, limited alternative supplies of stock water are provided by the underlying Basal Chadron Sandstone*". This being the case, where are these wells specifically located? Are they shown on any figures included with the document? If so, this is not immediately obvious and should be called out in this text. If these locations are not included, a new figure should be provided showing these locations.

Page 24: Paragraph 5; As mentioned previously in this review, it is unclear where the groundwater summary data was collected. Where is the specific name and location data for these wells? Where are the specific analytical results? The wells used for this summary should be shown on a figure, and the historic data for each well should be provided in tabular form to support the summary.

Page 25: Paragraph 2; As indicated in this text, well 61 shown in Appendix A is used for domestic as well as agricultural purposes. This well , while outside the proposed exemption boundary, will end up being located between two active uranium mining areas. What is the extraction rate from this well? Can another source of domestic water be supplied to this user? Some Basal Chadron wells are located in close proximity to the proposed exemption boundary. What are the historic extraction rates for these wells? How will CBR ensure that these well users will not increase flow rates during mining activities and thus effect the distribution of liberated uranium? What procedures will CBR have in place to be able to monitor flow rates from these wells so that hydraulic adjustments can be made to ensure containment of mining fluids? What are the "RC" wells, and why are they not in use? Are there plans to utilize these wells in the future? What about the location of a Chadron Well in the Crawford cemetery? This well is missing from the data shown, but the well does exist and is reported to be roughly 700 feet deep.

Page 26: Section 5.1; CBR states that there is no domestic use of the Basal Chadron Aquifer within the proposed aquifer exemption boundary. However, in close proximity outside the exemption boundary at least one well is used for domestic purposes, and a number of wells are used for agricultural purposes. This then seems to establish that the groundwater in the vicinity of the NTEA has some beneficial use, and is (or can be) used for domestic purposes. If that is the case, how does the proximity of these beneficial uses affect the argument for exemption?

Page 27: Section 5.2; CBR indicates that within the proposed exemption boundary, the criteria for exemption under Title 122, Chapter 5, Section 004.02A and 004.02C are satisfied, and therefore the exemption should be granted. Title 122, Ch 5, Sec 004 states that "*An aquifer or a portion of an aquifer which meets*

the criteria for an underground source of drinking water may be designated as an exempted aquifer if the following criteria are met: 004.01: It does not currently serve as a source of drinking water; and 004.02: It cannot now and will not in the future serve as a source of drinking water because..." of the conditions listed under 004.02A-D. However, as stated above, if groundwater from the Basal Chadron may be used as a domestic supply in close proximity to the exemption boundary, then it seems that passage of the test under Title 122, Ch 5, 004.01 is questionable. How will CBR address this issue in a public meeting?

This aquifer however is clearly mineral bearing and due to the mineral type, should not likely ever have been used as a domestic source of drinking water without some primary treatment to remove radioactive nuclide concentrations. This then presents an interesting paradox in that the unit has been used as a drinking water source, but is also mineral bearing and thus meets two contradictory criteria covered within the regulations. Is there possibly an overarching solution that can be presented by CBR with regards to domestic water supplies to protect the health and safety of persons in the vicinity of Crawford?

Page 27: Section 5.2.1; Statements in paragraph two of this section have been commented on elsewhere in this review. Again, here as elsewhere, it is not appropriate to rely on data from the CSA to argue sedimentologic or hydrogeologic characteristics for NTEA. Site specific data from NTEA is required to support claims within the exemption petition, and the document needs to stand alone without linkage to the CSA.

The same discussion applies to Section 5.2.2 on page 28. CBR should supply data from monitoring wells spatially distributed within the ore body at NTEA to make this argument. Presenting data from the CSA is not appropriate for the exemption petition. Data presented to support the argument that wellhead treatment for the removal of radioactive nuclide concentrations is nonspecific and it is not apparent from the discussion presented that costs for such technology would be prohibitive. Costs for wellhead treatment specific to Crawford area residents should be provided for review as part of the exemption petition.

Page 30: Conclusions; As stated in this review, many arguments presented in this document are not derived from site specific data. Therefore any conclusions drawn from these data for the NTEA may be flawed. Site specific data needs to be collected to support conclusions that advocate acceptance of the aquifer exemption petition.

General Comments on Figures and Tables: 1) All cross-sections would be better presented on large format 36 x 48 drawings. This would allow log traces and scales to be readable, and interpretations to be better visualized; 2) Labeling of borehole or well locations can be improved such that they are readable. This is particularly true with regards to the coincidence of holes with boundary lines, or

the proximity to other well/borehole locations. Leader lines might help in these instances. 3) Well location 114 on Figure 18 is shown as a Chadron well, yet it is listed in Appendix A as a Brule well. Which is it?; 4) Table 1 should be corrected to show the correct Pennsylvanian-Permian boundary. See Sawin et al., 2006 in Current Research, Kansas Geological Survey; 5) Table 3 should be corrected to show the most up-to-date nomenclature for the area; 6) Table 9 and 9a should have legends explaining units utilized, or a master legend should be supplied at the beginning of the "Tables" section detailing all units utilized on all tables; 7) Appendix A should include the quarter/quarter, section, township, and range location for each well; whether the well is registered or unregistered; well construction details including seal locations, gravel packs, casing and screen intervals; wells should be double checked for accuracy of formation location and depth and operational status, as some locations appear to be incorrect.

While NDEQ appreciates CBR's efforts to date, the current document is inadequate for public notice. Detailed comments are provided on the accompanying pages that highlight specific questions or noted deficiencies in the data provided to date. We trust that our review of the information provided will be helpful in your future efforts to secure an aquifer exemption for your mine expansion efforts. If you have any questions, or require additional information please feel free to contact me at your convenience at 402-471-4290.

Sincerely,

Dr. Steven A. Fischbein, P.G.
Program Manager
Underground Injection Control – Mineral Exploration
Water Quality Division – Ground Water Unit

cc.

Dr. Jim Stokey – CBR: Cover letter w/enclosure
Mr. Wade Beins – CBR: Cover letter w/enclosure
Professor Jim Swinehart – UNL-CSD: Cover letter w/enclosure
Mr. Stephen Cohen – NRC: Cover letter w/enclosure
Mr. Dave Carlson – NDEQ: Cover letter w/enclosure
Mr. Mike Linder – NDEQ: Cover letter
Mr. Dave Miesbach – NDEQ Cover letter