UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 40-8943-MLA2
CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 13-926-01-MLA-BD01
(Marsland Expansion Area)	)	

NRC STAFF'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW

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I. INTRODUCTION

1.1. The Atomic Safety and Licensing Board (ASLB) issues this Initial Decision on Contention 2, the sole admitted contention in this 10 C.F.R. Part 2, Subpart L proceeding. In this contention, the Oglala Sioux Tribe (OST or Intervenors) challenges the adequacy of the information related to geologic setting and potential impacts on surface water and groundwater in CBR's license amendment application for the Marsland Expansion Area (MEA) and the NRC Staff's final Environmental Assessment (EA) for the MEA.

1.2. After considering all relevant evidence in the record, we resolve Contention 2 in favor of the Staff and CBR. In doing so, we affirm that CBR has met its burden of demonstrating that, with respect to the issues raised in Contention 2, the MEA application complies with the Atomic Energy Act of 1954, as amended (AEA), and applicable NRC regulations in 10 C.F.R. Part 40. Likewise, we affirm that, with respect to the issues raised in Contention 2, the Staff has met its burden of demonstrating that the EA complies with the dictates of the National Environmental Policy Act (NEPA) and applicable NRC regulations in 10 C.F.R. Part 51.

II. BACKGROUND

A. The Proposed Action

2.1. CBR holds NRC source materials license SUA-1534, which authorizes operation of an existing in-situ uranium recovery (ISR) facility in Dawes County, Nebraska.[1] On May 16, 2012, CBR submitted an application requesting a license amendment to authorize construction and operation of an ISR expansion facility at the MEA, which is located approximately 11 miles southeast of the existing CBR facility.[2]

2.2. At the MEA, CBR intends to construct 11 mine units (MUs), also referred to as wellfields, along with the infrastructure necessary to recover uranium using the ISR process.[3] This infrastructure includes injection and recovery wells, monitoring wells, roads, buried pipelines, and a satellite building to house ion exchange and water treatment equipment.[4] CBR's proposed activities at the MEA include construction, ISR operations, groundwater restoration, and, ultimately, decommissioning.[5]

2.3. CBR's proposed uranium recovery method at the MEA will be similar to the method used at the existing CBR facility. The method involves injecting lixiviant—a solution containing groundwater, sodium bicarbonate, and an oxidant such as hydrogen peroxide or oxygen—into an underground aquifer (production zone) containing uranium deposits.[6] As lixiviant is pumped through the ore body, the uranium dissolves into the lixiviant. The uranium-bearing lixiviant is then pumped back to the surface, where the uranium is separated from the

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[1] Ex. NRC009.

[2] "License No. SUA-1534, Docket Number 40-8943, Marsland Expansion Area License Amendment Application" (ADAMS Package No. ML121600598) (May 16, 2012).

[3] Ex. NRC006 at 2-5; Ex. CBR006 at 1-6.

[4] Ex. NRC006 at 2-5; Ex. CBR006 at 1-5, 2-82, 3-1, 3-29.

[5] Ex. NRC006 at 2-5.

[6] Ex. NRC006 at 2-1 to 2-2; Ex. NRC008 at 16.

lixiviant using an ion exchange process. The remaining lixiviant is recharged with chemicals as necessary and re-injected into the production zone to repeat the cycle.[7]

2.4 Loaded ion exchange resin from the MEA will be transported by truck to the central processing facility (CPF) at the existing CBR facility for further processing into yellowcake.[8]

B. <u>CBR's Application</u>

2.5. The MEA application consists of a Technical Report (TR)[9] and an Environmental Report (ER).[10] The TR provided technical information to show that CBR meets applicable NRC safety requirements that apply to the construction and operation of the MEA. The safety requirements applicable to the MEA application are found in 10 C.F.R. Parts 20 and 40. The ER, which is required by NRC regulations in 10 C.F.R. Part 51, provided information on the affected environment as well as a description of the anticipated environmental impacts of the proposed MEA. The information in the ER informed the Staff's independent environmental review of the MEA application and thereby assisted the Staff in meeting the requirements of the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. §§ 4321 *et seq.*

2.6. Over the course of the Staff's review, CBR submitted several updates to both the TR and ER.[11] These updates addressed safety and environmental issues raised during the Staff's review, including responses to the Staff's requests for additional information (RAIs) on safety and environmental issues.

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[7] Ex. NRC006 at 2-1 to 2-2, 2-7 to 2-8.

[8] *Id*. at 2-8.

[9] Exs. CBR006-CBR009 contain the main text, references, figures, and tables from the TR. The TR also contained numerous appendices. Exs. CBR010 to CBR020, CBR028, and CBR030 to CBR032 are TR appendices relevant to Contention 2.

[10] Ex. CBR005-R contains the text, tables, figures and references from the ER, based on the compiled version of the ER prepared by the Staff in October 2017. Ex. NRC001 at 4.

[11] *See* Ex. NRC001 at 4.

C. The Staff's Safety Review

2.7. The Staff reviewed the MEA application to determine whether CBR had demonstrated that it will comply with the applicable regulatory requirements in 10 C.F.R. Parts 20 and 40. The Staff followed the guidance in NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," in performing its review.

2.8. After evaluating the MEA application, as updated, the Staff found that CBR met the applicable safety regulations for granting the requested license amendment. The Staff documented its safety findings in a Safety Evaluation Report (SER) for the MEA, which was issued in January 2018.[12]

D. The Staff's Environmental Review

2.9. In accordance with NEPA and the NRC's NEPA implementing regulations in 10 C.F.R. Part 51, the Staff conducted an environmental review of the MEA application to evaluate the potential environmental impacts associated with construction, ISR operations, groundwater restoration, and decommissioning of the MEA.

2.10. On June 30, 2014, the Staff placed the draft cultural resources sections of the EA, along with relevant supporting documents, on the NRC website, and provided a 30-day period for public review and comment.[13]

2.11. On December 15, 2017, the Staff published a notice of availability of its draft EA and draft finding of no significant impact (FONSI) in the *Federal Register* and provided an opportunity for public review and comment.[14]

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[12] Safety Evaluation Report for Marsland Expansion Area, Dawes County, Nebraska, Materials License No. SUA-1534 (January 2018).

[13] Letter from Marcia J. Simon, NRC Staff Counsel, to Licensing Board (June 30, 2014).

[14] "Draft Environmental Assessment and Draft Finding of No Significant Impact; Notice of Availability and Request for Comments," 82 Fed. Reg. 59,665, 59,666 (Dec. 15, 2017)

2.12. On May 3, 2018, the Staff issued the final EA and FONSI for the MEA.[15] The final EA contains updated information on the affected environment and the Staff's analysis of environmental impacts, as well as an appendix containing the Staff's responses to public comments received on the draft EA.

E. Issuance of the License Amendment

2.13. On May 23, 2018, pursuant to 10 C.F.R. § 2.1202(a), the Staff issued Amendment 3 to CBR's license SUA-1534.[16] In addition to the previously granted authority to possess and use source and byproduct material at the existing CBR facility, Amendment 3 authorizes CBR to construct and operate the MEA.[17] The amended license contains a number of license conditions related to both facilities, including some that are specific to the MEA.

III. PROCEDURAL HISTORY

3.1. On November 30, 2012, the Staff published a notice in the *Federal Register* offering the opportunity to request a hearing in the MEA license amendment proceeding.[18] On January 29, 2013, the OST filed a petition to intervene and request for a hearing containing six contentions.[19] On the same date, a group of individuals and organizations, collectively referred

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[15] "Environmental Assessment and Finding of No Significant Impact; Issuance," 83 Fed. Reg. 19,576 (May 3, 2018) (Ex. NRC007).

[16] Ex. NRC009.

[17] *Id.* at PDF 3.

[18] "Crow Butte Resources, Inc. License SUA-1534, License Amendment To Construct and Operate Marsland Expansion Area," 77 Fed. Reg. 71,454 (Nov. 30, 2012).

[19] Petition to Intervene and Request for Hearing of the Oglala Sioux Tribe (January 29, 2013) (OST Petition).

to as Consolidated Petitioners (CP), also filed a petition to intervene and request for a hearing containing 15 contentions.[20]

3.2. On May 10, 2013, we issued a decision granting the OST's petition and admitting two of the OST's contentions.[21] We denied the CP's petition after determining that none of the individuals or organizations comprising CP had demonstrated standing to intervene.[22] On appeal, the Commission affirmed our decision to admit the OST's contentions.[23]

3.3 Contention 2, as admitted by the Board, challenged the sufficiency of information in the MEA application regarding the geological setting of the area and the information needed to establish potential effects of the project on adjacent surface water and groundwater resources.[24] Contention 2 asserted failures to comply with NEPA, certain regulations in 10 C.F.R. Parts 40 and 51, and guidance in Sections 2.6 and 2.7 of NUREG-1569.[25] We consider Contention 2 to be a "hybrid" contention asserting both safety and environmental concerns regarding the adequacy of hydrogeological characterization of the MEA.[26]

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[20] Consolidated Request for Hearing and Petition for Leave to Intervene (January 29, 2018).

[21] *Crow Butte Resources, Inc*. (Marsland Expansion Area), LBP-13-6, 77 NRC 253, 304-05 (2013). Contention 1, as admitted by the Board and affirmed by the Commission, challenged the ER's description of the affected environment and assessment of impacts of the proposed MEA on archaeological, historical, and traditional cultural resources. As noted in ¶ 2.10 *supra*, the NRC made the draft cultural resources sections of the EA available for public comment on June 30, 2014. The OST did not file new or amended contentions on those sections. Subsequently, the Staff filed a motion for summary disposition of Contention 1, and on October 22, 2014, we granted the Staff's motion. Memorandum and Order (Ruling on Motion for Summary Disposition Regarding Oglala Sioux Contention 1) at 2 (October 22, 2014) (unpublished).

[22] *Id*. at 304.

[23] *Crow Butte Resources, Inc.* (Marsland Expansion Area), CLI-14-2, 79 NRC 11, 26 (2014).

[24] *Marsland*, LBP-13-6, 77 NRC at 306.

[25] *Id*.

[26] *Marsland*, LBP-18-3, 88 NRC 13, 21-22 (2018).

3.4. On December 11, 2017, the Staff notified the Board and parties that its draft EA was publicly available in ADAMS.[27] Pursuant to our direction in an April 2017 scheduling order, the deadline for filing a motion to admit new or amended contentions on the draft EA was January 16, 2018.[28] The OST did not move to admit any new or amended contentions, nor did the OST file a statement supporting migration of Contention 2 to the draft EA. On January 26, 2018, the Staff filed a motion to deny migration of Contention 2,[29] and CBR and the OST filed responses to the Staff's motion.[30]

3.5. On March 16, 2018, we issued a decision granting the Staff's motion with respect to Concern 2 and denying the motion with regard to Concerns 1, 3 and 4.[31]

3.6. On May 30, 2018, following the issuance of the Staff's final EA and FONSI, the OST filed a request to migrate Contention 2 to the Staff's final EA and submitted 14 new contentions challenging the final EA.[32] The new contentions asserted inadequacies or omissions in the EA on a variety of topics, including the purpose and need for the MEA, decommissioning, groundwater quantity (consumptive use) impacts, aquifer pumping test analysis methods and assumptions, baseline groundwater characterization, socioeconomic impacts, cultural resources, treaty rights, and environmental justice.[33]

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[27] Letter from Marcia J Simon, NRC Staff Counsel, to Licensing Board (Dec. 11, 2017). As indicated in ¶ 2.12 *supra*, the Staff issued a notice of availability of the draft EA and draft FONSI in the Federal Register on December 15, 2017.

[28] Memorandum and Order (Revised General Schedule), Appendix A (Apr. 20, 2017) (unpublished).

[29] NRC Staff's Motion to Deny Migration of Contention 2 (Jan. 26, 2018).

[30] Crow Butte Response to NRC Staff Motion to Deny Migration of Contention 2 (February 5, 2018); Oglala Sioux Tribe's Response to NRC Staff's Motion to Deny Migration of Contention 2 (February 5, 2018).

[31] *Marsland*, LBP-18-2, 87 NRC 21, 37 (2018).

[32] The Oglala Sioux Tribe's Migrated, Renewed, and New Marsland Expansion Final Environmental Assessment Contentions (May 30, 2018) (OST New Contentions).

[33] *See generally* OST New Contentions.

3.7. On July 20, 2018, we issued a decision ruling on the migration of Contention 2 and the admissibility of the OST's newly proffered contentions.[34] We ruled that, except for Concern 2, OST Contention 2 migrated as a challenge to the final EA.[35] We also ruled that all 14 of the OST's newly proffered contentions were inadmissible.[36] However, although we rejected new contentions E and F, which challenged the methods and assumptions used to analyze the MEA aquifer pumping test, we held that two additional parameters, storativity and transmissivity, fell within the scope of Concern 2.[37]

3.8. As a result of our rulings, the scope of the hearing was limited to those issues that were pled with particularity in Contention 2, which states as follows:

> Contention 2: Failure to Include Adequate Hydrogeological Information to Demonstrate Ability to Contain Fluid Migration
>
> The application and final environmental assessment fail to provide sufficient information regarding the geological setting of the area to meet the requirements of 10 C.F.R. Part 40, Appendix A, Criteria 4(e) and 5G(2); the National Environmental Policy Act; and NUREG-1569 section 2.6. The application and final environmental assessment similarly fail to provide sufficient information to establish potential effects of the project on the adjacent surface water and ground-water resources, as required by NUREG-1569 section 2.7, and the National Environmental Policy Act.[38]

3.9. As we clarified in our prior rulings, we view Contention 2 as raising the four specific concerns listed below:[39]

> Concern 1: the adequacy of the descriptions of the affected environment for establishing the potential effects of the proposed MEA operation on the adjacent surface water and groundwater resources.

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[34] *Marsland*, LBP-18-3, 88 NRC 13 (2018).

[35] *Id.* at 25, 52-53.

[36] *Id*. at 21, 53.

[37] *Id*. at 37-41.

[38] *Id*. at 52-53; Memorandum and Order (Correcting Language of Contention 2 and Associated Concern 2) at 1 (Oct. 25, 2018) (unpublished).

[39] *Marsland*, LBP-18-3, 88 NRC at 53; Memorandum and Order (Correcting Language of Contention 2 and Associated Concern 2) at 1 (Oct. 25, 2018) (unpublished).

Concern 2: exclusively as a safety concern, the absence in the applicant's technical report, in accord with NUREG-1569 section 2.7, of a description of the effective porosity, hydraulic conductivity, and hydraulic gradient of site hydrogeology, along with other information relative to the control and prevention of excursions such as transmissivity and storativity;

Concern 3: the failure to develop, in accord with NUREG-1569 section 2.7, an acceptable conceptual model of site hydrology that is adequately supported by site characterization data so as to demonstrate with scientific confidence that the area hydrogeology, including horizontal and vertical hydraulic conductivity, will result in the confinement of extraction fluids and expected operational and restoration performance;

Concern 4: whether the draft EA contains unsubstantiated assumptions as to the isolation of the aquifers in the ore-bearing zones.

3.10. On August 17, 2018, the parties (Staff, CBR, and the OST) filed direct testimony,[40] supporting exhibits,[41] and Initial Statements of Position.[42]

3.11. On September 5, 2018, the Staff timely filed its rebuttal testimony, additional supporting exhibits, and Rebuttal Statement of Position.[43] CBR and the OST filed their rebuttal testimony, additional supporting exhibits, and Rebuttal Statements of Position on September 7, 2018.[44]

3.12. On September 12, 2018, the Staff filed a motion in limine seeking to exclude several of the Intervenors' exhibits in whole or in part.[45] On September 17, 2018, the OST filed an answer to the Staff's motion.[46] On September 24, 2018, we ruled on the Staff's motion,

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40 Exs. NRC001, CBR001-R, OST003, OST004-R, and OST010.

41 Exs. NRC002-NRC013; Exs. CBR005-CBR032; Exs. OST005-OST009, OST011, OST012.

42 NRC Staff's Initial Statement of Position (Aug. 17, 2018); Crow Butte Resources' Initial Statement of Position (Aug. 17, 2018); Oglala Sioux Tribe's Initial Position Statement (Aug. 17, 2018).

43 Exs. NRC014-NRC017; NRC Staff's Rebuttal Statement of Position (Sept. 5, 2018).

44 Exs. CBR033-CBR039; Crow Butte Resources' Rebuttal Statement of Position (Sept. 7, 2018); Exs. OST013 -OST016; OST Rebuttal Statement (Sept. 7, 2018).

45 NRC Staff's Motion in Limine to Exclude Certain Exhibits Filed by Consolidated Intervenors and the Oglala Sioux Tribe (Sept. 12, 2018) (Staff's Motion in Limine).

46 Oglala Sioux Tribe's Answer to NRC Staff's Motion in Limine (Sept. 17, 2018).

granting in part and denying in part the Staff's request to exclude certain portions of the OST prefiled direct and rebuttal testimony and associated exhibits.[47]

3.13. From October 30 through November 1, 2018, we held an evidentiary hearing in Crawford, Nebraska. At the hearing, we admitted into evidence the prefiled testimony and supporting exhibits of the parties, with the exception of exhibits OST009, OST011, and OST012, which we struck based on our ruling on the Staff's motion in limine. We also admitted Board exhibit BRD001, a joint factual stipulation provided by the parties at our request.[48] During the hearing, the parties' witnesses presented additional testimony on Contention 2.[49]

3.14. On November 19, 2018, the parties filed joint proposed corrections to the transcript for the October 2018 evidentiary hearing.[50] On November 26, 2018, we issued an order adopting final transcript corrections and closing the evidentiary record for the proceeding.[51]

IV. LEGAL STANDARDS

4.1. Contention 2 raises challenges to the MEA application under the Atomic Energy Act of 1954, as amended (AEA)[52] and NEPA,[53] and the NRC regulations and guidance

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[47] Memorandum and Order (Granting in Part and Denying in Part Staff Motion in Limine) (September 24, 2018) (unpublished) (Board Ruling on Motion in Limine). In response to this decision, the OST resubmitted revised exhibits reflecting excluded testimony (Exs. OST004-R, OST014-R, OST015-R, and OST016-R). *Id*. at 19. The OST was also directed to file as Exhibits OST017-OST020 four documents referred to in Ex. OST016-R. *Id*.

[48] Memorandum and Order (Adopting Stipulated Factual Background) at 1-2 (October 15, 2018) (unpublished).

[49] Transcript (Tr.) at 300-1039.

[50] Joint Proposed Transcript Corrections (November 19, 2018).

[51] Memorandum and Order (Adopting Final Transcript Corrections, Providing Final Exhibit List, and Closing Evidentiary Record) (November 26, 2018) (unpublished).

[52] 42 U.S.C. § 2011 *et seq*.

[53] 42 U.S.C. § 4321 *et seq*.

documents implementing the agency's responsibilities pursuant to these Acts.[54] "Together, these statutes and the corresponding agency regulations govern an applicant's and the NRC Staff's roles in considering the safety and environmental effects of a proposed agency [ISR] licensing action under 10 C.F.R. Part 40."[55]

A. AEA Requirements

4.2. The AEA and the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA)[56] authorize the NRC to issue licenses for the possession and use of source material and byproduct material.[57] These statutes require the NRC to license facilities that meet NRC regulatory requirements developed to protect public health and safety from radiological hazards.

4.3. The AEA also provides hearing rights in licensing actions concerning "the granting, suspending, revoking, or amending of any license . . . upon the request of any person whose interest may be affected by the proceeding."[58] These hearing rights attach to the licensing action at issue here: the issuance of an amendment to CBR's source and 11e.(2) byproduct materials license to authorize construction and operation of the MEA.

4.4 The applicable NRC regulatory requirements that ISR facilities must meet are found in 10 C.F.R. Parts 20 and 40. These safety requirements include certain criteria in Appendix A to Part 40, which provides specific standards for operating uranium mills and

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[54] 10 C.F.R. Part 51.

[55] *Powertech USA*, *Inc*. (Dewey-Burdock In Situ Uranium Recovery Facility), LBP-15-16, 81 NRC 618, 636 (2015), *aff'd*, CLI-16-20, 84 NRC 219 (2016).

[56] Uranium Mill Tailings Radiation Control Act of 1978, 42 U.S.C. §§ 2022 *et seq*., 7901 *et seq*.

[57] The NRC regulates Section 11e.(2) byproduct material under 10 C.F.R. Part 40.

[58] 42 U.S.C. § 2239a(1)(a).

disposing of waste material. However, because the CBR facility project is not a conventional uranium mill, not all criteria in Appendix A must be met.[59]

B. NEPA Requirements

4.5. NEPA requires federal agencies to take a "hard look" at the environmental impacts of a proposed action, as well as reasonable alternatives to that action.[60] The purpose of the "hard look" requirement is to "'foster both informed agency decision-making and informed public participation.'"[61] This "hard look" requirement is tempered by a "rule of reason"[62] that requires agencies to address only those impacts that are reasonably foreseeable. Thus, under NEPA's rule of reason, the Staff need not address every environmental effect that could potentially result from the proposed action.[63] Rather, the Staff need only provide "[a] reasonably thorough discussion of the significant aspects of the probable environmental consequences[.]"[64]

4.6. Furthermore, "NEPA gives agencies broad discretion to keep their inquiries within appropriate and manageable boundaries."[65] To this end, "NEPA does not call for

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[59] *See Hydro Resources, Inc.*, CLI-99-22, 50 NRC 3, 9 (1999) ("We agree that those requirements in Part 40, such as many of the provisions in Appendix A, that, by their own terms, apply only to conventional uranium milling activities, cannot sensibly govern ISL mining.").

[60] *See Louisiana Energy Servs., L.P.* (Claiborne Enrichment Center), CLI-98-3, 47 NRC 77, 87-88 (1998).

[61] *Id.* at 88 (quoting *Marsh v. Oregon Natural Resources Council*, 490 U.S. 360, 371 (1989)).

[62] *See, e.g.*, *Long Island Lighting Co.* (Shoreham Nuclear Power Station, Unit 1), ALAB-156, 6 AEC 831, 836 (1973).

[63] *Ground Zero Ctr. For Non-Violent Action v. U.S. Dept. of the Navy*, 383 F.3d 1082, 1089-90 (9th Cir. 2004) (citing *NoGWEN Alliance of Lane County, Inc. v. Aldridge*, 855 F.2d 1380, 1385 (9th Cir. 1988)).

[64] *Trout Unlimited v. Morton*, 509 F.2d 1276, 1283 (9th Cir. 1974); *Warm Springs Dam Task Force v. Gribble*, 621 F.2d 1017, 1026-27 (9th Cir. 1980).

[65] *Ground Zero Ctr. For Non-Violent Action*, 383 F.3d at 1089-90 (citing *NoGWEN Alliance of Lane County,* 855 F.2d at 1385); *see also Southern Nuclear Operating Co.* (Early Site Permit for Vogtle ESP Site), LBP-09-07, 69 NRC 613, 631 (2009) (stating that the Staff "need not address every impact that could possibly result, but rather only those that are reasonably foreseeable or have some likelihood of occurring.").

certainty or precision, but an *estimate* of anticipated (not unduly speculative) impacts."[66] The proper inquiry is not whether an effect is "theoretically possible," but whether it is "reasonably probable that the situation will obtain."[67]

4.7. An environmental review document "is not intended to be 'a research document.'"[68] NEPA does not require the Staff to analyze "every conceivable aspect" of a proposed project.[69] "There is no NEPA requirement to use the best scientific methodology, and NEPA should be construed in the light of reason if it is not to demand virtually infinite study and resources."[70] Although the Staff can always gather more data in a particular area, it "must have some discretion to draw the line and move forward with decisionmaking."[71]

4.8. Additional considerations apply where an EA, rather than an Environmental Impact Statement (EIS), is prepared. Unlike an EIS, which is subject to a number of specified regulatory requirements,[72] there is no "universal formula for what an EA must contain and consider."[73] The NRC's NEPA regulations state that an EA must "identify the proposed action" and include a "brief discussion" of the need for the proposed action, alternatives, the

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[66] *Louisiana Energy Servs., L.P.* (National Enrichment Facility), CLI-05-20, 62 NRC 523, 536 (2005).

[67] *Northern States Power Co.* (Prairie Island Nuclear Generating Plant, Units 1 and 2), ALAB-455, 7 NRC 41, 49 (1978).

[68] *Entergy Nuclear Generation Co.* (Pilgrim Nuclear Power Station), CLI-10-22, 72 NRC 202, 208 (2010) (citing *Town of Winthrop v. FAA*, 533 F.3d 1, 13 (1st Cir. 2008)).

[69] *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340 (2002).

[70] *Entergy Nuclear Generation Co.* (Pilgrim Nuclear Power Station), CLI-10-11, 71 NRC 287, 315 (2010) (citing *Hells Canyon Alliance v. United States Forest Serv.*, 227 F.3d 1170, 1185 (9th Cir. 2000); *Natural Resources Defense Council v. Hodel*, 865 F.2d 288, 294 (D.C. Cir. 1988)) (internal quotation omitted).

[71] *Pilgrim*, CLI-10-11, 71 NRC at 315.

[72] *See, e.g.*, 10 C.F.R. §§ 51.70 and 51.71 (draft EIS), 10 C.F.R. §§ 51.90 and 51.91 (final EIS), 40 C.F.R. §§ 1502.15 and 1502.16 (all EISs).

[73] *Friends of Congaree Swamp v. Fed. Highway Admin.,* 786 F. Supp. 2d 1054, 1062 (D.S.C. 2011).

environmental impacts of the proposed action and alternatives, as appropriate, and a list of agencies and persons consulted and identification of sources used.[74]

4.9. The NRC's NEPA regulations, like those of the Council on Environmental Quality (CEQ), define an EA as follows:[75]

> An EA is a "concise public document" which serves to:
>
> (1) Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact.
>
> (2) Aid an agency's compliance with the Act when no environmental impact statement is necessary.
>
> (3) Facilitate preparation of a statement when one is necessary.

NRC regulations also require that after completing an EA, the Staff will determine whether to prepare an EIS or a FONSI on the proposed action.[76]

4.10. Because of the variety of possible factual variations in NEPA cases, an agency's obligations under NEPA are case-specific. The level of detail required "depends upon the nature and scope of the proposed action."[77] An EA requires less depth of consideration and less detail than an EIS.[78]

4.11. When reviewing an EIS or an EA for compliance with NEPA, a court must "take a holistic view of what the agency has done to assess environmental impact[s]," and must not "flyspeck" the agency's environmental analysis."[79] In the context of NRC proceedings, the

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[74] 10 C.F.R. § 51.30(a).

[75] *Pacific Gas & Electric Co*. (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation), CLI-08-26, 68 NRC 509, 514 and n.27 (2008); *see also* 10 C.F.R. § 51.14.

[76] 10 C.F.R. § 51.31(a).

[77] *California v. Block,* 690 F.2d 753, 761 (9th Cir.1982).

[78] *See Pa'ina Hawaii, L.L.C*., CLI-10-18, 72 NRC 56, 75 (2010).

[79] *See, e.g*., *Fuel Safe Washington v. FERC*, 389 F.3d 1313, 1323 (10th Cir. 2004) (describing the inquiry as "deciding whether claimed deficiencies in a FEIS are merely flyspecks, or are significant enough to

Commission has specifically stated that NRC hearings are not intended to fine-tune, add details or nuances, or edit Staff NEPA documents to meet an intervenor's preferred language or emphasis.[80] Furthermore, "in an NRC adjudication, it is Intervenors' burden to show [the] significance and materiality" of a mistake in the Staff's environmental review document.[81]

4.12. A licensing board may look beyond the face of the Staff's NEPA document and examine the entire administrative record to determine whether "the Staff's underlying review was sufficiently detailed to qualify as 'reasonable' and a 'hard look' under NEPA — even if the Staff's description of that review in the [NEPA document] was not." [82] Thus, "even if an [environmental review document] prepared by the Staff is found to be inadequate in certain respects, the Board's findings, as well as the adjudicatory record, 'become, in effect, part of the [environmental review document].'"[83] This applies whether the document is an EIS or an EA, and regardless of the type of hearing procedures involved.[84]

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defeat the goals of informed decision making and informed public comment") (quotation marks omitted); *Half Moon Bay Fishermans' Mktg. Ass'n v. Carlucci*, 857 F.2d 505, 508 (9th Cir.1988) ("The reviewing court may not 'flyspeck' an EIS.").

[80] *Exelon Generation Co*., LLC (Early Site Permit for Clinton ESP Site), CLI-05-29, 62 NRC 801, 811 (2005) (boards "do not sit to 'flyspeck' environmental documents or to add details or nuances."); *see also System Energy Resources, Inc*. (Early Site Permit for Grand Gulf ESP Site), CLI-05-4, 61 NRC 10, 19 (2005) (internal citations omitted) (editing Staff NEPA documents to meet an intervenor's preferred language or emphasis "is not a function of [the NRC] hearing process," and "boards do not sit to parse and fine-tune" the staff's NEPA documents).

[81] *Clinton ESP*, CLI-05-29, 62 NRC at 811.

[82] *Dominion Nuclear North Anna, LLC* (Early Site Permit for North Anna ESP Site), CLI-07-27, 66 NRC 215, 230 (2007).

[83] *Strata Energy, Inc*. (Ross In Situ Recovery Project), LBP-15-3, 81 NRC 65, 82 (2015), *aff'd*, CLI-16-13, 83 NRC 566 (2016) (citations omitted); *see also Pacific Gas and Electric Co*. (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation), CLI-08-26, 68 NRC 509, 526 (2008) ("Consistent with longstanding NRC practice," an NRC adjudicatory decision "becomes part of the environmental record of decision along with the environmental assessment itself.").

[84] *Pa'ina Hawaii, L.L.C*., Initial Decision (Ruling on Concerned Citizens of Honolulu Amended Environmental Contentions #3, #4, and #5) at 16-18 (August 27, 2009) (unpublished), *aff'd in part and rev'd in part on other grounds*, *Pa'ina Hawaii, L.L.C*., CLI-10-18, 72 NRC 56 (2010).

C. NRC Regulations and Guidance

4.13. The Staff conducted its safety review of the MEA application in accordance with applicable standards in 10 C.F.R. Parts 20 and 40 and consistent with guidance in NUREG-1569.[85] The Staff uses the guidance in NUREG-1569 "to determine whether the proposed activities will be protective of public health and safety and the environment and to fulfill NRC responsibilities under [NEPA]."[86] However, "[r]eview plans are not substitutes for the Commission's regulations, and compliance with a particular standard review plan is not required."[87] Thus, applicants may take approaches to demonstrating compliance that differ from the acceptance criteria in NUREG-1569.[88]

4.14. The Staff conducted its environmental review in accordance with the applicable standards in 10 C.F.R. Part 51 and NUREG-1748.[89] NUREG-1748 provides general procedures for the environmental review of licensing actions regulated by NRC's Office of Nuclear Material Safety and Safeguards (NMSS). In addition, in topic areas such as geology and hydrology, where there is significant overlap between the Staff's safety and environmental reviews, the Staff also uses NUREG-1569 to inform its environmental review.[90]

4.15. Although Staff guidance does not contain binding requirements, it is entitled to special weight in a hearing.[91] The Commission recently reiterated that Staff guidance

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[85] NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications (June 2003) (Ex. NRC010).

[86] Ex. NRC010 at 3.

[87] *Id*. at xviii.

[88] *Id*. at xxiv.

[89] NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs" (August 2003) (Ex. NRC011).

[90] Ex. NRC001 at 7-8.

[91] *See Yankee Atomic Elec. Co*. (Yankee Nuclear Power Station), CLI-05-15, 61 NRC 365, 375 n.26 (2005) ("We recognize, of course, that guidance documents do not have the force and effect of law. Nonetheless, guidance is at least implicitly endorsed by the Commission and therefore is entitled to

documents do not have the force of law, but they are entitled to special weight and should not lightly be set aside in favor of a board's own determination without sufficient justification.[92] In addition, because NUREG-1569 was explicitly endorsed by the Commission, it is to be given weight commensurate with its status as Commission-approved guidance.[93]

D. Scope of Proceeding

4.16. NRC hearings are limited to the scope of the admitted contentions, and if intervenors proffer testimony or evidence outside the scope of the admitted contentions, it should not be considered.[94]

4.17. The scope of an admitted contention is limited to the issues of law and fact pled with particularity in the intervention petition, including its stated bases, unless the contention is satisfactorily amended in accordance with NRC's rules.[95] The Board may not consider matters not in the evidentiary record.[96]

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correspondingly special weight."). *See also Nextera Energy Seabrook, LLC* (Seabrook Station, Unit 1), CLI-12-05, 75 NRC 301, 314 n.78 (2012) (explaining that a Staff-issued NUREG is entitled to special weight); *Private Fuel Storage LLC* (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255, 264 (2001) (same).

[92] *Entergy Nuclear Operations, Inc*. (Indian Point, Units 2 and 3), CLI-15-6, 81 NRC 340, 358-59 and n.85 (2015).

[93] VR-SECY-02-0204, Update of Uranium Recovery Guidance Documents (May 7, 2003).

[94] *See Southern Nuclear Operating Co.* (Early Site Permit for Vogtle ESP Site), CLI-10-5, 71 NRC 90, 100-01 (2010) (agreeing with the Staff that the licensing board properly excluded the intervenors' testimony and exhibits that were outside the scope of the admitted contention).

[95] *Vogtle ESP*, CLI-10-5, 71 NRC at 100.

[96] *See Pacific Gas & Electric Co.* (Diablo Canyon Nuclear Power Plant, Units 1 & 2), ALAB-580, 11 NRC 227, 230 (1980) (stating that "it is a statutory requirement that the adjudicatory decisions of this Commission stand or fall on the basis of the record on which they rest").

E. Burden of Proof

4.18. Generally, an applicant has the burden of proof in a licensing proceeding.[97] For contentions asserting failures to comply with NEPA, however, the burden of proof is on the Staff.[98] Because Contention 2 contains challenges to both the Staff's EA and the MEA application, the Staff bears the burden of proof for the aspects of the contention that question whether the Staff has satisfied its responsibilities under NEPA.[99]

4.19. However, because "the Staff, as a practical matter, relies heavily upon the Applicant's ER in preparing the [environmental review document], should the Applicant become a proponent of a particular challenged position set forth in the [environmental review document], the Applicant, as such a proponent, also has the burden on that matter."[100]

4.20. The standard of proof in this proceeding is preponderance of the evidence.[101] Because NEPA does not require certainty or precision or the use of best methodology, the Staff need not prove, and this Board need not find, that its results are the most accurate or were performed with the best methodology.[102] The Staff's NEPA analysis is deemed adequate

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[97] 10 C.F.R. § 2.325.

[98] *Progress Energy Florida, Inc.* (Levy County Nuclear Power Plant, Units 1 and 2), CLI-10-2, 71 NRC 27, 34 (2010).

[99] *See, e.g.*, *Levy County*, CLI-10-2, 71 NRC at 34.

[100] *Strata Energy, Inc.* (Ross In Situ Recovery Uranium Project), LBP-15-3, 81 NRC 65, 85 (Jan. 23, 2015) (quoting *Louisiana Energy Servs., L.P.* (Claiborne Enrichment Center), LBP-96-25, 44 NRC 331, 339 (1996), *rev'd on other grounds*, *Louisiana Energy Servs., L.P.* (Claiborne Enrichment Center) CLI-97-15, 46 NRC 294 (1997)).

[101] *See Pacific Gas and Electric Co.* (Diablo Canyon Power Plant Independent Spent Fuel Storage Installation), CLI-08-26, 68 NRC 509, 521 (2008) (applying a preponderance of the evidence standard to resolution of an environmental contention).

[102] *See Louisiana Energy Services*, CLI-05-20, 62 NRC at 536 (stating that NEPA does not require certainty or precision); *Pilgrim*, CLI-10-11, 71 NRC at 315 (stating that NEPA does not require use of the best methodology).

unless the Staff "has failed to take a 'hard look' at significant environmental questions – i.e., the Staff has unduly ignored or minimized pertinent environmental effects."[103]

4.21. Finally, in NRC adjudications, it is the Intervenors' burden to show the significance and materiality of mistakes in the Staff's environmental review document.[104] "Boards do not sit to 'flyspeck' environmental documents or to add details or nuances . . . . If the ER (or [environmental review document] on its face comes to grips with all important considerations, nothing more need be done."[105]

V. RULINGS ON LEGAL ISSUES

A. Admission of Exhibits

5.1 As a result of our ruling on the Staff's Motion in Limine, Exhibits OST009, OST011, and OST 012 were excluded from this proceeding and are not part of the evidentiary record.[106]

5.2 At the hearing, OST witness Dr. Kreamer sought to admit an additional exhibit, marked for identification as Exhibit OST021.[107] CBR and the NRC Staff objected to the admission of this exhibit.[108] After considering the objections, we ruled that the exhibit would not be admitted as evidence in the proceeding.[109]

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[103] *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 & 2; Catawba Nuclear Station, Units 1 & 2), CLI-03-17, 58 NRC 419, 431 (2003).

[104] *Clinton ESP*, CLI-05-29, 62 NRC at 811.

[105] *Id.* (quoting *System Energy Resources, Inc.* (early Site Permit for Grand Gulf Site), CLI-05-4, 61 NRC 10, 13 (2005)).

[106] Board Ruling on Motion in Limine at 1 n.1, 11.

[107] Tr. at 857-859, 928-29 (various).

[108] Tr. at 929 (T. Smith), 930-931 (M. Simon).

[109] Tr. at 935 (Bollwerk).

B. Expert Witness Qualifications

5.3. An expert opinion is only admissible if the witness is competent to give an expert opinion and adequately states and explains the factual basis for the expert opinion.[110] An admissible expert opinion must be "based upon sufficient facts or data to be the product of reliable principles and methods that the witness applied to the facts of the case."[111]

5.4. In addition, a party bears the burden of demonstrating that its witness is qualified to serve as an expert.[112] "A witness may qualify as an expert by knowledge, skill, experience, training, or education to testify [i]f scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue."[113]

5.5. In this proceeding, the qualifications of the Staff's and CBR's expert witnesses have not been challenged. We find that the Staff and CBR have demonstrated that each of their witnesses is qualified to serve as an expert on all aspects of Contention 2. Similarly, the qualifications of OST witnesses Dr. Kreamer and Mr. Wireman have not been challenged, and we find that they are qualified to serve as experts on all aspects of Contention 2.

5.6. In its Motion in Limine, the Staff sought to exclude two statements in Dr. LaGarry's rebuttal testimony in which he stated that certain actions were "requirements" of NEPA.[114] We note that the interpretation of NEPA requirements is a legal issue and, as such, is

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110 *Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), LBP-05-4, 61 NRC 71, 81 (2005).

111 *Id.* at 80.

112 *Duke Energy Corp.* (Catawba Nuclear Station, Units 1 and 2), CLI-04-21, 60 NRC 21, 27 (2004).

113 *Id.* at 27-28.

114 Staff's Motion in Limine at 19, citing Ex. OST016-R. Dr. LaGarry's first statement was that his understanding of NEPA is "that all license conditions . . . and related pumping tests to demonstrate confinement must be completed and evaluated before issuance of the license. . . ." Ex. OST016-R at 1. His second statement related to Dr. Kreamer's assertion that CBR selectively excluded aquifer pumping test data: "This suggests cherrypicking or suppression of adverse data, which according to NEPA must be reported." *Id*. at 2.

an inappropriate topic for a fact witness to offer an opinion on. During the hearing we questioned Dr. LaGarry on his knowledge of NEPA and, based on the results of our inquiry and a review of Dr. LaGarry's statement of professional qualifications, we conclude that he is not qualified to opine on such requirements and therefore we do not give any weight to the challenged statements.

5.7 Moreover, during the hearing Dr. LaGarry clarified that his areas of expertise are stratigraphy and paleontology; he is not an expert in hydrology or hydrogeology.[115] We have therefore weighed testimony from Dr. LaGarry concerning hydrology or hydrogeology accordingly.

VI. FINDINGS OF FACT

6.1. We find that the portions of the Staff's final EA that pertain to topics within the scope of Contention 2 are consistent with the requirements of NEPA, and that the portions of the MEA application that pertain to topics within the scope of Contention 2 demonstrate that the MEA application complies with applicable regulatory requirements. Accordingly, for the reasons stated below, we resolve Contention 2 in favor of the Staff and CBR.

6.2. In LBP-13-6, we identified Sections 3.4.3.2 and 3.4.3.3 of the ER as the sections of the application being challenged in this contention.[116] These correspond to Sections 2.7.2.2 and 2.7.2.3 of the TR.[117] In addition, these TR sections refer to discussions of water level measurements and groundwater geochemistry in Sections 2.9.3.2 and 2.9.3.3 of the TR.[118]

[115] *See*, *e.g.*, Tr. at 578 (stating that he is a stratigrapher, not a hydrogeological expert); Tr. at 785 (his training is in stratigraphy and paleontology); Tr. at 1006 (stating that he is not a groundwater geologist); Tr. at 1013 (stating that he is a "field stratigrapher and geologic mapper" and his subdiscipline "centers on surface exposures.").

[116] *Marsland*, LBP-13-6, 77 NRC at 293.

[117] Ex. NRC001 at 5.

[118] *Id*.

6.3. When the OST filed its petition to intervene on January 29, 2013, it provided two documents as support for Contention 2: an opinion written by Dr. Hannan LaGarry ("LaGarry Opinion" or "2013 Opinion") and a 2010 letter from EPA Region 8 to the NRC ("2010 EPA Letter").[119] The 2010 EPA Letter was not submitted as an exhibit for the MEA evidentiary hearing and was not referenced by any OST witness in either prefiled or oral testimony. Accordingly, we attach no evidentiary value to the 2010 EPA Letter in this decision.

6.4. The OST filed the LaGarry Opinion from 2013, with no substantive changes to the original version, as Dr. LaGarry's initial testimony in the evidentiary hearing.[120] Because the substantive information in that document was written well before the issuance of the Staff's draft and final EAs, we recognize that it does not address the Staff's analyses in the draft or final EA.

6.5. In Contention 2, the OST asserts that the MEA application fails to meet requirements in 10 C.F.R. Part 40, Appendix A, Criteria 4(e) and 5G(2). The Staff has testified that these criteria are not applicable to either the environmental or safety reviews of the MEA. Criterion 4(e) is not applicable because CBR did not propose any surface impoundments for the MEA, and, in any event, there is no evidence of capable faults in the vicinity of the MEA.[121] Criterion 5G(2) is not applicable because it addresses requirements for tailings disposal systems, and such systems are only used at conventional uranium mills, not ISR facilities such as the MEA.[122] The OST witnesses did not contest this testimony, nor did they provide any evidence to the contrary. We therefore find that these regulations are inapplicable to the MEA.

6.6. The OST also asserts that the application fails to meet "requirements" found in Sections 2.6 and 2.7 of NUREG-1569. As discussed in ¶ 4.13 above (Section IV.B),

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[119] OST Petition at 17.

[120] Ex. OST010. The admitted exhibit differs from the originally filed LaGarry Opinion solely in that it contains updated information on Dr. LaGarry's professional background and activities.

[121] Ex. NRC001 at 8.

[122] *Id.*

compliance with NUREG-1569 is not required, and applicants may propose different approaches than those stated in the acceptance criteria in NUREG-1569. In any event, as explained below in our detailed findings on the OST's specific concerns, we find that the Staff and CBR have demonstrated that the EA and the MEA application comport with the guidance in NUREG-1569 and applicable regulations.

6.7. In sections 2.3.1 and 2.4.1 of the SER, the Staff stated that the applicable regulatory requirement governing its reviews of geology and hydrology for the MEA is 10 C.F.R. § 40.41(c).[123] That regulation addresses the ability to maintain control of ISR production fluids by requiring a licensee to "confine [its] possession and use of source or byproduct material to the locations and purposes authorized in the license."

A. <u>Concern 1 – Information to Establish Potential Effects</u>

6.8. In LBP-18-3, we identified Concern 1 as a challenge to the MEA application and the final EA, and defined its scope as follows:

> the adequacy of the descriptions of the affected environment for establishing the potential effects of the proposed MEA operation on the adjacent surface water and groundwater resources.

6.9. NUREG-1748 provides guidance for the Staff's environmental reviews of materials facilities regulated by NMSS, including ISR facilities.[124] According to NUREG-1748, the description of the affected environment in an EA "provides a framework for the discussion of impacts" and should describe current environmental conditions that could be impacted by a proposed action.[125] The Staff testified that Sections 6.3.3 and 6.3.4 of NUREG-1748 contain general guidance on topics related to geology and water resources that should be discussed in an ER, and that the guidance in NUREG-1748 is consistent with the more detailed guidance in

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[123] Ex. NRC008 at 27, 45.

[124] Ex. NRC011 at 1-1.

[125] *Id*. at 3-9.

Sections 2.6 and 2.7 of NUREG-1569 that addresses the same topics.[126] Therefore, we find that the above-referenced sections of both documents are relevant to the Staff's environmental review of the MEA.

6.10. The Staff testified that the information on the affected environment needed to establish potential effects on surface water and groundwater resources includes information on geologic setting, surface water hydrology, and groundwater hydrology.[127] Citing the guidance in Sections 2.6 and 2.7 of NUREG-1569, the Staff identified specific types of information needed within each of those categories.[128] For geologic setting, relevant information includes a description of regional and local stratigraphy, including identification of mineralized zones and confining units; the geology and geochemistry of the mineralized zone and surrounding units; local and regional geologic structures; and a generalized stratigraphic column. For surface water hydrology, relevant information includes the location, type, size, characteristics, and use of surface water features; the potential for erosion and flooding; and surface water quality. And finally, for groundwater hydrology, relevant information includes a description of hydrostratigraphy, the hydraulic properties of aquifers and aquitards, and subsurface water quality and use. The OST witnesses did not contest the Staff's description of the scope of information needed to establish potential impacts. We find that the Staff's description is an appropriate standard for determining whether sufficient information was provided.

6.11. Sections 3.2 (geology), 3.3.1 and 3.11.3 (surface water hydrology), and 3.3.2, 3.3.3, and 3.11.2 (groundwater hydrology) of the EA provide the information on affected environment related to geology and water resources.[129] The Staff testified that these

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[126] Ex. NRC001 at 7, 13-14.

[127] *Id*. at 13.

[128] *Id*. at 6-7, 13-14.

[129] *Id*. at 9-10, 14-16; *see generally* Ex. NRC006 at 3-5 to 3-14, 3-18 to 3-36, 3-70 to 3-72.

subsections address all of the topic areas needed to establish potential impacts.[130] The Staff also testified that the discussions in the EA are based on the Staff's independent review of the descriptions and supporting data in the MEA application, which in turn are based on CBR's review of relevant literature and the results of CBR's field investigations.[131]

6.12 The Staff testified that the information provided in the MEA application covers the applicable topic areas in Sections 6.3.3 and 6.3.4 of NUREG-1748 and is consistent with the guidance in Sections 2.6 and 2.7 of NUREG-1569.[132] In its initial testimony, CBR identified, for each acceptance criterion in NUREG-1569 Sections 2.6 and 2.7, the sections of the ER and TR in which the information related to the acceptance criterion is provided.[133]

6.13. In Sections 2.3.3 of the SER, the Staff found that the TR presented a thorough evaluation of the geologic setting for the MEA and met the acceptance criteria in Section 2.6.3 of NUREG-1569.[134] Similarly, in Section 2.4.3 of the SER, the Staff found that CBR thoroughly characterized the surface water and groundwater hydrology for the MEA and met the acceptance criteria in Section 2.7.3 of NUREG-1569.[135]

6.14. OST witnesses Mr. Wireman and Dr. LaGarry asserted in their testimony that there were several deficiencies in the descriptions of information on geologic setting and hydrology provided in the EA and TR. We address those concerns in the subsections below.

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[130] Ex. NRC001 at 9, 14.

[131] *Id*. at 10-11, 16-17.

[132] *Id*. at 11, 17.

[133] Ex. CBR001-R at 15-23.

[134] Ex. NRC001 at 11-12, citing Ex. NRC008 at 28-38.

[135] Ex. NRC001 at 17-18, citing Ex. NRC008 at 45-57.

1. Groundwater Flow

6.15. In his prefiled testimony, Mr. Wireman asserted that the EA and TR contained inadequate discussion of recharge to or discharge from the Basal Chadron Sandstone (BCS) aquifer.[136] At the hearing, he stated that his ultimate concern is related to potential downgradient contamination after ISR operations are complete, given the difficulty in reaching background levels during restoration.[137]

6.16. In response, the Staff testified that, as discussed in Section 3.3.2.1 of the EA, recharge to the BCS aquifer occurs west or southwest of the MEA, and discharge occurs where the unit is exposed north of Crawford.[138] Figure 3-8 of the EA (identical to Ex. CBR021) contains a conceptual diagram of the flow within the BCS aquifer, including areas of recharge and discharge.[139] Referring to the same diagram, CBR testified that recharge areas occur at significant distances south and west of the MEA, and that discharge currently occurs in wells at the existing CBR facility and two flowing wells near Crawford.[140] In addition, CBR indicated that prior to development of the existing CBR facility, discharge occurred north and east of Crawford where the BCS is exposed, and that the BCS aquifer does not discharge to or subcrop in the White River.[141] Both the Staff and CBR testified that the recharge and discharge areas are sufficiently distant that they will not impact the behavior of the BCS aquifer.[142]

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[136] Ex. OST004-R at 2.

[137] Tr. at 612-13 (Wireman).

[138] Ex. NRC014 at 2-3; Ex. NRC006 at 3-27.

[139] Ex. NRC014 at 3; Ex. NRC006 at 3-29.

[140] Ex. CBR033 at 13; Tr. at 608-09 (Lewis). At the hearing, CBR clarified that the references to "Chadron" on page 13 of Ex. CBR033 should have been references to "Crawford." Tr. at 598-99, 685-86 (Lewis).

[141] Ex. CBR033 at 13; Tr. at 608-09 (Lewis).

[142] Ex. NRC014 at 3; Ex. CBR033 at 13.

6.17. Mr. Wireman provided no additional evidence that contradicts the above understanding of recharge and discharge areas. He criticized the conceptual diagram and information provided but did not explain why more precision and more data are needed. Although he expressed concerns about downgradient impacts, he provided no evidence of any downgradient discharge areas close to the MEA that were not considered in the EA or TR.[143] Accordingly, we find that the information on recharge and discharge in the EA and TR was sufficient.

6.18. Mr. Wireman also claimed that there is "significant uncertainty about groundwater flow" in the BCS aquifer downgradient of the MEA. Specifically, he questioned how groundwater flow in the BCS aquifer is unaffected by the Pine Ridge Escarpment, as stated in Section 3.3.2.1 of the EA, given that the EA also states that the escarpment acts as a groundwater divide in the surficial Brule and Arikaree aquifers.[144]

6.19. Mr. Wireman agreed with the Staff and CBR that the direction of groundwater flow in the BCS aquifer is to the north-northwest through the MEA.[145] The Staff testified that the flatness and continuity of the BCS aquifer and overlying formations, as shown in CBR's regional cross sections,[146] supports the conclusion that these formations were deposited without any interruption by uplift at the Pine Ridge Escarpment.[147] CBR's geologist, Mr. Shriver, provided

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[143] Mr. Wireman identified two outcrops of the BCS that are located at significant distances from the MEA. He said he had visited an outcrop at Orella Bridge, northwest of Crawford, and he had been told of another outcrop at Trunk Butte. Tr. at 600. Dr. LaGarry testified that Trunk Butte is approximately 30 miles east-northeast of the MEA. Tr. at 731 (LaGarry).

[144] Ex. OST004-R at 2.

[145] Ex. NRC006 at 3-28; Ex. CBR006 at 2-86; Tr. at 616 (Wireman).

[146] Ex. CBR008 at 87-90 (Figure 2.6-21 to 2.6-24). At the hearing, the Staff specifically discussed cross-section R1-R1' (Figure 2.6-23).

[147] Ex. NRC014 at 4; Tr. at 624-25 (Striz).

similar testimony and concurred with the Staff's explanation.[148] Although Dr. LaGarry disagreed with the Staff and CBR, claiming that their explanation is at odds with other geologic literature,[149] neither he nor Mr. Wireman provided any alternate explanation or evidence to support the OST's position or refute the site-specific characterization.

6.20. We find, based on the evidence of continuity in the regional cross-sections and the undisputed direction of groundwater flow to the northwest, that the Staff's statement that the Pine Ridge Escarpment does not affect groundwater flow in the BCS aquifer is supported by the record evidence.

6.21. As discussed in Section 3.11.2 of the EA and Section 2.9.3.3 of the TR, CBR provided water quality data for four consecutive calendar quarters from BCS monitoring wells located within the MEA.[150] Mr. Wireman asserted that additional upgradient and downgradient monitoring wells were needed in the BCS aquifer to fully evaluate downgradient impacts, particularly the risk to users outside the license area.[151] The Staff testified that additional downgradient monitoring wells are unnecessary for several reasons.[152] First, each mine unit at the MEA will be surrounded by a ring of monitoring wells installed in the BCS aquifer to detect excursions.[153] As required by License Condition (LC) 10.1.3, those wells will be spaced no further than 400 feet apart.[154] Also, as required by LC 11.1.5, CBR will conduct biweekly

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[148] Tr. at 617-19, 625 (Shriver).

[149] Tr. at 625-26. Dr. LaGarry did not provide any specific references to evidence in the record supporting this assertion.

[150] Ex. NRC006 at 3-70 to 3-71; Ex. CBR006 at 2-119. There were 11 monitoring wells sampled in the BCS aquifer. Ex. CBR006 at 2-119.

[151] Ex. OST004-R at 2-3; Tr. at 642 (Wireman).

[152] Ex. NRC014 at 6.

[153] *Id.*

[154] *Id.*; Ex. NRC009 at PDF 10.

sampling and testing of water from those wells to monitor for excursions, and if excursions are detected and confirmed, CBR must take appropriate corrective actions.[155] In addition, as required by LC 10.1.6, CBR must maintain an inward hydraulic gradient within each mine unit during operations and until restoration is completed.[156] The OST did not challenge the adequacy of the proposed excursion monitoring procedures and sampling methods to be used at the MEA.

6.22. In addition, as discussed in Section 3.3.3.2 of the EA and Section 2.2.4 of the TR, CBR conducted a water user survey to identify all private water supply wells used for domestic, agricultural, or livestock within a 2.25-mile area of review for the MEA, and found no active wells completed in the BCS aquifer.[157] The EA also states that the Staff reviewed well logs for irrigation and stock wells within two miles of the MEA license area boundary and did not identify any wells screened in the BCS aquifer.[158] The OST did not provide any evidence of downgradient users of water from the BCS aquifer who were not identified by CBR.

6.23. We find, based on the license condition requirements described above, and the lack of identified users of the BCS aquifer near the MEA, that additional monitoring wells in the BCS aquifer outside of the MEA license area are unnecessary for estimating potential impacts to surface and groundwater resources.

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[155] Ex. NRC009 at PDF 17. Appropriate corrective actions would include, for example, adjusting wellfield extraction and injection rates to draw fluids back into a wellfield. Ex. NRC014 at 6; Tr. at 666 (Striz).

[156] Ex. NRC009 at PDF 11.

[157] Ex. NRC006 at 3-35; Ex. CBR006 at 2-10 to 2-11.

[158] Ex. NRC006 at 3-36.

2. Surface Water Hydrology

6.24. Mr. Wireman asserted that the EA and TR are deficient because they contain "no data/information on surface water hydrology" at the MEA.[159] Specifically, he asserts that two ephemeral streams that traverse the MEA should be sampled "when ephemeral flow is occurring," and that Dooley Spring should be investigated.[160]

6.25. Section 3.3.1 of the EA and Section 2.7.1.1 of the TR state that CBR did not identify any surface water impoundments, lakes or ponds at the MEA, and that there is no recent evidence of persistent stream flow.[161] Section 3.11.3 of the EA explains further that the MEA contains only ephemeral drainages and that a lack of flow has prevented sampling.[162] Section 2.9.7.2 of the TR discusses sediment sampling that was performed at seven locations within the ephemeral drainages, and states that CBR has committed to collecting baseline water samples from these sampling points if water flow becomes available "at any time prior to mining."[163]

6.26. Mr. Wireman argued at the hearing that ephemeral flows should be sampled when water is available.[164] CBR testified that personnel have visited the MEA "on numerous occasions after a rainfall event" but have not been able to capture water.[165] The Staff and CBR reiterated that CBR has committed to collecting samples from the ephemeral drainages if water

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[159] Ex. OST004-R at 3.

[160] Ex. NRC006 at 36.

[161] *Id*. at 3-19; Ex. CBR006 at 2-78.

[162] Ex. NRC006 at 3-72; Ex. NRC014 at 7.

[163] Ex. CBR006 at 2-128.

[164] Tr. at 644 (Wireman).

[165] Tr. at 645 (Pavlick).

flow becomes available.[166] The Staff also reiterated that CBR has sampled the sediment and has committed to additional sampling of sediment, which would contain traces of any contamination in surface water runoff.[167]

6.27. With respect to Dooley Spring, CBR testified that Dooley Spring is not located within the MEA site; it is approximately 1.5 miles west of the MEA boundary.[168] The EA and TR describe Dooley Spring as "dry and revegetated."[169] At the evidentiary hearing, CBR testified that it has never found water on visits to Dooley Spring.[170]

6.28. At the hearing, the Staff testified that NRC guidance recommends sampling of perennial streams, but not ephemeral streams. Therefore, CBR's commitment to sample ephemeral drainages is "over and above" what NRC requires.[171]

6.29. Based on the above evidence, we find that the EA and TR adequately describe surface water features at and near the MEA, including the ephemeral drainages and Dooley Spring. Although not required, CBR has attempted to obtain water samples from Dooley Spring and from the ephemeral drainages after runoff events, and has committed to sample the latter prior to operations, if possible. Furthermore, we find Mr. Wireman's suggestion that the BCS aquifer could be the source of Dooley Spring[172] to be unsubstantiated and highly unlikely given

[166] Tr. at 646 (Lancaster); Tr. at 649 (Pavlick).

[167] Tr. at 647 (Back).

[168] Ex. CBR033 at 15. The location of Dooley Spring is shown in Figures 2.7-4 and 2.7-6 of the TR. Ex. CBR008-R at 94, 96.

[169] Ex. NRC006 at 3-41; Ex. CBR006 at 2-105.

[170] Tr. at 645, 646 (Pavlick).

[171] Tr. at 653 (Striz). Dr. Striz explained that ephemeral flows are not representative of any average water quality, and the NRC requires sampling of perennial streams "where it's representative of base flow and you can get some sort of assessment of what the average water quality is." *Id*.

[172] Tr. at 644-45 (Wireman).

the undisputed stratigraphy and depth of the BCS aquifer in the area.[173] For these reasons, we find that there was no need for additional sampling or investigation of these features to satisfy NEPA or to meet the acceptance criteria in NUREG-1569.

3. Geology

a. Deep Disposal Well Formations

6.30. Mr. Wireman stated in his initial testimony that CBR did not provide information on geologic formations to be used for deep disposal wells (DDWs).[174] Specifically, Mr. Wireman stated that CBR did not identify the formations to be used or their potential status as underground sources of drinking water (USDWs).[175]

6.31. Section 3.3.2.1 of the EA and Section 4.2.1.8 of the TR identify the proposed formations for DDWs as the Lower Dakota, Morrison, and Sundance Formations.[176] As stated in the TR, the proposed formations have been demonstrated to be located below the lowermost USDW and have total dissolved solids exceeding 10,000 mg/L.[177] CBR testified that there are no aquifers that meet the definition of a USDW below the injection zone.[178]

6.32. At the hearing, Mr. Wireman questioned how CBR had determined that the proposed DDW formations were below the lowermost USDW at the MEA.[179] The Staff testified

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[173] *See* Ex. BRD001 at 2, 4-7. In particular, the depth of the BCS at the MEA ranges from 850 to 1200 feet below ground surface. *Id*. at 7.

[174] Ex. OST004-R at 6.

[175] *Id*.

[176] Ex. NRC006 at 3-30; Ex. CBR006 at 4-11.

[177] Ex. CBR006 at 4-11, 7-20. In the Staff's analysis of potential impacts of the DDWs on groundwater quality, discussed in Section 4.3.2.2 of the EA, the Staff reported that the TDS levels in the Morrison and Sundance formations at the existing CBR facility were 24,000 and 40,000 mg/L, respectively. Ex. NRC006 at 4-23.

[178] Tr. at 737 (Pavlick). This information came from CBR's Class I application for the DDWs at Marsland. Tr. at 849 (Pavlick).

[179] Tr. at 709 (Wireman).

that the two DDWs operating at the existing CBR facility 11 miles from the MEA are a good indication.[180] In addition, the DDWs will be operated under the authority of a Class I Underground Injection Control (UIC) permit issued by the Nebraska Department of Environmental Quality (NDEQ).[181] License Condition 10.3.4 requires CBR to obtain and submit to the NRC a copy of its NDEQ permit authorizing construction of the DDWs at the MEA.[182] CBR will not be able to operate the MEA without doing so.[183]

6.33. Based on the above evidence, we find that the EA and TR provide the information Mr. Wireman claimed was missing. The documents identify the proposed geologic formations for the DDWs at the MEA and provide adequate discussion of their characteristics, including USDW status, to establish potential impacts on groundwater resources.

b. Pine Ridge and Niobrara River Faults

6.34. In his written testimony, Mr. Wireman asserted that CBR has not provided sufficient information regarding structural geology at the MEA.[184] Specifically, he claimed that CBR disagrees with previous researchers about the existence of the Pine Ridge and Niobrara River faults, and, as a result, there was no discussion on how these faults affect groundwater flow.[185]

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[180] Tr. at 711 (Striz).

[181] Ex. NRC006 at 4-23.

[182] Ex. NRC009 at PDF 15.

[183] Tr. at 711 (Striz).

[184] Ex. OST004-R at 3.

[185] *Id.*

6.35. CBR testified that, based on its analysis of regional cross sections,[186] there is no evidence of large vertical offsets that could act as a boundary for groundwater flow.[187] The Staff testified that its independent review of CBR's findings, described in Section 3.2.2.2 of the EA,[188] likewise concluded that there is no evidence of vertical offsets indicative of faulting in the MEA.[189] The Staff also testified that CBR's extensive site characterization data, including geophysical logs and structure contour maps, are more relevant and persuasive than interpretations by previous researchers.[190]

6.36. In his initial testimony, Dr. LaGarry stated that "Swinehart and others (1985) show known faults both north and south of Marsland" that "may allow transmission of mining fluids" upward into the High Plains Aquifer and laterally into adjacent areas.[191] Referring to a cross-section reproduced from Swinehart's paper, Dr. LaGarry stated that the faults shown in that figure were large enough to be discovered by Swinehart and his colleagues based on analysis of borehole data.[192]

6.37. Section 3.2.2.2 of the EA discusses the evidence of reported faults near the MEA and their potential impacts on confinement and surface water and groundwater quality.[193] As discussed in Section 3.2.2.2 of the EA, the literature reports two postulated faults near the MEA: the Pine Ridge fault, which is reportedly located along the northern edge of the Pine Ridge

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[186] Ex. CBR008-R.

[187] Ex. CBR033 at 17.

[188] Ex. NRC006 at 3-11 to 3-14.

[189] Ex. NRC014 at 9.

[190] *Id.*

[191] Ex. OST010 at 4. Excerpts from the Swinehart paper are provided in Ex. NRC013.

[192] Ex. OST010 at 4.

[193] Ex. NRC006 at 3-11 to 3-14. Section 2.3.3.2.2 of the SER provides a similar discussion and conclusions related to safe operation of the MEA. Ex. NRC008 at 33-36.

Escarpment, approximately 5 miles north of the northern MEA boundary; and the Niobrara River fault, which is reported to run near the southern margin of the MEA.[194] The EA describes the Staff's independent review of these faults based on available literature (including Swinehart's paper) and information provided by CBR, including CBR's interpretations of the subsurface conditions, CBR's site-specific and regional cross-sections, and CBR's site-specific and regional structure contour maps.[195] Based on its review of this information, the Staff concluded that there is no evidence of vertical offsets indicative of faults within the MEA.[196]

6.38. The Staff testified that Swinehart's study area covers the entire panhandle of Nebraska, which comprises hundreds of square miles, and his cross-sections do not pass through the actual location of the MEA.[197] Therefore, the Staff found Swinehart's large-scale regional interpretations unpersuasive compared with the site-specific cross-sections at the MEA.[198]

6.39. At the hearing, Dr. LaGarry acknowledged that Swinehart's cross-section A-A', the basis for Figure 1 in his testimony, is located approximately 30 miles west of the MEA.[199] After reviewing Swinehart's cross-section B-B', which is closer to the MEA (about 7.5 miles to the east),[200] Dr. LaGarry agreed that the Niobrara River fault does not appear to extend that far.[201] He agreed that the Pine Ridge fault is only inferred at that location, indicating the

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[194] Ex. NRC006 at 3-11.

[195] *Id*. at 3-11 to 3-14.

[196] *Id*. at 3-14.

[197] Ex. NRC001 at 35; Ex. NRC012 at PDF 3-4.

[198] Ex. NRC001 at 37.

[199] Tr. at 826.

[200] Ex. NRC012 at PDF 3-4.

[201] Tr. at 832 (LaGarry).

evidence for its existence is "less clear," and clarified that the reported location of the Pine Ridge fault is not underneath the MEA.[202]

6.40. Based on the evidence discussed above, we find that Dr. LaGarry's Figure 1 does not accurately represent the stratigraphy or presence of faults at the MEA site, and does not support the conclusion that either the Pine Ridge fault or the Niobrara River fault exists at the MEA.

6.41. In Section 3.2.2.2 of the EA, and in its testimony, the Staff listed several reasons why the reported faults near the MEA, even if present, are not problematic. For instance, the Staff estimated that it would take over 500 years for contaminants to reach the location of the Pine Ridge fault (approximately 5 miles from the northern MEA boundary), and during that time contaminants would attenuate through sorption and dilution.[203] In addition, groundwater flow in the BCS aquifer is to the northwest, away from the reported Niobrara River fault, and the inward hydraulic gradient required to be maintained during operations would prevent groundwater flow toward either the Pine Ridge fault or the Niobrara River fault. Finally, the strong downward gradient at the MEA (resulting from the elevation difference between the potentiometric surfaces of the BCS and Brule aquifers) would prevent upward migration of contaminants.[204]

6.42. We find, based on the evidence discussed above, that the Staff and CBR have adequately described and evaluated the two reported faults near the MEA. Both the EA and TR assessed the work of previous researchers, including the Swinehart work cited by Dr. LaGarry, and considered it alongside CBR's site-specific and regional cross-sections to reach reasoned conclusions about the existence of the two faults. In the EA, the Staff also discussed the

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[202] Tr. at 834, 836 (LaGarry).

[203] Ex. NRC006 at 3-14.

[204] Ex. NRC001 at 33. As discussed in Section VI.C.3.c *infra*, OST witnesses Mr. Wireman and Dr. Kreamer do not dispute the presence of the downward gradient.

potential effects of the faults, should they prove to exist, and explained why they would not significantly affect nearby water resources. Mr. Wireman did not provide any evidence to support his claims or to refute CBR's or the Staff's conclusions, but instead deferred to Dr. LaGarry, who conceded that Swinehart's work does not provide evidence of a Niobrara River fault near the MEA, and that the Pine Ridge fault is not underneath the MEA site.[205]

4. Groundwater Restoration

a. No Data on Background Concentrations

6.43. Citing the discussion in the TR describing "baseline restoration wells," Mr. Wireman asserted in his initial testimony that these wells have not been selected and "no data is provided regarding background concentrations for applicable constituents."[206]

6.44. Before injecting lixiviant in a mine unit, LC 11.1.3 requires CBR to establish background water quality data for the ore zone and overlying aquifers.[207] These data are used to define background groundwater protection standards under 10 C.F.R. Part 40, Appendix A, Criterion 5B(5).[208] The Staff and CBR testified that installation and testing of production, injection and monitoring wells used for this purpose can only occur after the site is licensed and a wellfield is constructed.[209]

6.45. At the evidentiary hearing, Mr. Wireman contended that once mining operations begin, any subsequent evaluation of water quality "is not baseline," and that, therefore, baseline concentrations must be evaluated before any mining takes place.[210] He claimed that water from

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[205] Tr. at 669, 733 (Wireman); Tr. at 832, 834, 836 (LaGarry).

[206] Ex. OST004-R at 3.

[207] Ex. NRC009 at PDF 16.

[208] *Id*.

[209] Ex. NRC014 at 11; Tr. at 655 (Nelson).

[210] Tr. at 661-662 (Wireman).

mine units impacted by ISR operations could move downgradient into an undeveloped mine unit, altering the chemistry from the original "baseline."[211] In response, the Staff testified that the license conditions requiring an inward hydraulic gradient and excursion monitoring will prevent contaminants from reaching other mine units in the way Mr. Wireman described.[212]

6.46. In the recent *Strata* decision, the licensing board in that proceeding distinguished between the establishment of background groundwater quality standards for restoration and the pre-licensing monitoring required under Criterion 7 of 10 C.F.R. Part 40, Appendix A, which requires an applicant to provide "complete baseline data" on an ISR site and its environs.[213] Consistent with that board's decision and Commission precedent, we find that the post-licensing establishment of groundwater protection standards for the MEA, as described in LC 11.1.3, is consistent with industry practice and NRC methodology, and does not violate NEPA. The OST did not challenge the adequacy of CBR's baseline data or data collection methods for the pre-licensing monitoring required under Criterion 7.

b. Applicable Groundwater Restoration Standards

6.47. Mr. Wireman also asserted that the TR and EA "are confusing regarding applicable restoration monitoring requirements and compliance standards," because the EA states that Criterion 5B(5) is the applicable standard but the TR cites both Criterion 5B(5) and NDEQ standards.[214] At the hearing, Mr. Wireman clarified that his confusion was whether the

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[211] *Id*. at 662.

[212] Tr. at 658, 666 (Striz). The NRC Staff also testified that in the event that baseline monitoring indicates that concentrations in a particular mine unit are higher than expected, the NRC can adjust the baseline values accordingly. Tr. at 660, 666 (Striz).

[213] *See Strata Energy*, LBP-15-3, 81 NRC at 90-92 (2015). The Commission has stated that, given the sequential nature of development of ISR wellfields, waiting until after licensing, but before operations begin to establish groundwater quality baselines is consistent with industry practice and NRC methodology. *Id*. at 91, citing *Hydro Resources, Inc*. (P.O. Box 777, Crownpoint, New Mexico 87313), CLI-06-1, 63 NRC 1, 6 (2006).

[214] Ex. OST004-R at 5.

NDEQ standards were applicable to CBR and, if so, did NDEQ standards constitute an alternate concentration limit (ACL).[215]

6.48. Section 4.3.2.2 of the EA states that CBR is required to restore groundwater quality in accordance with the standards in 10 C.F.R. Part 40, Appendix A, Criterion 5B(5). For a given hazardous constituent, Criterion 5B(5) requires restoration to the approved background concentration, the maximum concentration limit (MCL) in Table 5C of Part 50, Appendix A (if the constituent is listed in Table 5C and the MCL is higher than the approved background value), or an ACL approved by the Commission.[216]

6.49. At the hearing, CBR testified that it is required to meet both NRC and NDEQ restoration standards. Referring to Table 2.7-5 in the TR, CBR confirmed that the column marked "UMTRCA standards" corresponds to the standards in Table 5C of 10 C.F.R. Part 40, Appendix A, and the other two columns identify NDEQ requirements.[217] Under the dual regulatory scheme, CBR will have to meet the more stringent value for each constituent.[218] Mr. Wireman indicated that he understood and was satisfied knowing that CBR would have to meet UMTRCA standards if they are more stringent than NDEQ standards. .[219]

6.50. The initial goal of restoration is background or the MCL, whichever is higher.[220] If a licensee cannot achieve background or the MCL for a specific constituent after best practicable efforts, it can submit a license amendment request proposing an ACL for that

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[215] Tr. at 687 (Wireman).

[216] Ex. NRC014 at 11-12.

[217] Ex. CBR009 at 75.

[218] Tr. at 691-692 (Pavlick, Nelson). Dr. Striz of the NRC Staff testified that in most cases, the value in Table 5C are more stringent than NDEQ values. Tr. at 693 (Striz).

[219] Tr. at 693 (Wireman).

[220] Tr. at 694 (Pavlick) (CBR is required to start restoration with the goal of meeting background); Tr. at 695, 697 (Striz) (a licensee must meet background or the MCL, whichever is higher; if they cannot meet background for a specific constituent, they can propose an ACL).

constituent that addresses the factors in Criterion 5B(6).[221] If CBR were to propose an ACL for the MEA, it could propose any value that meets the Criterion 5B(6) requirements, including the NDEQ restoration standard for that constituent.[222]

6.51. The Staff explained that for stability monitoring the NRC requires four consecutive quarters of no statistically increasing trends.[223] CBR testified that it will conduct stability monitoring to meet both NRC and NDEQ requirements and confirmed that its description of stability monitoring in the TR is consistent with this requirement.[224]

6.52. Based on the above evidence, we find that the discussion in the EA identified the applicable NRC restoration standards and stability monitoring requirements, and that the TR identified both the NRC and NDEQ standards, consistent with the dual regulatory scheme. We also find that the EA and TR explained the process for requesting an ACL, consistent with NRC regulations.

5. Summary – Information to Establish Potential Effects

6.53. After reviewing all of the evidence discussed above, we find, based on a preponderance of the evidence, that the EA and TR both provide extensive descriptions the affected environment in terms of geology, surface water hydrology and groundwater hydrology at the MEA, and that the information provided is sufficient to establish potential effects on surface water and groundwater resources. We note that the OST has not taken issue with the vast majority of the information describing the affected environment for geology and hydrology in the EA and TR. For the reasons discussed above, we find the concerns the OST raised to be unsupported or immaterial to the Staff's ability to take a hard look at potential impacts as

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221 Tr. at 697 (Striz); Ex. NRC009 at PDF 11.

222 Tr. at 698 (Striz).

223 Tr. at 701 (Striz).

224 Ex. CBR033 at 19; Tr. at 702 (Pavlick).

required by NEPA and to CBR's ability to comply with applicable safety regulations. Accordingly, we resolve this portion of Contention 2 in favor of the Staff and CBR.

B. Concern 2 – Absence of Parameters

6.54. In our previous rulings, we identified Concern 2 as a safety concern challenging the TR, and defined its scope as follows:

> the absence in the applicant's technical report, in accord with NUREG-1569 section 2.7, of a description of the effective porosity, hydraulic conductivity, and hydraulic gradient of site hydrogeology, along with other information relative to the control and prevention of excursions such as transmissivity and storativity.

6.55. In this concern, the OST alleges that a description of certain aquifer parameters is absent from the TR. As we noted in prior rulings, this is an issue involving the omission of information rather than adequacy.[225] The specific parameters alleged to be omitted are effective porosity, hydraulic conductivity, hydraulic gradient, storativity, and transmissivity.

6.56. The parties have stipulated to the following definitions of these terms:[226] effective porosity is the percentage of void space in a rock matrix that is interconnected and allows fluid to flow through it; hydraulic conductivity is a measure of the ability of a porous material to transmit water; hydraulic gradient is the slope of the water table or potentiometric surface; storativity is the volume of water released from storage per unit change in hydraulic head per unit area in a confined aquifer; and transmissivity is the product of hydraulic conductivity and aquifer thickness.

6.57. In its initial testimony, the Staff explained the relevance of these parameters to ISR operations. Transmissivity, hydraulic conductivity, and hydraulic gradient within the production zone aquifer are relevant to selection of ISR wellfield patterns and injection and

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225 *See Marsland*, LBP-18-2, 87 NRC at 35-36; *Marsland*, LBP-18-3, 88 NRC at 22 n.6.

226 Ex. BRD001 at 3-4.

extraction flow rates.[227] They are also important in maintaining an inward hydraulic gradient within a mine unit during ISR operations to prevent excursions of lixiviant outside the mine unit.[228] Effective porosity can be used with hydraulic conductivity and hydraulic gradient to calculate groundwater velocity in a simple flow setting.[229]

6.58. With regard to the OST's claim that these parameters are absent from the TR, we find to the contrary. The hydraulic conductivities of the Upper and Middle Chadron Formations (upper confinement) and the Pierre Shale (lower confinement) are discussed in Section 2.7.2.3 of the TR.[230] The hydraulic conductivity, transmissivity, and storativity of the BCS aquifer were obtained from aquifer pumping test data and presented in Section 2.7.2.2 and Tables 2.7-2 to 2.7-4 of the TR.[231] Hydraulic gradients for the Arikaree, Brule, and BCS aquifers are discussed in Section 2.9.3.2 of the TR and presented in potentiometric contour maps.[232] Finally, CBR identified effective porosity values that were used in various calculations or modeling efforts. For example, CBR used an effective porosity of 0.20 to calculate groundwater velocities in the BCS aquifer.[233]

6.59. The OST witnesses did not provide any initial testimony to support the claim that a discussion of these parameters is absent from the TR, nor did they provide any rebuttal in response to the Staff's specific testimony identifying where such discussions were, in fact, included in the TR. The OST witnesses did not challenge the reported values of hydraulic

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[227] Ex. NRC001 at 20.

[228] *Id*.

[229] *Id*.

[230] Ex. CBR006 at 2-84 to 2-85.

[231] *Id*. at 2-81 to 2-84; Ex. CBR009 at 72-74.

[232] Ex. CBR006 at 2-116 to 2-117; Ex. CBR008-R at 105-116.

[233] Ex. CBR006 at 3-26.

gradient or hydraulic conductivity or the selected values for effective porosity presented in the TR. With regard to transmissivity and storativity, Dr. Kreamer's testimony was primarily focused on using the reported range in values of transmissivity and storativity to challenge the assumptions of homogeneity and isotropy used in the aquifer pumping test.[234] Dr. Kreamer admitted that he did not provide any evidence or analysis showing a difference in the ultimate results for transmissivity and storativity (i.e., differences that would be dramatic enough to change the conclusions about those aquifer parameters).[235]

6.60. Based on the facts adduced above, we find that CBR provided descriptions of effective porosity, hydraulic conductivity, hydraulic gradient, storativity, and transmissivity in the TR, and the OST did not provide any evidence or analysis demonstrating that these parameters are not sufficiently representative of conditions at the site in a manner that would materially alter the ability to operate safely. Accordingly, we resolve this portion of Contention 2 in CBR's favor.

C. <u>Concern 3 – Conceptual Model and Confinement</u>

6.61. In LBP-18-3, we identified Concern 3 as a challenge to the MEA application and the final EA, and defined its scope as follows:

> the failure to develop, in accord with NUREG-1569 section 2.7, an acceptable conceptual model of site hydrology that is adequately supported by site characterization data so as to demonstrate with scientific confidence that the area hydrogeology, including horizontal and vertical hydraulic conductivity, will result in the confinement of extraction fluids and expected operational and restoration performance.

6.62. The parties have stipulated that the lower confining unit, the Pierre Shale, is thick, homogeneous, laterally extensive marine shale with hydraulic conductivity estimated to

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[234] Dr. Kreamer testified that "transmissivities that range from 230 ft^2/day to 1780 ft^2/day and values of storage coefficient from 1.7×10^{-3} to 8.32×10^{-5} are not consistent with homogeneous conditions." Ex. OST003 at 6. We address Dr. Kreamer's concerns with the aquifer pumping test in our discussion of Concern 3 in Section VI.C.2.d and VI.C.3.b *infra*.

[235] Tr. at 400-403 (Kreamer).

range between 10^{-7} and 10^{-12} cm/sec.[236] The parties also acknowledged that during the Crow Butte license renewal proceeding, there was no dispute among the parties that the Pierre Shale served as an adequate lower confining unit.[237] The OST witnesses have not presented any testimony questioning the adequacy of the Pierre Shale as lower confinement for the MEA. Accordingly, we find that the Pierre Shale provides adequate vertical confinement beneath the BCS aquifer at the MEA, and we limit the remaining inquiry regarding demonstration of confinement to the upper confining layers.

6.63. In the discussion below, we first address the information that constitutes the hydrological conceptual models as presented in the EA and TR. We then examine the adequacy of the site characterization data that supports the model. Third, we address the bases for concluding that there is adequate vertical confinement. And finally, we address the potential pathways for contaminant migration to groundwater or surface water resources adjacent to the MEA: spills and leaks, vertical excursions, faults and fractures, and lateral migration.

1. <u>Description of Conceptual Model</u>

6.64. In its initial testimony, the Staff described a conceptual model of site hydrology as consisting of two components: the surface water conceptual model and the groundwater conceptual model. The surface water conceptual model describes “the presence, characteristics, and behavior of regional and local surface water features.”[238] The groundwater conceptual model describes “the presence and behavior of regional and local groundwater aquifers within the geologic setting.”[239]

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[236] Ex. BRD001 at 7.

[237] *Id*. at 8.

[238] Ex. NRC001 at 22.

[239] *Id*.

6.65. More specifically, the Staff testified that the surface water conceptual model includes information about watersheds and drainages, surface water feature types, size, and morphology; peak flow rates; potential for flooding; typical seasonal ranges for surface water levels and water quality; and information on past, present and future use.[240] The groundwater conceptual model includes information about hydrostratigraphy; the hydraulic properties of aquifers and aquitards; aquifer potentiometric surfaces and hydraulic gradients; groundwater flow directions and magnitudes; preferential flow pathways; recharge and discharge areas; water quality; and information on past, current and anticipated groundwater use.[241] The Staff testified that these descriptions of the components of the conceptual model of site hydrology are consistent with guidance in Sections 2.7.1 to 2.7.3 of NUREG-1569.[242]

6.66. Sections 3.3.1 and 3.11.3 of the EA contain information related to the surface water conceptual model for the MEA, and Sections 3.3.2 and 3.11.2 contain information related to the groundwater hydrology conceptual model.[243] The Staff testified that these sections address all of the aspects of a complete conceptual model for the MEA.[244] As discussed in ¶ 6.11 above, the information in these sections of the EA is based on the Staff's independent review of information provided in the MEA application and supporting data.

6.67. None of the OST witnesses challenged the Staff's definition of a conceptual model, or the location of information related to the conceptual model in the EA, in their prefiled testimony.

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[240] Ex. NRC001 at 22.

[241] *Id*. at 22-23.

[242] *Id*. at 23.

[243] *Id*.

[244] *Id*. at 24.

6.68. At the evidentiary hearing, the Staff reiterated that NUREG-1569 describe the components of a site conceptual model.[245] The Staff also distinguished between a numerical model and a conceptual model, stating that "typically a numerical model takes the components of a conceptual model and integrates them into a numerical approach."[246] Dr. Kreamer stated that conceptual models vary depending on purpose, suggesting that ISR operations can depend on simplified models but contaminant hydrology often requires numerical modeling.[247]

6.69. Based on the evidence adduced above, we find that the hydrological conceptual model comprises the elements described in the Staff's testimony, which reflects the guidance in Section 2.7 of NUREG-1569.

6.70. We also note that the key issue in Concern 3 is whether the conceptual model demonstrates "that the area hydrogeology . . . will result in confinement of extraction fluids and expected operational and restoration performance." Given the use of the term "hydrogeology" in this issue statement, we consider this concern to focus on the *groundwater* hydrological conceptual model for the MEA, and the remainder of the discussion in this section will be specific to that conceptual model.

2. <u>Adequacy of Site Characterization Data</u>

6.71. The Staff and CBR testified that the conceptual model, as described in the EA and TR, relied extensively on site characterization data from CBR's subsurface investigation at the MEA.[248] Below, we review the major elements of CBR's site characterization and the OST witnesses' concerns about their adequacy.

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[245] Tr. at 865 (Striz).

[246] Tr. at 864 (Back).

[247] Tr. at 867 (Kreamer).

[248] Ex. NRC001 at 10, 12, 16, 24-25.

a. Stratigraphic information

6.72. As part of the investigation, CBR drilled over 1600 boreholes within the MEA license area and over 2100 boreholes within the surrounding 2.25-mile AOR.[249] Using geophysical logs and drill cutting observations from 57 boreholes, CBR constructed 14 stratigraphic cross-sections that cover the entire MEA site.[250] The locations of the cross-sections were chosen to provide "extensive coverage north to south and east to west across the entire permit area and a very representative view of the data from the boreholes."[251] CBR also provided regional cross-sections showing stratigraphy from south of the Niobrara River north to the existing CBR facility and the North Trend Expansion Area.[252] Dr. LaGarry acknowledged that the cross-sections represent "a tremendous amount of work," and stated he has "no reason to doubt them" and he "accept[s] them at face value."[253]

6.73. CBR also created isopach maps (showing formation thicknesses) and structure contour maps (showing top elevations of formations) based on borehole data.[254] The Intervenors did not provide any testimony or evidence indicating that they object to or take issue with the information provided on these maps.

6.74. Based on the evidence discussed above, we find that CBR's cross-sections, isopach maps, and structure contour maps, are based on reliable data that were obtained using standard techniques.

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[249] Ex. NRC001 at 24; Ex. CBR006 at 3-7; CBR005-R at 3-6.

[250] Ex. NRC001 at 24-25; Ex. CBR006 at 2-42 to 2-49; Ex. CBR008-R at 48-62 (Figures 2.6-2 and 2.6-3a to 2.6-3n).

[251] Tr. at 745-46 (Pavlick); Ex. CBR008-R at 48 (Figure 2.6-2).

[252] Ex. NRC001 at 11; Ex. CBR006 at 2-58 to 2-59; Ex. CBR008-R at 87-90 (Figures 2.6-21 to 2.6-24).

[253] Tr. at 743 (LaGarry).

[254] Ex. NRC001 at 11; Ex. CBR008-R at 72-80 (Figures 2.6-6 to 2.6-14).

b. Chemical and physical properties of stratigraphic units

6.75. CBR provided information on chemical and physical properties of the confining units and the mineralized zone based on drill cuttings and analysis of representative core samples taken from seven locations at the MEA site.[255] Cores were retrieved from the Arikaree, Brule, Upper and Middle Chadron, Basal Chadron Sandstone, and Pierre Shale formations.[256]

6.76. CBR performed grain size analyses and X-ray diffraction to characterize chemical and mineralogical properties, and obtained hydraulic conductivities using estimates from grain size analysis or falling-head permeameter testing.[257] The OST did not provide any testimony indicating they objected to the test methods or results obtained from this characterization of core samples.

6.77. Based on the above evidence, we find that the results of chemical, physical, and mineralogical analysis of core samples, including grain size analyses and hydraulic conductivity determinations, are based on reliable data that were obtained using standard techniques.

c. Potentiometric surfaces and water quality

6.78. CBR measured static water levels in monitoring wells in the Arikaree, Brule, and BCS aquifers to determine the groundwater flow regime at the MEA from vertical and horizontal hydraulic gradients.[258] This information was presented in potentiometric surface maps for each

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[255] Ex. NRC001 at 11; Ex. CBR006 at 2-42; Ex. CBR009 at PDF 64 (Table 2.6-3).

[256] Ex. CBR006 at 2-42; Ex. CBR009 at PDF 64 (Table 2.6-3).

[257] Ex. CBR006 at 2-47 to 2-52, 2-79 to 2-87; Ex. CBR015; Ex. CBR031, Ex. CBR032.

[258] Ex. NRC001 at 16; Ex. CBR006 at 2-115 to 2-119.

aquifer.[259] The Intervenors did not provide any testimony or evidence objecting to the methods used or the results obtained from these measurements.

6.79. To define groundwater geochemistry, CBR obtained groundwater quality data by sampling and testing water from active private water supply wells within two kilometers of the MEA license boundary, as well as CBR's onsite monitoring wells in the Arikaree, Brule and BCS aquifers.[260] The Intervenors did not provide any testimony or evidence objecting to the methods used or results obtained from this water quality characterization.

6.80. Based on the above evidence, we find that CBR's potentiometric surface maps and groundwater quality data are based on reliable data that were obtained using standard techniques.

d. Aquifer Pumping Test

6.81. As discussed in Section 3.3.2.3 of the EA and Section 2.7.2.2 of the TR, CBR performed a regional aquifer pumping test at the MEA in 2011.[261] The purpose of the test was to estimate aquifer parameters (transmissivity, storativity, and hydraulic conductivity) within the BCS aquifer, to assess connectivity within the BCS aquifer, and to assess the integrity of the upper confining layers and the hydraulic isolation of the BCS aquifer from the overlying Brule aquifer.[262]

6.82. The pumping test was conducted for 103 hours at an average pumping rate of 27 gpm and had a radius of influence (ROI) of over 8,800 feet (approximately 1.6 miles).[263] During

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[259] Ex. CBR008-R at 105-116 (Figures 2.9-4a-d, 2.9-5a-d, and 2.9-6a-d)

[260] Ex. NRC001 at 16-17; Ex. CBR006 at 2-114 to 2-115.

[261] Ex. NRC006 at 3-31; Ex. CBR006 at 2-81 to 2-84. The aquifer test is also discussed in Section 2.4.3.3 of the SER. Ex. NRC008 at 53-54.

[262] Ex. CBR006 at 2-82; Tr. at 356-57 (Lewis).

[263] Ex. NRC006 at 3-31; Ex. CBR006 at 2-82.

this test, CBR monitored the water levels in the pumping well and eight additional observation wells in the Basal Chadron Sandstone aquifer, and in three observation wells in the overlying Brule aquifer. The aquifer pumping test was designed and conducted under a plan approved by the NDEQ.[264]

6.83. CBR analyzed the aquifer pumping test results using AquiferWin32 software, using a confined aquifer as the conceptual model.[265] The initial curve fit was performed using the software's internal algorithms and then professional judgement was used to adjust the curve fit.[266]

6.84. The Intervenors hydrogeology witnesses, particularly Dr. Kreamer, raised a number of concerns regarding the design and analysis of the aquifer pumping test.[267] We address these in the subsections below.

i. Exclusion of Data from Failed Test

6.85. Dr. Kreamer's first criticism was that CBR did not include in its test report the data from an earlier, failed test that was terminated after 19 hours.[268] He claimed that these data should have been provided for analysis because they could have provided "additional insight" on the hydrogeological conditions at the MEA.[269] Both CBR and the Staff testified that the results of the first test would not have provided useful information.[270] CBR considered the test redundant because it used a different pumping well, located only 67 feet from the original

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[264] Ex. NRC008 at 53; Ex. CBR006 at 2-82; Ex. CBR022; Ex. CBR023.

[265] Tr. at 394 (Lewis).

[266] Tr. at 394 (Lewis).

[267] Ex. OST003; Ex. OST004-R at 4.

[268] Ex. OST003 at 2.

[269] *Id.*

[270] Ex. CBR033 at 4; Ex. NRC014 at 16.

one, and otherwise used the same observation wells as the first test.[271] The Staff testified at the hearing that there was no reason to analyze the original test data when the test was essentially repeated under much better conditions.[272]

ii. Selective Analysis of Data

6.86. Dr. Kreamer also claimed that CBR selectively analyzed portions of the data and excluded others. At the hearing, he acknowledged that all of the data for the second test were provided, and he clarified that his reference to selective use of data referred to how the data were being matched to the type curves.[273] The Staff testified that choosing the portion of the curve to match to is a matter of professional judgment, and the authors of the aquifer testing report explained their rationale for the portions they chose.[274] Dr. Kreamer acknowledged at the hearing that "typically, these things are matched in judgment of the people doing the analysis."[275] The Staff also testified that the authors of the aquifer test report appropriately chose not to match early time data.[276] Dr. Kreamer also acknowledged at the hearing that early time data is sometimes not reliable and can be influenced by wellbore effects.[277]

iii. Failure to Perform Cooper-Jacob Analysis

6.87. Dr. Kreamer next claimed that a Cooper-Jacob analysis was not provided as stated in the aquifer pumping test report.[278] The report states that Theis drawdown and

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[271] Tr. at 377 (Lewis). CBR also testified that it used the data from the first test to aid in designing the second test. *Id*.

[272] Tr. at 376 (Back).

[273] Tr. at 379, 380 (Kreamer).

[274] Ex. NRC014 at 17-18.

[275] Tr. at 385 (Kreamer).

[276] Ex. NRC014 at 18.

[277] Tr. at 385, 398 (Kreamer).

[278] Ex. OST003 at 2.

recovery methods and the Cooper-Jacob distance-drawdown method were used to analyze the data, and Figure 18 of the report contains the Cooper-Jacob distance-drawdown plot.[279] At the hearing, the Staff observed that the Cooper-Jacob method, not the Theis method, had, in fact, been used to analyze the recovery data.[280] The Staff explained that there are two types of Cooper-Jacob analyses, and the one involving time is a shortcut to the Theis method.[281] Dr. Kreamer acknowledged that the Cooper-Jacob is the same sort of analysis as the Theis method but his concern is that recharge boundaries would be more obvious on a Cooper-Jacob plot.[282] CBR testified that the distance-drawdown method is a different way of presenting information, and the information from it can be used to calculate well inefficiencies.[283]

iv. <u>Inadequate Site Coverage from Single Test</u>

6.88. Dr. Kreamer and Mr. Wireman both claimed that a single aquifer pumping test for the MEA was inadequate because it did not cover a majority of the site.[284] As reported in the EA and TR, the radius of influence of the pumping test was approximately 8800 feet, or 1.6 miles.[285] CBR testified that Cameco's approach of performing a single test is consistent with industry practice and that this specific test was designed to characterize the location of the first

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[279] Ex. CBR016 at 11, 49.

[280] Tr. at 428 (Striz).

[281] Tr. at 421 (Back). In its rebuttal testimony, the Staff explained (referring to the original paper by Cooper and Jacob) that the Cooper-Jacob time-drawdown analysis is an approximation to the Theis analysis, and that the Cooper-Jacob method was developed because it is easier to fit a straight line through the data, not because it provides any additional information. Ex. NRC014 at 20-21, citing Ex. CBR025 at 90-91.

[282] Tr. at 422 (Kreamer).

[283] Tr. at 427 (Lewis).

[284] Ex. OST003 at 2, Ex. OST004-R at 4.

[285] Ex. NRC006 at 3-31, Ex. CBR006 at 2-82.

four mine units that would be developed.[286] Mr. Wireman testified that he does not believe it is industry practice to use one test for an area this size.[287] The Staff testified that one test is sufficient because site characterization data such as geophysical logs, borings, and relatively consistent water levels shows very similar conditions and consistency throughout the site.[288]

6.89. CBR acknowledged that LC 11.3.4 requires additional aquifer tests as mine units are developed.[289] The Staff testified that these tests will be part of the wellfield packages that will be submitted to further verify the conceptual model.[290] Mr. Wireman responded that those future tests would not do any good with respect to characterizing groundwater flow or evaluating risks from contamination and their results would not be reported in the EA.[291] The Staff testified that if these future tests indicated that CBR could not control lixiviant in a particular area, CBR would have to submit a license amendment request with a plan for safe operations under those conditions.[292]

6.90. At the hearing, CBR's hydrogeologist, Mr. Lewis, stated that the operation of CBR's existing ISR facility, which is located approximately 11 miles from the MEA, has served as "the biggest pump test that has been conducted for the Marsland facility."[293] CBR has

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[286] Ex. CBR033 at 7-8.

[287] Tr. at 441 (Wireman).

[288] Tr. at 442 (Back).

[289] Ex. CBR033 at 7-8; Tr. at 439 (Shriver).

[290] Ex. NRC014 at 24.

[291] Tr. at 441 (Wireman).

[292] Tr. at 443-44 (Lancaster).

[293] Tr. at 395 (Lewis).

observed 20 feet of drawdown at the MEA as a result of CBR's existing operations, which have an estimated ROI of 13 miles.[294]

v. Offsite Effects

6.91. Dr. Kreamer's next criticism of the aquifer test was that the radius of influence extended outside the boundaries of the license area.[295] He claimed that the test drew water from offsite locations and stated that offsite factors have a greater influence on late-time data.[296] CBR testified that the test results represent average aquifer conditions over the ROI, and the fact that the ROI extends offsite to the east and west is irrelevant to the results.[297] At the hearing, CBR testified, and Dr. LaGarry agreed, that the radius of influence of the aquifer test did not extend beyond where the BCS pinches out (about 7 miles to the west and 3 miles to the east of the MEA boundary).[298]

6.92. In response to Dr. Kreamer's testimony that "the pumping test drew water from these off-site locations,"[299] the Staff testified that drawdowns observed in the furthest wells are a response to a decrease in pressure caused by the pumping well and are unrelated to water movement from offsite.[300] At the hearing, Dr. Kreamer testified that he disagreed, because "when you lower a piezometric surface anywhere through pumping, water is released" in some direction.[301] In response, the Staff explained that the drawdown response comes primarily from

[294] Tr. at 496 (Lewis).

[295] Ex. OST003 at 2.

[296] *Id*.

[297] Ex. CBR033 at 8.

[298] Tr. at 448 (Lewis); Tr. at 449 (LaGarry).

[299] Ex. OST003 at 2.

[300] Ex. NRC014 at 23.

[301] Tr. at 453 (Kreamer).

expansion of the water and collapse of the matrix, not movement of water from significant distances away (i.e., offsite). Thus, in a confined aquifer, you see a response at great distances because of a pressure drop, not because of water movement through the aquifer.[302] Dr. Kreamer agreed with the Staff that a decrease in water level corresponds to release of water from storage, and said that when you have a small drop in piezometric surface, the quantity of water is small but the water goes somewhere.[303]

6.93. Dr. Kreamer did not identify the "offsite factors" he referred to in his testimony or explain how they would affect the test results or conclusions. The Staff testified that the late-time data observed in the response curves for more distant observation wells did not indicate any offsite influences that were significantly different than those observed in the middle-time data.[304]

vi. Inappropriate Analysis Methods

6.94. Dr. Kreamer asserted in his testimony, and repeatedly at the hearing, that it was inappropriate for CBR to use the Theis and Cooper-Jacob methods to analyze the aquifer test data because the underlying assumptions to the method were not met.[305] He claimed that the following assumptions were violated: first, the aquifer is homogeneous and isotropic; second, the aquifer is confined and of infinite lateral extent; and third, that the aquifer has effective uniform thickness.[306]

6.95. The Staff testified that these methods are widely used and accepted methods that are applied in practice to heterogeneous and anisotropic systems, and that at some scale

[302] Tr. at 454-55 (Back).

[303] Tr. at 455 (Kreamer).

[304] Ex. NRC014 at 23.

[305] Ex. OST003 at 2, 7.

[306] *Id.*

all geologic systems are heterogeneous and anisotropic.[307] Mr. Wireman agreed that the Theis equation and analysis is commonly used as a starting point to determine whether a more sophisticated analysis is needed,[308] and Dr. Kreamer admitted he has used Theis curves "thousands of times."[309]

6.96. In its testimony, the Staff cited a discussion in Driscoll's textbook, "Groundwater and Wells," which stated that the assumptions do not severely limit the use of the Theis equations in practice.[310] According to Driscoll, the assumption of uniform hydraulic conductivity (homogeneity) is rarely found in a real aquifer, and lack of stratification (isotropy) and lack of constant thickness are not important limitations.[311] Dr. Kreamer agreed that Driscoll was talking about simplifying assumptions for analytical solutions to aquifer tests, but insisted that Driscoll was talking about well production, not contaminant hydrology.[312]

6.97. The Staff explained that the size and duration of the aquifer test allowed averaging of the hydraulic behavior over the radius of influence, which minimizes the impact of any small-scale anisotropy and heterogeneity.[313] The Staff also testified that CBR's subsurface characterization at the MEA shows no features that indicate significant heterogeneity, and this

[307] Ex. NRC014 at 25. Dr. Kreamer agreed that this is true, and also acknowledged that as you increase the scale, a system will become more homogeneous if no structural features are present. Tr. at 491-93.

[308] Tr. at 682 (Kreamer).

[309] Tr. at 950 (Kreamer). Judge Wardwell pointed out to Dr. Kreamer that despite his repeated assertions that the Theis and Cooper-Jacob approaches were inappropriate, he relied on them to support his position on leakage. Tr. at 1024 (Wardwell). In response, Dr. Kreamer said he would have run a more complete analysis but did not have time to do so, and even with the invalid assumptions, it does show there is a potential problem. *Id*. at 1024-25.

[310] Ex. NRC014 at 26, citing Ex. NRC016 at 3.

[311] Ex. NRC016 at 3.

[312] Tr. at 464 (Kreamer).

[313] Ex. NRC014 at 26.

lack of heterogeneity is also reflected in the smoothness and flatness of the potentiometric surface of the BCS aquifer.[314]

6.98. With regard to the assumption that the aquifer behaves as a confined aquifer, the Staff testified that the BCS aquifer is by definition a confined aquifer because its potentiometric surface rises above its top elevation.[315] Dr. Kreamer agreed that this is the hydrogeological definition of a confined aquifer.[316] Dr. Kreamer also agreed that every aquitard leaks to some degree, although the leakage may be so small that it is insignificant.[317]

6.99. With regard to the assumption of infinite extent, the Staff testified that CBR's cross-sections demonstrate the continuity of the BCS aquifer within and beyond the MEA site.[318] Furthermore, as stated earlier in ¶ 6.91, CBR confirmed that the BCS pinches out well beyond the site boundaries.

6.100. With regard to the assumption of uniform thickness, the parties agreed that the BCS ranges in thickness from 20 to 90 feet over the MEA site.[319] The Staff and CBR testified that there are no abrupt changes in thickness laterally across the site.[320] The gradual variation in thickness can be observed in CBR's cross sections and in the isopach map for the BCS aquifer.[321]

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[314] Ex. NRC014 at 27.

[315] *Id*.

[316] Tr. at 450-51 (Kreamer) ("the confining comes from a high piezometric surface or the level of the piezometric surface, and it is above the top of the formation. Under that definition it's confined.").

[317] Tr. at 452 (Kreamer).

[318] Ex. NRC014 at 28.

[319] Ex. BRD001 at 2.

[320] Tr. at 481 (Shriver); Tr. at 483 (Back).

[321] Tr. at 482 (Back).

vii. Incomplete Well Screening

6.101. Dr. Kreamer asserted that the BCS observation wells may not have been screened entirely in the BCS aquifer or may have been partially screened in other aquifers.[322] The Staff testified that, when the well location was taken into account, the aquifer thicknesses at all well locations but one (Monitor-5) were less than 50 feet.[323] In addition, CBR's well completion reports indicated that the wells were fully screened in the BCS aquifer.[324] CBR testified that the wells penetrated all or the majority of the BCS, and the large distance between wells make partial penetration effects negligible.[325] At the evidentiary hearing, CBR testified that all wells were screened to the bottom of the BCS, and all wells were screened to within a few feet of the top of the BCS.[326]

6.102. In the subsections above, the Intervenors raised a number of criticisms regarding the design and analysis of CBR's aquifer pumping test at the MEA. After reviewing the evidence, summarized above, we find that the test was adequate to demonstrate confinement of the BCS aquifer and to estimate hydraulic parameters (transmissivity and storativity). The test was carried out under a plan approved by NDEQ. With respect to the data analysis and interpretation, CBR used software designed for that purpose, guided by professional judgment. CBR gave reasonable explanations for its decisions on which data to use in fitting curves. We also find that CBR's use of the Theis method was appropriate, that the assumptions inherent in the Theis method were reasonably satisfied, and that the Cooper-Jacob approximation was

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[322] Ex. OST003 at 2. Dr. Kreamer's claim is based on a comparison of range of reported screening intervals (22 to 50 feet) and the range in thickness of the BCS aquifer (20 to 90 feet). *Id*.

[323] Ex. NRC014 at 25.

[324] *Id*.

[325] Ex. CBR033 at 9.

[326] Tr. at 474, 479 (Shriver). Mr. Shriver explained that the wells were screened to the top except where there was a sand lens and a thin shale layer above the main sand body. In those cases, the well was screened to the top of the main sand body. Id. at 479.

used to conduct a time-drawdown analysis for the recovery data.[327] While Dr. Kreamer may have a different view of how to analyze and interpret this test, and suggested that more rigorous and extensive analysis methods should have been used, he has not demonstrated that such methods were necessary or that they would have resulted in materially different conclusions. We note that NEPA "does not call for certainty or precision" [328] or use of the best scientific methodology.[329]

3. Bases for Vertical Confinement

6.103. In Section 3.3.2.5 of the EA, the Staff identified six lines of evidence supporting the conclusion of adequate vertical confinement.[330] These include the thickness, continuity, and properties of the upper confining units at the MEA; the lack of drawdown in the Brule aquifer during the MEA aquifer pumping test; the strong downward gradient at the MEA resulting from the large potentiometric surface difference between the Brule and BCS aquifers; the difference in elevation of several hundred feet between the potentiometric surface of the BCS aquifer and the top of the BCS formation; geochemical differences in water from the Brule and BCS aquifers, and groundwater age differences.[331] We discuss each of these bases in the subsections below.

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[327] We also find that the Theis and Cooper-Jacob analyses are sufficiently similar methods that CBR's use of one of the other had no bearing on the ultimate conclusions of the analyses.

[328] *Louisiana Energy Servs., L.P.* (National Enrichment Facility), CLI-05-20, 62 NRC 523, 536 (2005).

[329] *Pilgrim*, CLI-10-11, 71 NRC at 315 (citations omitted).

[330] Ex. NRC006 at 3-34.

[331] *Id*. In Section 2.7.2.3 of the TR, CBR discussed its bases for concluding that there is adequate vertical confinement of the BCS aquifer at the MEA. These bases fall under four of the bases identified by the Staff: the lack of discernible drawdown in Brule observation wells during the aquifer pumping test; the strong downward gradient resulting from large differences in observed hydraulic head between the Brule and BCS aquifers; significant differences in geochemical groundwater characteristics between the Brule and BCS aquifers; and the thickness, continuity and properties of the upper confining layers based on CBR's site-specific investigations. Ex. CBR006 at 2-87.

a. Characteristics of Upper Confining Units

6.104. The parties stipulated to the following characteristics of the Brule Formation: The Brule Formation at the MEA consists predominantly of the Brown Siltstone Member and the underlying Whitney Member. Thick fine to medium-grained sandstones at the base of the Brown Siltstone constitute the first overlying aquifer at the MEA. The Whitney member, which lies beneath the Brown Siltstone, consists of siltstones with isolated beds of sandstone and volcanic ash. The overall thickness of the Brule Formation ranges from 350-550 feet, generally thinning from north to south across the MEA.[332]

6.105. The Staff testified that, although not designated as an upper confining unit, the lower Brule Formation consists almost entirely of silts and clays and therefore may serve as an additional confining layer.[333]

6.106. The parties stipulated to the following characteristics of the Upper and Middle Chadron Formations:[334] the Upper and Middle Chadron units comprise the upper confining units between the Brule Formation and the BCS aquifer at the MEA. Both units are clay-rich with bentonitic clay and interbedded sand or sandstone. These units are laterally continuous at the MEA, with a combined thickness ranging from approximately 360 to 450 feet, generally thinning toward the south of the MEA. Based on grain size analysis, both units are classified as siltstones, with more than 50 percent of grain sizes falling in the silt-clay fraction range, indicating the low-permeability nature of the units.

6.107. Based on calculations using particle size distribution data and the Kozeny-Carman equation, the average hydraulic conductivity of the upper confining units was estimated

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[332] Ex. BRD001 at 5-6.

[333] Ex. NRC001 at 29. In Table 3-6 of the EA, the Staff identifies the Whitney Member of the Brule as an aquitard and part of the upper confining layer. Ex. NRC006 at 3-25.

[334] Ex. BRD001 at 6.

to be 3.7 x 10^{-5} cm/s, and the hydraulic conductivity measured on undisturbed samples using the Falling Head Permeameter test was 1.3 x 10^{-7} cm/s.[335]

6.108. The OST asserts that no fracture analysis was done to determine whether fractures that could serve as preferential pathways might exist in the upper confining layers.[336] We address this criticism in Section VI.C.4.c below.

b. Lack of Drawdown in Aquifer Pumping Test

6.109. In the EA and TR, the Staff and CBR cited the lack of response to pumping (i.e., no discernable drawdown) in the three observation wells in the overlying Brule aquifer as a basis for concluding that there is sufficient confinement between the Brule and BCS aquifers.[337] Dr. Kreamer agreed that the aquifer test data showed no drawdown in the Brule wells, but he claimed that the monitoring system in the Brule was not adequate because of heterogeneities.[338] However, Dr. LaGarry testified that the Brown Siltstone (which is equivalent to the Sharps Formation), which is part of the Brule aquifer, is uniform, consistent, and homogeneous.[339]

6.110. In addition, the Staff testified that two other observations from the aquifer test also signified sufficient confinement. First, with an average pumping rate of 27 gpm over 4 days, CBR observed pressure responses in the most distant BCS observation wells, which were up to 8,800 feet away from the pumping well.[340] If water was being supplied from storage

[335] Ex. CBR006 at 2-81.

[336] Ex. OST014-R at 2, 3; Tr. at 966 (Kreamer).

[337] Ex. NRC006 at 3-33; Ex. CBR006 at 2-83.

[338] Tr. at 389-90 (Kreamer).

[339] Tr. at 748, 767 (LaGarry).

[340] Ex. NRC014 at 20.

or recharge, those wells would not have exhibited any drawdown.[341] Second, the storativity values calculated from the aquifer test data fall within the range for a confined aquifer.[342] Dr. Kreamer agreed that this conclusion "is consistent with a confined aquifer."[343]

6.111. Dr. Kreamer also asserted that if data from the MEA aquifer test were analyzed differently, they would demonstrate lack of confinement.[344] He stated that departure from the classic Theis curve consistent with leakage is evident in the MEA pumping test.[345] At the hearing, Dr. Kreamer identified the pumping well (Figure C1) and Monitor-3 (Figure C3) as examples that showed late-time flattening of the curve, which he attributed to leakage.[346]

6.112. In the aquifer test report, CBR stated that drawdown data for wells CPW-1A (the pumping well), CPW-1 and Monitor 3 show late-time flattening of the curve, while drawdown data for Monitor-5 and all other distant wells exhibited a more typical confined aquifer response.[347] The aquifer test report also states that the type curve matching for CPW-1A, CPW-1 and Monitor-3 focused on middle-time data.[348] The Staff witnesses agreed that two of the observation wells (CPW-1 and Monitor-3) and the pumping well (CPW-1A) showed late-time deviations in the Theis curves that could be interpreted as recharge.[349] At the hearing, Mr.

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[341] *Id*.

[342] Ex. NRC014 at 15, 20 (citing NRC015 at PDF 3-4).

[343] Tr. at 996 (Kreamer).

[344] Ex. OST003 at 2.

[345] *Id*. at 3.

[346] Tr. at 381-82, 404 (Kreamer).

[347] Ex. CBR016 at 13.

[348] *Id*.

[349] Ex. NRC014 at 19.

Lewis of CBR testified that seven of the eight curves exhibited what he considered to be normal behavior. The exception was Monitor-3, which showed flattening of the curve in late time.[350]

6.113. Dr. Kreamer claimed that CBR did not consider leakage (or recharge) as an explanation for late-time deviations.[351] CBR explained in the aquifer test report and in testimony that the flattening of the curves in late time was due to variations in transmissivity caused by local thickening of the aquifer to the west of the pumped well.[352] The Staff testified that Dr. Kreamer's explanation that the deviations were the result of leakage are implausible given the other lines of evidence demonstrating confinement.[353]

6.114. The Staff testified that there are several plausible explanations that can mimic a recharge boundary.[354] These include an increase in transmissivity (CBR's explanation), release of water from storage in the overlying aquitard due to compression of the matrix, and wellbore storage effects or near-wellbore effects.[355] Mr. Wireman did not dispute that these were all plausible explanations, and he agreed that the pumping well can affect drawdown in close observation wells.[356]

6.115. Based on the evidence discussed above, we find that the lack of drawdown in Brule observation wells is a valid basis supporting the conclusion that there is adequate vertical confinement at the MEA. We also find that the two other observations from the aquifer pumping test discussed above likewise support the conclusion that there is confinement between the

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[350] Tr. at 433 (Lewis). He also stated that the pumped well had early time deviations, which was expected. *Id.*

[351] Ex. OST003 at 6.

[352] Ex. CBR016 at 13; Tr. at 404-05 (Lewis).

[353] Ex. NRC014 at 19.

[354] *Id*.

[355] *Id*. at 19-20.

[356] Tr. at 565 (Wireman).

Brule and BCS aquifers. We find that Dr. Kreamer's suggestion that deviations in data from wells that are close to the pumping well must be the result of leakage is implausible given the other evidence of confinement and the plausible alternative explanations advanced by the Staff and CBR.

6.116. In his rebuttal testimony, Dr. Kreamer criticized CBR's use of the Theis method, asserting that a leaky aquifer evaluation using the de Glee, Hantush-Jacob, or Walton methods, or numerical analysis, would be more appropriate.[357] CBR testified that a leaky aquifer analysis is not particularly difficult or more involved, but CBR did not perform such an analysis because of the "overwhelming" evidence that this system acts as a confined system with no significant leakage.[358]

6.117. As discussed in ¶ 6.90 above, CBR's operations at its existing facility have served as a large-scale aquifer test with a radius of influence of 13 miles that has resulted in an observed a drawdown of 20 feet in the BCS aquifer at the MEA.[359] CBR's expert testified that this result could not have occurred if there was significant leakage in the BCS aquifer.[360] The OST witnesses did not challenge this statement. The Staff agreed with CBR's explanation, stating that a recharge boundary would have been evident given the drawdown from the main

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[357] Ex. OST014-R at 2-3. At the hearing, witnesses for all parties agreed that except for allowing for leakage in the overlying or underlying stratum, these methods share the same assumptions as the Theis method: homogeneity, isotropy, infinite extent, and constant thickness. Tr. at 508-09 (Kreamer); Tr. at 515 (Lewis); Tr. at 515 (Back).

[358] Tr. at 495-96, 498 (Lewis).

[359] Tr. at 395-396, 496 (Lewis).

[360] Tr. at 396, 500 (Lewis). In fact, CBR attempted to fit a leaky aquifer solution to the data from those operations and could not achieve any drawdown at the MEA using leaky aquifer type curves. Tr. at 964-65 (Lewis).

facility.[361] The Staff also testified that the MEA aquifer test would not have reached wells 8,800 feet away in the short period of time if there had been significant recharge.[362]

6.118. Based on the evidence discussed above, particularly the drawdown from existing operations as an indicator of confinement and the fact that the methods proposed by Dr. Kreamer otherwise rest on the same assumptions that he has criticized in Theis method, we find that a leaky aquifer analysis was unnecessary and would not have yielded additional useful information.

c. Differences in Potentiometric Surfaces

6.119. In the EA and TR, the Staff and CBR cited the strong downward gradient between the Brule and the BCS aquifer as a basis for confinement. This downward gradient exists because the potentiometric surface of the Brule is significantly higher than that of the Basal Chadron Sandstone throughout the entire MEA.[363] This strong downward hydraulic gradient precludes upward flow from the Basal Chadron Sandstone to the Brule.[364] As a result, any groundwater movement through the confining units, should pathways for such flow exist, would be downward from the Brule aquifer to the BCS aquifer.[365] At the hearing, Mr. Wireman and Dr. Kreamer did not dispute the existence of this downward gradient.[366] Furthermore, Dr.

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[361] Tr. at 502 (Striz)

[362] Tr. at 502 (Striz). Dr. Striz noted that the wells showing apparent recharge are located close to the pumping wells, and attributed the drawdown in those wells to well inefficiencies and possible vertical flow effects. *Id*. at 503. Dr. Striz testified that the Theis curve should not be fit to the data until a well has achieved fully developed radial flow, which cannot occur if there are wellbore or inertial effects. Tr. at 949.

[363] Ex. CBR008-R at 112, 116.

[364] Ex. NRC001 at 30-31.

[365] *Id*. at 33.

[366] Tr. at 632 (Wireman), Tr. at 993 (Kreamer).

Kreamer admitted that the downward gradient "does bode well" for lack of vertically upward contaminant movement.[367]

6.120. CBR's site characterization data based on well water level measurements demonstrates that a strong downward gradient exists at the MEA. Because the Intervenors do not dispute this, and because they acknowledge that the downward gradient makes it unlikely that contaminants can move upward vertically from the BCS aquifer to the Brule aquifer, we find that the downward gradient is a basis for concluding there is adequate vertical confinement of the BCS aquifer at the MEA.

d. Elevation Difference – Potentiometric Surface to Top of Formation

6.121. In Section 3.3.2.5 of the EA, the Staff explained that the potentiometric surface of the BCS aquifer rises hundreds of feet above the top elevation of the formation, which indicates that the BCS aquifer is confined.[368] The difference in elevation between the top of the potentiometric surface and the top of the formation is significant: about 400-500 feet over the entire MEA.[369] In the EA, the Staff explained that if the BCS aquifer was in good communication with overlying aquifers, "the pressure within the aquifer would dissipate and reequilibrate to much lower levels. . . ."[370]

6.122. The Staff testified that this situation (a potentiometric surface significantly higher than the top elevation of the aquifer) can only occur in a confined aquifer with overlying strata that are effective confining units.[371] At the hearing, Dr. Kreamer disagreed with that statement,

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[367] Tr. at 993 (Kreamer).

[368] Ex. NRC006 at 3-34.

[369] This is based on a comparison of Figures 2.6-12 and 2.9-6a-d in the TR. Ex. CBR008-R at 78, 113-116.

[370] Ex. NRC006 at 3-33.

[371] Ex. NRC001 at 30.

citing an example he knew of where the lower aquifer was considered leaky.[372] However, Dr. Kreamer provided no further details or data about his example.

6.123. Based on the above evidence, we find that the significant (over 400 foot) elevation difference supports the conclusion that there is no communication between the BCS aquifer and the overlying Brule. Although Dr. Kreamer suggested that such a difference in elevation can be found in cases involving leaky confined aquifers, he did not provide any information about the example he cited that would allow us to determine that it is truly an analogous situation. We find it unlikely that an aquifer with any significant leakage would maintain such a large elevation difference as the BCS aquifer at the MEA, and we therefore agree with the Staff's conclusion that the elevation difference is a basis for concluding that adequate vertical confinement exists.

e. Geochemical Differences

6.124. As discussed in Section 3.3.2.5 of the EA and Section 2.7.2.3 of the TR, the Staff and CBR identified geochemical differences as support for the conclusion that the Brule and BCS aquifers are not hydraulically connected.[373] The Staff testified that CBR's water quality data show distinct differences in geochemistry (total dissolved solids and major anions and cations, such as calcium, sodium, sulfate and bicarbonate) between the Brule and Basal Chadron Sandstone aquifers that indicate hydraulic isolation.[374] The EA also summarizes results from a

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[372] Tr. at 991. Dr. Kreamer had earlier agreed that if "the confining comes from a high piezometric surface or the level of the piezometric surface, and it is above the top of the formation," then under that definition it is confined. Tr. at 451.

[373] Ex. NRC006 at 3-33; Ex. CBR006 at 2-87.

[374] Ex. NRC001 at 31.

1988 study which concluded that the geochemical characteristics of the Brule and BCS aquifers indicate that they are not naturally interconnected.[375]

6.125. In his rebuttal testimony, Dr. Kreamer asserted that this basis is unsound for two reasons.[376] First, he claimed that any downward leaking water would change in chemical composition as it passed through fractures in the clay-rich units overlying the BCS aquifer.[377] CBR's hydrogeologist testified that the chemical quality of the waters is very different.[378] He agreed, however, that chemical transport is more complex than hydraulic transport of fluids in porous media, and said he would not give chemical changes between aquifers as much weight as other lines of evidence.[379]

6.126. Dr. Kreamer's second reason for asserting that the geochemical differences do not demonstrate confinement is that the current water quality differences represent unstressed conditions, not those associated with production and injection.[380] However, we note that, as CBR has testified, operations at the existing CBR facility have resulted in 20 feet of drawdown at the MEA site.[381] Therefore, we conclude that the BCS aquifer at the MEA site has in fact been stressed, and that the water quality differences have nonetheless persisted.

6.127. Based on the above evidence, we find that the average values of several chemical constituents in the Brule and BCS aquifers differ substantially. These include sulfate, chloride, TDS, anions, and cations.[382] We do not find Dr. Kreamer's rationales to be persuasive,

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[375] Ex. NRC006 at 3-33.

[376] Ex. OST014-R at 3.

[377] *Id.*; Tr. at 953-54.

[378] Tr. at 953 (Lewis).

[379] Tr. at 955-56 (Lewis).

[380] Tr. at 957-58 (Kreamer).

[381] Tr. at 496 (Lewis).

[382] *See* Ex. CBR009 at PDF 87.

because his first reason presupposes that there is appreciable movement of water down through 400 feet or more of low-permeability confining units, and his second reason is not supported as explained above. We agree with the Staff and CBR that the geochemical differences signify isolation of the two aquifers, consistent with the conclusion of previous researchers.

f. Groundwater Age Data

6.128. In Section 3.3.2.1 of the EA, the Staff reports ranges of groundwater residence times based on isotopic age dating performed at the existing Crow Butte facility for the Brule aquifer and the BCS aquifer.[383] Based on these data, the residence times for the Brule aquifer range from 250,000 to 300,000 years, while the residence times for the BCS aquifer range from 300,000 to 500,000 years.[384] In the EA, the Staff cited these large groundwater age differences as evidence of confinement,[385] and testified that if the Basal Chadron Sandstone aquifer was not hydraulically isolated from the Brule aquifer, the relative groundwater age would be much more similar.[386]

6.129. At the hearing, Dr. Kreamer testified that, because the upper value of the age range for the Brule is the same as the lower value of the age range for the BCS aquifer, "the two could be in communication."[387] He also opined that in his view the error bars are constrained and could be bigger, but did not provide any evidence to back up this opinion.[388]

6.130. While there may be some overlap in the age ranges provided in the EA, the data still suggest that there is a difference in ages in the groundwater in the Brule and BCS aquifers.

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[383] Ex. NRC006 at 3-28.

[384] *Id*.

[385] *Id*. at 3-34.

[386] Ex. NRC001 at 31.

[387] Tr. at 993 (Kreamer).

[388] Tr. at 994 (Kreamer).

Although perhaps not as strong a basis as the others, we nevertheless find that these differences support the conclusion that the BCS aquifer is confined from the Brule.

g. Summary

6.131. In summary, based on all of the evidence discussed above, we find that the Staff and CBR have provided sufficient bases for concluding that the BCS aquifer is sufficiently isolated from the overlying Brule aquifer.

4. Potential Migration Pathways

6.132. Dr. LaGarry has generally asserted that contaminants can be transmitted to the surficial aquifers at the MEA through three pathways: surface spills and leaks, underground leaks and spills (i.e., vertical excursions), and faults or fractures.[389] Dr. LaGarry also suggests that once contaminants reach the surficial aquifer by one of these pathways, they could migrate laterally to agricultural wells, stock tanks, the White River, or the Niobrara River.[390]

6.133. The White River is located 10-15 miles northwest of the MEA in a different drainage basin.[391] We therefore find it implausible that CBR's operations at the MEA could affect the White River by any of the pathways Dr. LaGarry identified.

6.134. In Sections 4.3.1.1 and 4.3.2.2 of the EA, the Staff evaluated the potential impacts of ISR operations on surface water and groundwater quality. The Staff considered potential impacts due to surface spills and leaks, underground pipe leaks and well casing failures, vertical excursions, and horizontal excursions (lateral migration within the production zone). In Section 3.2.2.2 of the EA, the Staff evaluated the existence of two reported faults near the MEA and the potential for significant adverse impacts of such faults if they existed.[392] We

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[389] Ex. OST010 at 4.

[390] *Id*. at 5.

[391] Tr. at 716, 727-28 (LaGarry); Tr. at 728 (Shriver).

[392] Ex. NRC006 at 3-11 to 3-14.

discuss each of these potential contaminant migration pathways in turn below, and ultimately conclude that the Staff's conclusions are well-supported and that their analyses satisfy the NEPA "hard look" standard.

a. Spills and Leaks

6.135. In Sections 4.3.1.1 and 4.3.2.2 of the EA, the Staff analyzed potential impacts to surface water and groundwater from spills and leaks and concluded they would be SMALL.[393] At the MEA, there are two potential pathways for spills and leaks to reach adjacent surface water or groundwater resources: via ephemeral drainages during a significant rain event[394] or via migration through the surficial aquifer.[395] As discussed in the EA, spills or leaks at the MEA that could impact surface waters or the surficial aquifer include surface spills of barren lixiviant or wastewater, leaks from exposed or buried piping, and well casing failures.[396]

6.136. As discussed in detail in Sections 4.3.1.1 and 4.3.2.2 of the EA, the Staff's conclusion that impacts from spills and leaks would be SMALL is based on a number of operational controls, design features, procedures and monitoring that would be in place at the MEA to prevent and detect spills and leaks and to address and minimize impacts should they occur.[397] These design features, controls and monitoring apply to surface spills and leaks, pipe breaks or ruptures, and well casing failures.

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[393] Ex. NRC006 at 4-10 to 4-13, 4-22 to 4-23.

[394] Ex. NRC001 at 37. Section 3.3.1 notes that the only surface water features at the MEA are ephemeral drainages, and the Staff testified that these would only be expected to carry water during significant rain events. *Id*. The Staff addressed this pathway in Section 4.3.1.1 of the EA. Ex. NRC006 at 4-12.

[395] Ex. NRC001 at 37. In Section 3.3.2.1 of the EA, the Staff explained that groundwater flow in the surficial aquifers at the MEA flows southeast toward the Niobrara River, and that shallow groundwater provides recharge to the Niobrara River in this area. Ex. NRC006 at 3-27. The Staff addressed this pathway in Section 4.3.2.2 of the EA. Ex. NRC006 at 4-22 to 4-23.

[396] Ex. NRC006 at 4-12, 4-22 to 4-23.

[397] *Id*. at 4-10 to 4-13, 4-22 to 4-23.

6.137. To prevent surface spills and leaks, CBR will use curbing and berms and other design features to control runoff, contain spills and facilitate clean up.[398] To minimize potential spills from underground pipe leaks, CBR has alarms and instrumentation in place to monitor flow rates and trunk line pressures and alert operators to leaks or spills.[399] Piping will be constructed from high density polyethylene, placed underground below the frost line, and pressure tested prior to use.[400] License Condition 10.1.12 requires daily monitoring of well flow rates and manifold pressures, and sets a maximum limit on injections pressures.[401]

6.138. CBR will have administrative controls and procedures in place, including a Storm Water Pollution and Prevention Plan (SWPPP) under its National Pollutant Discharge and Effluent System (NPDES) permit and a Spill Prevention Control and Countermeasure (SPCC) plan. The SWPPP will contain requirements to contain storm runoff and address spill prevention and control, and the SPCC will include procedures for spill reporting, response, and cleanup. The Staff reviewed records of spills at the existing CBR facility and concluded that CBR has appropriately addressed spills at that site and has mitigated their impacts satisfactorily.[402]

6.139. To minimize potential spills from well failures, CBR will be required under LC 10.1.4 to conduct mechanical integrity testing (MIT) of wells initially and every five years.[403]

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398 Ex. NRC006 at 4-12.

399 *Id*.

400 *Id*.

401 Ex. NRC009 at PDF 12.

402 Ex. NRC006 at 4-12.

403 *Id*. at 4-23; Ex. NRC009 at PDF 10-11.

In addition, any time a leak is suspected, a well will be tested for mechanical integrity. Well integrity is also subject to oversight under CBR's NDEQ Class III injection well permit.[404]

6.140. CBR identified an irrigation well near the eastern MEA license area boundary.[405] As discussed in Section 4.3.2.2 of the EA, CBR performed an analysis of the potential for a shallow well casing leak in an MEA wellfield to impact this well, and concluded that there would be no impact.[406] At the hearing, CBR testified about its selection of parameters for this analysis, and we find that their choices were reasonable. The OST did not identify any additional agricultural wells in the vicinity of the MEA.

6.141. Dr. LaGarry acknowledged at the hearing that these design features, controls, monitoring, and procedures will likely prevent or mitigate most spills or leaks that would occur at the MEA.[407]

6.142. Based on the above evidence, although the High Plains aquifer and the Niobrara River are near the MEA, we find it highly unlikely that CBR's operations would result in spills or leaks that would affect those water bodies. This finding is based on the comprehensive design features, procedures, and administrative controls that CBR will employ at the MEA (described above and in the EA), which Dr. LaGarry has acknowledged will likely prevent or mitigate most spills or leaks that might occur at the MEA.

b. Vertical Excursions

6.143. In his testimony, Dr. LaGarry describes excursions from the BCS aquifer into the Arikaree Formation as a potential contamination pathway.[408] The Staff testified that such

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[404] Ex. NRC006 at 4-23.

[405] Ex. CBR006 at 2-11.

[406] Ex. NRC006 at 4-22; Exs. CBR010 and CBR011.

[407] Tr. at 771 (LaGarry) (agreeing that the safety precautions in place "would likely catch most things").

[408] Ex. OST010 at 4.

vertical excursions are unlikely because of the multiple bases demonstrating confinement, particularly the strong downward gradient at the MEA, which would prevent upward migration of contaminants from the production zone to the overlying Brule and Arikaree aquifers, and the thick, continuous confining layer between the Basal Chadron Sandstone aquifer and the Brule aquifer.[409] The Staff also testified that CBR has plugged and abandoned all exploratory drill holes at the MEA, and all wells installed at the MEA will be subject to mechanical integrity testing to minimize unanticipated casing leaks.[410]

6.144. In addition, CBR will install excursion monitoring wells in the Brule and Arikaree aquifers at a density of one well per four acres.[411] As required by LC 11.1.5, these wells will be sampled at intervals of no more than 14 days for indicators to detect vertical excursions. If an excursion is detected, CBR will be required to increase the sampling frequency and implement appropriate corrective actions.[412]

c. Faults and Fractures

6.145. Dr. LaGarry asserted that "lack of containment" due to faults fractures and joints is a potential pathway for contaminants to reach the surficial aquifers in and around the MEA.[413] The Intervenors claim that the Staff and CBR should have performed fracture analyses for the MEA, particularly for the upper confining layers.[414] However, the OST witnesses agreed that the

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409 Ex. NRC001 at 39-40.

410 Ex. NRC006 at 5-2, Ex. NRC008 at 36-37.

411 Ex. CBR006 at 5-56, 7-46. CBR is required under LC 9.2 to follow this commitment. Tr. at 639 (Lancaster).

412 Ex. NRC006 at 6-2; Ex. NRC009 at PDF 17.

413 Ex. OST010 at 4-5.

414 Ex. OST014-R at 3.

ultimate concern is not the mere presence of faults, fractures or joints, but whether such features can act as preferential pathways for contaminants.[415]

6.146. In his testimony, Dr. LaGarry also stated that, based on his past work, "there are likely hundreds more that are too small to be shown on such a diagram [referring to Figure 1]."[416] While it may be true that faults and joints are common in northwestern Nebraska, the OST witnesses have not provided any site-specific data indicating the presence of significant faults, fractures, or joints creating continuous pathways through the confining layers at the MEA.

6.147. In his rebuttal testimony, Dr. LaGarry stated that "joint sets visible in bedrock exposed around [the] MEA" could act as contaminant pathways.[417] He cited a poster by Maher and Shuster as evidence of such joint sets.[418] But, as Dr. LaGarry acknowledged at the hearing, the locations mentioned in the Maher and Shuster poster are located 30-100 miles from the MEA.[419]

6.148. Dr. LaGarry also explained that Maher and Shuster's work is based on surface observations of fractures in eroded areas.[420] Dr. LaGarry acknowledged that an exposed surface, which has been subject to release of stress and weathering, is a different environment than the interior of the confining layers at the MEA, which has been covered by several hundred feet of overburden.[421] Nonetheless, he claimed that what Maher and Shuster saw at the surface

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[415] Tr. at 677 (Wireman); 791-92 (LaGarry).

[416] Ex. OST010 at 4-5.

[417] Ex. OST016-R at 1.

[418] Ex. OST017.

[419] Tr. at 845 (LaGarry).

[420] Tr. at 801-02 (LaGarry).

[421] Tr. at 802-03 (LaGarry).

was a good representation of what fractures would look like in the upper confining units at the MEA.[422] Both CBR and the Staff's experts disagreed, stating that in their professional opinions, observations of surface fractures would not be the same as what is several hundred feet underground.[423] The Staff also noted that swelling clays in the confining layers and the weight of the overburden would serve to seal or close fractures.[424]

6.149. Dr. LaGarry also cited a draft paper by Maher describing various possible causal mechanisms of fractures.[425] Dr. LaGarry testified that this paper identifies several potential mechanisms that could create fractures in rocks.[426] However, Dr. LaGarry did not explain how this document, or the mechanisms it discusses, have any bearing on the MEA.[427]

6.150. Dr. LaGarry also criticized CBR's use of geophysical logging of boreholes and cross-sections to identify faults, stating that these methods "do not delineate faults" and that surface techniques such as electrical resistivity, seismic reflection, or ground penetrating radar would be better.[428] Dr. LaGarry did not explain why surface techniques would be better, but referred to an annotated bibliography on the use of surface geophysical techniques by Lewis and Haeni.[429]

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[422] Tr. at 804 (LaGarry).

[423] Tr. at 805 (Shriver); Tr. at 807 (Lancaster).

[424] Tr. at 808 (Lancaster).

[425] Ex. OST018-R.

[426] Tr. at 811. Dr. LaGarry provided the bulk of this exhibit after the hearing and did not explain how it supports the view that fractures exist in the confining units at the MEA and, more importantly, that they serve as preferential pathways for contamination.

[427] *See, e.g.*, Ex. OST018-R at PDF 1. In addition, the document includes a disclaimer stating that it is a draft that is "still very much in revision," and the summary table near the end of the document also states that it is "very much a draft copy, a work in progress, and is incomplete and may have significant errors." *Id*. at PDF 33.

[428] Ex. OST016-R at 2.

[429] *Id*., citing Ex. OST019.

6.151. The Lewis and Haeni document is a compilation of references about the theory and application of surface geophysical techniques to locate fractures in bedrock.[430] In the introduction, the authors acknowledge that "[s]urface and borehole geophysical methods both have been successfully used to locate and characterize fractures in bedrock."[431] The authors then cite several advantages of surface methods: they are less expensive than drilling; when performed in conjunction with drilling, they can reduce the number of boreholes needed; and they create little or no environmental disturbance.[432] At the hearing, Dr. LaGarry acknowledged that the authors did not state that surface techniques give superior results.[433]

6.152. At the hearing, CBR's geologist testified that cross-sections of geophysical logs are a good determination of displacement faults, and that he did not see any significant offsets in the cross-sections.[434] He also reviewed geologic reports and photographs of core samples taken from all of the formations and saw no discussion of fracturing in the reports or evidence of fracturing in the photos.[435] Based on the other evidence of lack of communication between the BCS and overlying aquifers, he did not think there was a need for further fracture investigation.[436]

6.153. Dr. LaGarry testified that it would be hard to discern faults with less than one meter of displacement on cross-sections.[437] He also said fractures would not show

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[430] Ex. OST019 at 1.

[431] *Id.* at 2.

[432] *Id.*

[433] Tr. at 844 (LaGarry).

[434] Tr. at 796 (Shriver).

[435] Tr. at 796-97 (Shriver).

[436] Tr. at 797 (Shriver).

[437] Tr. at 799 (LaGarry).

displacements, and vertical joints or fractures would be missed if they did not intersect with a borehole.[438] CBR testified that the types of offsets Dr. LaGarry refers to would be apparent in geophysical logs. For example, compressional or reverse faulting would express itself as repeating of strata, while significant offsets could result in missing strata, and they did not see such indications in the logs.[439]

6.154. Based on the evidence discussed above, we find that there is no evidence of specific, field-verified faults in the vicinity of the MEA that can serve as preferential pathways. We do not rule out the presence of isolated small faults or fractures in the Arikaree, Brule, and Upper and Middle Chadron formations at the MEA site. Nonetheless, based on the discussion of faults in the EA and TR, and our consideration of additional evidence in the record (discussed above), we find it highly unlikely that a preferential pathway for contaminant migration consisting of a single fault or a connected pathway of faults and fractures, exists in the upper confining layers at the MEA. We also find that the use of cross-sections from borehole logs was sufficient to identify faults at the MEA.[440] Furthermore, for the reasons identified by the Staff in Section 3.3.2.5 of the EA, even if such a pathway existed, we find that it would be unlikely to lead to significant environmental impacts.

[438] Tr. at 799-800 LaGarry).

[439] Tr. at 805-06 (Lewis).

[440] We note that Dr. LaGarry relied on Swinehart's cross-sections constructed from borehole data to assert that the Pine Ridge and Niobrara River faults are present at the MEA. *See* Ex. OST010 at 4.

d. Lateral Migration (Horizontal Excursions)

6.155. In Section 4.3.2.2 of the EA, the Staff discussed the potential impacts of horizontal excursions (i.e., lateral migration of ISR production fluids within the Basal Chadron Sandstone aquifer) and concluded that impacts would be SMALL.[441]

6.156. The Staff's conclusion is based on several reasons. First, CBR is required under LC 10.1.6 to maintain an inward hydraulic gradient in all wellfields until restoration is completed.[442] The purpose of the inward gradient is to contain movement of process fluids (i.e., to prevent horizontal excursions).[443] Second, as discussed in Section 4.3.2.2 of the EA, each wellfield will be surrounded by a ring of monitoring wells in the Basal Chadron Sandstone aquifer.[444] As required by LC 11.1.5, CBR will be required to monitor these wells through biweekly testing, and, if an excursion is confirmed, CBR would be required to take corrective actions (e.g., adjusting wellfield extraction and injection rates to draw fluids back into the wellfield) and conduct more frequent (weekly) sampling.[445]

6.157. As part of its review of the MEA application, the Staff reviewed the excursion monitoring history at the existing Crow Butte license area.[446] Although CBR has confirmed several horizontal excursions within the Basal Chadron Sandstone aquifer at the existing Crow Butte license area, those excursions were controlled and mitigated through corrective actions without impacts on surrounding surface water or groundwater.[447]

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[441] Ex. NRC006 at 4-21 to 4-22.

[442] *Id*. at 2-8, 4-16; Ex. NRC009 at PDF 11.

[443] Ex. NRC006 at 2-8.

[444] *Id*. at 4-21.

[445] Ex. NRC009 at PDF 17.

[446] Ex. NRC006 at 4-22; Ex. NRC008 at 71.

[447] *Id*.

6.158. Although OST witnesses mentioned the possibility of lateral migration of ISR production fluids,[448] they did not provide any testimony that challenged the Staff's analysis of potential impacts of horizontal excursions. We find that horizontal excursions are highly unlikely to impact areas outside the exempted portion of the aquifer for on the reasons described above.

6.159. Having reviewed the evidence and testimony presented by the parties, we find that the Staff took a hard look at the potential migration pathways proposed by the OST witnesses. The Staff considered potential surface spills and leaks, underground leaks from pipes, and well casing failures in its review and identified protective measures that are in place to prevent spills and leaks or minimize their impacts. The Staff likewise considered both vertical and horizontal excursions and identified excursion monitoring and other requirements, such as the inward hydraulic gradient, that are designed to prevent and control excursions. The Staff also reviewed historical records of spills and excursions at the existing CBR facility, and how they were resolved. Finally, as we previously concluded in Sections VI.A.3.b and VI.C.4.c above, we find that there is no evidence of faults, fractures, or joints that could act as continuous preferential pathways for contaminant migration at the MEA.

4. <u>Conclusion – Conceptual Model and Confinement</u>

6.160. Having reviewed the evidence and testimony, we find by a preponderance of the evidence that the EA and MEA application described a hydrological conceptual model for the MEA that is based on extensive and reliable site characterization data. Furthermore, the EA and application included detailed assessments of vertical confinement and horizontal containment of the Basal Chadron Sandstone aquifer at the MEA. We find that CBR demonstrated that the Basal Chadron Sandstone aquifer is vertically confined based on several lines of evidence, including the characteristics of the upper confining layers, the lack of drawdown in the aquifer pumping test, the strong downward gradient, the significant elevation

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[448] *See*, *e.g.*, Ex. OST010 at 5.

difference between the potentiometric surface of the BCS aquifer and the top of the formation, differences in geochemistry between the Basal Chadron Sandstone and Brule aquifers, and differences in groundwater age.

6.161. We also find that, in analyzing environmental impacts, the Staff addressed the various pathways that the Intervenors proposed as possible routes for contaminants to escape the MEA license area. Based on a thorough review of potential impacts to surface water and ground water quality from CBR's operations at the MEA, as documented in Sections 4.3.1.1 and 4.3.2.2 of the EA, the Staff concluded that impacts would be SMALL.

6.162. For the above reasons, we find that the Staff satisfied the "hard look" requirement of NEPA in considering CBR's hydrologic conceptual model, site characterization data, and evidence of confinement when assessing potential impacts to adjacent surface water and groundwater resources. We also find that CBR provided an acceptable hydrologic conceptual model for the MEA that was adequately supported by site characterization data and demonstrates with scientific confidence that CBR will be able to contain fluid migration, both vertically and horizontally, at the MEA. We therefore resolve Concern 3 in favor of the Staff and CBR.

D. <u>Concern 4 – Unsubstantiated Assumptions</u>

6.163. In LBP-18-3, we identified Concern 4 as a challenge to the MEA application and the final EA, and defined its scope as follows:

> whether the TR and final EA contains unsubstantiated assumptions as to the isolation of the aquifers in the ore-bearing zones.

6.164. In its petition to intervene, the OST did not identify any specific "unsubstantiated assumptions" concerning the isolation of aquifers. In our findings on Concern 3, we have already addressed the bases for the Staff and CBR's conclusions about vertical confinement between the BCS aquifer and the overlying Brule aquifer.

6.165. We previously found that there are multiple lines of evidence supporting the conclusion that there is adequate confinement of the BCS aquifer at the MEA, all supported by test data. Our findings are discussed in detail in Section VI.C.3 above. Below we briefly reiterate the bases for confinement and the site characterization information that supports and substantiates them.

6.166. The OST stipulated that the upper confining units are composed of thick, continuous layers of siltstones and claystones with low hydraulic conductivities. The descriptions of those units are based on site characterization data from borehole logs and laboratory tests.

6.167. The lack of drawdown in the aquifer test is based on water level measurements taken in three wells in the Brule aquifer during the test.

6.168. The conclusion that a downward gradient exists at the site is based on water level measurements in wells. The conclusion that the BCS aquifer rises significantly over the top of the formation is also based on water level measurements coupled with information in structure contour maps. None of the measurements on which these are based were disputed.

6.169. The geochemical differences between the Brule and BCS aquifer are based on laboratory tests of water samples, and the groundwater age data is based on residence times measured by isotopic age dating.

6.170. As discussed above and in Section VI.C.3, all of the bases for confinement were substantiated by data. Therefore, we find that there are no "unsubstantiated assumptions" in the EA or the TR related to isolation of the BCS aquifer from overlying aquifers, and we resolve Concern 4 in favor of the Staff and CBR.

VII. CONCLUSIONS OF LAW

7.1 The Board has considered all of the evidence presented by the parties on Contention 2. Based upon a review of the entire record in this proceeding, and based upon the findings of fact set forth above, which are supported by reliable, probative and substantial evidence in the record, the Board has decided all matters in controversy concerning Contention 2, and reaches the following conclusions.

7.2 The Board concludes that the Staff's EA provides sufficient information in its description of the affected environment for geology and water resources to allow the establishment of potential impacts to surface water and groundwater resources near the MEA, and to allow the Staff to take a hard look at those potential impacts as required by NEPA. We also conclude that the TR provides sufficient information on geology and hydrology to demonstrate CBR's ability to comply with applicable regulatory requirements in 10 C.F.R. Part 40 at the MEA.

7.3 The Board concludes that the MEA application included a description of hydraulic conductivity, hydraulic gradient, effective porosity, transmissivity, and storativity as necessary to demonstrate its ability to conduct ISR operations and groundwater restoration in accordance with NRC regulations.

7.4 The Board concludes that the EA and TR both describe the hydrologic conceptual model for the MEA, and that the conceptual model in the EA and TR is adequately supported by extensive site characterization data. We also conclude that the conceptual model for the MEA demonstrates with scientific confidence that there will be adequate confinement of ISR production fluids at the MEA. Finally, we conclude that the Staff satisfied NEPA's "hard look" requirement in its consideration of CBR's hydrologic conceptual model, site characterization data, and evidence of confinement when assessing potential impacts to adjacent surface water and groundwater resources at the MEA.

7.5 The Board concludes that the EA and TR do not contain unsubstantiated assumptions related to isolation of aquifers at the MEA.

7.6 We therefore affirm that the Staff's environmental review, and its EA and FONSI, comply with the requirements of NEPA. We also affirm that the MEA application demonstrates that CBR will comply with the requirements of the AEA and NRC regulations. Accordingly, we resolve Contention 2 in favor of the Staff and CBR.

Respectfully submitted,

/Signed (electronically) by/

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/Executed in Accord with 10 C.F.R. 2.204(d)/

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Dated at Rockville, Maryland
this 3rd day of December, 2018.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 40-8943-MLA-2
CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 13-926-01-MLA-BD01
(Marsland Expansion Area)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing "NRC Staff's Proposed Findings of Fact and Conclusions of Law" in the above-captioned proceeding have been served via the Electronic Information Exchange ("EIE"), the NRC's E-Filing System, this 3rd day of December, 2018, which to the best of my knowledge resulted in transmittal of the foregoing to those on the EIE Service List for the above-captioned proceeding.

/Signed (electronically) by/
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