7 ENVIRONMENTAL EFFECTS

The objective of the mining and environmental monitoring program is to conduct an economically viable and environmentally responsible operation. The environmental monitoring programs used to ensure that the potential sources of land, water, and air pollution are controlled and monitored, are presented in Section 5.7.

This section discusses and describes the short- and long-term impacts associated with operations and the consequences of possible accidents at the CPF and the MEA. Environmental impacts of the proposed satellite facility on scenic resources are discussed in Section 2.4.2. Some of the more pertinent cumulative impact concerns associated with the construction and operation of the MEA, TCEA, and NTEA are discussed in this section. However, a more detailed discussion of the cumulative impacts of the CPF operations and the construction and operation of the proposed MEA, TCEA, and NTEA can be found in Section 4.14 of the associated MEA Environmental Report. Cumulative impacts are minimized due to the nature of the operations of the CBR projects, distance between the project sites, regional topography. There are some discussions of cumulative impacts in this section

7.1 Environmental Effects of Site Preparation and Construction

CBR has developed plans for the development of the site based largely on the knowledge on the size of the ore body (depth, width and length) and U_3O_8 content arrived at through exploration and delineation work at the MEA site.

It is estimated that a total of approximately 1,756 acres could be affected over the life of the MEA Project. Estimates of acreages have been provided for the currently planned facilities as well as potential additional acreages that could be developed in the future (based on current knowledge of the ore body; **Table 7.1-1**).

Approximately 591 acres will be required for the currently planned facilities, which consist of the satellite building and associated facilities (1.8 acres), the DDW's (3.0 acres), access roads to the satellite facility and DDW's (1.7 acres) and 11 MUs (587.6 acres). The number of acres associated with roadways located within the MUs is included in the total MU acreage estimates. The number of acres of different types of habitat cover estimated to be impacted by the current planned construction activities are shown in **Table 7.1-1**.

Based on the current knowledge of the MEA ore body, it has been estimated that 1,162 acres in addition to the 594.1 acres could be disturbed over the life of the project. Estimates of the additional number of acres of different types of habitat cover that may be affected are shown in **Table 7.1-1**. As shown, the major type of habitat that would be affected is mixed-grass prairie, which makes up approximately 65 percent of the total 1,756 acres.

The initial site preparation and construction associated with the MEA satellite facility will include the following:

- Construction of a satellite process facility located approximately 11.1 miles (17.9 km) south-southeast of the current process facility (centerpoint of MEA satellite building to centerpoint of CPF building). This satellite facility will be housed in a building approximately 130 feet long by 100 feet wide and will contain IX and associated equipment capable of processing 6,000 gpm of production flow and 1,500 gpm of restoration flow.

- Placement of a modular office building.
- Construction of chemical storage facilities, and other support facilities.
- Construction of a DDW for disposal of wastewater.
- A deep well injection building and associated facilities.
- Access roads, as required.

Site preparation and construction will include topsoil salvage, building erection, and access road construction. Note that wellfield construction activities and completion of injection, production, and monitor wells are discussed in Section 7.2 because these are ongoing activities at an ISR facility. This section strictly discusses the short-term impacts of initial site preparation and construction where they differ from the impacts of operations.

Environmental impacts of construction of the satellite facility are estimated based on the studies conducted by CBR, which are discussed in Section 2. The impacts are also projected based on experience with the current operation and those that have been associated with this type of construction at the Crow Butte project over the past 17 years of commercial operation by CBR.

As stated above, construction of the satellite facility will require disturbance of an estimated 591 acres for the satellite facility and support facilities, such as 11 MUs, DDWs, and road improvements. Of this total, approximately 1.8 acres will be associated with the satellite facility and approximately 0.5 acres for each DDW; plus additional 1.7 acres of access roads. Surface disturbances will include construction of access roads, facility site grading, construction of DDW, and contouring for control of surface runoff. All areas disturbed will be reclaimed during final decommissioning. The planned timeline for construction, production, restoration, and decommissioning was presented in Section 1.

The primary surface disturbances associated with solution mining are the sites containing the processing facilities, associated facilities, and the DDW. Surface disturbances also occur during well drilling, pipeline installation, and road construction. These more superficial disturbances; however, involve relatively small areas or have short-term impacts.

Due to the relatively minor nature of disturbances created by ISR mining and the lack of evaporation ponds, no areas will be disturbed to the extent that subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. The existing contours will only be interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post-mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary during the operating period. These changes will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction.

These surface impacts are unavoidable and will last for the duration of the project until final decommissioning. Mitigation measures for land surface impacts are discussed in Section 6.2.

7.1.1 Air Quality Effects of Construction

The relatively dry air in the MEA region, combined with seasonal high temperatures and wind extremes, create the potential for airborne dust from wellfield construction activities and traffic on unpaved roads. Under these conditions, it is expected that short-term air quality will be impacted in the immediate vicinity of the proposed project. However, based on historical experience, overall construction activities at the satellite facility are expected to cause minimal effects on local air quality.

Effects to air quality would be increased suspended particulates from vehicular traffic on unpaved roads (in addition to existing fugitive dust caused by wind erosion) and diesel emissions from construction equipment. Application of water to unpaved roads would reduce the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be short-term only, ceasing once the operational phase begins. NRC estimated fugitive dust emissions during construction of uranium ISR operations are less than 2 percent of the NAAQS for $PM_{2.5}$ and less than 1 percent for PM_{10} (NRC 2009).

There will be an increase in the total suspended particulates (TSP) in the region as a result of construction of the satellite facility. This increase will be greatest during the site preparation phase of the satellite facility. Revegetation will be performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction are revegetated with the exception of facility pad areas, roads, and parking/storage areas. Of these, the only significant source of TSP is dust emissions from unpaved roads.

Specific regulatory issues associated with air quality impacts of operation are discussed in Section 7.2.1.2.

Cumulative Impact

Any potential cumulative impacts to the area air quality as a result of construction of the MEA, TCEA and NTEA satellite sites would be expected to be minimal. The construction for the sites will be completed sequentially, so construction would be not occurring at the same time. In addition, the distance between the sites would minimize any construction impacts should occur at the same time.

7.1.2 Land Use Impacts of Construction

The principal land uses for the 591 acres (**Table 7.1-1**) associated with the proposed eleven MUs, processing facility, DDW, and access roads, which consist primarily of cropland (71.7 acres) and livestock range (491.2 acres [347.6 acres of mixed grass prairie and 143.6 acres of degraded rangeland]). The entirety of this approximately 591-acre area will be dedicated to the project's needs over the 1-year construction period. As presented previously, livestock and livestock products carry a value of $40.40 per acre, while non-livestock lands carry a value of $13.61 per acre. Based on this information, and assuming all available and suitable acreage within the MEA is currently employed to its greatest efficiency and effect, construction activities in the MEA would result in the lost livestock production of approximately $19,845 per year, and the lost production of crops valued at $976 per year. The exclusion of agricultural activities from this area during construction would not have a significant impact on local agricultural production due to the small size of land taken out of production; construction and operation would not have a significant impact

on landowners due to the payment of royalties and leases, which will offset the losses from the land being removed from agricultural production.

The long-term principal land uses for an additional 1,162 acres associated with project development will result in a total of 1,753 acres over the life of the project. The main types of habitat cover within the 1,753 acres will include cropland (128.4 acres), livestock range (1,370.7 acres [1,142.7 acres mixed-grass prairie and 228 acres degraded rangeland]), and mixed conifer (194.6 acres). The entirety of this approximately 1,753 acres may be dedicated to the project's needs over the life of the project. Using the assumptions above, construction activities over the life of the project could result in the loss of livestock production of approximately $55,376.

7.1.3 Geologic and Soil Impacts of Construction

7.1.3.1 Geologic Impacts of Construction

Geologic impacts are expected to be minimal, if any. Impacts to paleontological resources are likely to be significant. Due to the presence of highly sensitive geologic formations within the MEA, surface disturbances that occur during construction of the satellite facility buildings, access roads, and wellfield will likely have direct impacts to paleontological resources, particularly in areas of thin soil cover and bedrock exposure.

7.1.3.2 Soil Impacts of Construction

Construction of the satellite facilities will affect soils. With proper implementation of BMPs, effects to soils are not expected to be significant within the MEA.

The severity of soil impacts would depend on the number of acres disturbed and the type of disturbance. Potential impacts include soil loss, sedimentation, compaction, salinity, loss of soil productivity, and soil contamination. Effects to soils at the MEA would result from the clearing of vegetation, excavating, leveling, stockpiling, compacting, and redistributing soils during construction and reclamation. Disturbance related to the construction and operation of the satellite facility would continue until the area is revegetated.

Wind erosion is possible throughout the MEA. Many soils meet the criteria for high wind erosion hazard (SCS 1977). These soils include one or more major fine sand or sandy loam constituents that can easily be picked up and spread by wind. Vegetation removal presents the greatest threat to soils with potential for wind erosion. Wind erosion will be controlled by removing vegetation only where necessary, avoiding clearing and grading on erosive areas, surfacing roads with locally obtained gravel, and timely reclamation.

Water erosion is also possible at the MEA, especially in areas disturbed by road and wellfield construction. Various soils meet the criteria for severe water erosion hazard (SCS 1977). These soils have low permeability and high K-factors, making them susceptible to water erosion. The K-factor describes soil erodibility; it represents both the susceptibility of soil to erosion and the rate of runoff. It is calculated from soil texture, organic matter, and soil structure. Construction and operation would increase soil loss through water erosion. Removal of vegetation for any activity exposes soils to increased erosion. Excavation could break down soil aggregates, increasing runoff and promoting gully formation. Soil loss will be reduced substantially by avoiding construction in highly erosive areas such as badlands and steep drainages. Locating roads in areas where cuts and

fills would not be required, surfacing roads with gravel, installing drainage controls, and reseeding and installing water bars across reclaimed areas will also aid in reducing soil loss due to water erosion.

An assessment of the potential for flooding or erosion that could impact the proposed in-situ Marsland mining processing facilities and mine units was performed for the MEA. The results of this study are discussed in Section 3.1.4.3. The complete report of the hydrologic and erosion study, including tables and figures, can be found in **Appendix K-1** (ARCADIS 2012). The study addressed guidance in NUREG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium in-situ facility. The ultimate objective of the MEA study was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented. The results of this study will be used for further analysis, mitigation measures or modification of location of surface facilities, including well locations during the final engineering phase and prior to well installation and construction activities.

Sedimentation in streams and rivers within the MEA and in the Niobrara River immediately to the south could result from soil loss. Sedimentation could alter water quality and the fluvial characteristics of area drainages. Installation of appropriate erosion control measures as required by the CBR Construction Stormwater NPDES authorization (see Section 7.1.4) and avoidance of erosive soils will aid in reducing sedimentation.

Activity on the site has the potential to compact soils. Soils sensitive to compaction do exist on the site. Compaction of the soils could decrease infiltration and promote higher runoff. Construction and traffic will be minimized where possible, and soils will be loosened prior to reseeding during reclamation to control the effects of soil compaction.

Any soil on the site can be saline depending on site-specific soil conditions, such as permeability, clay content, quality of nearby surface waters, plant species, and drainage characteristics. Saline soils are extremely susceptible to soil loss caused by development. Soil erosion in areas with high salt content would contribute to salinity in the Niobrara River. Reclamation of saline soils can be difficult, and no method that works in all situations has yet been found.

Satellite facility development would displace topsoil, which would adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This would result in a reduction of natural soil productivity.

A number of erosion and productivity problems resulting from satellite facility construction may cause a long-term declining trend in soil resources. Long-term impacts to soil productivity and stability would occur as a result of large-scale surface grading and leveling until successful reclamation. Reduction in soil fertility levels and reduced productivity would affect diversity of reestablished vegetative communities. Moisture infiltration would be reduced, creating droughty soil conditions. Vegetation would undergo physiological drought reactions.

Surface spillage of hazardous materials could occur at the satellite facility. If not remediated quickly, these materials have the potential to adversely impact soil resources. To minimize

potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan will be implemented. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures.

Soil Impact Mitigation Measures

BMPs have been included in the project description and will be followed to control erosion, minimize disturbance, and facilitate reclamation. The following mitigation measures will help reduce the effects to soil resources at the MEA. BMPs and mitigation measures relevant to soil resources are also discussed in the water quality and reclamation sections of this document. Fundamentally, efforts will be made to preserve existing vegetation where practical.

Sediment Control

- Divert surface runoff from undisturbed areas around the disturbed area.
- Retain sediment within the disturbed area.
- Surface drainage shall not be directed over the unprotected face of the fill.
- Operations and disturbance on slopes greater than 40 percent need special sediment controls and should be designed and implemented appropriately.
- Avoid continuous disturbance that provides continuous conduit for routing sediment to streams.
- Inspect and maintain all erosion control structures.
- Repair significant erosion features, clogged culverts, and other hydrological controls in a timely manner.
- If BMPs do not result in compliance with applicable standards, modify or improve such BMPs to meet the controlling standard of surface water quality.

Topsoil

- Topsoil should be removed prior to any development activity to prevent loss or contamination.
- When necessary to substitute for or supplement available topsoil, use overburden that is equally conducive to plant growth as topsoil.
- To the extent possible, directly haul (live handle) topsoil from the site of salvage to concurrent reclamation sites.
- Avoid excessive compaction of topsoil and overburden used as plant growth medium by limiting the number of vehicle passes, handling soil while saturated, and scarifying compacted soils.
- Time topsoil redistribution so seeding or other protective measures can be readily applied to prevent compaction and erosion.

Roads

- Restrict the length and grade of roadbeds.
- Surface roads with durable material (i.e., locally obtained native gravel).
- Create cut and fill slopes that are stable.
- Revegetate the entire road prism including cut and fill slopes.
- Create and maintain vegetative buffer strips and construct sediment barriers (e.g., straw bales, wire-backed silt fences, check dams) during the useful life of roads.

Regraded Material

- Design regraded material to control erosion using activities that may include slope reduction, terracing, silt fences, chemical binders, seeding, mulching, and other activities.
- Divert all surface water above regraded material away from the area and into protected channels.
- Shape and compact regraded material to allow surface drainage and ensure long-term stability.
- Concurrently reclaim regraded material to minimize surface runoff.

Implementation of the above BMPs, SPCCs, and SWPPPs will minimize effects to soils associated with the construction of the satellite facility.

7.1.4 Surface Water Impacts of Construction

When stormwater drains off a construction site, it can carry sediment and other pollutants that can potentially harm lakes, streams, and wetlands. The EPA estimates that 20 to 150 tons of soil per acre are lost every year to stormwater runoff from construction sites. For this reason, stormwater runoff may need to be controlled by the NDEQ NPDES regulations.

Construction activities at the CBR project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEQ permitting regulations for control of construction stormwater discharges contained in Title 119 (NDEQ 2005b). CBR is required by NDEQ General Construction Stormwater NPDES Permit NER 100000 to implement procedures that control runoff and the deposition of sediment in surface water features during construction activities. These procedures are contained in the SHEQMS Volume VI, Environmental Manual and require active engineering measures (such as berms) and administrative measures (such as work activity sequencing) to control runoff and sedimentation of surface water features. CBR must annually submit a construction plan for the coming year and obtain authorization from the NDEQ under the general permit.

Administrative and engineering controls implemented by CBR during initial site preparation and construction of the satellite facility and related facilities are expected to ensure that surface water impacts are minimal.

7.1.5 Population Impacts of Construction

Construction activities will require the hiring of four to seven temporary construction workers over the estimated 1-year construction and development period. It is expected that these positions will

be filled by local labor from Dawes County or an adjacent county, or by individuals currently employed on other Cameco projects.

7.1.6 Social and Economic Impacts of Construction

The social and economic impacts to the City of Crawford and surrounding areas during the construction of the original Crow Butte facility were slight given the relatively small scale of activities. Given the similar size of the MEA facilities and scope of the project, the impact of MEA-related construction activities will be similarly slight. CBR estimates that four to seven temporary construction workers will be involved in constructing the MEA facility. The social and economic impacts of construction are discussed in more detail in Section 7.6.

7.1.7 Noise Impacts of Construction

The project area is surrounded by agricultural lands and rural residences. The existing ambient noise in the vicinity of the project area is dominated by intermittent noise from the Burlington Northern Santa Fe (BNSF) rail line located approximately 1 mile (1.6 km) west of the MEA boundary at its closest point. Intermittent, low levels of traffic noise from Hollibaugh and River Roads and agricultural equipment also occur. These roads are used primarily to access local residences and agricultural lands. Nebraska SH 2/71 is located about 4.5 miles (7.24 km) west of the MEA boundary. Noise from BNSF trains on the rail line and traffic noise from the roads would be intermittently audible to receptors within and in close proximity to the MEA.

Increased vehicle travel and the operation of construction equipment at the satellite facility during the construction phase of the project would result in a slight increase in noise impacts to residents who live close to the MEA. Potential noise impacts from construction equipment are expected to occur primarily from operation of drilling rigs during wellfield development. Although noise levels associated with a typical water well drilling rig may reach or exceed 100 A-weighted decibels (dBA) within 2 meters (6.6 feet) of the rig compressor, noise levels decrease to less than 90 dBA within 6 meters (20 feet) (NRC 2009) and 55 dBA at 1,067 meters (3,500 feet) from the source (BLM 2005). Impacts to residences and other sensitive receptors 300 meters (984 feet) or more from the facility would be small (NRC 2009). One occupied residence, located within the MEA, is approximately 200 meters (656 feet) from the proposed wellfield in MU 4. Construction noise impacts at this residence would likely be moderate. All other residences near the MEA boundary are more than 300 meters from the proposed wellfield.

Construction activities would typically occur over an 8-hour work day, 5 days per week. Noise from construction would not be generated during nighttime hours. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic (including movement of heavy equipment, which would be much less dense and slower than typical highway traffic) would be barely perceptible over the existing ambient noise that is intermittently dominated by the BNSF railroad. Noise from construction and construction traffic would be temporary and would briefly add to existing noise levels.

7.2 Environmental Effects of Operations

The major environmental concerns during the operation of the satellite facility will be air quality effects, land use and water quality impacts, ecological impacts, and radiological impacts.

7.2.1 Air Quality Impacts of Operations

The relatively dry air in the MEA region, combined with seasonal high temperatures and wind extremes, create the potential for airborne dust from well field construction activities and traffic on unpaved roads. Under these conditions, it is expected that short-term air quality impacts in the immediate vicinity of the proposed project will be repetitious. However, based on historical experience, overall construction activities at the satellite facility are expected to cause minimal effects on local air quality.

Construction activities at the satellite facility would cause minimal effects on local air quality. Effects to air quality would be increased by the addition of suspended fugitive dust particulates generated from vehicular traffic on unpaved roads (in addition to existing fugitive dust caused by wind erosion) and diesel emissions from construction equipment. Application of water (as necessary) to unpaved roads would reduce the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be short-term only, ceasing once the operational phase begins. NRC estimated fugitive dust emissions during the construction phase of uranium ISR operations are to be less than 2 percent of the NAAQS for $PM_{2.5}$ and less than 1 percent for PM_{10} (NRC 2009).

There will be an increase in the total suspended particulates (TSP) in the region as a result of construction of the satellite facility. This increase will be greatest during the site preparation phase of the satellite facility. Revegetation will be performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction will be revegetated with the exception of facility pad areas, roads, and parking/storage areas. Of these, the only significant source of TSP is dust emissions from unpaved roads.

7.2.1.1 Particulate Emissions During Operations

The primary new emission source of non-radiological fugitive dust will be from re-entrained dust from vehicle travel on paved and unpaved roads. Fugitive dust emissions would be generated by activities such as on-site traffic related to operations and maintenance, employee traffic to and from the site, resin transfers from the satellite facility to the main CPF, and traffic delivering supplies to the site and product from the site.

Particulate matter with a diameter of ten micrometers (PM_{10}) was estimated using equations from EPA's AP 42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources, Sections 13.2.2.2 (EPA 2006) and 13.2.1.3 (EPA 2011b).

For this analysis, PM_{10} from tailpipe emissions are estimated using On Road Emission Factors from California ARB EMFAC2002 Scenario Year 2004 (Model Year A11965 to 2004). These emissions are expected to be minor and should not affect the local ambient air quality. Tailpipe emissions would also include NO_x, CO, SO_2, and non-methane-ethane VOCs, which are not estimated in this analysis.

The project will be located in a NAAQS attainment area for all criteria pollutants. The operations of the satellite facility are not expected to result in major significant amounts of fugitive dust, and would therefore not be considered a major source of emissions under state permitting regulations.,

The amount of dust, as PM_{10}, generated from traveling on unpaved roads during operations can be estimated from the following equations taken from AP 42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources (13.2.2.2 equations 1a and 1b). While both equations 1a and 1b provide a PM emission factor for unpaved roads, the difference is based on whether the road is within an industrial site or accessible to the public.

$$E = k\,(s/12)^{a}\,(w/13)^{b} \qquad (1a)$$

$$E = \frac{k\,(s/12)^{a}\,(S/30)^{b}}{(M/0.5)^{c}} - C \qquad (1b)$$

where k, a, b, c and d are empirical constants given below and

E = size-specific emission factor (lb/VMT)

s = surface material silt content (%)

W = mean vehicle weight (tons)

M = surface material moisture content (%)

S = mean vehicle speed (mph)

C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

The constants for Equations 1a and 1b are taken from Tables 13.2.2-2 and 13.2.2-4, where:

k = 1.5 lb/VMT(equation 1a) and k = 1.8 (equation 1b)

a = 0.9 (equation 1a) and a= 1 (equation 1b)

b = 0.45 (equation 1a)

c = 0.2 (equation 1b)

d = 0.5 (equation 1b)

C= 0.00047 (equation 1b)

Surface material silt content is estimated at 10 percent by using the stone quarrying and processing mean average from Table 13.2.2-1 (EPA 2006). Mean vehicle weight is estimated at an average of 5.5 tons per vehicle based on estimated weights of 2 tons for employee and contractor vehicles, 5 tons for delivery vehicles, and 40 tons for resin transfer trucks. Resin transfer trucks make up approximately 3 percent of the vehicle traffic. Mean vehicle speeds are estimated at 30 miles per hour on paved roads. Surface moisture content is estimated at 13 percent based on Table 13.2.2-3 (EPA 2006).

Onsite Emissions

Onsite emissions are generated within the project boundaries. Fugitive dust emissions generated within the project boundaries are calculated by estimating vehicle miles traveled (VMTs) within the MEA and the CPF. The roads located within the MEA and CPF boundaries are unpaved. Equation 1a from 13.2.2.2 (EPA 2006) is used to calculate an emission factor for vehicles traveling on unpaved surfaces at industrial sites. Calculations are for PM_{10}.

The total travel on unpaved within the project boundaries for personnel, resin transfer, deliveries, and incidental travel will be approximately 22,854 miles (36,780 km per year)per year based on the following assumptions:

- Twelve employees and seven contractors arriving at the MEA and traveling 1.22 miles (2 km) round trip (RT) daily
- Ten employees traveling both within the CPF (1.34 miles [2.1 km] RT daily) and the MEA (1.22 RT miles [2 km] daily)
- Seven delivery trucks (50 per week) traveling within the MEA (1.22 RT miles [2 km] daily)
- Two resin trucks traveling both within the CPF (1.34 miles [2.1 km] RT daily) and the MEA (1.22 RT miles [2 km] daily)

Equations 1a and 1b emission factors can be extrapolated to annual average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual average emissions are inversely proportional to the number of days with measurable (more than 0.254 mm [0.01 inch]) precipitation (EPA 2006) where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = emission factor from Equation 1a or 1b

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

Onsite Emission - Unpaved

With an emission factor of 1.27 lb per VMTk, there will be a total PM_{10} emission of approximately 14.5 tons per year, uncontrolled, as a result of increased traffic on unpaved roads onsite. Mitigation measures, such as the application of water to unpaved roads, will be implemented as necessary. Application of water as dust control would reduce the total PM_{10} emissions. Assuming a 10 percent control efficiency with the application of water as dust control, total PM_{10} emissions would be approximately 13.05 tons per year, controlled.

For this analysis, PM_{10} from tailpipe emissions are estimated using On Road Emission Factors from California ARB EMFAC2002 Scenario Year 2004 (Model Year A11965 to 2004). Assuming 22,854 VMT per year onsite, and assuming a worst-case scenario that all vehicles are diesel-powered heavy-duty trucks (using the All Model Year Diesel Powered Heavy Duty Trucks from California Climate Action Registry General Reporting Protocol, Version 3.1, January 2009, Table C.4), PM_{10} emissions are estimated at 11.86 pounds per year.

Off Site Emissions

Off site emissions are generated outside the project boundaries. Fugitive dust emissions generated outside the project boundaries are calculated by estimating VMTs from Crawford to the MEA and VMTs between the MEA and the CPF. The roads traveled outside the project boundaries are both paved and unpaved. Equation 1b from 13.2.2.2 (EPA 2006) is used to calculate an emission factor for vehicles traveling on publicly accessible roads, dominated by light-duty vehicles on unpaved surfaces. Calculations are for $PM_{10.}$ Equation 2 from 13.2.1.3 (EPA 2011b) is used to calculate the quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road extrapolated to average uncontrolled conditions by application of a precipitation correction term. Calculations are for $PM_{10.}$

The total travel on paved and unpaved roads outside the project boundaries for personnel, resin transfer, deliveries, and incidental travel will be approximately 713,780 miles per year (1,148,717 km per year). Unpaved VMTs (201,445 miles [324,194 km]) and paved VMTs (512,334 miles [824,521 km]) are based on the following assumptions:

- Twelve employees and seven contractors traveling from Crawford to the MEA (11.94 RT miles RT [19 km] daily unpaved and 36.8 miles [59 km] RT daily paved)
- Ten employees traveling between the MEA and the CPF (19.98 miles [32 km] RT daily unpaved and 36.8 miles [59 km] RT daily paved)
- Seven delivery trucks (50 per week) traveling from Crawford to the MEA (11.94 RT miles [19 km] daily unpaved and 36.8 miles [59 km] RT daily paved)
- Two resin trucks traveling between the MEA and the CPF (19.98 miles [32 km] RT daily unpaved and 36.8 miles [59 km] RT daily paved)

The number of VMT for resins trucks (assumed 5 tons) is reduced for offsite travel. Therefore, the mean vehicle weight is estimated at an average of 4.6 tons.

Offsite Emission - Unpaved

The emission factor is extrapolated to annual average uncontrolled conditions based on natural mitigation because of rainfall and other precipitation from the above referenced EPA equation (EPA 2006). Unpaved roads off site are graveled. Surface material silt content is estimated at 4.8 percent by using the sand and gravel processing mean average from Table 13.2.2-1 (EPA 2006).

With an emission factor of 0.29 lb per VMT for PM_{10} generated on unpaved public roads, there will be a total dust emission of approximately 29 tons per year, uncontrolled, as a result of increased traffic on unpaved roads off site. Mitigation measures, such as the application of water to unpaved roads, will be implemented as necessary. Application of water as dust control would reduce the total PM_{10} emissions. Assuming a 10 percent control efficiency with the application of water as dust control, total PM_{10} emissions would be approximately 26 tons per year, controlled.

Offsite Emission - Paved

The quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road may be estimated using the following empirical expression:

E_{ext} = [k (sL)0.91 x (W)1.02] (1 – P/4N) (equation 2 from 13.2.1.3)

where k, sL, W, and S are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as k

P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period

N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).:

k = particle size multiplier for particle size range and units of interest

sL = road surface silt loading (grams per square meter) (g/m2), and

W = average weight (tons) of the vehicles traveling the road.

For PM_{10}, k is 0.0022 lb/VMT (Table 13.2.1-1), and the average weight of vehicles is estimated at 4.6 tons. Silt loading is estimated at 0.2 (Table 13.2.1.-2). The number of wet days is estimated at 85 annually (Figure 13.2.1-2). The number of days in the averaging period is 365.

With an emission factor of 0.0.0023 lb per VMT for PM_{10} generated on paved public roads, there will be a total dust emission of approximately 0.58 per year, uncontrolled, as a result of increased traffic on unpaved roads off site. Mitigation measures, such as the application of water to unpaved roads, would reduce annual emissions.

For this analysis, PM_{10} from tailpipe emissions are estimate using On Road Emission Factors from California ARB EMFAC2002 Scenario Year 2004 (Model Year A11965 to 2004). Assuming 713,780 VMT per year off site, and assuming a worst-case scenario that all vehicles are diesel-powered heavy-duty trucks (using the All Model Year Diesel Powered Heavy Duty Trucks from California Climate Action Registry General Reporting Protocol, Version 3.1, January 2009, Table C.4), PM_{10} emissions are estimated at 373 pounds per year.

7.2.1.2 **Criteria Pollutant Regulatory Compliance Issues**

The statements in this section apply to both construction and operations phase of the proposed satellite facility.

The NAAQS for PM_{10} are 150 micrograms per cubic meter ($\mu g/m^3$; 24-hour average), and 50 $\mu g/m^3$ (annual average). The NAAQS standards for other pollutants are presented in **Table 2.5-16**. All counties within the 50-mile (80-km) radius of the project are in attainment of NAAQS. Concentrations of the criteria pollutants from the operations are not expected to exceed the regulated or "threshold" level for one or more of the NAAQS pollutants within the 50-mile (80-km) radius.

In addition to the NAAQS, there are national standards for the PSD of air quality (see discussions in Section 2.5.5.2). The PSD program is administered by the States of Nebraska and South Dakota, with their programs designed to protect the air quality in area that are in attainment with the NAAQS and to prevent degradation of air quality in areas below the standard (designated as clean air areas). The PSD requirements establish allowable pollution "increments" that may be added to the air in each area while still protecting air quality. The increment is the maximum allowable deterioration of air quality. The maximum allowable increments applicable to Nebraska and South Dakota are shown in **Table 2.5-26.**

The allowable increments vary by location across the states. Those areas characterized as Class I (i.e., National Parks and Wilderness Areas) and allow less incremental pollution increase. Class III areas are planning areas set aside for industrial growth. Class II areas are essentially all other areas of the state not designated as Class I or Class III. There are no Class I National Park and Wilderness Areas in Nebraska. The State of South Dakota has two Class I Areas: Badlands and Wind Cave National Parks. The Wind Caves National Park is the closer of the two to the MEA, at a distance of approximately 60 miles (96.6 km). Therefore, due to the distances to the MEA project site, no impacts associated with PSD requirements at these sites would be expected based on the estimated amount of emissions from the MEA operations site.

Cumulative Impacts

Cumulative impacts to air quality due to operations of the CPF, NTEA, TCEA, and MEA project sites would be expected to be small due to the nature of the operations, controls (e.g., dust control), and distance between the facilities (**Figure 1.3-1**)

Agricultural activities and vehicles traveling on public roads would continue to generate dust and vehicle emissions. Implementation of the proposed project would result in fugitive dust and pollutant emissions from the combustion of fuel to power the engines of construction vehicles and equipment. Combustion of gasoline and diesel fuels by combustion engines (vehicles, generators, construction equipment, etc.) would generate local emissions of PM, NOx, CO, VOCs, and SO2 during the site preparation and construction period. While specific construction equipment including size, number of vehicles, and the hours each piece of equipment would operate is not quantified, the emissions for these operations would be small.

When all three expansion areas and the existing Crow Butte Operation are operational, the maximum combined dust emissions would be less than 55.1 tons per year. The combined dust emissions under implementation of the proposed expansion projects are expected to be minor, dispersed, and should not affect the local ambient air quality. Mitigation measures, such as the application of water or dust control chemicals to unpaved roads would be implemented as necessary, along with speed limits on the mine property. Construction and operation of the expansion areas would result in negligible incremental emissions.

The combined emissions of the proposed expansion areas and the existing operation are not anticipated to jeopardize NAAQS attainment status in the region or impair visibility within any federally mandated PSD Class I area. Consequently, implementation of the proposed expansion projects would result in small cumulative effects on air quality when considered with other activities in the area.

7.2.2 Land Use Impacts of Operations

The principal land uses for the MEA and the 2.25-mile (3.62-km) AOR is grazing livestock and raising of crops. Rangeland accounts for 82.6 percent of the land use in the MEA and surrounding 2.25-mile (3.62-km) AOR as discussed in Section 2.2. The secondary land use within the MEA license boundary is cropland, which accounted for 8.9 percent of the land use in the MEA and the AOR. Land use was discussed in detail in Section 2.2.

For the proposed disturbance of 591 acres for the proposed MUs, satellite facilities, eleven MUs, and roadways, cropland accounts for 71.7 acres or 12.2 percent of the 591-acre total area. Rangeland accounts for 491.2 acres or 82.0 percent of the total area. Rangeland rehabilitation (6.9 acres), structural biotope (8.9 acres), forest land (5.6 acres), and drainage (7.3 acres) are the only other impacted land uses. **Table 7.1-1** provides the acres disturbed by the MEA satellite facility, MUs, and access routes, and **Figure 2.2-1** shows the land use designations for the MEA AOR.

As a result of site preparation and construction, cattle production will be excluded from the areas that are under development. The total estimated area that will be impacted during the course of currently planned project is the 491.2 acres (mixed-grass prairie and degraded rangeland) associated with the satellite facility, wellfield, and roads. As discussed in Section 2.2, livestock and livestock products carry a value of $55.62 per acre, indicating that livestock production on impacted rangeland within the MEA carries a potential value of approximately $27,320.

As a result of site preparation and construction, crop production will be excluded from the areas that are under development. The total estimated cropland area that will be impacted during the course of the project is 71.7 acres associated with the satellite facility, wellfield, and roads. As presented previously, non-livestock lands carry a value of $13.61 per acre. Based on this information, the lost production of crops would be valued at $976 per year.

Considering the relatively small size of the area impacted by operations, the exclusion of agricultural activities from this area over the course of the project operation will not significantly impact local or regional agricultural production. The limited impacts are considered temporary and reversible by returning the land to its former grazing use through post-mining surface reclamation.

The current operations in the licensed area have shown that CBR can successfully restore the land surface following mining operations. Surface reclamation activities, including contouring and revegetation, have been performed routinely following initial MU construction. Additionally, CBR recently completed surface and subsurface reclamation of a significant portion of MU 1 following approval of groundwater restoration. These areas have been successfully recontoured, and revegetation has been completed in accordance with NDEQ requirements.

Cumulative Impacts

No planned land development projects were identified near the proposed project. The original license area for the Crow Butte Operation is approximately 2,861 acres and the surface area affected over the estimated life of the project is approximately 2,000 acres. Late in the project when all three expansion areas and the existing operation are operating simultaneously, the expansion areas will displace an additional combined total of 2,543 acres (assuming only 11 MUs) from crop production or livestock grazing. Wheat and hay are the major crops grown on croplands within the area. In 2007, Dawes County had 44,100 acres of cropland used to grow alfalfa hay and 43,445 acres used for winter wheat (NASS 2009a).

Dawes County is comprised of approximately 202,946 acres of cropland and 616,467 acres of permanent pasture and rangeland (other than cropland and woodland pastured), for a total of 819,413 acres of agricultural land (NASS 2013). The land uses displaced by the proposed project represent approximately 0.003 percent of the total agricultural land in Dawes County. Landowner mineral royalties and leases will offset the loss of crops. Considering the relatively small size of the area affected, the exclusion of agricultural activities from the expansion areas over the life of the operation should not have a significant effect on local agricultural production.

These effects would occur over the life of the project; however, once mining is completed, these effects would be reversible by returning the land to its former cropland or rangeland uses through post-mining surface reclamation. Mitigation measures for the loss of agricultural production over the course of the project are discussed in Section 5.1 of the MEA ER. When considered with all the other activities in the area, implementation of the proposed expansion projects would result in a small cumulative effect on land uses.

7.2.3 Geologic and Soil Impacts of Operations

7.2.3.1 Geologic Impacts of Operations

Geologic impacts are expected to be minimal, if any. No significant matrix compression or ground

subsidence is expected, as the net withdrawal of fluid from the basal sandstone of the Chadron Formation will be on the order of 1 percent or less, and the anticipated drawdown over the life of the project is expected to be on the order of 10 percent of the available head, or less. Further, once mining and restoration operations are completed and restoration approved, groundwater levels will return to near original conditions under a natural gradient. No faults are present within the project area that would be subject to potential reactivation due to fluid injection.

Impacts to paleontological resources due to operations are expected to be minimal.

Cumulative Impacts

The proposed CBR expansion areas (i.e., MEA, NTEA, and TCEA) would have no notable effects on geology of the region. Therefore, there would be no cumulative impacts.

7.2.3.2 Soil Impacts of Operations

Operational impacts to soils are expected to be minor, and would only occur if BMPs and mitigation measures are not properly constructed, maintained, and monitored. Improper surfacing of access roads could lead to rutting and erosion. Off-road travel could lead to unforeseen vegetation removal, soil compaction, and localized soil loss due to wind and water erosion.

As during construction activities, release of hazardous materials to soils would lead to decreased soil productivity and an increase in soil loss due to erosion. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures.

Cumulative Impacts

Soils in the area would continue to be disturbed from past, present, or reasonably foreseeable future actions (RFFAs) associated with the existing CPF and proposed MEA, NTEA and TCEA projects. With proper implementation of BMPs to prevent erosion and control sediment, however, cumulative effects to soils are not expected to be significant. Rather, the proposed expansion projects would result in minimal or no cumulative effects to soils.

7.2.4 Archeological Resources Impacts of Operations

ARCADIS (Graves et al. 2011) completed an intensive pedestrian block cultural resources inventory of approximately 4,500 acres for the MEA during the period from November 2010 to February 2011. The MEA was inventoried for the presence of historic properties (cultural resources that are listed or eligible for listing on the NRHP) and may be impacted by proposed mine development. This inventory recorded 15 newly discovered historic sites and five historic isolated finds and updated the documentation on two previously recorded historic farmstead sites. All of the newly recorded historic sites were recommended not eligible for the NRHP and do not qualify as historic properties. Isolated finds are by definition not eligible for the NRHP. Historic farmstead DWOO-242 is recommended not eligible for the NRHP, but appears to be currently or recently occupied. Site DWOO-243 may have the potential to yield information important in history and may be potentially eligible for the NRHP, but is not recommended eligible based on the currently available information. Avoidance of these two sites by project actions is recommended. If these recommendations are followed, the proposed project will have no adverse effect on historic properties, and no further cultural resource investigations are recommended.

CBR requested ARCADIS complete a field survey of an additional 160 acres in section 36 T30N R51W completed during the original field investigation but not reported in the original report. The 160 acres was field investigated by ARCADIS on February 19, 2011 and no new cultural resources were discovered (Graves and Graves 2012). One historic bridge (25DW362) was identified in section 36 T30N R51W and reported within the original cultural resource inventory report. An addendum to the original cultural resources report was prepared to address the additional 160 acres (Graves and Graves 2012). Historic site 25DW362 was recommended not eligible for listing on the NRHP with SHPO concurrence.

The Nebraska SHPO concurred with the findings of the addition to the cultural resources report that no archaeological, architectural, or historic context property resources will be affected by the proposed project (NSHS 2012). As stated in the SHPO concurrence letter, the SHPO's review does not constitute the opinions of any Native American Tribes that may have an interest in Traditional Cultural Properties potentially affected by this project.

<u>Cumulative Impacts</u>

The cumulative effects area for cultural resources is defined as each of the expansion areas (NTEA, TCEA, and MEA) and one-mile (1.6 km) radius around each of these expansion areas. No traditional cultural areas or historic properties have been identified in the general area that would merit consideration of a larger area of potential effects. Records searches have been completed for each of these cumulative effects areas and complete intensive cultural resource inventories have been completed for each of the expansion areas. A variety of potentially important prehistoric and historic resources are present in the general area, including Fort Robinson State Historic Park north of the TCEA. There are historic properties within the Fort Robinson State Historic Park near the TCEA. However, sites within the park are protected and would not be adversely affected. One previously reported historic structure in the MEA is recommended potentially eligible for the NRHP and is therefore a historic property. This historic property would be avoided. The project would have no effect to historic properties. Therefore, the project would not contribute to cumulative adverse effects to historic properties resulting from the incremental effect of the proposed expansion project when added to other past, present or RFFAs.

7.2.5 Groundwater Impacts of Operations

Potential impacts to water resources from mining and restoration activities include the following:

7.2.5.1 Groundwater Consumption

Groundwater impacts and consumption related to the satellite facility operation will be fully assessed in an Industrial Groundwater Permit application required by NDNR (application to be submitted following NDEQ approval of the MEA Class III UIC permit). Information from the existing Groundwater Permit for the current license area indicates that the drawdown from mining operations in the basal sandstone of the Chadron Formation is minimal (e.g., on the order of 10 percent of the available head). Based on drawdown data from years of operation in the current license area, and on the formation characteristics from the MEA pumping test, the drawdown effect on the Chadron aquifer as a result of operations has been and is expected to remain minimal.

Groundwater consumption from the operation is expected to be on the order of 0.5 to 2.0 percent of the total mining flow (6,000 gpm). Consumptive volume (1,500 gpm) will increase during

aquifer restoration, especially during the groundwater sweep phase. However, it is expected that, in peak years, the net consumption for the entire operation will be on the order of 50 to 100 gpm.

A simple hydrologic drawdown-distance analysis, using the Theis (1935) equation for confined aquifers, was conducted to estimate the drawdown at the MEA. The analysis used the water balance disposal estimate for the year 2024, which corresponds to the tenth year of operations. The year 2024 in the Marsland water balance is the year during which the highest consumptive ground water use is assumed. The analysis assumes that four MUs are in restoration with an estimated 250 gpm of consumptive water use, and that five MUs are in production with a bleed stream of 65 gpm. The total consumptive water use estimated for that year is 315 gpm. The 315 gpm consumptive water use represents the worst-case water use during the operation of the MEA. Consistent with Section 7.2.3.1, the available head over the formation is expected to be reduced by 10 percent.

The drawdown analysis of the MEA estimates that the drawdown during the worst-case year of operation is approximately 30 feet in the areas where active restoration is occurring. The estimated drawdown is about 6 percent to 7 percent of the total head available. The static water level at Marsland is about 465 ft, and the expected water level during the tenth year of operations is estimated to be 435 ft. The drawdown in the basal sandstone of the Chadron Formation, at the monitor well ring, is approximately 15 ft, and the worst-case drawdown at the edge of the 2.25 mile review area will be about 2 ft. As such, this analysis of the MEA is in reasonable agreement with the actual operating data from the CBR Mine.

CBR reviewed private wells within a 2.25-mile radius of the MEA and found that none of the wells were completed in the basal sandstone of the Chadron Formation. All of the well completions are in the overlying Brule Formation and Arikaree Group because the wells are much shallower (60 to 300 feet) than the basal sandstone of the Chadron Formation (1,000 ft +), and the water quality of the overlying formations is superior to that of the basal sandstone of the Chadron Sandstone. Further, the pumping test demonstrated the integrity of the confining layer that separates the aquifer in the basal sandstone of the Chadron Formation from the overlying aquifers.

The assumptions include:

- Consumptive Water Use
  - The consumptive water use estimates were taken from the MEA water balance for the year 2024.
  - The estimated total consumptive water use for the year is estimated at a total of 315 gpm.
    - 250 gpm RO concentrate
    - 65 gpm of production bleed
  - The activities for that year are as follows:
    - Mine Unit 1 is in stability.
    - Mine Unit 2 is in RO treatment.
    - Mine Unit 3 is in RO treatment.
    - Mine Unit 4 is in IX treatment.
    - Mine Unit 5 is in IX treatment.
  - Mine Units 6 through 10 are in production.
  - The withdrawal of the restoration bleed and the production bleed is approximated as a line of wells equally spaced along the length of the MEA.

- The withdrawal of the restoration bleed is from 11 wells spaced at equal distances over 2.5 miles.
  - ♦ The pumping rate of the 11 wells is assumed at 22.7 gpm.
  - ♦ The restoration bleed is simulated over the RO sweep and IX restoration area.
- The withdrawal of the production bleed is from 11 wells spaced at equal distances over 2.5 miles.
  - ♦ The pumping rate of the 11 production bleed wells is 5.9 gpm.
  - ♦ The production bleed is simulated over the production area.

➢ Drawdown Analysis
- ▪ Analysis Theory
  - Analysis uses Theis (1935)
    - ♦ Aquifer has infinite extent, is homogeneous, and is isotropic. (No boundary conditions)
    - ♦ Well fully penetrates the confined aquifer, resulting in horizontal flow to the well, and flow is laminar.
    - ♦ Aquifer has uniform thickness.
    - ♦ Aquifer is fully confined and discharge is derived from storage in the aquifer.
    - ♦ The equation for predicting drawdown (s) at the well is as follows:
      - ➢ S= (Q/4pi T) x W(u) where
        - ▪ s is the drawdown
        - ▪ T is the transmissivity
        - ▪ Q is the pumping rate
        - ▪ W(u) is the well function
    - ♦ Time period for the calculation is assumed to be 3 months of continuous pumping.
  - The analysis assumes that the drawdown of interfering wells is additive because the aquifer is confined.
- ▪ Methodology
  - Hydraulic information taken from **Table 2.7-3** Summary of 2011 Marsland Pumping Test Results
    - ♦ Formation data used in the analysis:
      - ➢ Avg. Transmissivity (ft^2/day): 1012
      - ➢ Avg. Hyd. Cond. (ft/day): 25
      - ➢ Avg. Storativity: $7.46x10^{-5}$
- ▪ Methodology
  - Well drawdown calculations done using USGS Excel Spreadsheet Confined_Predict.xls
    - ♦ A series of drawdown calculations were done was conducted for various distances from the pump well.
      - ➢ Drawdown calculations were conducted for the restoration wells and production wells.
    - ♦ The drawdown estimates for the MEA were calculated using a spreadsheet with the drawdown values arranged at the proper distance on an assumed straight line and added to obtain the overall drawdown at the distance point.

References consulted for carrying out this drawdown analysis were Fetter 1994 and Driscoll 1986.

7.2.5.2 Potential Declines in Groundwater Quality

Excursions represent a potential effect on the adjacent groundwater as a result of operations. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality in the exempted aquifer compared to pre-mining conditions. Movement of this water out of the wellfield into the monitor well ring results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, poor well integrity, and hydrofracturing of the ore zone or surrounding units.

To date, there have been several confirmed horizontal excursions in the basal sandstone of the Chadron Formation in the current license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In the majority of the excursions, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent UCLs. In no case did the excursions threaten the water quality of an underground source of drinking water because the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. **Table 7.2-1** summarizes the excursions reported for the current license area.

The subsurface interval composed of the Lower Dakota, Morrison, and Sundance Formations has been identified as the DDW Injection Zone at the MEA. The subsurface geologic characteristics beneath the MEA will prevent disposal fluids injected into the Injection Zone from impacting the overlying fresh water aquifers (i.e., Brule and Chadron Formations). Between the lowermost Chadron Formation and the Injection Zone are more than 2,500 feet of sediments primarily consisting of low permeability shale. This separating aquitard protects against vertical migration of injected fluids to the overlying Brule and Chadron Formations. Shales above and below the Injection Zone will encase the disposal fluids within the receiving formations and no structural elements with the potential to disrupt the natural vertical containment have been identified. The primary groundwater supply in and near the MEA is the Brule Formation, typically encountered at depths from approximately 30 to 200 feet below land surface, with the exception of locations where the overlying alluvium is not present. In general, the static water level for the Brule Formation wells in the MEA ranges from 50 to 150 feet below land surface, depending on local topography.

The estimated concentrations of TDS within the Injection Zone are in excess of 10,000 mg/L. No harmful or reactive incompatibility between the formation brine and the waste constituents are expected.

CBR has satisfactorily operated a Class I DDW at the nearby CBR CPF facility since 1994 without any adverse impacts. A second DDW well was approved and placed into operation in fourth quarter of 2011.

7.2.5.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as an uncontrolled release of process liquids due to a wellfield accident. If there should be a wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding soil, could occur. Wellfield accidents could take the form of a slow leak or a catastrophic failure, a shallow

excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

The satellite building will have curbing around the structure, which will contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation.

The DDW will receive wastewater from the wastewater tanks located at the satellite processing facility via an underground PVC/HDPE pipeline. Flow rates from the tankage, tank levels, and flow rates are all controlled and monitored to ensure any potential leakage is rapidly detected. All flows and pressures will have limits and alarms programmed in to alert the operator as limits are approached and to control feed pumps. The details of these systems will be addressed in the Class I permit application that will be submitted to the NDEQ as part of the required permitting process. CBR has successfully operated a Class I DDW for approximately 19 years without any significant spills or releases.

Another potential cause of groundwater impacts from accidents could be releases as a result of a spill of injection or production solutions from a wellfield building or associated piping. To control these types of releases, all piping is either PVC, HDPE with butt-welded joints, or equivalent. All piping is leak-tested prior to production flow and following repairs or maintenance.

7.2.5.4 Cumulative Impacts

Potential cumulative impacts to groundwater resources are expected to be minimal due to the site controls and distance from the MEA site to the CPF and proposed TCEA and NTEA. The operational control and instrumentation systems and excursion monitoring system to be used at the MEA site are designed to quickly detect potential excursions and any leaks, spills or releases. Therefore, any area of impact would be considered to be small. These same conditions will also apply to operations at the proposed NTEA and TCEA, and already apply at the CPF site. Therefore, it would be extremely unlikely for any groundwater impacts reaching beyond the license boundary at the MEA site, as well as the CPF, NTEA and TCEA could contribute to any cumulative impacts.

The NRC has indicated a concern with potential cumulative impacts on groundwater from operating multiple ISR facilities in the Crawford basin. In an effort to try to address these concerns, an evaluation of the potential cumulative impacts associated with development of expansion areas was conducted, and includes an assessment of water levels and water quality in the basal sandstone of the Chadron Formation, as well as overlying and underlying aquifers. Additionally, the effect of deep disposal well operation on the Lower Dakota, Morrison, and Sundance Formations was assessed. Existing water level data collected prior to, and during active mining at the CPF site and expansion areas, hydraulic testing results, water quality results, and deep disposal well design calculations were consulted in conjunction with the anticipated mine development and production timelines to assess potential cumulative impacts.

<u>Water Level Impacts</u>

As has been demonstrated at the CPF, water levels in the basal sandstone of the Chadron Formation have decreased approximately 60 feet due to production (bleed rate implementation) in order to maintain an inward hydraulic gradient. Water quality in the basal sandstone of the Chadron

Formation is considered poor as compared to the shallower Brule formation. Therefore, there are limited wells completed in the basal sandstone of the Chadron Formation to allow for monitoring of offsite water levels. According to a 1991 Industrial Groundwater Use Permit, water levels in Crawford are expected to decrease up to 20 feet from static levels as a result of mining operations at the CPF site (CBR 2007).

Additionally, pumping tests have been conducted in the basal sandstone of the Chadron Formation at similar rates as anticipated production bleed rates. These tests have generally been less than three days in duration, and have resulted in estimated water level decreases greater than one foot at a distance up to 5,700 feet from the pumping well (Petrotek 2002). The cone of depression would continue to expand during long-duration pumping, as is the case during production and groundwater restoration activities. Therefore, the results of pumping tests as well as observed and projected water levels resulting from the CPF mining operations indicate that water levels in the basal sandstone of the Chadron Formation will decrease in a mining unit, with drawdown propagating up to several miles from the pumping center.

Observed water levels in the overlying Brule Formation resulting from CPF mining operations and during pumping tests indicate the basal sandstone of the Chadron Formation and Brule Formations are hydraulically disconnected. Therefore, sustained water level decreases in the basal sandstone of the Chadron Formation are expected to have an insignificant effect on Brule Formation water levels.

The disposal option for process bleed water and groundwater restoration that is likely to impact groundwater levels or water quality is injection into the Lower Dakota, Morrison, and/or Sundance Formations using deep disposal wells. Each expansion area is expected to operate up to two deep disposal wells. Characterization of the injection zone of Deep Disposal Well #2 at the CPF site indicates the formation thickness is approximately 67 feet. In order to calculate a radius of influence resulting from deep disposal well injection over the course of 10 years, mobile porosity was assumed to be 10 percent. The radius of influence resulting from injecting 45 gpm into a single well over 10 years is approximately 1,200 feet. The calculated radius of influence assumes uniform flow across the full injection interval (thickness) and area, and that no impediments to injection such as injection pressure or aquifer boundaries exist. While deep disposal well configurations and locations at each expansion area are not yet determined, this calculation provides some estimate of the area where deep disposal wells will displace formation groundwater, which may result in increased pressures or redistribution of groundwater to adjacent areas.

An analysis of the drawdown impacts resulting from MEA operations, and the cumulative drawdown impacts resulting from the simultaneous operation of the MEA, Crow Butte, and Three Crow Expansion Area facilities, was conducted and is located in **Appendix GG** (AquiferTek 2016b). The drawdown of the potentiometric surface of the basal sandstone of the Chadron Formation was computed using the Theis solutions for confined aquifers (Theis, 1935). Drawdown impacts were computed over the period 2011 through 2052, corresponding to the approximate historical groundwater monitoring period at MEA, future ISR facility operations and aquifer recovery period. Cumulative drawdown impacts from multiple ISR facilities were computed by summing the drawdown impacts of individual facilities using the principal of superposition. Additional drawdown resulting from a lateral no-flow boundary was computed using image well theory (Ferris and others, 1962).

CBO will use performance confirmation to verify actual mining performance follows model drawdown projections (**Appendix GG, AquiferTek, 2016b**) to ensure that the basal sandstone of the Chadron Formation remains saturated. To monitor performance, CBO will install within each mine unit a minimum of one monitor well for collection of quarterly water level data. If needed recalibration of the models drawdown projections will be performed and if necessary, a corrective action plan will be developed and submitted to the NRC for review and approval.

Potential cumulative impacts to the Lower Dakota, Morrison, and Sundance Formations resulting from operation of deep disposal wells at expansion area mines are unclear. While ROI calculations indicate the area where formation water will be displaced by injected water, it is unclear where the displaced water migrates. The ability of these confined aquifers to accept injected water is limited by the presence of overlying and underlying confining units, aquifer storage, and hydraulic connection within the injected formation and with adjacent aquifers. Little characterization of the Lower Dakota, Morrison, or Sundance Formations is available in the area of interest that would enable a meaningful evaluation of overlapping influences among the four mines.

Surface water levels have been shown to be unaffected by current mining operations, as no discharge to surface water is permitted and the deep disposal aquifers appear to be hydraulically disconnected from surface water. No changes to the lack of surface water impacts are expected as a result of expanded mining operations.

Water Quality Impacts

Water quality in the basal sandstone of the Chadron Formation during mining is controlled by induced hydraulic gradients toward the mine unit that limit injectate excursions. Monitoring wells outside the production wellfield are sampled biweekly to ensure that extraction wells are adequately removing the injectate. Changes to extraction well pumping rates are made to remedy observed injectate excursions that are indicated by perimeter monitoring well water quality results. Therefore, water quality in the basal sandstone of the Chadron Formation is not expected to be significantly affected during mining.

Mining unit-specific groundwater restoration water quality goals are determined as endpoints for restoration activities. During groundwater restoration, water is returned to at, or near background conditions using the best practice technology for treatment. If background concentrations for mining-related groundwater constituents cannot be achieved using best practice cleanup technologies, NDEQ groundwater standards become the restoration goal. The objective of groundwater restoration is to return water quality back to that which is consistent with pre-mining use. Future use of groundwater is not expected to be affected by mining activities.

The combined water quality controls in place during mining and aquifer restoration goals should result in water quality in mine units that are not significantly different than background, and do not influence future use. Therefore, cumulative influences on water quality of the basal sandstone of the Chadron Formation resulting from operation of multiple mines is not expected. Injected water quality in the Morrison, and Sundance Formations is monitored on a daily or weekly basis, depending on the parameter, and reported to the NDEQ on a monthly basis. Therefore, water quality in the deep injection formations will not be adversely impacted beyond what is permitted due to operation of deep disposal wells at multiple mines as long as injectate water quality does not deviate from permit limitations.

Conclusions

A drawdown impact assessment was completed for the basal sandstone of the Chadron Formation at the MEA and for the simultaneous operation of the MEA, CBO, and TCEA (e.g. cumulative drawdown assessment) along with an assessment of the projected available head and basal Chadron potentiometric surface at the time of maximum cumulative drawdown **Appendix GG** (AquiferTek, May 2016b)

Results of the impact assessment indicates maximum cumulative drawdown at the MEA will be less than 111 feet over the period of combined ISR operations (2011-2042). Minimum available head at the MEA is projected to be greater than 320 feet within the MEA ISR wellfields, and greater than 270 feet within the MEA permit area for the duration of combined ISR operations.

Model drawdown projections can be considered conservative because they do not include the impact of groundwater recharge on the basal sandstone of the Chadron Formation over a large radius of influence and because consumptive use for the MEA and TCEA are based in part on a conservative 30% reverse osmosis (RO) efficiency during wellfield restoration (25% RO efficiency has been routinely achieved at the CBO facility).

The drawdown impact assessment does not include potential drawdown impacts resulting from groundwater withdrawals other than Cameco ISR operations, including large seasonal agricultural groundwater withdrawals from a tributary arm of the basal sandstone of the Chadron Formation approximately 35 to 50 miles southwest of the MEA in the North Platte drainage. Irrigation wells in the North Platte Irrigation District have been operating for over 40 years. Although there may not be a direct hydraulic connection between the tributary arm of the basal sandstone of the Chadron Formation in the North Platte drainage and the MEA (Sibray, 2010), there does appear to be less direct flow paths (on the order of 60 to 100 miles in length) that may hydraulically connect the MEA and the North Platte basin. Given the large reported seasonal groundwater withdrawals in excess of 1000 GPM from the basal sandstone of the Chadron Formation in the North Platte drainage, some measurable drawdown impact at the MEA would not be unexpected in a confined aquifer over a long period of time. Some of the historical drawdown observed at the MEA may therefore be attributable to irrigation withdrawals southwest of the MEA, and not entirely due to CBO operations.

Wastewater injected into the Lower Dakota, Morrison, and Sundance Formations using deep disposal wells will likely have injected radii of influences of greater than a 1,000 feet. These injections will displace formation groundwater, although it is unclear where that water will migrate. Little characterization of the Lower Dakota, Morrison, and Sundance Formations has been completed and only observations of injection pressures and flow rates can be used to infer the ability to dispose of water using this method. The Morrison Formation has demonstrated the capacity to accept large volumes of an injected waste stream over an extended period of time at the nearby CPF.

The subsurface geologic characteristics beneath the proposed expansion areas will prevent disposal fluids injected into the deep disposal well injection zone from impacting the overlying fresh water aquifers. Between the lowermost drinking water source aquifer and the deep disposal well injection are more than 2,500 feet of sediments primarily consisting of low permeability shale. This separating aquitard protects against vertical migration of injected fluids to the drinking water source aquifers. Shales above and below the deep disposal well injection zone will encase the disposal

fluids within the receiving formations and no structural elements with the potential to disrupt the natural vertical containment have been identified.

Water quality in the basal sandstone of the Chadron Formation during production is maintained by providing hydraulic control of the injectate. Changes to extraction well operation are made to remedy observed injectate excursions. Formation water quality is restored to either background conditions, or conditions that are consistent with pre-mining water quality under the direction of the NDEQ. As a result, no significant degradation of water quality is expected to result from operation of expansion area mines. Water quality of the Lower Dakota, Morrison, and Sundance Formations is protected by permitted specifications on injectate water quality. Therefore, if permit limitations are not exceeded, there will be no adverse cumulative impact beyond permitted levels as a result of operation of multiple mines. The EPA and NDEQ will not authorize deep disposal via a Class I injection well unless the permitting process demonstrates that adequate operating procedures and controls will be in place and the well will be properly sited so that the confinement zones and proper well construction minimizes the potential for migration of fluids outside of the approved injection zone. The conditions and conclusions addressed in this section apply to the current CPF operations and the proposed MEA, TCEA and NTEA sites.

7.2.6 Surface Water Impacts of Operations

7.2.6.1 Surface Water Impacts from Sedimentation

Protection of surface water from stormwater runoff during ongoing wellfield construction related to operations is regulated by the NDEQ as discussed in Section 7.1.4.

7.2.6.2 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as failure or an uncontrolled release of process liquids due to a wellfield accident. Section 7.1.4 discussed the measures to prevent and control wellfield spills. Wellfield areas are installed with dikes or berms as an additional measure to protect surface water. The berms prevent surface spills from entering all surface water bodies and drainages that connect to surface water bodies and eliminate public dose and contaminant pathways to surface water.

The satellite building will have secondary containment (curbing around the structure) to contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation. In addition, there is a regular program of inspections and preventive maintenance.

<u>Cumulative Impacts</u>

The MEA site is located south of the Pine Ridge Escarpment, whereas the CPF, TCEA and NTEA are located to the north of this feature. Any surface runoff that could leave the NTEA, TCEA, and CPF site would flow toward the White River, and any surface runoff leaving the MEA site would flow toward the Niobrara River (**Figure 1.3-1**). Although potential cumulative impacts could be alleged with the CPF, NTEA, and TCEA sites, this would be highly unlikely due to lack of permitted surface wastewater discharges, spill controls, containment of potentially contaminated rainfall or snowfall due to curbing and berms and site operating procedures to prevent releases of

contaminated rainfall or snowmelt. Due to its location and the area topography, the MEA site would not contribute to any potential cumulative impacts associated with the other CBR regional operations. Mitigation measures at the MEA site that would minimize impacts to the Niobrara River are discussed in Sections 7.1.4 and 7.2.7. These and similar mitigation measures would also apply to the CPF, TCEA, and NTEA, as discussed in their NRC application documents. In addition, there are no industrial or agricultural activities in the area that would be associated with cumulative impacts due to the MEA operations.

Historically, surface water quality has not been shown to be affected by current mining operations, as no discharge to surface water is permitted, groundwater impacts to surface water have not occurred, and the deep disposal aquifers appear to be hydraulically disconnected from surface water. No adverse changes to surface water quality are expected as a result of mining in the proposed expansion areas.

7.2.7 Ecological Impacts of Operations

7.2.7.1 Impact Significance Criteria

The following impact significance criteria were used to determine the significance of construction and operation of the proposed project on wildlife and vegetation resources within the project area. These criteria were developed based on professional judgment, involvement in other NEPA projects throughout the West, and state and federal regulations:

- Removal of vegetation such that following reclamation, the disturbed area(s) would not have adequate cover (density) and species composition (diversity) to support pre-existing land uses, including wildlife habitat;
- Unauthorized discharge of dredged or fill materials into, or excavation of, waters of the U.S., including special aquatic sites, wetlands, and other areas subject to the Section 404 of the Clean Water Act, Executive Order 11988 - floodplains, and Executive Order 11990 - wetlands and riparian zones;
- Reclamation is not accomplished in compliance with Executive Order 13112 (Invasive Species);
- Introduction and establishment of noxious or other undesirable invasive, non-native plant species to the degree that such establishment results in listed invasive, non-native species occupying any undisturbed rangeland outside of established disturbance areas or hampers successful revegetation of desirable species in disturbed areas;
- A substantial increase in direct mortality of wildlife caused by road kills, harassment, or other causes;
- Incidental take of a special status species to the extent that such impact would threaten the viability of the local population;
- Elimination or permanent reduction in size of an officially designated critical wildlife habitat, or otherwise rendering such habitat unsuitable;
- Any effect, direct or indirect, resulting in a long-term decline in recruitment and/or survival of a wildlife population; and

- Construction disturbance during the avian breeding season or impacts to reproductive success which could result in the incidental loss of fertile eggs or nestlings, or otherwise lead to nest abandonment, which would violate the regulations prescribed by the Migratory Bird Treaty Act (MBTA).

7.2.7.2 **Vegetation**

As described in detail in Section 3, a total of 11 MUs, satellite facility, and access roads will be constructed in 2014 with an expected mine life of operation of approximately 7 years. As shown on **Figure 2.8-1**, wellfield development will occur primarily in areas dominated by mixed-grass prairie and degraded rangeland vegetation.

Vegetation removal and soil handling associated with the construction and installation of the mine units, pipelines, access roads, and satellite facilities would affect vegetation resources both directly and indirectly. Direct impacts would include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types) due to soil disturbance and grading activities. Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition and/or changes in vegetative density; reduction of wildlife habitat; and changes in visual aesthetics.

The total number of acres currently identified as having the potential for disturbance within the 4,622.3-acre license area over the long-term operation of the project will be approximately 1,753 acres (**Table 7.1-1**). Initially, the construction of the satellite building(s)/associated facilities, MU No. 1 and needed roadways would have short-term surface disturbances of approximately 78 acres (approximately 2 percent of the total license boundary acreage). The production building and associated facilities would disturb an area of 1.8 acres (area within fence-line of production facilities). **Table 7.1-1** provides a breakdown of the area of disturbance by the type of habitat cover acreage.

Over the life of the project, it is currently estimated that 38 percent of the total license area acreage would be disturbed due to site development and operation. The likelihood of impact is greatest for the primary vegetation cover types of mixed-grass prairie (1,143 acres) and degraded rangeland (228 aces), which occupy approximately 78 percent of the total acreage with the potential for disturbance (1,753 acres). Mixed-grass prairie and degraded rangeland habitat cover (1,143 and 228 acres, respectively) account for 25 percent and 5 percent, respectively, of the total license acreage of 4,622.3 acres. There are no plans to disturb the deciduous streambank forest habitat cover type within the license boundary; other cover types would be subject to minor amounts of disturbance (**Table 7.1-1**).

The majority of new roads are located within the proposed wellfield. A new access road will serve as the entrance roadway to the satellite production facility and offices. Estimated acreage disturbance was based on a 25-foot wide entrance road and 12-foot wide MU roads. Road locations and distances can be seen on **Figure 4.2-1.**

The proposed DDW will be located to the northeast of the satellite facility (**Figure 1.7-5**) located within mixed-grass prairie habitat consisting of an area of approximately 50 x 50 feet. Potential

impacts from the DDW are considered minimal, which is based on the operating history of the DDW located at the current CBR operating facilities.

Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of invasive, non-native species within the MEA. Non-native species invasion and establishment as a result of previous and current disturbance has become an increasingly concern in western states. These species often out-compete desirable species, including special-status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. Currently, the MEA has a relatively high level of noxious weeds and other unwanted invasive, non-native species in the areas adjacent to roads, but to a lesser degree in areas located farther from roads.

In general, the duration of effects on cultivated agricultural land and mixed-grass prairie vegetation are significantly different. Cropland areas can be readily returned to production through fertilizer treatments and compaction relief. However, disturbed native prairie tracts require reclamation treatments and natural succession to return to pre-disturbance conditions of diversity (both species and structural). Reestablishment of mixed-grass prairie to pre-disturbance conditions would be influenced by factors that are both climatic (growing season, temperature, and precipitation patterns) and edaphic (physical, chemical, and biological) conditions in the soil.

Previously planted agricultural fields would be recontoured to approximate pre-existing contours and ripped to depths of 12 to 18 inches to relieve compaction. Mixed-grass prairie tracts disturbed by surface activities would be completely reclaimed. Reclamation of mixed-grass prairie would generally include: (1) complete cleanup of the disturbed areas (wellfield and access roads), (2) restoring the disturbed areas to the approximate ground contour that existed before construction, (3) replacing topsoil, if removed, over all disturbed areas, (4) ripping disturbed areas to a depth of 12 to 18 inches, and (5) seeding recontoured areas with a locally adapted, certified weed-free seed mixture.

7.2.7.3 Surface Waters and Wetlands

Dooley Spring, Willow Creek, and other ephemeral features are the only potentially available surface waters within the MEA. These features lack defined banks and have no streambed. Generally, these features are dry and they would only be expected to carry water during exceptional precipitation events. Direct disturbance to these features would take place where they would be crossed by access roads. This would occur in several locations, including one location along the main access road to the satellite facility. Culverts will be installed below each road crossing to maintain natural flows. Therefore, there would not be any long-term direct impacts on the integrity of any of the drainages within the MEA.

The Niobrara River is a perennial stream located downstream of the MEA; this river could potentially be indirectly affected by changes in water quality or quantity. Water quantity would not be changed by the proposed project. Hydrologic analysis completed for this project indicates that the MEA generally carries a low potential for erosion (and therefore a low potential for sediment delivery to the Niobrara River). However, there are some small, localized areas within the MEA that carry a moderate to high erosion potential. If wells cannot be placed outside of areas within the wellfield deemed to carry moderate to high erosion risks, mitigation measures (e.g., berms) will be implemented to minimize the potential for flooding and erosion. The mitigation

measures will be defined during final engineering and prior to any construction. As a result of these mitigation measures, sediment delivery to the Niobrara River will be negligible.

One wetland site was identified by HWA (2011) within the MEA. This wetland is located outside of the area proposed for disturbance. Therefore, no direct impacts to wetlands are anticipated. Also, for the reasons mentioned above, the potential for sedimentation of wetlands within and near the MEA is anticipated to be minimal due to mitigation measures that would be implemented to reduce erosion risk.

7.2.7.4 Wildlife and Fisheries

The effects on wildlife would be associated with construction and operation of project facilities, which include displacement of individuals of some wildlife species, loss of wildlife habitats, and an increase in the potential for collisions between wildlife and motor vehicles. Other potential effects include a rise in the potential for poaching, harassment, and disturbance of wildlife because of increased human presence primarily associated with increased vehicle traffic. The magnitude of impacts to wildlife resources would depend on a number of factors, including the time of year, type and duration of disturbance, and species of wildlife present.

7.2.7.5 Big Game Mammals

The principal wildlife impacts likely to be associated within the proposed project include: (1) a direct loss of elk, deer, and pronghorn habitat; (2) the displacement of these big game species; (3) an increase in the potential for collisions between wildlife and motor vehicles; and (4) an increase in the potential for poaching and harassment of wildlife.

Direct removal of habitat used by big game mammals would include 1,143 acres of mixed-grass prairie. Small amounts of drainage (31.2 acres), mixed conifer (194.6 acres), and range rehabilitation (7.1 acres) cover types would also be removed. Because mixed-grass prairie would be the primary vegetation type affected, the proposed project would be more likely to affect big game species that primarily inhabit grassland vegetation (e.g., pronghorn) than big game species that primarily inhabit shrubland, forested, or riparian areas (e.g., elk, deer). The amount of habitat disturbed would decline over time as construction areas not needed for the production phase were reclaimed to their pre-existing contours and vegetation type. Overall, direct loss of habitat would have a minor, short- to long-term impact on big game species using the MEA.

In addition to the direct removal of habitat due to the development of wells and associated satellite facilities, disturbances from drilling activities and traffic would affect wildlife use of the habitat immediately adjacent to these areas. Big game habitat would effectively be reduced by an amount greater than the disturbance footprint acreage, because big game would avoid a wider area than just the infrastructure itself. Big game mammals may adjust their ranges or seasonal migration routes slightly to avoid the new source of disturbance on the landscape. This could result in reduced herd productivity if animals have to expend more energy to travel between seasonal ranges or if adjacent habitats are not of a similar or higher quality to the habitats lost or cannot absorb the additional individuals. If avoidance responses extend out to 0.5 mile (0.8 km) beyond the MEA, this would equate to 1.8 percent of the overlapping elk herd unit, 0.5 percent of the overlapping deer herd unit, and 0.5 percent of the overlapping pronghorn herd unit being affected by the proposed project.

However, big game mammals are adaptable and may adjust over time to non-threatening, predictable human activity. In addition, the magnitude of displacement would decrease over time as: (1) the animals have more time to adjust to the operational circumstances; and (2) the extent of the most intensive activities such as drilling and road building diminishes and the wellfields are put into production. By the time the mine units are under full production, construction activities will have ceased, and traffic and human activities in general would be greatly reduced. As a result, this impact over the long term would be minimal and it is unlikely that big game mammals would be permanently displaced under full field development. The level of big game mammal use of the project area is more likely to be determined by the quantity and quality of forage available. Forage would be restored once disturbed areas were reclaimed.

The potential for vehicle collisions with big game mammals would increase as a result of increased vehicular traffic associated with the presence of construction crews and would continue (although at a reduced rate) throughout all phases of the wellfield operations. To minimize the potential for wildlife collisions, drivers would be required to follow posted speed limits. Development of new roads would allow greater access to more areas and may lead to an increased potential for poaching of big game animals. Vehicle collision impacts and poaching of big game mammals are anticipated to occur infrequently, and no long-term adverse effects on populations are expected.

Based on the foregoing, long-term adverse effects are not expected on any local big game mammal populations.

7.2.7.6 Carnivores and Small Mammals

The direct disturbance of wildlife habitat in the MEA likely would reduce the availability and effectiveness of habitat for a variety of common small mammals and their predators. The initial phases of surface disturbance and noise would result in some direct mortality to small mammals and avoidance of the area by carnivore species that are more sensitive to human disturbance. In addition, a slight increase in mortality from increased vehicle use of roads in the area would be expected.

Carnivores and small mammals inhabiting the mixed-grass prairie and degraded rangeland vegetation types would be more affected by direct habitat loss than carnivores and small mammals inhabiting other vegetation types in the MEA. The temporary disturbances that occur during the construction period would tend to favor generalist wildlife species that are relatively tolerant of human activity, such as ground squirrels and striped skunks, and would have more impact on species that are relatively sensitive to human activity, such as mountain lions. Because of the high reproductive potential of small mammals, they would rapidly repopulate reclaimed areas as habitats become suitable. The initial phases of surface disturbance would result in some direct mortality and displacement of small mammals from construction sites. Quantifying these changes is not possible because population data are lacking. However, the impact is likely to be low, and the high reproductive potential of these small mammals would enable populations to quickly repopulate the area once reclamation efforts are initiated. No black-tailed prairie dog colonies are located within or near the proposed disturbance area, so there would not be any impacts on this species.

Bats have a lower reproductive potential than other small mammals, so the removal of bat roost sites, maternity colonies, or hibernacula could have an adverse effect on local bat populations. However, the majority of habitat that would be affected by the proposed project is open, mixed-grass prairie, which is not generally suitable for bat roosting. There would be only 194.6 acres of

impact to any forested habitat (mixed conifer), and no deciduous streambank forest (the most likely bat roosting habitat in the MEA) would be affected.

7.2.7.7 Passerines and Upland Game Birds

Impacts to passerines would include short- and long-term habitat loss, primarily for birds using mixed-grass prairie habitat, and an effective loss of habitat extending beyond the disturbed areas if birds avoid the project facilities due to noise or activity. These effects are likely to attenuate with time as construction areas are reclaimed to the original habitat and as human activity decreases after the construction period ends. Generalist species that are more tolerant of human activity (e.g., mourning doves) are likely to be least affected by the proposed project, while specialist species that are more sensitive (e.g., grasshopper sparrows) may be affected more. Overall, given the reclamation practices that would be put into place, the minimal long-term surface footprint of the project, and the measures that would be taken to avoid impacting nesting birds, impacts on passerines are anticipated to be minor and not significant at the population level for any species.

The potential effects of the operation and maintenance of project facilities on upland game birds may include direct mortality of eggs or nestlings (if construction were to take place during the nesting season), habitat loss, and nest abandonment and reproductive failure caused by project-related disturbance and increased noise. Other potential effects on upland game birds involve increased public access and subsequent human disturbance that could result from new construction and production activities. These effects will attenuate with time as areas no longer needed for the project are reclaimed and human activity decreases after the construction phase.

No sharp-tailed grouse leks are known to occur within the project area. However, noise related to drilling and production activities may affect sharp-tailed grouse use of leks and/or reproductive success. Reduction of noise levels in areas near leks would minimize this potential impact. If leks are found, surface disturbance will be avoided within 0.25 mile (0.4 km) of leks. If disturbance activities within the 0.25-mile (0.4 km) lek buffer areas are avoided, no impacts are expected. Areas with large tracts of mixed-grass prairie would provide the best quality nesting habitat, 1,143 acres of which would be directly affected by the proposed project. Some of this area would be reclaimed once no longer needed for the production phase. To protect sharp-tailed grouse nesting habitats, construction activities will be limited within a one-mile (1.6-km) radius of an active lek between March 1 and June 30. Significant impacts to leks and subsequent reproductive success are not expected if these guidelines are implemented.

7.2.7.8 Raptors

As noted in Section 2.8.7.3, seven raptor nests were observed within the MEA boundary during the 2011field survey. The potential impacts to raptors within the MEA include: (1) direct loss of nesting habitat; (2) disturbance to nesting raptors from noise and activity and reduction in nest productivity; (3) temporary reductions in prey populations; and (4) mortality associated with roads.

The proposed project would result in the loss of 1,337 acres of potential raptor nesting habitat in the MEA over the life of the project, which includes mixed-grass prairie and mixed conifer vegetation types. Over time, some of this habitat would be restored through reclamation of areas no longer needed for production. Overall, long-term habitat losses would be minor. The development of wellfield pads and satellite facilities would disturb an estimated 1,143 acres of mixed-grass prairie, a potential habitat for several species of small mammals that serve as prey

items for raptors. This impact would affect approximately 8 percent of the total project area, although this is not likely to be a limiting factor of raptor use within this area. The small amount of short-term change in prey base populations created by the construction activities is minimal in comparison to the overall status of the rodent and lagomorph populations. While prey populations would likely sustain some impact during the initial phase of the project, prey numbers would be expected to soon rebound to pre-disturbance levels following reclamation or active agricultural uses. Once reclaimed or in active agricultural uses, these areas would likely promote an increased density and biomass of small mammals comparable to those of undisturbed areas. For these reasons, implementation of the project is not expected to produce any appreciable long-term negative changes to the raptor prey base within the MEA.

There will be no new public roads constructed. However, there will be increased traffic due to site operations on current county roads. As use of the project area increases, the potential for encounters between raptors and humans would increase and could result in increased disturbance to nests and foraging areas. Closure to public vehicle use for roads located near active raptor nests would offset this potential impact. Some raptor species feed on road-killed carrion on and along the roads, while others (owls) may attempt to capture small rodents and insects that are illuminated in headlights. These raptor behaviors put them in the path of oncoming vehicles where they are in danger of being struck and killed. The potential for such collisions would be reduced by requiring drivers to follow all posted speed limits.

7.2.7.9 Reptiles and Amphibians

The primary impacts on reptiles and amphibians would include 1) direct mortality of individuals during the construction period; 2) ongoing mortality of individuals from increased vehicle traffic; 3) short- and long-term loss of terrestrial habitats; 4) changes in water quality in aquatic habitats.

The proposed project has the potential to result in the direct mortality of individual reptiles and amphibians that use terrestrial habitats where construction will take place. Quantifying these changes is not possible because population data are lacking; however, once construction was completed and human activity greatly reduced, the potential for direct mortality would decrease significantly. Mortality could also result from increased vehicle traffic on project roads. This would be a long-term affect but is not likely to result in population-level changes to any amphibian or reptile species.

There would be 1,143 acres of habitat loss for amphibians and reptiles that use native grassland habitats, and 194.6 acres of habitat loss for amphibians and reptiles that use coniferous habitats. Reptiles and amphibians may also use degraded rangeland, drainages, and range rehabilitation habitats in the MEA, of which 228 acres, 31.2 acres, and 7.1 acres would be lost, respectively. Some of the construction areas would be reclaimed when no longer needed and could then be re-populated by reptiles and amphibians. Long-term loss of both terrestrial and aquatic habitats would be minimal overall. As described in Section 7.2.7.3, mitigation measures would be used to minimize impacts on surface waters that may be used by reptiles and amphibians, and there would be no direct loss of wetland habitats that could serve as amphibian breeding sites.

7.2.7.10 Fish and Macroinvertebrates

Suitable habitat for fish and macroinvertebrates exists within the Niobrara River and its tributaries. Fish and macroinvertebrates in the Niobrara River could be affected by reductions in water quality

as a result of upstream activities. Construction activities could result in runoff carrying sediment into surface waters downstream of the MEA. As discussed in Section 7.2.7.3, the potential for this to occur is low, given the low erosion potential of most the MEA and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

7.2.7.11 Threatened and Endangered Species

Black-footed Ferret

Because there are no known black-footed ferret populations in Nebraska, impacts to this species are highly unlikely. Also, there is no suitable habitat for this species (black-tailed prairie dog colonies) within the proposed disturbance area.

Whooping Crane

No impacts to whooping cranes are anticipated to occur as a result of the proposed project, because suitable migration stopover habitat is not present within the MEA.

Gray Wolf

Gray wolves are highly unlikely to occur in the MEA; therefore, impacts on this species would be highly unlikely. If dispersing gray wolves were to pass through the vicinity, these individuals would likely avoid the area due to anthropogenic noise and activity.

Swift Fox

Because swift fox are known to occur within the region, and suitable mixed-grass prairie habitat occurs throughout the MEA, potential impacts to this species may result from project implementation. Construction activities within these mixed-grass prairie habitats could affect potential swift fox denning and foraging habitats. Destruction of swift fox dens could result in direct mortality of adults or pups. If swift fox are denning in the immediate vicinity of a planned project facility, construction activities may displace adults away from the den, at least during daytime periods of construction. Displacement could prevent the adults from securing adequate food for pups or prevent adults for adequately caring for their young. In addition, vehicular traffic associated with the construction and operation of project facilities could result in vehicle collisions resulting in direct mortality.

Because the potential for the mortality and/or displacement of swift fox from construction and operational activities exists within mixed-grass prairie, mitigation measures will be implemented to avoid and/or reduce such incidents. Prior to beginning construction activities in suitable swift fox habitat, CBR will have qualified biologists perform surveys for swift fox dens, and avoidance measures will be implemented to protect any dens that are located. Surveys will be conducted that are consistent with the NGPC standard protocol included in the CBR Mineral Exploration Permit Number NE0210824 as Attachment 1, issued by the NDEQ on August 19, 2009. The procedures in Attachment 1 are specific to drilling of boreholes; therefore, these procedures have been expanded to include Marsland project development activities (e.g., construction, operational activities [e.g., wellfield development, satellite facility facilities, and access roadways] and decommissioning). The modified survey protocol to be used for the swift fox in the MEA is presented in **Appendix O** of Volume II of this application.

Based upon the analysis of the effects of project implementation and the current and potential status of this species in the MEA, it is concluded that the proposed project and planned mitigation measures will result in no adverse population-level effects on the swift fox.

Fish

Three state-listed fish species (the blacknose shiner, northern redbelly dace, and finescale dace) may occur downstream of the MEA and therefore may be affected by the proposed project. No direct effects to these species are anticipated because they do not occur within the MEA. However, indirect effects may include changes in water quality of the Niobrara River associated with upstream activities. As discussed in Section 7.2.7.3, the potential for sediment delivery to the Niobrara River is low given the low erosion potential of most of the MEA and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

Cumulative Impacts

Significant cumulative impacts to ecological resources are not anticipated, as no substantive impairment of ecological stability or diminishment of biological diversity within the MEA is expected to occur as a result of the proposed project. The project would add to the effects of other past, present, and future activities occurring in the region, including the effects of other past, present, and future uranium mining operations. When combined with these other activities, the MEA would have minor cumulative effects on ecological resources. The most substantial of these effects would be the loss of 348 acres (for development of 11 MUs) 1,143 acres (for potential additional long-term development activities) **(Table 7.1-1)** of mixed-grass prairie habitat. However, because the overall long-term surface footprint of the project would minimal, and much of the area proposed for disturbance during the construction phase would be promptly reclaimed to the pre-existing contour and cover type, long-term loss of mixed-grass prairie habitat would have a minor impact on regional ecological resources. Similarly, disturbance to wildlife from noise and activity would initially have a minor cumulative impact on the region's wildlife. This impact would diminish over time as human presence decreases after the construction phase is completed.

7.2.8 Noise Impacts of Operations

Noise sources during operation are expected to increase due to increased vehicle travel and increased numbers of employees traveling to and from the City of Crawford for work and from resin transfer to the CPF. Train usage would not increase as a result of operation. Processing equipment at the MEA would be minimal and is not expected to add to existing noise sources. Increases in noise levels due to operation are expected to be lower than noise levels generated during construction. Therefore, it is expected that noise levels during operation would be barely perceptible over the existing ambient noise that is dominated by the BNSF railroad.

Cumulative Impacts

Agricultural activities, vehicular traffic and heavy train traffic in the vicinity of the proposed expansion areas of MEA, NTEA, and TCEA would contribute to regional noise effects. Under implementation of the proposed expansion projects, the sources of noise would be widely dispersed and barely perceptible over the background noise. Implementation of the proposed expansion projects would result in small cumulative effects on noise when considered with other past, present, and RFFAs in the vicinity because of the rural nature of the area.

7.3 Radiological Effects

An assessment of the radiological effects of the satellite facility must consider the types of emissions, the potential pathways present, and an evaluation of potential consequences.

The satellite facility will have a production flow capacity of approximately 6,000 gpm and will use fixed-bed downflow IX columns to separate uranium from the pregnant production fluid. The facility will also have a capacity to treat 1,500 gpm of restoration solution. The restoration process will use fixed-bed downflow IX columns to remove the uranium and RO to remove the dissolved solids. Waste disposal at the satellite facility will be via a deep injection well. The satellite facility will not have precipitation equipment. The loaded IX resin will be transferred from the columns to a resin trailer for transport to the CPF for regeneration and stripping. The reclaimed resin will be transported back to the satellite facility and reused in IX columns.

The uranium-bearing regenerate at the CPF is treated in the uranium precipitation circuit. The precipitated uranium is vacuum dried.

The primary airborne radiological emission from the facility will be radon-222 gas (radon) and its decay products. Radon is present in the ore body and is formed from the decay of radium-226. Radon is dissolved in the lixiviant as it travels through the ore body to a production well, where the solution is brought to the surface. The concentration of radon in the production solution is calculated using methods found in RG 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (March 1987). The details of this calculation are found in **Appendix M.**

MILDOS-AREA was used to model radiological impacts on human and environmental receptors (e.g., air and soil) using site-specific radon release estimates, meteorological and population data, and other parameters (Savignac 2014). The following sections briefly discuss the assumptions and methods used to estimate the potential radiological impacts of the satellite facility coupled with the CPF. A detailed presentation of the source term and other MILDOS-AREA parameters is included in **Appendix M**. The anticipated effects are compared to the naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring radon gas, comprises the primary radiological impact to the environment in the region surrounding the proposed project.

7.3.1 Exposure Pathways

The proposed satellite is an *in-situ* uranium recovery facility. The only source of planned radioactive emissions from the facility is radon gas and its decay products, which dissolves in the leaching solution. Radon gas may be released as the solution is brought to the surface and processed in the satellite facility. Unplanned emissions from the site are possible as a result of accidents and engineered structure failure, but are not addressed in the MILDOS-AREA modeling. A human exposure pathway diagram addressing planned and unplanned radiological emissions is presented in **Figure 7.3-1.**

The satellite facility will have pressurized downflow IX columns capable of processing 6,000 gpm of production solution. The satellite facility will also have IX and RO equipment with a capacity of 1,500 gpm to process restoration solutions. Up-flow IX columns are not planned for the MEA.

Within the pressurized columns, most of the radon will remain in solution and will be returned to the formation. There will be minor releases of radon during the air blowdown prior to resin transfer. The air blowdown and the gas released from the vent during column filling will be vented into the exhaust manifold and discharged via the main radon exhaust stack. It is estimated that less than 1 percent of the total radon contained in the process solutions will be vented to atmosphere.

In the source term calculation, Cameco estimates that in the absence of evaporation ponds, 75 percent of the radon released will be vented from the satellite facility, and 25 percent of the radon will be released from the wellfields.

After the IX resin is loaded, it will be transferred to a resin trailer. The trailer will transfer the resin to the CPF for additional processing. The stripped and regenerated resin will be transferred to the trailer, returned to the satellite facility, and transferred into a process column. It is anticipated that one round trip will occur every other day.

The injection wells will generally be closed and pressurized, but periodically vented. A sensitivity analysis demonstrated that radiation doses using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite facility did not appear to be significantly different from the doses calculated using a 10 percent/90 percent distribution, respectively (Savignac 2014). See discussions in Section 7.3.3.3 and **Appendix M**.

Atmospheric emissions of radon will distribute to all quadrants of the area surrounding the MEA and the CPF. Radon itself impacts human health or the environment marginally, because it is an inert noble gas. Radon has a relatively short half-life (3.8 days), and its decay products are short-lived, alpha emitting, non-gaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. **Figure 7.3-1** shows that all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radon were evaluated using MILDOS-AREA (Savignac 2014).

7.3.2 Exposures from Water Pathways

The solutions in the zone to be mined will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The satellite facility will not have surge/evaporation ponds or surge tanks to store waste solutions, thereby eliminating the potential of releases and exposures via water pathways. Wastewater tanks located in the satellite building will discharge to a DDW, which will be the primary method of waste disposal at the satellite facility. The deep well will be completed at a depth of approximately 4,000 to 5,000 ft, isolated from any underground source of drinking water by approximately 1,500 ft of Pierre Shale. The well will be constructed under a permit from the NDEQ and meet all requirements of the UIC program.

The satellite facility will be located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and will be pumped to the DDWs. The pad will be of sufficient size to contain the contents of the largest tank if it ruptures.

Because no routine liquid discharges of process water are expected, there are no definable water-related pathways.

7.3.3 Exposures from Air Pathways

The only source of radionuclide emissions is radon released into the atmosphere through the satellite vent system or from the wellfield. As shown on **Figure 7.3-1**, atmospheric releases of radon can result in radiation exposure via three pathways: inhalation, ingestion, and external exposure.

Radiation dose rates were determined using the NRC computer code MILDOS for the proposed MEA project (Savignac 2014). The objective of this evaluation was to:

- Determine the radiation doses to members of the public within a 50-mile (80-km) radius of the MEA using the NRC computer code MILDOS.
- Determine the additional radiation dose from nearby uranium extraction facilities.
- Determine the potential annual dose rate to workers on the site.
- Determine the sensitivity of the MILDOS estimates of radiation dose.
- Determine the location of the highest radiation dose.

This section summarizes the major findings of the MILDOS evaluation. For more detailed information on assumptions, inputs, outputs, and other elements of the model, the MILDOS report is provided in **Appendix M**.

For comparison, naturally occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mrem/yr.

7.3.3.1 MILDOS Output – Radiation Dose Rates

Table 7.3-1 presents the dose rates calculated for the major cities and towns within a 50-mile (80-km) radius of the MEA; ten residences; two unoccupied structures; and for the north, south, east, and west property boundaries. Residences #1 and #2 are not currently occupied but are occupiable. Locations of the nearby and regional receptors are shown on **Figures 7.3-2** and **7.3-3**, respectively. The dose rates were calculated using the MEA onsite meteorological data and using the 316 gpm maximum wastewater flow rate expected in years nine through twenty.

Because radon is released from both the mine units wellhouses and from the satellite plant, the doses were proportioned 25 percent from the mine units and 75 percent from the satellite. **Table 7.3-1** presents the total dose from the satellite facility, MEA MUs 1 through 5 and A through F under typical operating conditions from both sources of radon. Conclusions from those dose rates are as follows:

- All dose rates to the public at the property boundaries, the cities and towns within a 50-mile (80-km) radius from the MEA, and at the nearest residence were below the 100 mrem/yr limit specified in 10 CFR 20 (TEDE).
- The highest cumulative MEA boundary dose rate was 55 mrem/yr at the south property boundary.
- The highest cumulative dose rate at the nearest Residence #2 (unoccupied) was 27 mrem/yr.

- The highest cumulative dose rate from all existing and proposed ISR facilities at cities and towns within a 50-mile (80-km) radius from the MEA was 6.0 mrem/year at Crawford, and 3 mrem/yr at both the Towns of Hemingford and Marsland.
- The average dose rate from the nearby ISR facilities was 2 mrem/yr.
- The 40 CFR 190 dose rate was 0 mrem/yr which was below the 10 mrem/yr dose limit for emissions that exclude radon and its progeny.
- The total population effective dose rate was 411 person-rem/year.

For comparison naturally occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mrem/yr.

The radiation doses from the production wells and from the wells in restoration are identical. See **Appendix M** for production well doses, restoration well doses, and new well doses.

7.3.3.2 MILDOS Output – Public and Occupational Radiation Dose Rates

Dose rates for the public inside the license boundary apply to delivery personnel, regulatory inspectors, visitors, or other personnel that may spend up to 10 hours per month on site. Occupational dose rates apply to personnel that may spend an estimated 2,000 hours per year working on site such as company employees or contractors.

Table 7.3-2 shows the MEA public and occupational dose rates. At maximum flow during years nine through twenty, the maximum dose rate to the public attributable to Marsland was 0.16 mrem/yr, and the maximum occupational dose rate to employees and contractors was 32 mrem/yr with an average of 17 mrem/yr.

In addition, ranchers holding the leases for the MEA may graze cattle and cut hay within the license boundary, but only outside the perimeter monitor well ring. For simplicity, and to ensure a conservative result, we will assume that the rancher will perform the grazing and haying at the point 1.5 km southeast of the satellite plant where the maximum dose is expected. This will not occur as this location is within a mine unit and will be off limits. Regardless, it is reasonable to assume a rancher will spend 416 hours per year attending grazing cattle (8 hours per day, 1 day per week, 52 weeks per year and up to 160 hours per year cutting hay (8 hours per day, 5 days/week, 4 weeks per year).

At the point 1.5 km southeast of the plant the incremental dose to the rancher would be 8.5 mrem/year for grazing and 3.3 mrem/year for haying. As noted earlier, this situation cannot occur and any dose to ranchers performing these activities will be significantly less.

7.3.3.3 Radon Release Points

The radiation dose rates from typical operations used the following:

- 25 percent radon released from the MU wellhouse
- 75 percent radon released from the satellite plant vent stack

That distribution has been used historically in MILDOS assessments. For comparison, dose rates were calculated using:

- 10 percent radon released from the MU wellhead houses.
- 90 percent radon released from the satellite plant vent stack.

The dose rates from both distributions are presented in **Appendix M**. A comparison of the 25 percent/75 percent distribution of radon in column 2 with the 10 percent/90 percent distribution of radon release shows that the averages and standard distributions are nearly identical. That similarity suggests that, within the range of values selected for the radon distribution between releases at the mine units and releases at the satellite plant, the distribution is not important to assessing the doses to people around the MEA site.

A MILDOS sensitivity analysis was conducted. Such an analysis identifies how input parameters affect the calculated radiation dose. Input parameters and variables are discussed in **Appendix M.**

The sensitivity analysis demonstrated that:

- Neither the occupational or public dose rates exceeded 100 mrem/yr.
- Radiation doses calculated using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite plant did not appear to be significantly different from the doses calculated using a 10 percent/90 percent distribution, respectively.
- The maximum dose to the public on site 10 hours/month is 0.16 mrem/yr.
- The average and maximum occupational dose rates to employees and contractors on site 2,000 hours/yr is 17 and 32 mrem/yr, respectively.

7.3.4 Exposure to Flora and Fauna

There are two primary potential pathways for radiological exposures to flora and fauna: radon emissions and accidental spills of radiological containing fluids (e.g., lixiviant).

7.3.4.1 Radon Releases

Radon emissions at satellite uranium *in-situ* facilities such as the proposed satellite facility (i.e., no yellowcake dryer and associated facilities) are considered the primary air contaminant during operations. Radon emissions during normal operations are considered the most important pathway for exposure to flora and fauna due to deposition of radon-222 decay products on surface water, surface soils, and vegetation. The MILDOS-AREA model provides an estimate of surface deposition rate as a function of distance from the source for the radon-222 decay products and calculates surface concentrations.

The exposure to flora and fauna was evaluated in the Environmental Report submitted in September of 1987 (Ferret Exploration Company of Nebraska 1987), and the doses were found to be negligible. Based on this evaluation, the proposed MEA, TCEA, and NTEA projects are not expected to have a measurable impact on dose to flora and fauna.

The potential exists for individual mobile fauna (e.g., small mammals and birds) to have contact with higher but short-term contact with concentrations of radon-222 than the public due to the potential proximity to releases. However, due to the typical mobility of such animals, it is likely that exposure to individuals would be intermittent, as opposed to a constant concentration for the entire year.

There are currently no regulatory dosimetric standards for the protection of flora and fauna, with radiological protection frameworks being traditionally focused on the protection of man. Historically, the International Commission on Radiological Protection (ICRP) has maintained a position towards human health versus non-human species that protection of humans from radiation exposure implicitly ensures an adequate protection of other living organisms and, therefore, the environment (Brechignac 2002 [ICRP 1977 and 1991]). However, the development of a system capable of ensuring adequate protection of the environment against the harmful effects of ionizing radiation is currently being debated (Brechignac 2002). The ICRP has issued a draft report for public comment primarily documenting methods that allow prediction of known concentrations of radionuclides within an organism's habitat (ICRP 2010). This work is still underway.

7.3.4.2 Fluid Discharges

There are currently no planned discharges from the satellite facility, with wastewaters being discharged to a Class I DDW. Therefore, any fluid discharges would be associated with spills (e.g., pipeline break or leak). Spills of this type would be expected to occur within the restricted wellfield areas and between the wellfield and satellite process facility. The satellite processing building, fuel tanks, and chemical tanks would be constructed on pads engineered to contain any spill from a pipe rupture, leaking vessel, or inadvertent spill. Therefore, it is unlikely that any spills in the processing area would reach soils and vegetation. CBR operating procedures provide for ongoing monitoring of operational activities and for a rapid corrective action response to any spill, which would result in cleanup of the spilled material and, if applicable, removal of any contaminated soil and vegetation.

Long-term experience at CBR has shown that single-event spills typically do not cause significant contamination of soil and vegetation.

There is limited potential for wildlife or domestic animals to consume contaminated vegetation or seeds. Other than the potential for accidental spills discussed above, which would be immediately assessed and cleaned up, the satellite facility would not be expected to significantly impact food sources such as vegetation and seeds that local animals depend upon.

7.4 Non-Radiological Effects

Non-radiological effects of site preparation and construction activities are discussed in Section 7.1, including impacts on air quality, land use, surface water, population, social and economic, and noise impacts. Impacts on operational activities are discussed in Section 7.2, including air quality, land use, soil, groundwater, surface water, ecology, and noise impacts.

As discussed in Sections 7.1 and 7.2, overall emissions associated with equipment and facility operations during site preparation, construction and operations would be expected to be minimal and should not affect the local ambient air quality. Non-radiological emissions include NO_x, CO, SO_2, VOCs, and particulate matter (operating equipment and fugitive dust due to traffic on unpaved areas). During operations, a gaseous and airborne effluent will consist of air ventilated from the process building ventilation system and from process vessels and tanks. This gaseous effluent would primarily contain radon gas as previously discussed in Sections 4 and 7.3. The gaseous and airborne effluent will not contain any significant non-radiological emissions.

In addition to gaseous and airborne effluents, three types of wastes would be generated at the proposed satellite facility: liquid, solid, and sanitary. The operational-generated liquid wastes would be disposed of through a DDW. Such liquid wastes would consist of: wellfield bleed streams, facility washdown water, groundwater restoration water, liquids resulting from rainwater/snow fall, and spills within the curbed process areas. Accumulations of rainfall/snowmelt and any spills within the curbed bulk chemical, lubricant storage facility, and the fuel diked area will be removed and disposed of per the site SPCC Plan. Well development water in the wellfield will be collected in dedicated tanker trucks and transported to the main satellite processing facility for disposal in the DDW.

The proposed satellite facility will not use surge/evaporation ponds; therefore, there would be no discharge from these ponds. In addition, there will not be any surge tanks.

The DDW will permanently dispose of liquid wastes and will be permitted under a Class I UIC Permit issued by the NDEQ. There are currently two DDWs in operation at the CPF. The Class I UIC Permits for these two disposal wells located at the CPF implement injection limits and require monthly monitoring for RCRA metals to ensure that hazardous waste is not injected. Based on the monitoring for the current CPF DDW, there is no non-radiological impact expected due to the liquid effluents from the satellite facility.

Solid wastes generated would consist of waste such as spent resin, resin fines, filters, miscellaneous pipe and fittings, and domestic waste. These wastes are classified as contaminated or non-contaminated waste according to radiological survey results. Byproduct waste that cannot be decontaminated is packaged and stored until it can be shipped to a licensed waste disposal site or licensed mill tailings facility. Non-contaminated solid waste is collected regularly on the site and disposed of in a sanitary landfill permitted by the NDEQ. The CBR estimate of annual quantities of non-contaminated generated solid waste for the Marsland site is presented in Section 4.2.2.1. No significant non-radiological impacts associated with management of relatively small quantities of solid wastes would be expected.

The MEA is expected to only generate a small amount of hazardous waste and is expected to be classified as a Conditionally Exempt Small Quantity Generator. The potential for any adverse impacts due to the handling and disposal of hazardous waste would be minimal due to the small

quantities handled and operational procedures in the SHEQMS Volume VI, Environmental Manual. The SHEQMS is reviewed annually and the sections updated as required.

Sanitary liquid waste will be disposed of in an onsite wastewater treatment system (i.e., septic) permitted by the NDEQ under the Class V UIC Regulations. Septic tank solids will be periodically removed by companies or individuals licensed for such activities by the State of Nebraska. There have been no problems associated with operating a similar sanitary system at the CPF, and no problems would be expected for the satellite facility.

For any spill, the free liquids would be recovered and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated. Spills are also discussed in Section 4.2.1.3.

In summary, the design and construction of the satellite facility will concentrate on minimizing the potential for releases of non-radiological waste materials. For example, CBR would use diking or flow cut-off and flow isolation procedures for radiological and non-radiological spill control. A QA/QC system will be used, which would involve pre-operational testing of equipment, periodic testing and regular inspection of equipment (e.g., pipelines, manifolds), and associated monitoring on line flows and pressures with automatic shutdowns in response to flow or pressure changes. Consequently, any spills should be small with little impacts on the environment. For any spill, the free liquids would be recovered and disposed of in the DDW and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated.

7.5 Effects of Accidents

Accidents involving human safety associated with the *in-situ* uranium mining technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. *In-situ* mining provides a higher level of safety for personnel and neighboring communities compared to conventional mining methods or other energy-related industries. Accidents that may occur would be quite minor when compared to other industries, such as an explosion at an oil refinery or chemical plant. Radiological accidents that might occur would be easily detected and mitigated. The remote location of the facility and the low level of radioactivity associated with the process both decrease the potential hazard of an accident to the general public.

NRC has previously evaluated the effects of accidents at uranium milling facilities in NUREG–0706 and specifically at uranium ISR facilities in NUREG/CR-6733 (NRC 1980b, CNWRA 2001). These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures are followed and properly trained personnel are employed. The CBR emergency management procedures contained in the CBR SHEQMS Volume VIII, Emergency Manual, have been developed to implement the recommendations contained in the NRC analyses. Training programs contained in the CBR SHEQMS Volume VII, Training Manual, have been developed to ensure that CBR personnel have been adequately trained to respond to all potential emergencies. The CBR SHEQMS Volume II, Management Procedures, requires periodic testing of emergency procedures and training by conducting drills.

NUREG-0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG-0706 are applicable to ISR facilities, such as transportation accidents; however, many of the analyses do not apply due to the significantly different mining and processing methods. ISR facilities do not handle large quantities of radioactive materials, such as crushed ore and tailings, so the quantity of material that could be affected by an incident is significantly lower than at a mill site.

NUREG/CR-6733 specifically addressed risks at ISR facilities and identified the following "risk insights".

7.5.1 Chemical Risk

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. The use of hazardous chemicals at CBR is regulated by the OSHA. CBR is subject to the Process Safety Management of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119.

Of the highly hazardous chemicals, toxics, and reactives listed in Appendix A to 29 CFR §1910.119, none will be used at the satellite facility. The satellite facility will use O_2, CO_2, and $NaHCO_3$ for addition to the injection solution. Na_2S may be used as a reductant during groundwater restoration activities. All other operations requiring process chemicals described in NUREG/CR-6733 will be performed at the CPF.

Crow Butte construction, operating, and emergency procedures have been developed to implement the codes and standards that regulate hazardous chemical use.

7.5.1.1 O_2

O_2 presents a substantial fire and explosion hazard. The O_2 storage facility is typically designed and installed by the O_2 supplier and meets applicable industry standards. As currently practiced at the CPF, CBR will install wellfield O_2 distribution systems at the Marsland site. Combustibles, such as oil and grease, will burn in O_2 if ignited. CBR ensures that all O_2 service components are cleaned to remove all oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1 (CGA 2000). Construction of O_2 systems in the wellfield is addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a spill or fire involving O_2 systems are contained in the SHEQMS Volume VIII, Emergency Manual.

7.5.1.2 CO_2

The primary hazard associated with the use of CO_2 is concentration in confined spaces, presenting an asphyxiation hazard. Bulk CO_2 facilities are typically located outdoors and are subject to industry design standards. Floor level ventilation and CO_2 monitoring at low points is currently performed at the CPF to protect workers from undetected leaks of CO_2. Operation of CO_2 systems is currently addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a leak involving CO_2 are contained in the SHEQMS Volume VIII, Emergency Manual.

7.5.1.3 $NaHCO_3$

$NaCO_3$ is primarily an inhalation hazard. CBR typically uses soda ash and CO_2 to prepare $NaCO_3$ for injection in the wellfield. Soda ash storage and handling systems are designed to industry standards to control the discharge of dry material. Operation of $NaCO_3$ systems is currently addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a spill involving $NaCO_3$ or soda ash are contained in the SHEQMS Volume VIII, Emergency Manual.

7.5.2 Radiological Risk

7.5.2.1 Tank Failure

A spill of the materials contained in the process tanks at the satellite facility will present a minimal radiological risk. Process fluids will be contained in vessels and piping circuits within the processing building. O_2, H_2O_2, CO_2, propane, and fuel will be stored in outside storage tanks. The tanks at the satellite facility will contain injection and production solutions and IX resin. Elution, precipitation, and drying will be performed at the CPF. The satellite facility will be designed to control and confine liquid spills from tanks should they occur. The facility building structure and concrete curb will contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to a floor sump. The floor sump system will direct any spilled solutions back into the facility process circuit or to the waste disposal system. Bermed areas, tank containments, or double-walled tanks will perform a similar function for process vessels located outside the satellite building.

All tanks will be constructed of fiberglass or steel. Instantaneous failure of a tank is unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary.

7.5.2.2 Facility Pipe Failure

The rupture of a pipeline within the satellite processing area would easily visible and could be repaired quickly. Spilled solution will be contained and removed in the same fashion as for a tank failure.

Response procedures for the radiological risk from releases are currently contained in the SHEQMS Volume VIII, Emergency Manual. These procedures also provide instructions for emergency notification including notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

7.5.3 Groundwater Contamination Risk

7.5.3.1 Lixiviant Excursion

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the exempted portion of the ore-body aquifer. A vertical excursion is a movement of ISR fluids into overlying or underlying aquifers.

CBR controls lateral movement of lixiviant by maintaining wellfield production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution is either recycled in the processing facility or is sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the MU, the wellfield is said to be balanced.

CBR monitors for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. The current NRC License and NDEQ Class III UIC Permit require that Chadron aquifer monitor wells be located no more than 300 feet from the nearest mineral production wells and no more than 400 feet from each other. These spacing requirements have proven effective for monitoring horizontal excursions CBR and will be employed at the satellite facility or as otherwise provided in the final permit. Monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the satellite facility. The program was discussed in detail in Section 5.7.8.

Section 7.2.5.2 provided a discussion of horizontal excursions reported at the current Crow Butte operation. The historical experience indicates that the selected indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected (NRC 2001).

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. CBR controls vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the NDEQ for review and approval before well construction activities may proceed. Well construction and integrity testing is conducted in accordance with NDEQ regulations contained in Title 122 and methods approved by NRC and NDEQ. Construction and integrity testing methods were discussed in detail in Section 3.1. Well abandonment is conducted in accordance with methods approved and monitored by the NDEQ and discussed in detail in Section 6.2. Procedures for these activities are contained in the SHEQMS Volume III, Operating Manual.

CBR monitors for vertical excursions in the overlying aquifers using shallow monitor wells. These wells are located within the wellfield boundary at a density of one well per 4 acres. Shallow monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the satellite facility, subject to NRC/NDEQ approval. The program was discussed in detail in Section 5.7.8.

7.5.4 Wellfield Spill Risk

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the satellite facility, would result in either a release of barren or pregnant lixiviant solution, which would contaminate the ground in the area of the break. All piping from the satellite facility to and within the wellfield will be buried for frost protection. Pipelines are constructed of PVC, HDPE with butt-welded joints, or equivalent. All pipelines are pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each MU will have a number of wellhouses where injection and production wells will be continuously monitored for pressure and flow. With the control system currently employed at CPF, individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the satellite control room via the computer system. In addition, each wellfield building will have a "wet building" alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective at the current operation in detection of significant piping failures (e.g., failed fusion weld).

Occasionally, small leaks at pipe joints and fittings in the wellhouses or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. CBR currently implements a program of continuous wellfield monitoring by roving wellfield operators and required periodic inspections of each well that is in service. Based on experience from the current operation, small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination based on monitoring using field survey instruments and soil samples for radium-226 and uranium. Following repair of a leak, CBR procedures require that the affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination may be removed as appropriate.

7.5.5 Transportation Accident Risk

Transportation of materials to and from the satellite facility can be classified as follows:

- Shipments of process chemicals or fuel from suppliers to the site
- Shipment of radioactive waste from the site to a licensed disposal facility
- Shipments of uranium-laden resin from the satellite facility to the CPF and return shipments of barren, eluted resin from the CPF back to the satellite facility

The first two types of transportation risks do not represent an increase over the risks associated with operation of the current Crow Butte facility because production from the proposed satellite facility is planned to replace declining production at the current facility. The shipment of loaded IX resin from the satellite and the return of barren, eluted resin represent an additional transportation risk that was not considered for the current operation.

NUREG-0706 concluded that the probability of a truck accident in any year is 11 percent for each uranium extraction facility or mill. This calculation used average accident probabilities (4.0×10^{-7}/km for rural interstate, 1.4×10^{-6}/km for rural two-lane road, and 1.4×10^{-6}/km for urban interstate) that NUREG/CR-6733 determined were conservative with respect to probability distributions used in a later NRC transportation risk assessment (CNWRA 2001). For Marsland, uranium-loaded and barren resin will be routinely transported by tank truck from the satellite facility to the CPF. For the Crown Point ISR site in New Mexico, NRC determined that the probability of an accident involving such a truck was 0.009 in any year (NRC 1997).

Accident risks involving potential transportation occurrences and mitigating measures are discussed below:

7.5.5.1 Accidents Involving Shipments of Process Chemicals

Based on the current production timeline and material balance, it is estimated that approximately 150 bulk chemical deliveries per year will be made to the satellite facility. This averages about one truck per working day for delivery of chemicals throughout the operational life of the project. Types of deliveries include CO_2, O_2, bicarbonate, H_2O_2, and soda ash.

7.5.5.2 Accidents Involving Radioactive Wastes

Low level radioactive 11e.(2) byproduct material or unusable contaminated equipment generated during operations will be transported to an approved licensed disposal site. Because of the low levels of radioactive concentrations involved, these infrequent shipments are considered to have minimal potential impact in the event of an accident.

7.5.5.3 Accidents Involving Resin Transfers

One of the potential additional risks associated with operation of a satellite facility is the transfer of the IX resin to and from the satellite facility.

Resin will be transported to and from the satellite facility in a 4,000-gallon capacity tanker trailer. It is currently anticipated that one load of uranium-laden resin will be transported to the CPF for elution and one load of barren eluted resin will be returned to the satellite facility on a daily basis.

The transfer of resin between the satellite facility and the CPF will occur on SH 2/71 and county and private roads. CBR has established a primary access route and an alternate access route. The primary access route will entail approximately 18 miles (28.9 km) of travel on SH 2/71 and approximately 12 miles (19.3 km) on county and private roads (**Figure 4.2-1**). The Alternate A access route is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. The planned access routes are discussed in more detail in Section 4.2.1.13.

Resin or eluate shipments will be treated similarly to yellowcake shipments in regards to DOT and NRC regulations. Shipments will be handled as LSA material for both uranium-laden and barren eluted resin. Pertinent procedures include:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.
- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index, and the package identification number.
- Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.
- Licensed and trained CBR drivers will transport the resin between the satellite facility and the CPF.
- Crow Butte's current emergency response plan for yellowcake and other transportation accidents to or from the Crow Butte site is contained in the SHEQMS Volume VIII, Emergency Manual. This plan will be expanded to include an emergency resin transfer accident procedure. Personnel at both the satellite facility and the CPF will receive training for responding to a resin transfer transportation accident.

Currently, CBR intends to treat the eluted resin the same as the uranium-loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and NRC regulations will be the primary determining factor.

The worst-case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium-laden resin where the entire tanker contents were spilled. Because the uranium is ionically bonded to the resin, and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological or environmental impact of a similar accident with barren, eluted resin would be very minor. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, CBR will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each resin hauling truck will be equipped with a radio that can communicate with either the CPF or the satellite facility. In the event of an accident and spill, the driver can radio to both sites to obtain help.
- A check-in and check-out procedure will be instituted where the driver will call the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, a crew would respond and search for this vehicle. This system will ensure a reasonably quick response time in the case that the driver is incapacitated in the accident.
- Each resin transport vehicle will be equipped with an emergency spill kit that the driver can use to begin containment of any spilled material.
- Both the satellite and central process facilities will be equipped with emergency response packages to quickly respond to a transportation accident.
- Personnel at the satellite and central process facilities, as well as the designated truck drivers, will have specialized training to handle an emergency response to a transportation accident.

7.5.6 Natural Disaster Risk

NUREG/CR-6733 evaluates the potential risks to an ISR facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities and the possible reaction of process chemicals during either event. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. CBR is committed to following these standards.

7.5.6.1 Tornado Risk

NUREG/CR 6733 evaluates tornado risks associated with ISL facilities for the release of radioactive materials or hazardous chemical due to the effects of a tornado. It was determined that in the event of a tornado strike, chemical storage tanks could fail result in the release of chemicals. This guidance document concluded the risk of a tornado strike on an ISL facility was very low and that no design or operational changes were necessary to mitigate the potential risks. However, it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

The Crow Butte operation is located in an area subject to tornadoes. The site is located in Dawes County, Nebraska in which five tornado touch downs were reported during the period of 2000 and 2012 between the months of May and August (NOAA 2012). The five tornado events did not exceed a Fujita or Enhanced Fujita scale (F- or EF-scale, respectively) magnitude of F0 or EF0 and no injuries, deaths, property or crop damage occurred. According to the Fujita Tornado Damage Scale, a typical F0 tornado event will exhibit wind estimates less than 73 mph and produce light damage to the surrounding area. Most tornado events were reported to have taken place in open country, rangeland, and wooded areas. One of the tornados reported in Chadron had a magnitude of EF0 and produced damage to a tree and a windmill. The tornado events had damage paths ranging from 0 to 0.4 miles (3.6 km) in length and had path widths ranging from 20 to 30 yards. Although Dawes County can be considered relatively weak in tornado risk, surrounding counties such as Sheridan County have been known to have tornado events classified as F1. Within the same

time period, Sheridan County experienced an F1 tornado that caused approximately $150,000 in property damage.

It has been concluded that tornado risk in Dawes County is relatively low compared to the surrounding region. Dawes County historical area-adjusted tornado activity is significantly below Nebraska state average, and is 1.6 times below the overall U.S. average (City-Data 2012). The tornado index, a measure of the probability of tornado events and calculated using historical tornado events data and USA.com algorithms, was 205.07 for the State of Nebraska as a whole and 64.92 for Dawes County (USA.com 2013). During the final design phase, CBR will assess the location(s) and construction of chemical storage tanks and containment features in order to reduce the risk of potential leaks caused by tornado damage which may result in harmful chemical reactions.

CBR emergency procedures currently contained in the SHEQMS Volume VIII, Emergency Manual, provide instructions for response and mitigation of natural disasters and spills or radioactive materials. CBR's Emergency Manual contain emergency provisions such as notification to personnel of severe weather; evacuation procedures, security plans and threats associated with source material, medical emergencies, damage inspection/assessment and reporting, and cleanup and mitigation of spills of chemicals. CBR will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, the site's SOPs, training and personnel protective equipment will be available to personnel for response and mitigation of hazardous chemical releases.

7.5.6.2 **Seismic Risk**

The project area, along with most of the State of Nebraska, is in seismic risk Zone 1. Most of the central United States is within seismic risk Zone 1, and only minor damage is expected from earthquakes that occur within this area. Dawes County-area historical earthquake activity is significantly above Nebraska state average, but it is 85 percent smaller than the overall U.S. average (City-Data 2012). Seismology was discussed in detail in Section 2.6. No historical earthquake events that had recorded magnitudes of 3.5 or above have been reported in or near Dawes County (USA.com 2013).

NUREG/CR-6733 concluded that risk from earthquakes at ISL facilities was no greater than for a tornado strike, and that no design or operational changes were required to mitigate the risk. However, the NRC advised that it was important to located chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

As stated above for potential tornado strikes, CBR emergency procedures currently contained in the SHEQMS Volume VIII, Emergency Manual, provide instructions for response and mitigation of natural disasters and spills or radioactive materials. CBR will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, the site's SOPs, training and personnel protective equipment will be available to personnel for response and mitigation of hazardous chemical releases.

7.5.6.3 **Fires**

Historically, there have been no fires of any significance during CBR commercial operations, and none would be expected to occur at the proposed MEA site. CBR's Emergency Manual maintains

procedures for dealing with potential fires, whether associated with man-made events at the operations or associated with wildfires.

Wildfires have typically not been a problem in the area of the MEA and are not considered a major threat to the MEA site. On August 31, 2012, CBR was ordered by the Dawes County Sheriff's Office to evacuate the current Crow Butte operations site due to threatening wildfire to the east of the project (CBR 2012). CBR advised the NRC of this order and operations were temporarily shutdown and site personnel evacuated. All project personnel were evacuated with the exception of a crew of five CBR personnel that remained on-site for security purposes. On September 1, 2012, the evacuation order was lifted and operations were re-started on September 2, 2013. The wildfire never entered the licensed area and as a result there were no releases to the environment. During the evacuation, all source material on the site was kept under 24-hour surveillance. CBR's Emergency Manual procedures were followed during the evacuation and there were no incidents.

7.5.6.4 **Flooding**

Flooding is considered a low-risk issue due to the lack of permanent streams or rivers flowing through the MEA project and historical annual rainfalls and snowmelt. CBR personnel are unaware of any historical flooding of the site. CBR conducted an erosion analysis of the MEA site and will use the results of that study in siting assets and providing mitigation measures to prevent any potential damage associated with flooding. The potential for flooding or erosion that could impact the proposed *in-situ* Marsland mining processing facilities and mine units is discussed in Section 3.1.4.

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7.6 Economic and Social Effects of Construction and Operation

The preliminary evaluation of socioeconomic impacts of the commercial facility was completed in 1987 as reported in the original commercial license application. The preliminary evaluation was divided into two phases: construction and operation. The evaluation concluded that the construction phase would cause a moderate, positive impact to the local economy, resulting from the purchases of goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs would be minor or non-existent and temporary.

Since the inception of the operational phase, the overall effect of the current Cameco facility operations on the local and regional economy has been beneficial. Purchases of goods and services by the mine and mine employees contribute directly to the local economy. Local, state, and federal governments benefit from taxes paid by the mine and its employees. Indirect impacts, resulting from the circulation and recirculation of direct payments through the economy, are also beneficial. These economic effects further stimulate the economy, resulting in the creation of additional jobs.

The current mine operation has not resulted in any significant impact to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the City of Crawford or in Dawes County. As discussed in further detail below, CBR currently employs a workforce of approximately 68 employees and 2 contractors employing 14 contractors. The majority of these employees have been hired from the surrounding communities.

In summary, monetary benefits have and continue to accrue to the community from the presence of the existing Crow Butte Project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the potential economic impact of the MEA.

7.6.1 Tax Revenues

Table 7.6-1 summarizes the recent tax revenues from the Crow Butte project in U.S. dollars.

Future tax revenues depend on uranium prices, which cannot be forecast with accuracy; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. Spot market values for U_3O_8 peaked at approximately $125 per pound in 2007, and have since fallen to approximately $50 per pound as of August 2011 (UxC 2011). It is likely that market values will not return to the 2007 high in the near future and that future tax revenues will more likely be representative of 2008 and 2009 levels.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of $950,000 per year in combined taxes.

Beneficiaries of CBR contributions to the General Fund, and therefore to Dawes County government subdivisions, include school districts, fire districts, county and municipal government agencies, and the White River Natural Resource District.

7.6.2 Temporary and Permanent Jobs

7.6.2.1 Current Staffing Levels

CBR currently employs approximately 68 employees and 2 contractors employing 14 people on a full-time basis. Short-term contractors and part-time employees are also employed for specific projects and/or during the summer months. This level of employment is significant to the local economies. Total employment in Dawes County in 2010 was 5,691 (BEA 2011). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County. In 2009, the CBR total payroll was $4,155,000. Of the total Dawes County wage and salary payments of $106,652,000 in 2009, the CBR payroll represented about 4 percent.

Total CBR payroll for the past 5 years was:

2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,155,000
2010	$4,200,000

The average annual wage for all workers in Dawes County was $27,347 in 2009. By way of comparison, the average wage for CBR employees was approximately $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonuses, or benefits.

7.6.2.2 Projected Short-Term and Long-Term Staffing Levels

The Marsland Expansion will require 10 to 12 full-time employees, 4 to 7 full-time contractor employees, and 10 to 15 part-time employees and short-term contractors for construction activities. The full- and part-time employees will be needed for the satellite facility and wellfield operator and maintenance positions. Contractor employees (e.g., drilling rig operators) may also increase by four to seven employees depending on the desired production rate. It is anticipated that the majority of the proposed MEA full-time and part-time workforce and contractors would be available from the current labor force in Dawes County. The annual unemployment rate in Dawes County in 2010 was 4.5 percent, equating to 216 individuals (BLS 2011). CBR expects that any new positions will be filled from this pool of available labor. These additional positions should increase payroll by approximately $40,000 per month, or $400,000 to $480,000 per year.

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current CBR staff (less than 5 percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal.

Because skills and services required for the proposed MEA project would be available in the existing local labor force, it is not anticipated that the proposed project would require the migration of additional workers into the nearby City of Crawford and City of Chadron, or Dawes County. In the event that proposed project requirements for specialized skills could not be met with the current workforce or local labor force, a small number of workers could be hired from outside of Dawes County. However, any such labor needs would represent a negligible change in the population of Dawes County. It is not anticipated that there would be any change in the local population from implementation of the proposed project.

Because no changes in employment or population are anticipated as a direct result of implementation of the Proposed Action, no impacts to housing availability, including public housing, are expected. There would be no short- or long-term employees that would require temporary housing; therefore, the proposed project would not affect the lodging capacities of nearby communities.

There would be no noticeable increase in the local population from the construction, operation, and maintenance of the proposed project; consequently, there would be no increase in the need for law enforcement and fire safety, medical facilities, public schools, grocery stores, or other community resources in Dawes County.

No increases in existing levels of domestic water usage in Dawes County are expected, nor are effects to existing domestic water facilities anticipated from an increase in population. In addition, the water requirements of the MEA construction and operations would not affect municipal water systems.

Electricity, water, propane and other fuel, sanitary water, and wastewater treatment required for construction and operations will be provided by the utilities that currently provide these services to existing CBR operations. The proposed project may increase the total quantities of electricity, water, propane and other fuel consumed by CBR activities for a limited period of time during operations at MEA because the satellite facility would commence operations as operations in the Crow Butte Permit Area are winding down. Because the scope of production at MEA would be similar to current operations in the Crow Butte Permit Area, it is anticipated that fuel and utility requirements would also be similar. No substantial increases are likely for new operations at the satellite facility over existing operational uses.

It is not anticipated that construction or operational activities would increase costs to other customers supplied by the affected utilities, or increase the requirement for utility services beyond the capacities of the providers. There would be no substantial uses of electricity for construction activities. Fuel would continue to be provided by local suppliers. There would be no interruption of fuel deliveries to other customers from increased propane, diesel, and gasoline usage at MEA construction sites.

The Solid Waste Agency of Northwest Nebraska currently has the capacity for approximately 99 years of service, and would not be affected by the receipt of construction wastes or trash from the satellite facility. Other wastes are managed on site by CBR. Provision of waste services by local waste disposal providers would not be affected, as wastes are managed on site by CBR.

7.6.3 Impact on the Local Economy

It is anticipated than the monetary benefits and costs from the satellite facility would be similar to those associated with current CBR operations. In addition to providing a number of well-paid jobs in the local communities of the Cities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services in the local area.

Total CBR payments made to Nebraska businesses for the past 5 years were:

2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$8,185,000
2010	$4,330,900

The vast majority of these purchases were made in the City of Crawford and Dawes County. This level of business is expected to continue depending upon CBR project activities in any given year, although not in strict proportion to production. As production at the CPF mine site ceases due to depleted ore reserves, expansion areas will be brought on stream. These expansion areas will be sequenced (brought on line) in a manner that will continue CPF production consistent with current production rates. While there are some savings due to some fixed costs, additional expenses are expected to be higher (e.g., wellfield development). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds of uranium produced. Local purchases that will be made annually for the MEA are estimated to be in excess of $1,000,000. Most of these purchases will continue to be made in the City of Crawford and Dawes County. In addition, mineral royalty payments accrue to local landowners. Production royalties of $532,000 were paid to land owners in 2010. Additional royalty payments would be made to MEA landowners. Most of the landowners are residents of Dawes County; therefore, beneficial impacts to county revenues and local businesses will be accrued through the spending and circulation of these dollars in the local economy.

7.6.4 Economic Impact Summary

As discussed in this section, CBR currently provides a positive economic impact to the local Dawes County economy. Development of the MEA would have a positive impact on the local economy as summarized in **Table 7.6-2**. The Proposed Action requires no in-migrating workforce from outside of the local area that currently provides the CBR labor force (primarily communities in Dawes County). Consequently, no increases in housing or community service demands would occur, and existing and planned facilities would not be adversely affected.

8 ALTERNATIVES TO PROPOSED ACTION

8.1 No-Action Alternative

8.1.1 Summary of Current Activity

CBR currently operates the CPF, a commercial ISR uranium mining operation located approximately 4 miles (6.4 km) southeast of the City of Crawford in Dawes County, Nebraska. Operation is allowed under NRC Source Materials License SUA-1534.

An R&D facility was operated in 1986 and 1987. Construction of the CPF began in 1988, with production beginning in April of 1991. The total original license area is 3,300 acres, and the surface area affected by the current commercial project is approximately 1,100 acres. Facilities include the R&D facility (which now houses the Restoration Circuit), the CPF and office building, solar evaporation ponds, parking, access roads, and the wellfield.

In the current license area, uranium is recovered by *in-situ* leaching from the basal sandstone of the Chadron Formation at a depth that varies from 400 feet to 900 feet. The overall width of the mineralized area varies from 1,000 feet to 5,000 feet. The ore body ranges in grade from less than 0.05 percent to greater than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. Production is currently in progress in MUs 6 through 11. Groundwater restoration has been completed and regulatory approval has been received in MU 1. Groundwater restoration is currently underway in MUs 2 through 6.

The CPF is operating with a licensed flow rate of 9,000 gpm. Maximum allowable throughput from the facility under SUA-1534 is currently 2,000,000 pounds of U_3O_8 per year.

8.1.2 Impacts of the No-Action Alternative

The no-action alternative would allow CBR to continue mining operations in the CPF license area. Based on current plans and mining timelines discussed in Section 1 (**Table 1.7-1** and **Figure 1.7-1**), CBR could continue production at the current license area until 2014, when reserves are expected to be depleted to the point where commercial production would no longer be economical and would be discontinued. Restoration and reclamation would become the primary activities, with final restoration and reclamation completed in 2025.

When commercially recoverable resources are depleted in the CPF license area, all activities at the site not associated with groundwater restoration and decommissioning will be completed, resulting in the loss of a significant portion of the total employment at the site. In actuality, many of these jobs would be lost well before 2014. For example, the well drilling, installation, and wellfield construction activities would be completed several years before the completion of mining activities, and these positions would no longer be necessary. At the completion of decommissioning activities, all employment opportunities at the mine would be terminated.

In addition to the loss of significant employment opportunities in the City of Crawford and Dawes County, the premature closing of the CPF before commercially viable resources are recovered would adversely affect the economic base of Dawes County. As discussed in further detail in

Section 9, the CPF currently provides a significant economic impact to the local Dawes County economy as shown in **Table 7.6-1**.

If this amendment request is denied, the negative impact on the Dawes County economy would be felt as early as 2013 when employment levels for drilling and construction activities would be cut and purchases of services and materials would diminish.

In addition, a decision to not amend SUA-1534 to allow mining in the proposed MEA would leave a large resource unavailable for energy production supplies. In 2012, total domestic U.S. uranium concentrate production was approximately 4,100,000 pounds of U_3O_8, of which 800,000 pounds (or approximately 20 percent) was produced at the CPF (EIA 2013a). During the same year, purchases of domestic U.S. uranium by U.S. civilian nuclear power reactors U.S. and foreign suppliers were approximately 58,000,000 pounds of U_3O_8e (equivalent), with approximately 17 percent supplied by domestic producers (EIA 2013b). Foreign-origin uranium accounted for the remaining 83 percent of deliveries. The CPF represents an important source of new domestic uranium supplies essential to providing a continuing source of fuel to power generation facilities.

In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this amendment request would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits.

Denial of the amendment request would have an adverse economic effect on the individuals who have surface leases with CBR and own the mineral rights in the MEA.

8.2 Proposed Action

The proposed MEA map and MU timeline are shown on **Figures 1.7-3** and **1.7-4,** respectively. There will be a total of 11 MUs, with construction for MU-1 to commence in 2014. Production for the project (all MUs) will start in 2015 and terminate in the year 2039. Restoration in designated MUs will commence in the year 2020 and be completed in 2044. Site reclamation will be completed in 2046. The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent with an average ore grade of 0.22 percent.

The proposed MEA contains a licensed area of approximately 4,622.3 acres. Of this potential licensed area, the total surface area that may be affected over the life of the project will be approximately 1,753 acres for the proposed MUs, processing facility, disposal well, well sites, and access roads. Currently, these areas include cropland (128.4 acres) and livestock range (1,370.7 acres [mixed grass prairie – 1142.7 and degraded rangeland – 228 acres]).

The proposed satellite facility will be located within a 1.8-acre fenced in area in sections 26 and 35 of T30N, R51W; sections 1, 2, 12, and 13 of T29N R51W; and sections 7, 18, 19, 20, 29, and 30 of T29N, R50W. This area will also contain the chemical storage areas. The DDW will be located approximately 0.3 mile (0.5 km) north-northeast of the satellite facilities (**Figure 1.7-5**). **Figure 5.7-2** shows the plan view of the satellite facilities.

Figure 1.3-1 shows the location of the current license area and the proposed MEA.

The MEA will be developed and operated by CBR. All land within the proposed license boundary of the MEA is privately owned. CBR has obtained surface and mineral leases from the appropriate landowners necessary to construct and operate the required ISR facilities.

Commercial production at the CPF is expected to extend over the next 10 years with the uranium reserves at both areas largely depleted by 2015. Commercial production at the proposed MEA would occur over 24 years between 2015 and 2024. Aquifer and reclamation will be concurrent with operations, plus an additional period at the end of the project for final decommissioning and surface reclamation. More detailed timelines are provided in Section 1.

The CPF recovers uranium from the basal sandstone of the Chadron Formation. In the MEA, uranium will also be recovered from the basal sandstone of the Chadron Formation. The depth in the MEA ranges from 850 to 1,200 feet. The width varies from 1,000 feet to 4,000 feet.

The satellite facility process structure will be a building approximately 130 feet long by 100 feet wide. The proposed satellite facility equipment will include the following systems:

- IX
- Filtration
- Resin transfer
- Chemical addition

The *in-situ* process consists of an oxidation step and a dissolution step. The oxidants used in the facility are H_2O_2 and/or gaseous O_2. A $NaHCO_3$ lixiviant is used for the dissolution step.

The uranium-bearing solution resulting from the leaching of uranium underground is recovered from the wellfield and piped to the satellite facility for extraction. The satellite facility process employs the following steps:

- Loading of uranium complexes onto an IX resin;
- Reconstitution of the solution by the addition of $NaHCO_3$ and O_2;
- Shipment of loaded IX resin to the CPF; and
- Restoration of groundwater following mining activities.

The satellite facility will be designed for a maximum flow rate, excluding restoration flow, of 6,000 gpm (restoration would account for another 1,500 gpm). Uranium-bearing resin will be transferred to the CPF for elution and packaging of yellowcake.

The operation of the satellite facility results in a number of effluent streams. Airborne effluents are limited to the release of radon-222 gas during the uranium recovery process. Liquid wastes are handled through evaporation and/or deep well injection.

Groundwater restoration activities consist of four steps:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- Aquifer recirculation

Groundwater restoration will take place concurrently with development and production. The primary goal of the groundwater restoration is to return the water quality of the affected zone to a chemical quality consistent with baseline conditions required by 10 CFR 40, Appendix A, Criterion 5(B)(5) [or an approved ACL under 5(B)(5)(c)]; or, as a secondary goal, to the quality level specified by the NDEQ.

Following groundwater restoration, all injection and recovery wells will be reclaimed using appropriate plugging and abandonment procedures. In addition, a sequential land reclamation and revegetation program will be implemented on the site. This reclamation will be performed on all disturbed areas, including the satellite facility, wellfield, and roads. The current estimate of the total acreage to be affected over the life of the MEA project is 1,753 acres.

CBR will maintain financial responsibility for groundwater restoration, facility decommissioning, and surface reclamation. Currently, an irrevocable letter of credit is maintained based on the estimated costs of the aforementioned activities.

The environmental impacts of the requested action will be minimal as discussed in Section 7. The primary radiological air impacts will be from the release of radon gas during production, which will be minimized by the use of pressurized downflow IX columns. In addition, radon gas quickly dissipates in the atmosphere and results in a minimal additional exposure to the public as discussed in Section 4. All drying and packaging will be performed at the CPF using a vacuum drying system, thereby minimizing the potential for radioactive air particulate releases at MEA.

ISR alters the geochemistry and the water quality in the mining zone. CBR has proven in the current licensed area that impacts to groundwater can be controlled through stringent well construction

techniques, wellfield operating methodologies that minimize excursions, and the use of BPTs to restore the groundwater to premining baseline or class of use after mining activities are complete.

The impacts discussed in Section 7 include short-term and long-term impacts. However, it should be noted that uranium ISR mining technique allows the entire mine site to be decommissioned and returned to unrestricted use within a relatively short time.

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8.3 Reasonable Alternatives

8.3.1 Process Alternatives

8.3.1.1 Lixiviant Chemistry

CBR is employing a $NaHCO_3$ lixiviant that is an alkaline solution. Where the groundwater contains carbonate, as it does at CBR, an alkaline lixiviant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixiviant. Also, test results at other projects indicate only limited success with acidic lixiviants, while the $NaHCO_3$ has proven highly successful to date at the Crow Butte operations. Alternate leach solutions include ammonium carbonate solutions and acidic leach solutions. These solutions have been used in solution mining programs in other locations; however, operators have experienced difficulty in restoring and stabilizing the aquifer. Consequently, these solutions were excluded from consideration.

8.3.1.2 Groundwater Restoration

The restoration of the R&D project, the successful completion of restoration in MU-1, and the current restoration activities in MUs 2 through 5 at the current licensed CPF exhibit the effectiveness of the restoration methods. These methods (groundwater sweep, permeate/reductant injection and aquifer recirculation) have been shown to restore groundwater to pre-mining quality. No feasible alternative groundwater restoration method is currently available for the CPF and proposed MEA. The NRC and NDEQ consider the method currently employed at the CPF as the best practicable technology.

8.3.1.3 Waste Management Alternatives

Liquid wastes that are expected to be generated during operations and restoration phases of the proposed MEA project, and the applicant will be required to manage and dispose of liquid byproduct material in compliance with applicable state and federal regulations, as established by license and permit conditions. Liquid wastes are the largest volume of wastes that will be generated and managed during operation and restoration phases. Section 4.0 of this document discusses the types of liquid and solid wastes that are expected to be generated during operations and restoration.

Liquid 11e.(2) Byproduct Material

Liquid 11e.(2) byproduct wastewaters generated at the MEA site during production and restoration are proposed to be managed by DDWs. This is the only disposal option that will be used at the MEA site for approximately the first 5 years of operations. It is expected that two DDWs will accommodate all wastewater generated from startup in 2015 through the end of 2020. As discussed in Section 3.1.7, CBR will assess the need for additional disposal options that are expected to be needed in 2021, when groundwater restoration will result in increased wastewater volumes, which will require additional disposal capacity.

Two MEA DDWs will be completed at an approximate depth of 4,000 to 5,000 ft, isolated from any underground source of drinking water by approximately 1,800 feet of shale (Pierre and Graneros Shales). These discharges must be authorized by the State of Nebraska under a Class I UIC Permit to receive such wastes, and CBR will obtain the necessary permits. CBR will ensure that the DDWs will have sufficient capacity to handle the disposal of the total liquid effluent

generation. The disposal capacity will ensure the disposal of liquids under normal operating conditions during production and restoration phases. Additional discussions as to the liquid waste disposal are presented in Section 4.2.1.7.

CBR considered and rejected using either surge\evaporation ponds, point source discharge or land application as a disposal method for currently planned operations at Marsland due to required treatment and monitoring costs and potential environmental impacts. However, as the project develops, a determination will be made as to the extent of additional wastewater management alternatives that may be needed in addition to the DDWs to handle all of the generated wastewater streams amenable to disposal by DDW. Additional alternative evaluations will consider options such as additional DDWs, surge tanks, surge/evaporation ponds, land application or treated wastewater discharge. CBR will be able to assess the maximum injection rates for the two initial DDWs, and the resulting information will be of value in planning future DDWs and/or other disposal options. CBR will submit the necessary license amendment(s) and waste alternative analyses to the NRC and request approval as per applicable license condition(s), as well as permits required by the NDEQ and other appropriate state agencies.

Surge Tanks

Surge tanks may be a viable option in the future in addressing increased production and restoration flows. If a reasonable number of surge tanks can handle the proposed wastewater volumes, then that may be the only option required. This would assume that additional DDWs would be added and the overall disposal capacity was sufficient.

Surge tanks have advantages over evaporation ponds, including:

- Less waste solids would be generated with tanks since the tanks would be enclosed and windblown dust and dirt would not enter the tanks as it would with open evaporation ponds;
- Tanks sediments could be managed and removed in a more environmentally acceptable manner as compared to evaporation ponds;
- Tanks would eliminate the potential for exposure of wildlife (birds, small mammals, amphibians, and reptiles) to the open evaporation ponds;
- Tanks would have less potential of contamination to the surrounding area as compared to the potential of spray via enhanced evaporation (sprayers) from the evaporation ponds;
- Tanks (mounted on concrete foundations with spill contaminant) would have less potential of contamination of the soils underneath and around the tanks (e.g., liner leaks of ponds);
- Potential radon emissions would be less of a risk with enclosed tanks (vented in a manner to minimize employee/public exposures) as compared to large. open ponds (e.g., evaporation spray systems);
- Tanks would require a smaller footprint than evaporation pond(s);
- Waste volumes of tanks would be less than for evaporation ponds (ponds will have liners and additional expected contaminated soils to be disposed of as byproduct material).

Surge/Evaporation Ponds

Surge/evaporation ponds could be a viable alternative in the future if it is determined that additional surge capacity requirements are such that the quantity required could not be reasonably handled with additional storage tanks (e.g., size constraints).and DDWs. The surge/evaporation ponds

would allow for additional wastewater disposal through passive or enhanced (spray systems) evaporation, especially during the warmer times of the year. Additional surge tanks could be used to the extent possible to minimize the size of any required surge/evaporation ponds. A stated above, prior to the increase in production flows that would result in two DDWs not being able to adequately dispose of the generated wastewaters, a detailed evaluation will be made of viable waste management alternatives. The objective of the alternatives evaluation will be to select options that will adequately handle the maximum amounts of produced wastewaters, while providing for protection of the environment and safe operations by the employees.

Evaporation ponds are commonly used at ISR facilities for the disposal of liquid wastes, which involves pumping liquids into one or more ponds and allowing natural solar radiation to reduce the volume through evaporation. Wastewaters discharged to evaporation ponds are not always treated prior to discharge to the ponds, which can result in radionuclides and other metals to be concentrated as the liquids evaporate. The basic design criteria for an evaporation pond system are contained in 10 CFR Part 40, Appendix A, Criteria 5A and 5E. The NRC has established standards for the location of pond(s), design and construction of the required clay or geosynthetic liner systems, pond embankments and leak detection systems (NRC 2003, NRC 2008). Pond inspection and maintenance criteria are also established by NRC regulations.

Evaporation pond effectiveness depends on how much waste is being generated over a given time period, evaporation rates for the area being used, and how quickly liquid wastes are generated. Evaporation rates will vary seasonally, being dependent largely upon temperature, relative humidity, with the rate of evaporation being highest during warm, dry conditions and lower during cool, humid conditions. The pond size and surface area of a pond can be increased in order to enhance evaporation when the evaporation rates are low or seasonal conditions reduce evaporation.

NRC recommends that evaporation pond include sufficient freeboard and reserve capacity. The NRC recommends a freeboard of approximately 3 to 6 feet (distance from water level to top of embankment) and a reserve capacity that will allow the entire contents of one or more ponds to be transferred to other ponds in the event of a leak requiring repair or to handle additional wastewater volumes.

With ponds being open to the atmosphere, dust and dirt can be blown into the ponds, with the concentrations of dissolved solids increasing due to evaporation. This could result in the precipitation of salts form the solution. Periodic cleaning of the ponds may be required in order to maintain good repair and the necessary freeboard. The accumulated pond sediments may need to be disposed of as byproduct material at a licensed disposal facility. When the site is permanently closed, pond liners, accumulated materials, and any contaminated solid underlying/or adjacent to the pond liner may need to be disposed of as byproduct material.

During the winter months in northwest Nebraska ponds can ice over, resulting in reduced evaporation rates. In order to adequately manage wastewaters year-round in this region, additional storage capacity or one or more additional disposal options would be needed for a typical ISR facility (e.g., land application and/or point source discharge).

<u>Land Application</u>

In general, liquid waste disposal using the land application alternative would involve pre-treatment of liquid waste in lined settling ponds followed by application of treated waste through center pivot

or other types of irrigation sprinklers to agricultural production areas. Application would be seasonally-restricted to the approximately mid-March through early-July winter wheat growing season. Treatment may require IX columns, reverse osmosis, and barium/radium sulfate precipitation to decrease uranium and radium levels in the wastewater below the permitted discharge limits. Until the site and facilities are decommissioned, any byproduct material in storage facilities and within tanks, ponds and radium-settling basins would need to be managed to prevent any releases (NRC 2003).

Land application would require the construction of additional facilities, including radium settling pond(s), outlet pond(s) to intercept treated water from the radium settling pond(s), storage pond(s) to store treated water during the non-irrigation season, and emergency containment pond(s). Storage tanks could alternatively be used in place of the settling, storage, and emergency containment ponds.

Although not a preferred option at this time, land application may be a feasible option in the future when used in conjunction with other disposal options such as disposal via DDW with support facilities such as surge tanks or ponds. If land application disposal is determined to be needed in the future, a facility specific land application plan under a license amendment application will be submitted to the NRC for review and approval. In addition, required permits/approvals from the NDEQ and other applicable state agencies will be obtained.

Discharge to Surface Drainage

Discharge of wastewater would be expected to require treatment similar to what is described above for land application. Radionuclides and specific radionuclide parameters would have to meet applicable NDEQ and NRC discharge standards. An NPDES Permit would have to be obtained from the NDEQ, and a license condition allowing the activity issued by the NRC. Although not a preferred option at this time, it may a viable option for future disposal if warranted due to capacity issues.

Solid Wastes

The disposal of solid wastes will be consistent with current disposal activities at the current CPF. All non-radioactive solid waste solid wastes will be transported from the site for disposal and will be disposed of in a landfill that has been permitted under subtitle D of RCRA. Contaminated wastes will be shipped to an NRC-approved facility for disposal. Should an NRC (or Agreement State)-licensed disposal facility not be available to CBR at the time of decommissioning, the alternative of onsite burial may be necessary. This alternative could incur long-term monitoring requirements and higher reclamation costs. At this time, CBR believes that offsite disposal of 11(e)2 byproduct material from the MEA at a licensed disposal facility is the best alternative, and there are no plans for onsite disposal.

8.4 Alternatives Considered but Eliminated

As a part of the analysis conducted by CBR, several mining alternatives were considered. Due to the significant environmental impacts and cost associated with these alternative mining methods in relation to the MEA ore body, they were eliminated from further consideration.

8.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to solution mining for the uranium deposits in the project area. Neither of these methods is economically viable for producing the MEA reserves at this time. These alternative methods are not economically feasible for several reasons including the spatial characteristics of the mineral deposit and environmental factors. The depth of the deposit and subsequent overburden ratio makes surface mining impractical. Surface mining is commonly undertaken on large, shallow (less than 300 feet) ore deposits. At the MEA, uranium is recovered from depths ranging from 850 to 1,200 feet.

In addition, the physical characteristics of the deposit and the overlying materials make underground mining infeasible for the MEA or CPF. The costs of mine development, including surface facilities, shaft, subsurface stations, ventilation systems, and drifting would decrease the economic efficiency of the project.

From an environmental perspective, open pit mining or underground mining and the associated milling process involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased not only from the mining process but also from milling and the resultant mill tailings. Moreover, the personnel injury rate is traditionally much higher in open pit and underground mines than has been the experience at ISR solution mining operations.

Both open pit and underground mining methods would require substantial dewatering to depress the potentiometric surface of the local aquifers to provide access to the ore. The groundwater would contain naturally high levels of radium-226 that would have to be removed prior to discharge, resulting in additional radioactive solids that would have to be disposed. For conventional mining, a mill tailings pond containing 5,000,000 to 10,000,000 tons of solid tailings waste from the uranium mill would also be required.

In a comparison of the overall impacts of uranium ISR with conventional mining, an NRC evaluation (NRC 1982) concluded that environmental and socioeconomic advantages of ISR include the following:

Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much lower.

1. No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by uranium ISR is generally less than 1 percent of that produced by conventional milling methods (more than 948 kg [2,090 lb] of tailings usually result from processing each metric ton [2,200 lb] of ore).
2. Because no ore and overburden stockpiles or tailings pile(s) are created and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.
3. The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5 percent of the radium in an ore body is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings and the potential for radiation exposure is significantly lower than that associated with conventional mining and milling.

4. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.
5. Solution mining results in significantly less water consumption than conventional mining and milling.
6. The socioeconomic advantages of uranium ISR include:
   - The ability to mine a lower grade ore;
   - A lower capital investment;
   - Less risk to the miner;
   - Shorter lead time before production begins; and
   - Lower manpower requirements.

Finally, and perhaps most important, because CBR is an established commercial solution mining site, there are no viable alternative mining methods at this time. The current market price of uranium makes an established solution mining operation the most economically viable method of mining uranium at Marsland at this time.

8.4.2 Production Facility Alternatives

The option existed for CBR to construct a new yellowcake production facility for the MEA project rather than the proposed satellite facility. The selected option was the construction of a new satellite facility instead because the existing CBR production facility is only approximately 11.1 miles (17.9 km) to the north-northwest of the proposed MEA site (centerpoint of CPF building to centerpoint of MEA satellite building).

The use of the existing facility as a centralized processing facility will allow processing of uranium-loaded resin from the CBR's proposed MEA satellite facility and two other nearby proposed satellite facilities (i.e., NTEA and TCEA). Such a centralized design enhances the economics of uranium production in the region by maximizing production capacity while minimizing further capital expenditures on processing facilities. The construction and operational cost of a satellite facility would be significantly lower than that of a new production facility. The potential for release of radiological particulates would be lower for a satellite facility due to it being a "wet" process because no yellowcake would be produced. Other advantages include: less land disturbance for the operating assets; non-radiological air emissions (e.g., fugitive dust, diesel, and gasoline emissions) during operations would be lower; fewer employees working at the site being potentially exposed to radiation; less byproduct and other types of waste generated that would need to be handled and disposed of; smaller deposits located within the MEA can be mined with the resin trucked to the CPF; and the front end of the "milling" process can be begun independent of the larger CPF.

In summary, the construction and operation of a new processing facility was not deemed to be a viable economical alternative and would result in more environmental impacts than a new satellite facility. Transportation of the uranium-loaded resin from the satellite facility to the main processing facility would serve as an additional risk. However, such risk is deemed minimal with the use of trucks designed for hauling resin, trained drivers, required speed of the vehicles, conditions of the roadways, minimal amount of road traffic in the area, and relative short distance between the two facilities.

8.5 Cumulative Effects

8.5.1 Cumulative Radiological Impacts

On October 17, 2006, CBR submitted a license amendment request to the NRC requesting an increase in the licensed flow at the CPF. License Condition 10.5 of SUA-1534 limited current operation to an annual facility throughput of 5,000 gpm exclusive of restoration flow. CBR requested an amendment to this license condition to increase the licensed flow to increase production and assist restoration efforts. The production increase was to be accomplished by expanding the existing facility and mining existing wellfield to lower levels of soluble uranium. CBR requested approval to increase the annual facility throughput to 9,000 gpm exclusive of restoration flow. The amendment request did not change the annual licensed production rate of 2,000,000 pounds of U_3O_8 per year. NRC issued the license amendment on Nov. 30, 2007.

The only environmental impact of the increased flow rate at the current operation is a corresponding increase in the emission of radon-222 from the current operation. The amendment estimated a 22 percent increase in the maximum public dose and that the maximum public dose would remain well below the limit found in 10 CFR § 20.1301.

8.5.2 Future Development

CBR has identified several additional areas in the region near the CPF that are being considered for development. Licensing and permitting efforts are ongoing for two additional satellite facilities – NTEA and TCEA. Development of additional facilities are not currently planned, although such development depends on further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR could submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development in the Crawford area would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area, using NTEA, TCEA, and MEA.

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8.6 Comparison of the Predicted Environmental Impacts

Table 8.6-1 summarizes the environmental impacts for the no-action alternative (Section 8.1), the preferred alternative (Proposed Action; Section 8.2), and the process alternatives (Section 8.3.1) and production facility alternatives (Section 8.4.2). The predicted impacts for the mining alternatives discussed in Section 8.4.1 are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts were discussed in greater detail in Section 7.

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9 COST-BENEFIT ANALYSIS

9.1 General

The general need for production of uranium is assumed to be an integral part of the nuclear fuel cycle, with the ultimate objective being the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operations required for the fuel cycle are justified in terms of the benefits of energy generation to society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility, such as the CPF and the proposed satellite facility, must be reasonable compared to that typical operation.

9.2 Economic Impacts

Monetary benefits have accrued to the community from the presence of the CPF, such as local expenditures of operating funds and the federal, state, and local taxes paid by the project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community (or for the project) because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date and projects the incremental impacts from operation of the proposed satellite facility.

9.2.1 Tax Revenues

Table 7.6-1 summarizes the tax revenues from the CPF.

Future tax revenues depend on uranium prices, which cannot be accurately forecast; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of approximately $50 per pound of U_3O_8 in August 2011 [UxC 2011]), the production from MEA should contribute to higher tax revenues.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of $950,000 per year in combined taxes.

9.2.2 Temporary and Permanent Jobs

9.2.2.1 Current Staffing Levels

CBR currently employs approximately 68 employees and 2 contractors employing 14 people on a full-time basis. Short-term contractors and part-time employees are also employed for specific projects and/or during the summer months. This level of employment is significant to the local economies. Total employment in Dawes County in 2010 was 5,691 (BEA 2011). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County.

In 2009, the CBR total payroll was $4,155,000 million. Of the total Dawes County wage and salary payments of $106,652,000 in 2009, the CBR payroll represented approximately 4 percent.

Total CBR payroll for the past 5 years was:

2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,155,000
2010	$4,200,000

The average annual wage for all workers in Dawes County was $27,347 in 2009. By comparison, the average wage for CBR was approximately $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonuses, or benefits.

9.2.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of the MEA will provide approximately 10 to 15 temporary construction jobs for up to 1 year. Permanent CBR employees will perform all other facility construction (e.g., wells and wellfield).

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than 5 percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of positions required at the current facility and those that will be created by any future expansion will be filled with individuals from the local workforce. Therefore, that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. The annual unemployment rate in Dawes County in 2010 was 4.5 percent, equating to 216 individuals (BLS 2011). CBR expects that any new positions will be filled from this pool of available labor.

CBR projects that the current staffing level will increase by 10 to 12 full-time CBR employees. These new employees will be needed for facility operators and wellfield operator and maintenance positions. Contractor employees (e.g., drilling rig operators) may also increase by four to seven employees depending on the desired production rate. The majority if not all of these new positions will be filled with local hires.

These additional positions should increase payroll by approximately $40,000 per month, or $400,000 to $480,000 per year.

9.2.3 Impact on the Local Economy

In addition to providing a significant number of well-paid jobs in the local communities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area.

Total CBR payments made to Nebraska businesses for the past 4 years were:

2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$7,838,700
2010	$4,330,900

The vast majority of these purchases were made in the City of Crawford and Dawes County.

This level of business is expected to continue dependent upon CBR project activities in any given year, and should increase somewhat with the addition of expanded production from the proposed MEA and from restoration activities, although not in strict proportion to production. While there are some savings due to some fixed costs, there are additional expenses that are expected to be higher (wellfield development). Therefore, it can be assumed that the overall effect on local purchases will be relatively proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3,650,000 to $4,350,000 per year.

9.2.4 Economic Impact Summary

As discussed in this section, CBR currently provides a significant economic impact to the local Dawes County economy. Approval of the proposed project would have a positive impact on the local economy as summarized **Table 7.6-2**.

9.2.5 Estimated Value of Marsland Resource

CBR continues to develop the reserve estimates for the MEA. Based on the current recoverable resource estimate of 5,667,926 pounds of U_3O_8 and the current market price of uranium ($50 per pound in August 2011 [UxC 2011]), the total estimated value of the energy resources at MEA is approximately $283,396,300. This value will fluctuate as the market price and realized price vary.

9.2.6 Short-Term External Costs

9.2.6.1 Housing Impacts

The available housing resources should be adequate to support short-term needs during facility construction. In 2010, a total of 568 housing units were vacant in Dawes County out of a total housing base of 4,252 units (USCB 2011). Of the vacant units, 168 were available for rent. In addition to this availability of rental housing units, there are two small hotels in the City of Crawford that generally have vacancies and routinely provide units for itinerant workers such as railroad crews. Temporary housing resources have experienced little change in the past two decades.

Recent data for the City of Crawford indicate that in 2010 there were a total of 567 houses in Crawford, with 470 occupied (334 by owners and 136 by renters; USCB 2011). This indicated that 97 housing units were available for purchase or rent. In 2008, the housing density was 467

houses/condos per square mile. The median rent being asked for vacant rental units in 2008 was $337/month. The median purchase price for a home was $51,856 (City-Data 2010).

9.2.6.2 Noise and Congestion

CBR projects an increase in the noise and congestion in the immediate area of the satellite facility during initial construction of the facility. This will include heavy truck and equipment traffic and access to the jobsite by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary in nature. The increase in noise should be considered in light of the project location, which has two minor rural roads (Hollibaugh and River Roads) used primarily for access.

A BNSF rail line is located east of SH 2/71 and is approximately 1.1 miles (1.8 km) from the MEA boundary at the closest point. Noise from the trains on the BNSF rail line would be intermittently audible to receptors within and in close proximity to the MEA. Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

9.2.6.3 Local Services

As previously noted, CBR actively recruits and trains local residents for positions at the mine. CBR expects that the majority of permanent positions at the MEA will be filled with local hires. As a result of employing the local workforce, the impact on local services should be minimal. In many cases, these services (e.g., schools) are underutilized due to population trends in the area.

9.2.7 Long-Term External Costs

9.2.7.1 Housing and Services

Because of the small number of people who have needed to move into the area to support CBR activities in the past, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of long-term positions that will be created by the MEA project will be filled with individuals from the local workforce. Therefore, there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. As stated earlier, CBR expects that the new positions at the satellite facility will be filled from the local pool of available labor.

9.2.7.2 Noise and Traffic Congestion

CBR projects a minor increase in the long-term noise and traffic congestion in the immediate area of the satellite facility. Most of this will consist of increased traffic from employees commuting to and from the work site and performing work in the wellfield. Some increase in heavy truck traffic will occur due to deliveries of process chemicals such as O_2 and the shipment of IX resin from the satellite facility to the CPF. Delivery and IX shipments should average two per day. These impacts will be most noticeable to residents in the immediate vicinity of the facility.

The 2010 average daily traffic counts for a segment of SH 2/71 near Marsland at the southern end of the MEA was 675 total vehicles, including 90 heavy commercial vehicles. Traffic levels on SH 2/71 increase to 695 total vehicles, including 90 heavy commercial vehicles in the vicinity of East

Belmont Road (NDOR 2010). Secondary and private roads connect with East Belmont Road, River Road, Hollibaugh Road, and Squaw Mound Road to provide access to residences and agricultural lands within the MEA. The limited additional traffic related to the MEA operation will not significantly affect these routes.

9.2.7.3 Aesthetic Impacts

The primary visible surface structures proposed for the MEA include wellhead covers, wellhouses, electrical distribution lines, one satellite processing building. The project will use existing and new roads to access each wellhouse, the DDW building, and the satellite processing building. Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture which characterize the existing landscape. The project would primarily affect agricultural land.

In foreground-middleground views, the satellite processing building, wellhouses, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light tan exposed soils in geometrically shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite facility processing building, wellhouses, and wellhead covers would be painted to harmonize with the surrounding soil and vegetation cover. These facilities would be visible from Squaw Mound Road and the residence within the license boundary, but would be subordinate in scale to the rural landscape.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of these would blend with the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone. However, the wellhead covers would be painted a tan color that would harmonize with the surrounding vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

9.2.7.4 Land Access Restrictions

Property owners of land located within the immediate wellfield and facility boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease and mineral royalty payments to the landowners.

9.2.8 Most Affected Population

The expected impacts from the proposed MEA can be characterized as an incremental increase in the impacts from current CBR operations. For the most part, the impact from operation of the current Crow Butte Uranium Project has been positive. CBR has provided much-needed well compensated employment opportunities for the local population. Additionally, the policy of purchasing goods and services locally to the extent possible has had a positive economic impact on an area facing economic challenges. Tax expenditures and particularly the recent increases in local property taxes paid due to the increase in the price of uranium have had a positive economic impact on local government-provided services.

Offsetting these positive impacts to the local population are increases in noise, traffic congestion, and aesthetic impacts for residents in and adjacent to the proposed satellite facility. Most residents located in the proposed license area are landowners that have mineral and/or surface leases with CBR and will benefit economically from the presence of the facility.

9.2.9 Satellite Facility Decommissioning Costs

Approval of the proposed satellite facility will result in CBR incurring additional decommissioning liabilities for the installed facilities. The actual estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

This section presents a written estimate of the costs for "environmental protection" deemed to be necessary during and after the cessation of operations. These cost estimates focus on costs associated with the restoration and reclamation (decommissioning) of the MEA in order to ensure that adequate funds are available for permanent closure of the project. The cost estimates address the above-referenced "measures" of concern. The estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

The NRC requires a financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover costs of reclamation activities. Evidence of financial responsibility in the form of a letter of credit or other form satisfactory to the NDEQ in accordance with Title 122, Chapter 13, shall be provided to the NDEQ in an amount equal to or greater than the total costs indicated in the Surety Cost Estimate as required, along with an audit statement from an independent professional auditing firm. CBR will review the cost estimate annually and update in order to ensure adequacy of the dollar amount. The purpose is to ensure that there are sufficient funds available for decontamination, decommissioning, and reclamation of the facility in the event CBR is incapable of performing the tasks.

NRC License SUA-1534 requires that CBR continuously maintains an approved surety instrument for Crow Butte Resources, Inc., in favor of the State of Nebraska. CBR is required to ensure that the financial assurance instrument, when authorized by the State of Nebraska, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil and water sample analyses, and groundwater restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or

decommissioning plan cost estimates and annual updates will follow the outline in Appendix C to NUREG-1569, entitled "Recommended Outline for Site-Specific In-Situ Leach Facility Reclamation and Stabilization Cost Estimates."

Groundwater and surface reclamation and restoration methods to be used for the MEA are discussed in Section 6. A decommissioning plan shall be based on factors such as the mine plan, baseline environmental information, and any other factors that will ensure the long-term physical, geotechnical, and geochemical stability of the site. Restoration of a specific MU can be started as soon as mining is completed, hence the importance of integrating the mine plan and the decommissioning plan. Restoration of a specific MU can occur while uranium recovery operations continue at other MUs. Once groundwater restoration has been completed in the final MU and approved by the NDEQ, decommissioning of the satellite processing plant, remaining CPF evaporation ponds, and other structures can be initiated.

The cost estimates presented in this section are based on the cost per year to restore one MU and reclaim one MU (surface and subsurface features). The CBR mine plan calls for sequential restoration and reclamation, and CBR will have approximately two to three MUs in restoration, mining, or reclamation at any one time. The surety cost estimates will be adjusted as necessary when additional MUs are to be brought on line and the proposed operations are better defined. A current and updated surety is required at least 90 days prior to commencement of construction of a new MU or significant expansion.

Cost information is presented in the following tables located in **Appendix P**:

Table P.1-1	Primary Assumptions Serving as the Basis for Surety Cost Estimates Associated with Restoration and Reclamation of One (1) Mine Unit
Table P.1-2	Marsland Total Restoration and Reclamation – 2013 Surety Estimate
Table P.1-3	Marsland Groundwater Restoration – 2013 Surety Estimate
Table P.1-4	Marsland Wellfield Reclamation – 2013 Surety Estimate
Table P.1-5	Marsland Well Abandonment Unit – 2013 Surety Estimate
Table P.1-6	Marsland Satellite Facility Equipment Decommissioning – 2011 Surety Estimate
Table P.1-7	Marsland Building Demolition Cost – 2013 Surety Estimate
Table P.1-8	Marsland Miscellaneous Site Reclamation – 2013 Surety Estimate
Table P.1-9	Marsland Deep Disposal Well Reclamation – 2013 Surety Estimate
Table P.1-10	Marsland Groundwater IX Treatment (GIX) Restoration 9Unit Cost]
Table P.1-11	Marsland Groundwater Reverse Osmosis (RO) Treatment [Unit Cost] – 2013 Surety Estimate
Table P.1-12	Marsland Groundwater Recirculation [Unit Cost] – 2013 Surety Estimate
Table P.1-13	Marsland Well Abandonment [Unit Cost] – 2013 Surety Estimate
Table P.1-14	Five Year Mechanical Integrity Tests (MIT) – 2013 Surety Estimate
Table P.1-15	Marsland Master Cost Basis – 2013 Surety Estimate

Table P.1-1 presents the primary assumptions that serve as the basis for the surety cost estimates associated with restoration and reclamation of one mine unit (as of June 11, 2013). **Table P.1-2** provides a summary of the total estimated costs for projected restoration and reclamation activities

for MU 1$2,286,647), which includes a contract administration and contingency fees of 10 and 15 percent, respectively. The remaining tables further refine the cost estimates and the basis for the tasks and cost estimates. The DDW will operate under a separate Class I UIC Permit, but the reclamation cost estimates for this well have been provided as part of the total surety estimate for the MEA.

9.3 The Benefit-Cost Summary

The benefit-cost summary for a fuel-cycle facility such as the CPF involves comparing the societal benefit of a constant U_3O_8 supply (ultimately providing energy) against possible local environmental costs for which there is no directly related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- Groundwater impact
- Radiological impact
- Disturbance of the land

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to a pre-mining quality. The successful restoration of groundwater at the CPF during the R&D project and the commercial restoration of MU 1 have demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the current and proposed project are small, with all radioactive wastes being transported and disposed of offsite. Radiological impacts to air and water are also minimal. Extensive ongoing environmental monitoring of air, water, and vegetation has shown no appreciable impact to the environment from the CPF.

The disturbance of the land for a satellite facility and related activities is quite small, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for previous uses.

9.4 Summary

In considering the energy value of the U_3O_8 produced to U.S energy needs, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the proposed MEA is favorable, and that amending SUA-1534 is the appropriate regulatory action.

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10 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

10.1 Environmental Approvals for the Current Licensed Area

As discussed previously, this is an amendment application for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1998. A license renewal application for continued operation of the CPF was submitted to the NRC on November 27, 2007. NRC approval is pending. A license amendment for the addition of the proposed NTEA satellite facility was submitted to the NRC on May 30, 2007. NRC approval is pending.

All other required permits for the existing CPF have been obtained and maintained as required by applicable regulatory requirements. A summary of the relevant permits and authorizations for the current license area is given in **Table 10.1-1**. License, permits and authorizations anticipated for the Marsland satellite facility are shown in **Table 10.1-2**.

10.1.1 Environmental Approvals and License/Permits

The MEA will be subject licensing and permitting requirements similar to the CPF. **Table 10.1-2** contains a summary list of the type of license, permit or authorization, the granting authority, and the status.

10.1.2 Licensing and Permitting Consultations

During the course of the preparation of this License Amendment application and the NDEQ Class III UIC Application for the MEA, the following agency contacts were consulted:

U.S. Nuclear Regulatory Commission

Mr. Ronald Burrows, Project Manager
Decommissioning and Uranium Recovery Licensing Directorate
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10.1.3 Environmental Consultations

During the course of the preparation of this license amendment application, several agencies were consulted for information required for various sections of the application:

Uses of Adjacent Lands and Waters (Section 2.2)

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Surface Water (Section 2.7.1)

Assistance was requested in providing available surface water flow and water quality data for the Niobrara River in the proposed project area:

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Ecology (Section 2.8)

Preparation of the ecology discussion (Section 2.8) required consultations with the following individuals and agencies:

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Historic, Scenic, and Cultural Resources (Section 2.4.1)

Preparation of the historic, scenic, and cultural resources discussion required consultations with the following individuals and agencies:

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Population Distribution (Section 2.3)

Preparation of the population distribution discussion (Section 2.3) required consultations with the following individuals and agencies:

- T. Vogl, School Clerk, Crawford Public Schools

10.1.4 List of Preparers

The following individuals and organizations were involved in the preparation of this Technical Report supporting the amendment request for Source Materials License SUA-1534 to allow development of the MEA:

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Aqui-Ver, Inc. (Aqui-Ver). 2013b. Letter Report from Robert L. Lewis, P.G., Principal Hydrogeologist to Doug Pavlick and John Schmuck, Crow Butte Resources, Crawford, NE Regarding Hydraulic containment analysis for the Marsland Expansion Area. May 30.

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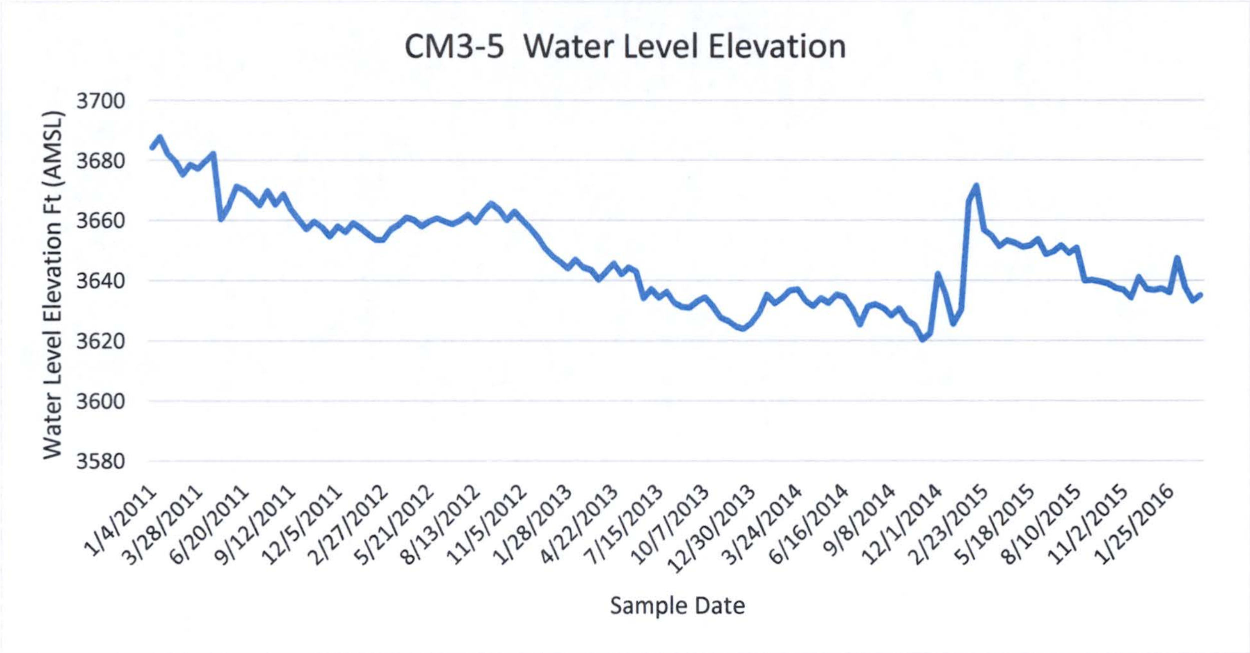
Response to Open Issues
Marsland Expansion Area
Technical Report

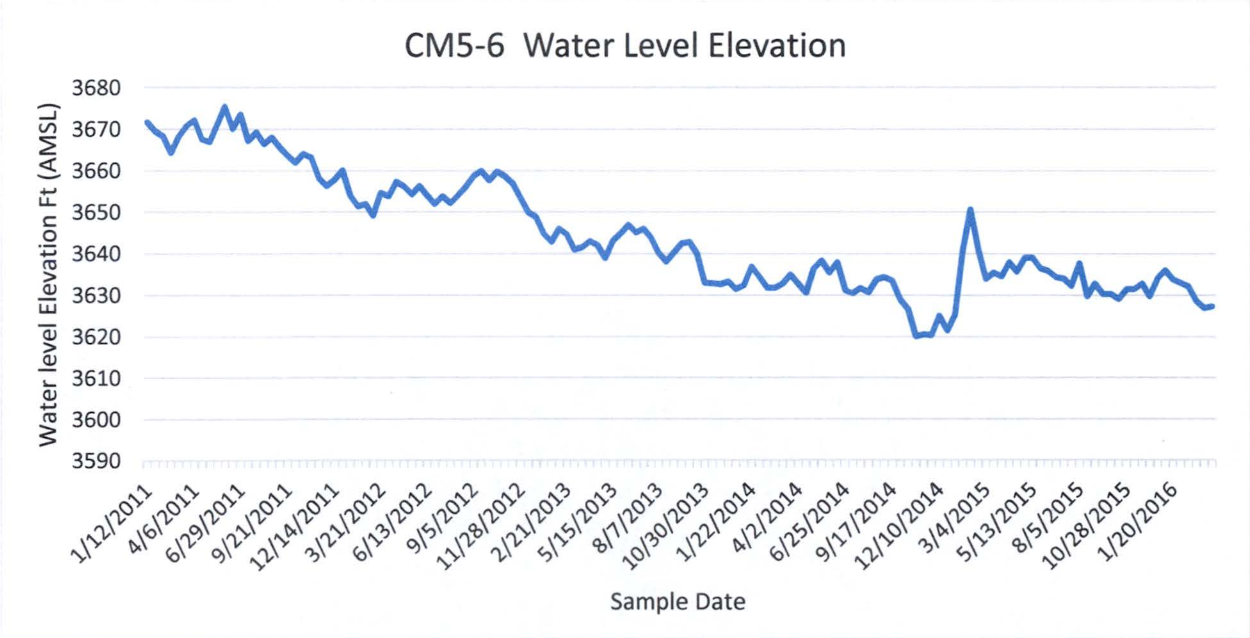
Attachment C

Attachment C CBO Hydrographs

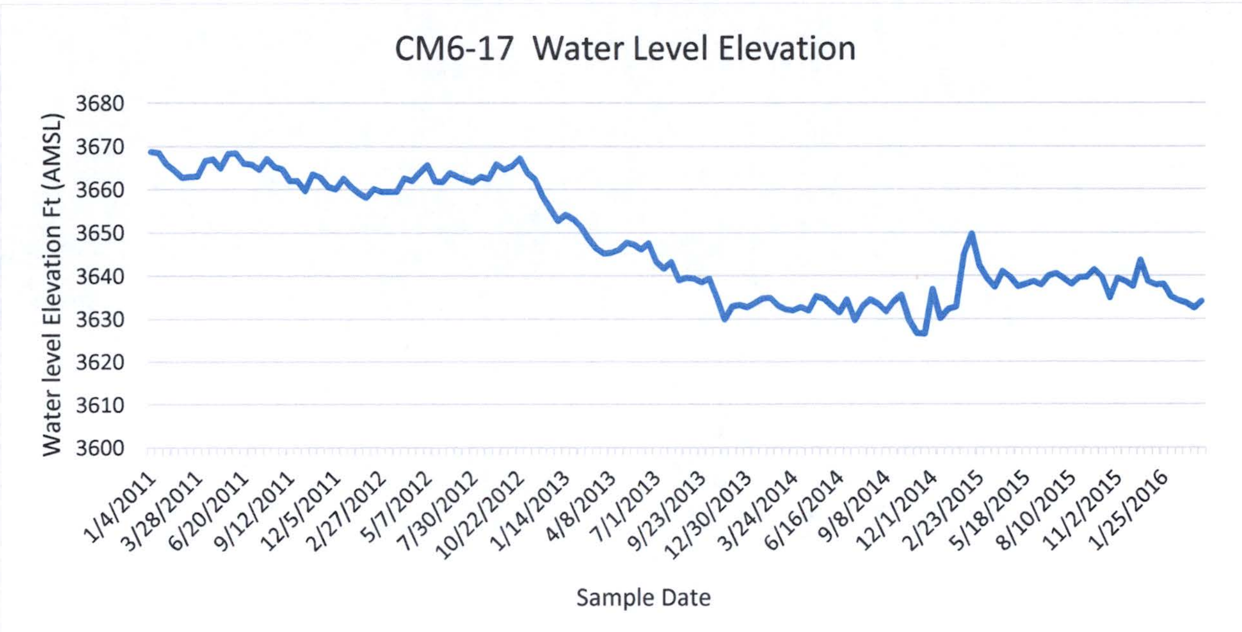
Attachment C Figure 1

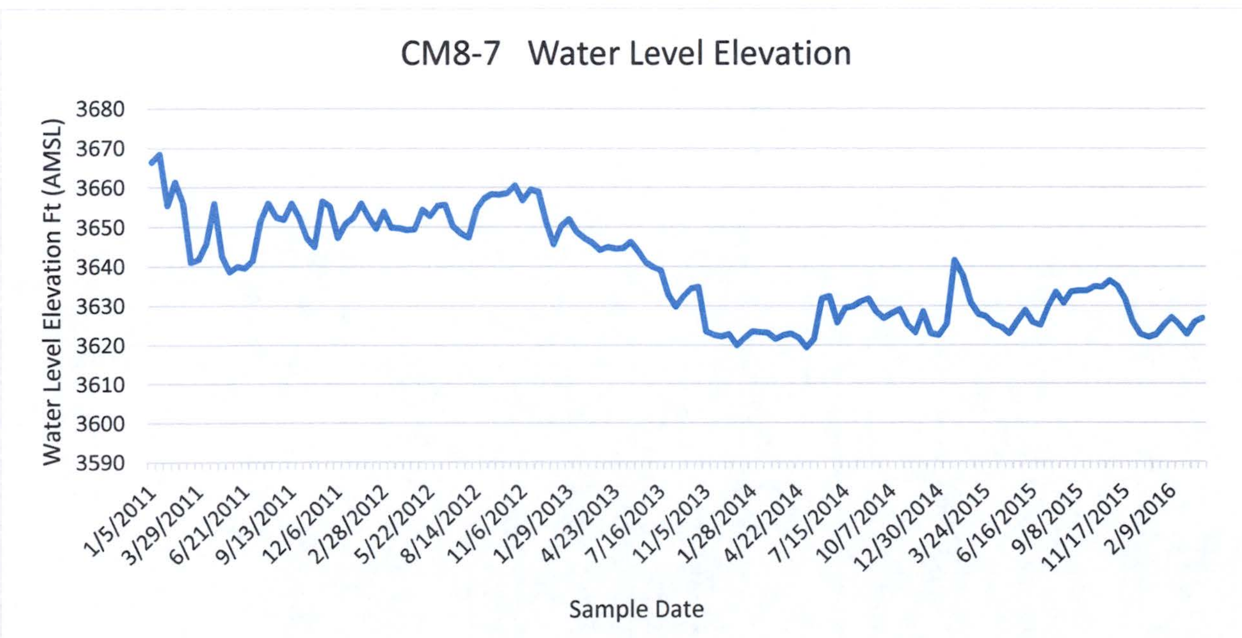
Crow Butte Monitor Well
Hydrographs
Basal Chadron Sandstone





Crow Butte Monitor Well
Hydrographs
Basal Chadron Sandstone





Crow Butte Monitor Well
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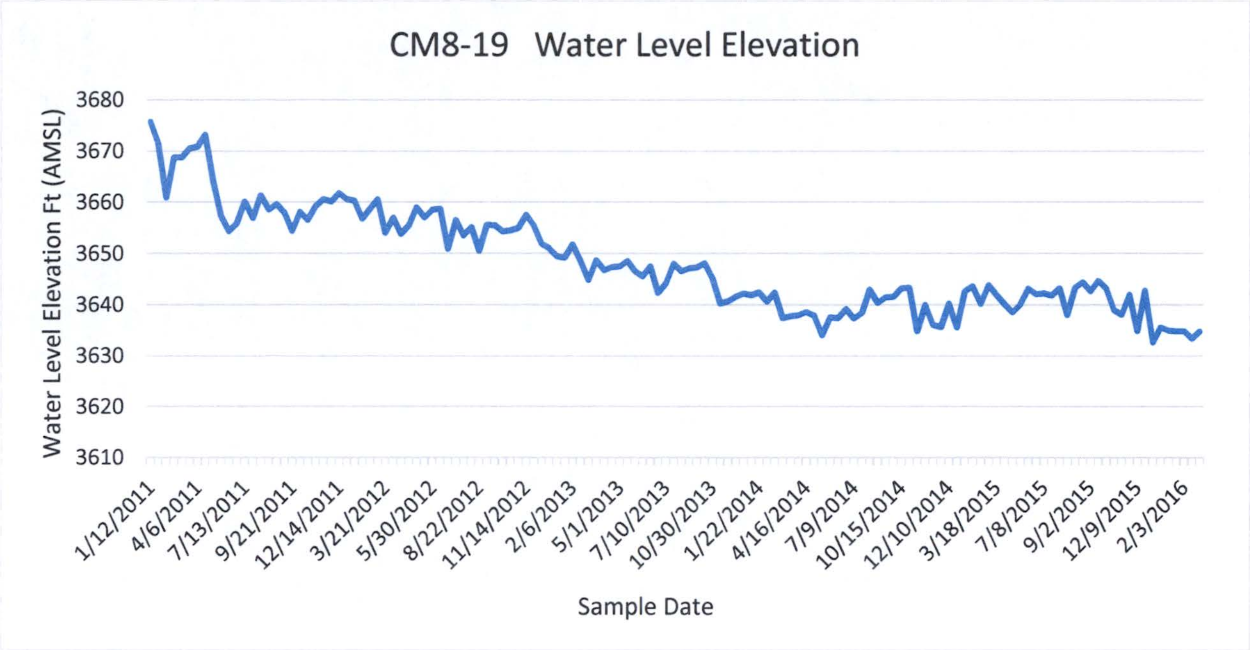
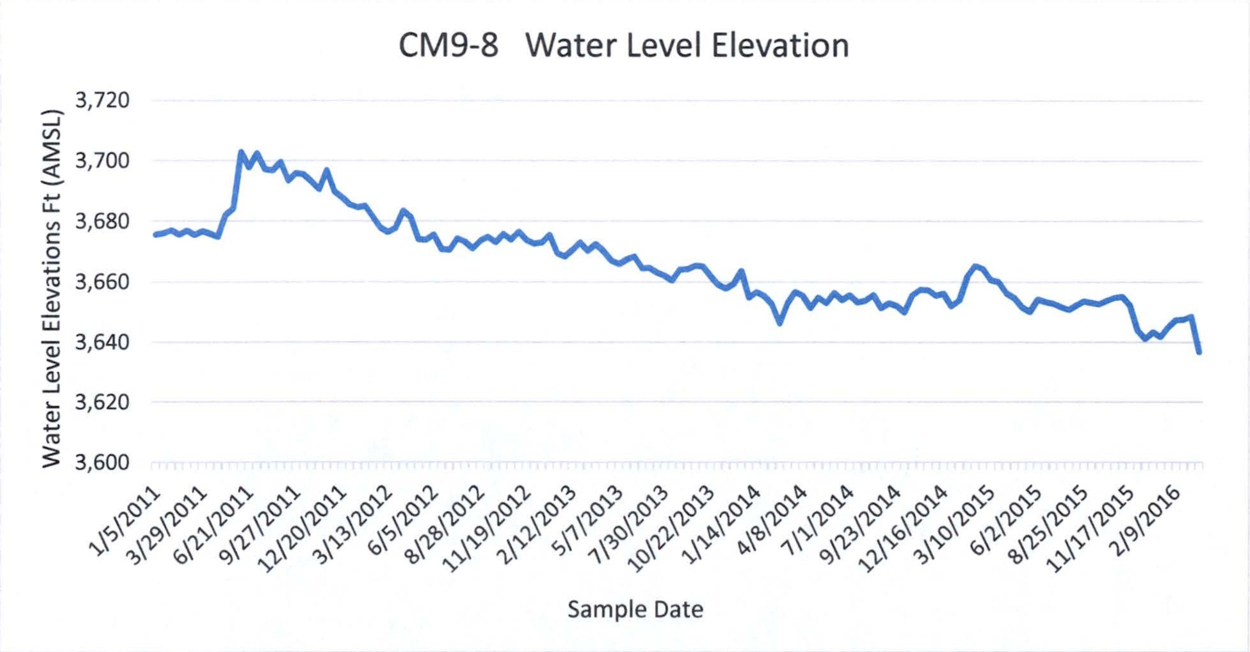
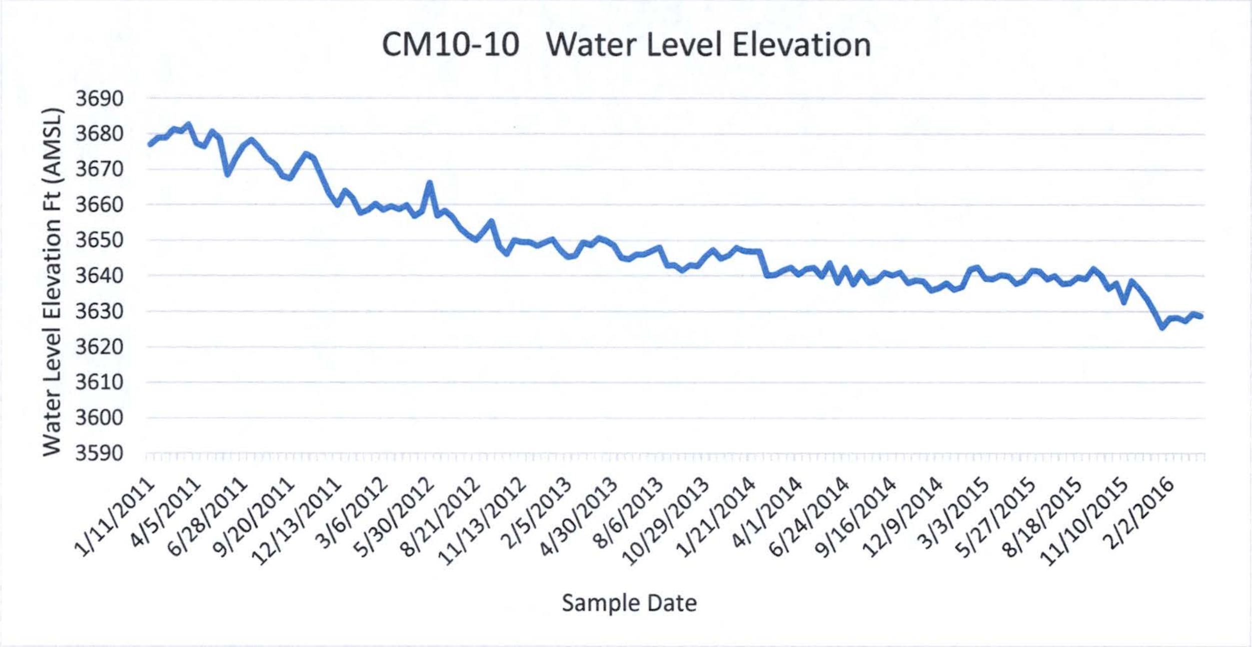
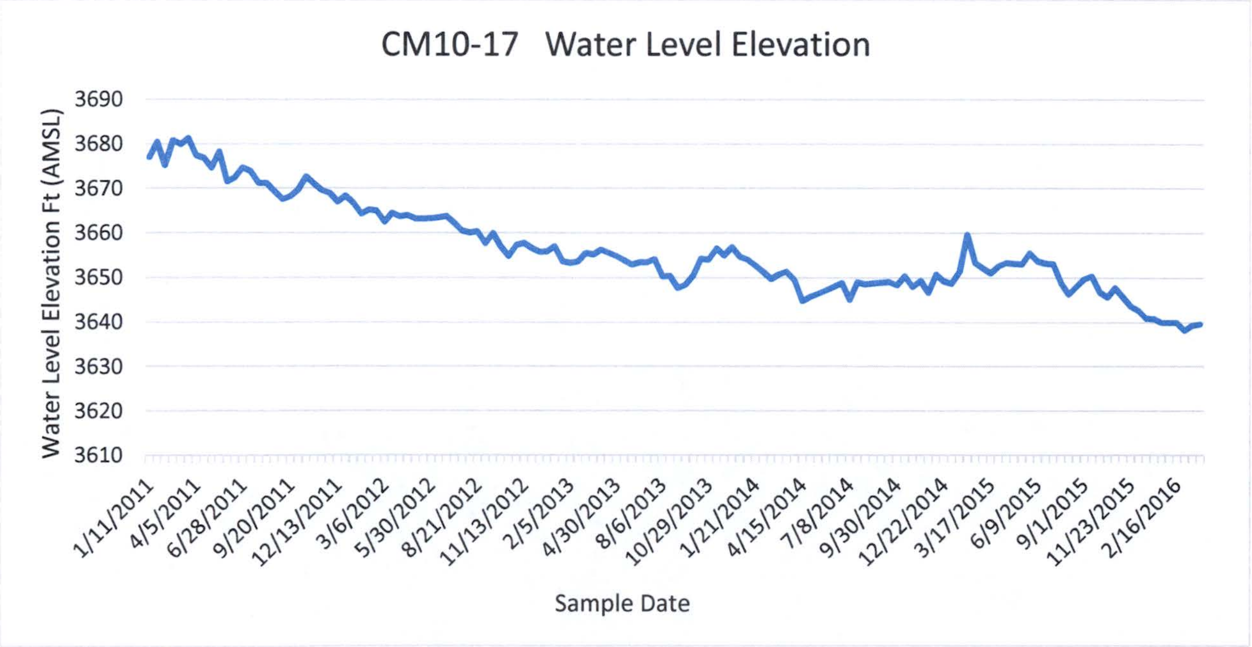


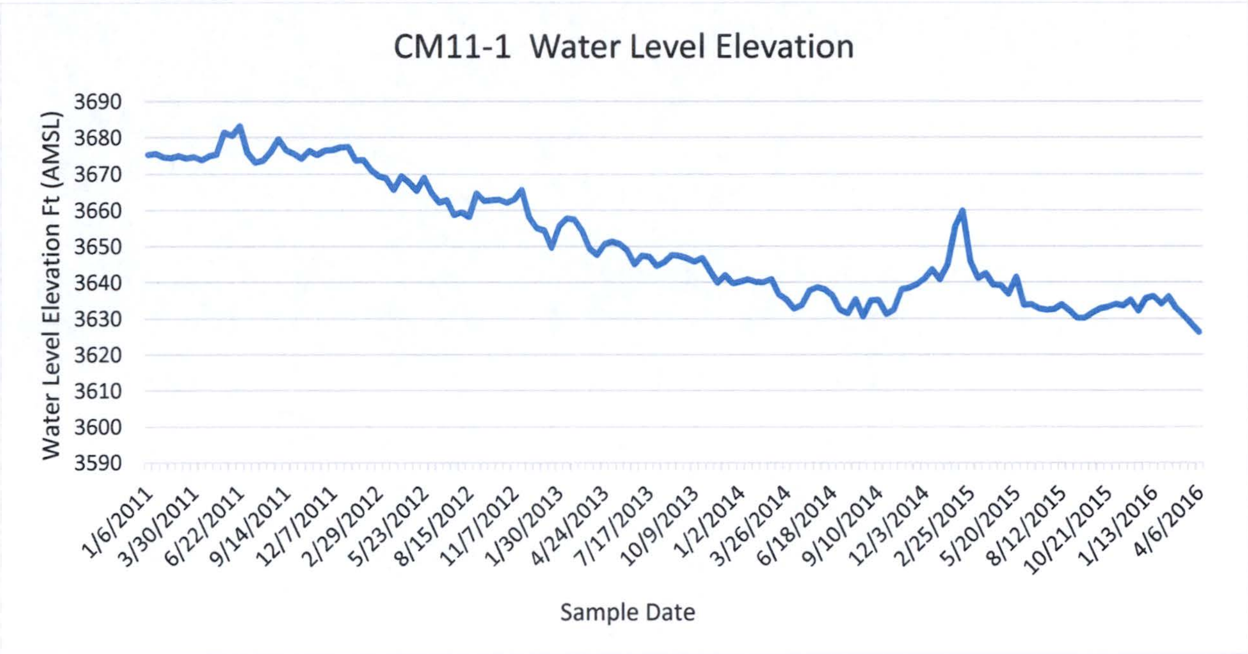


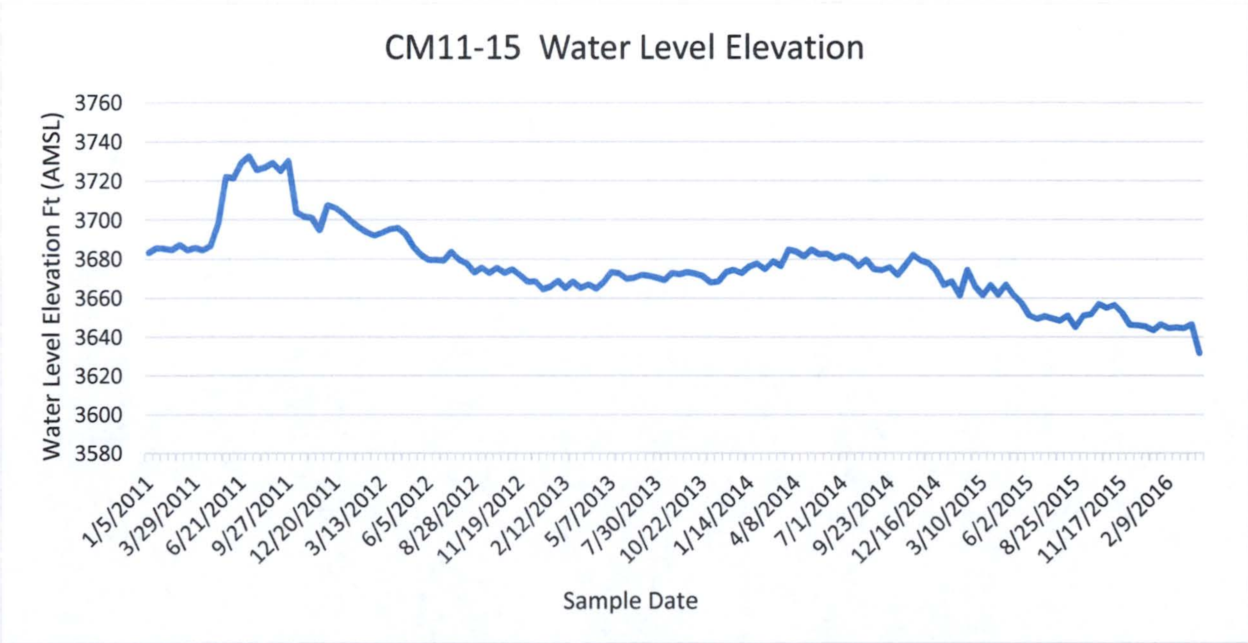
Crow Butte Monitor Well Hydrographs Basal Chadron Sandstone





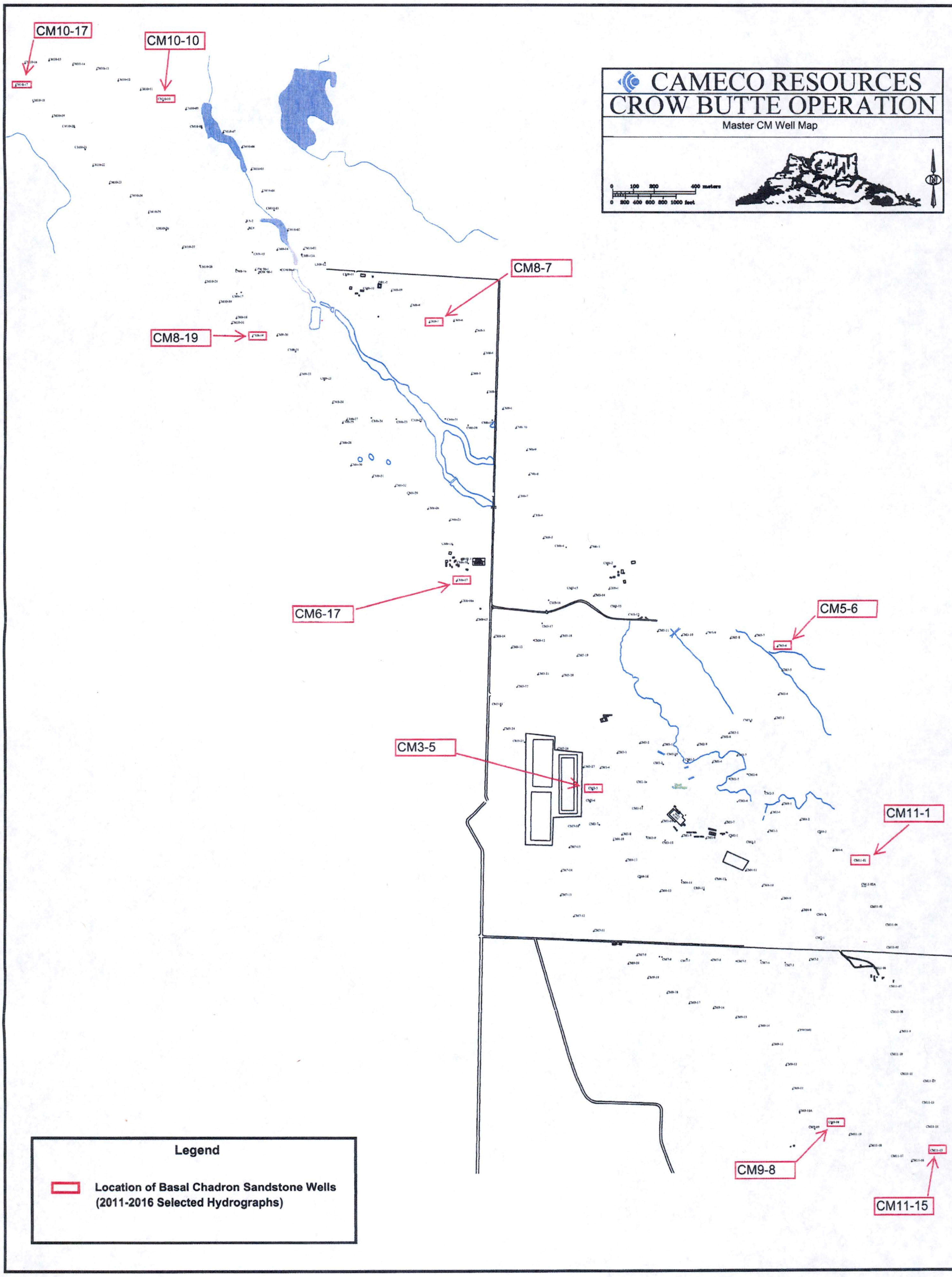
Crow Butte Monitor Well
Hydrographs
Basal Chadron Sandstone





Cameco Resources - Crow Butte Operation
Marsland Technical Report - Open Issues (April 6, 2016)

Crow Butte Monitor Wells
Basal Chadron Sandstone



Attachment C
Figure 1

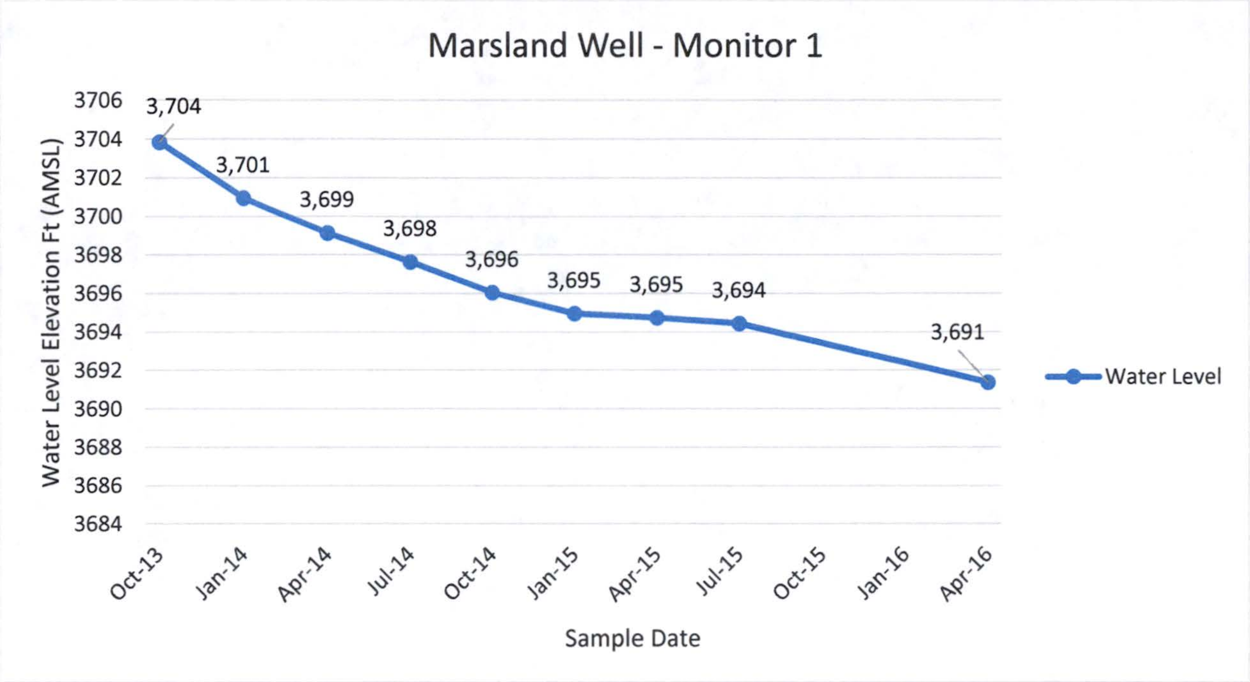
Response to Open Issues
Marsland Expansion Area
Technical Report

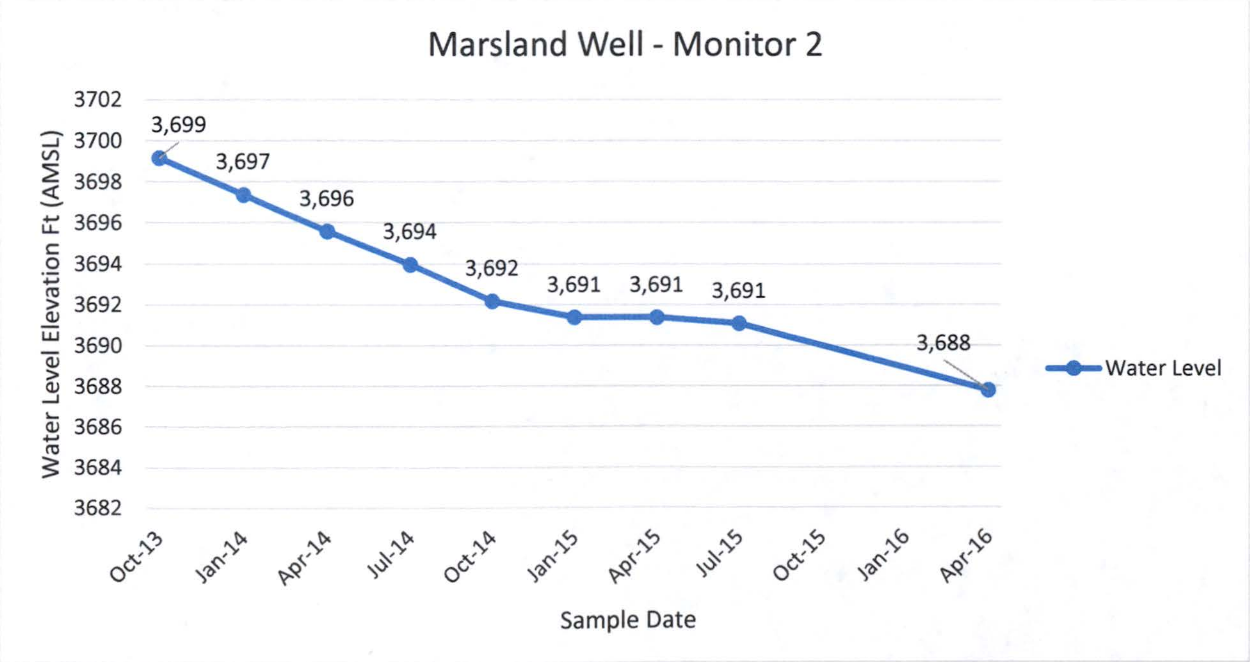
Attachment D1

Attachment D1 Marsland Expansion Area Hydrographs

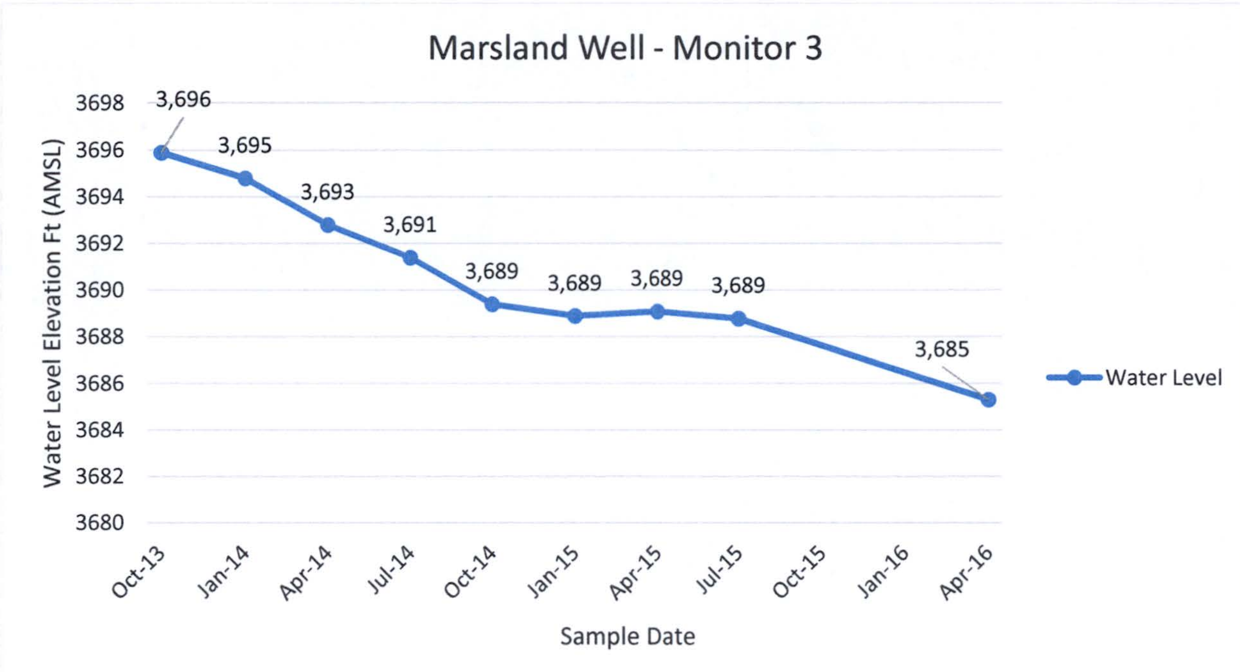
Cameco Resources – Crow Butte Operation
Marsland Technical Report – Open Issues
April 6, 2016

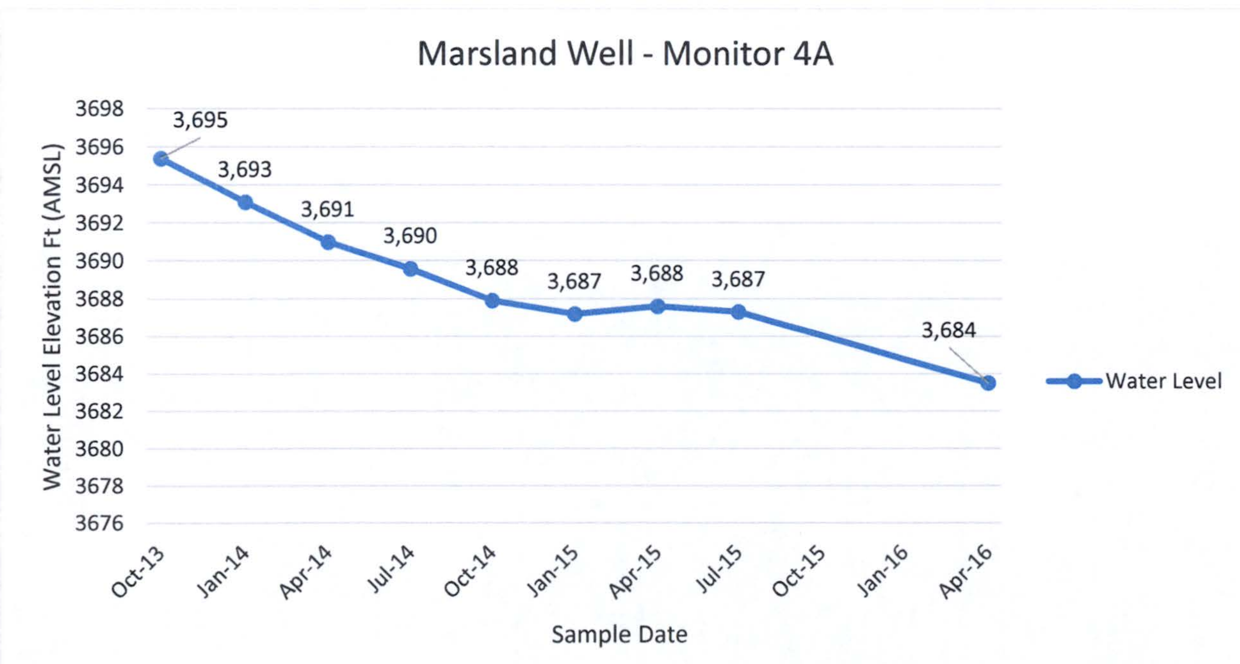
Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



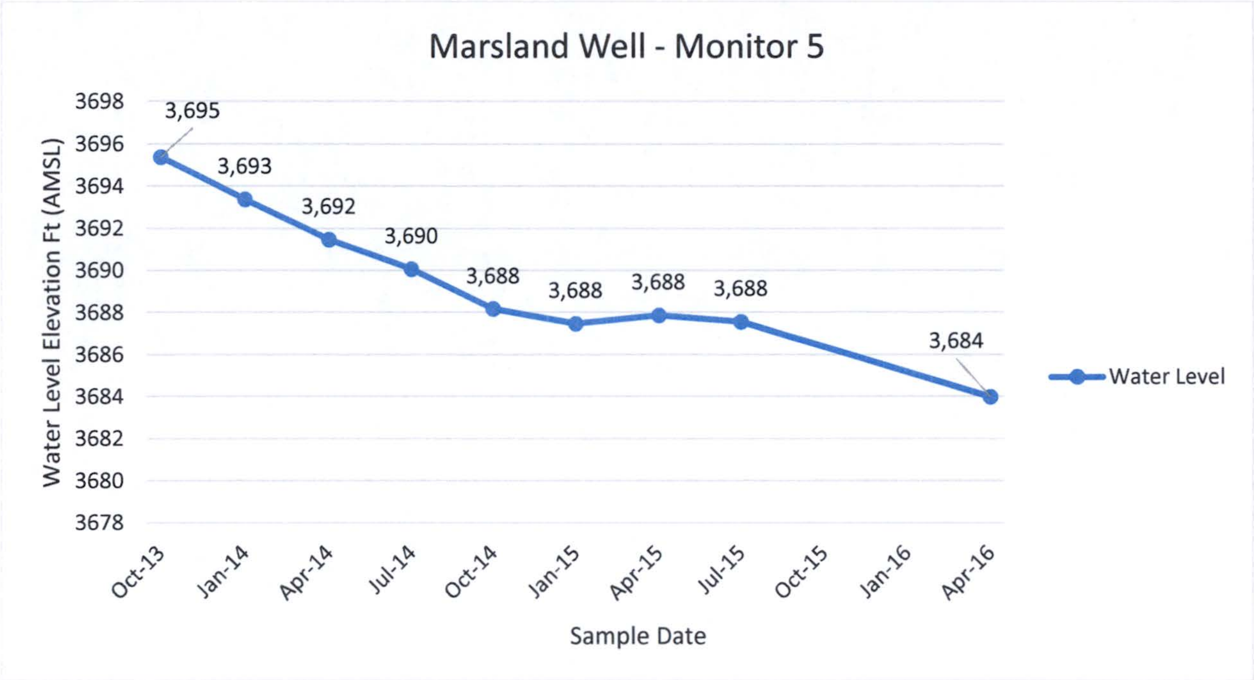


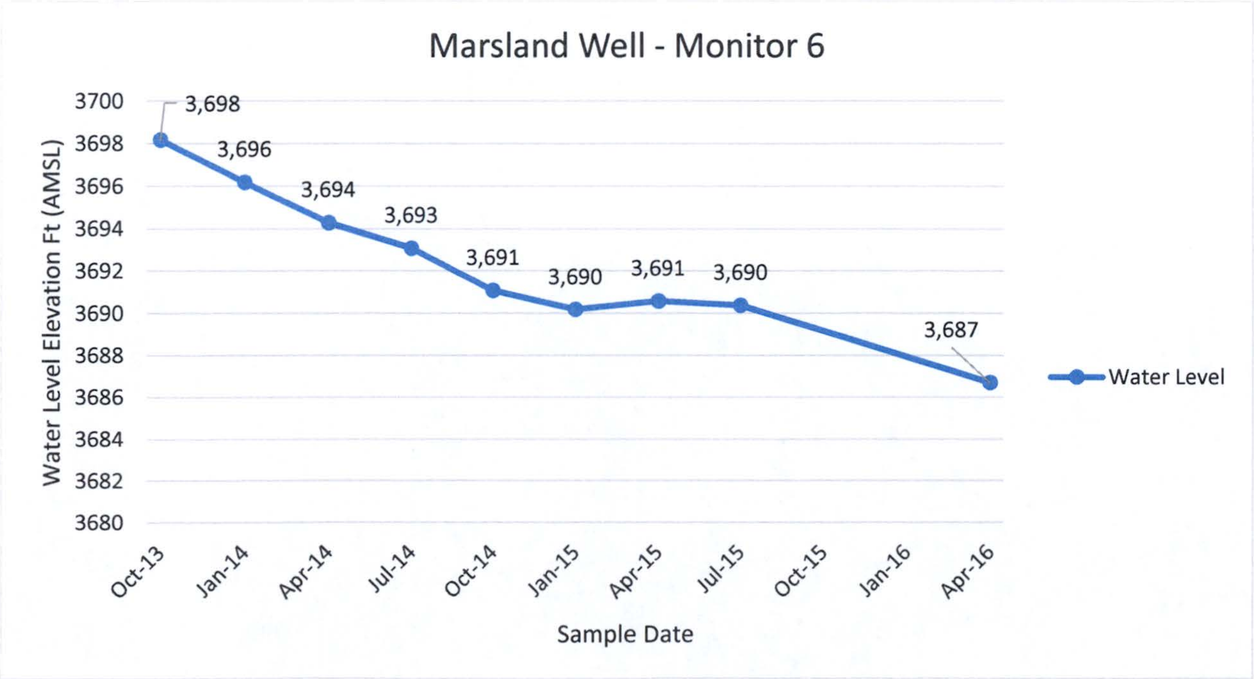
Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



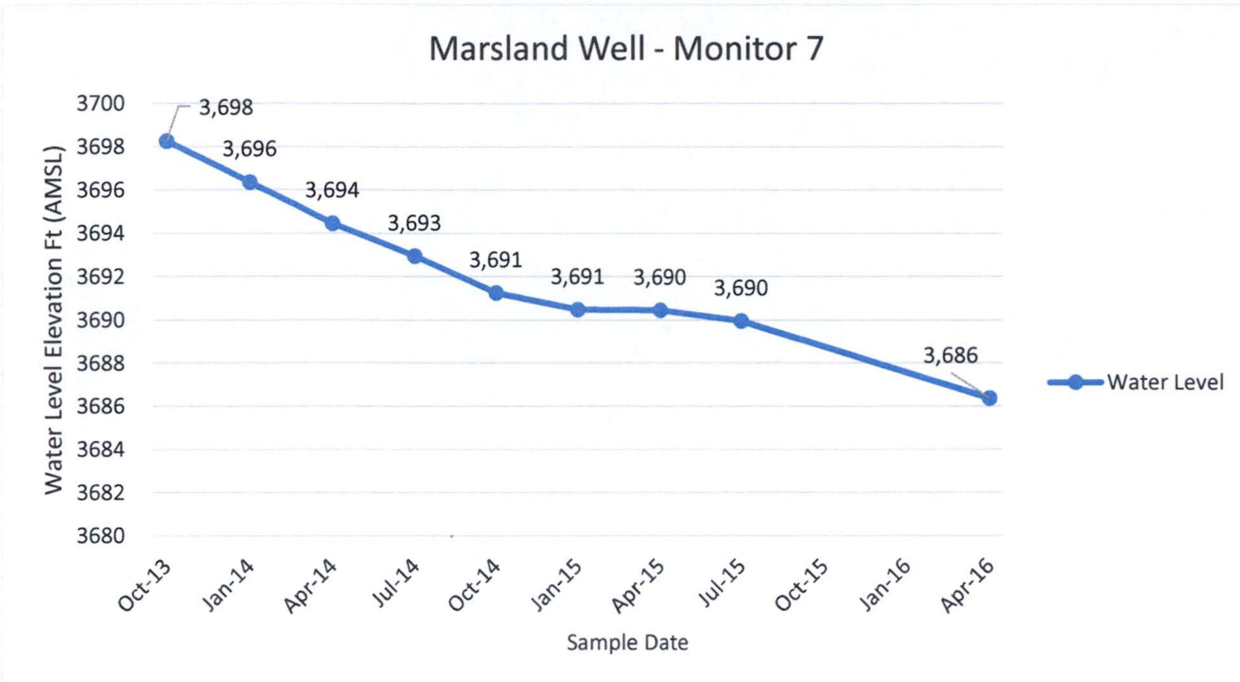


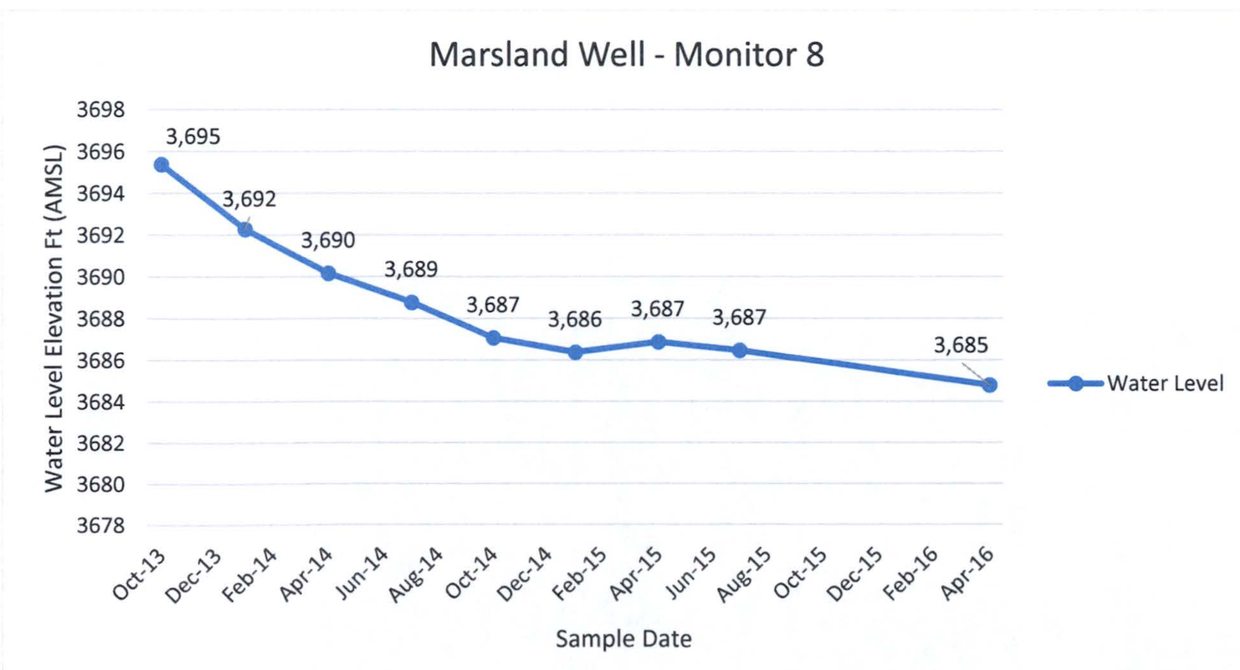
Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



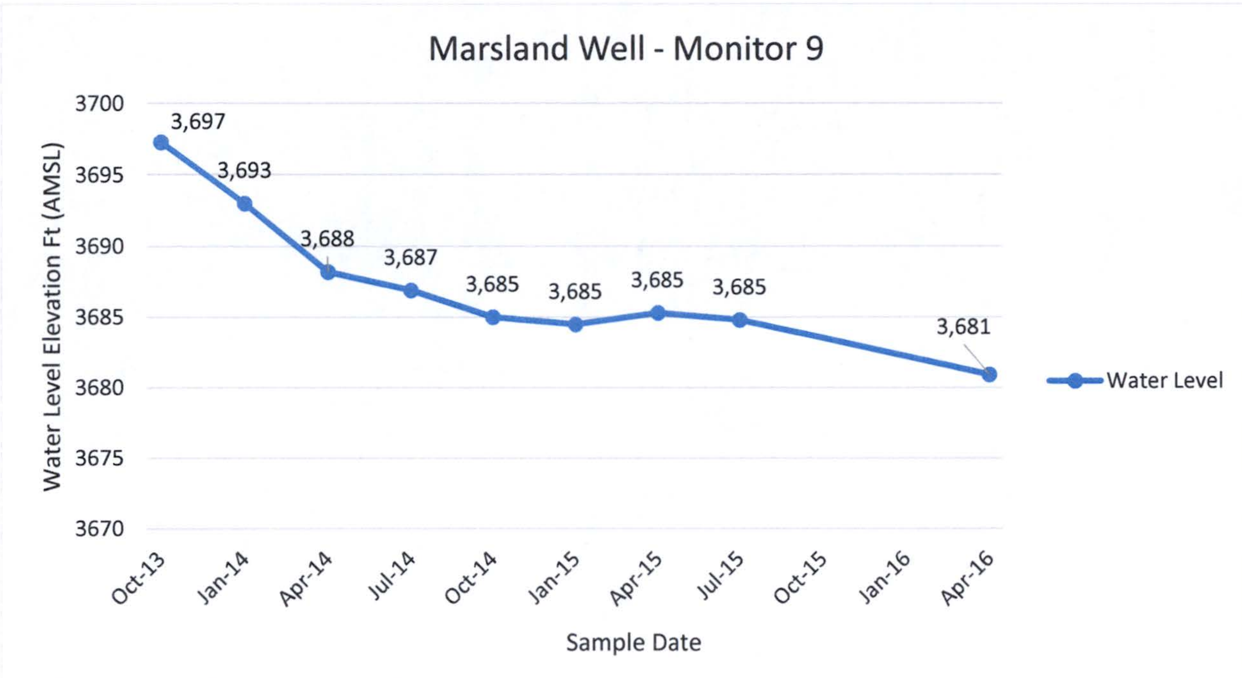


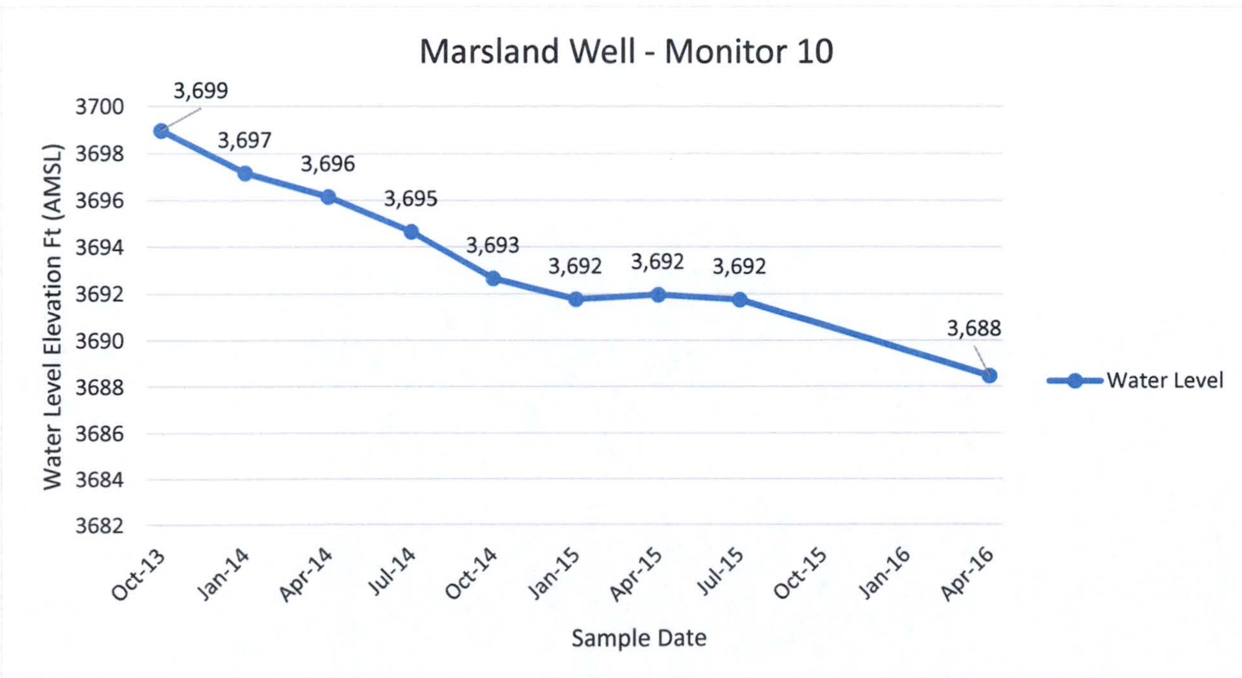
Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



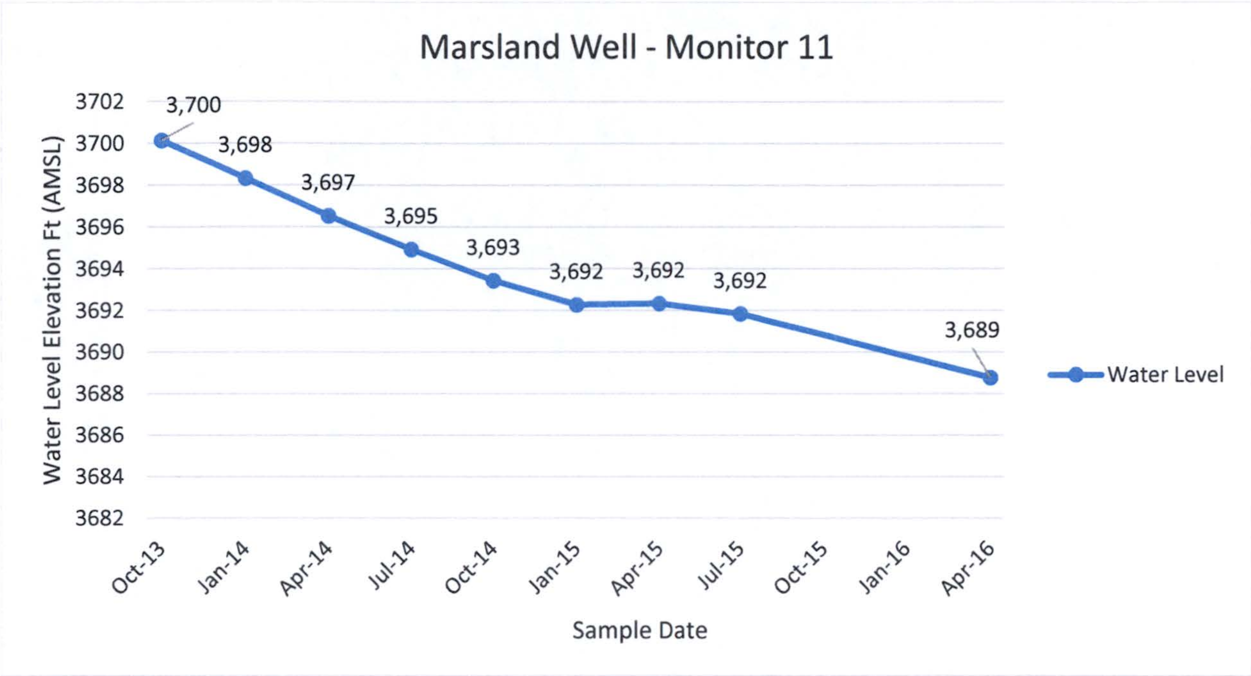


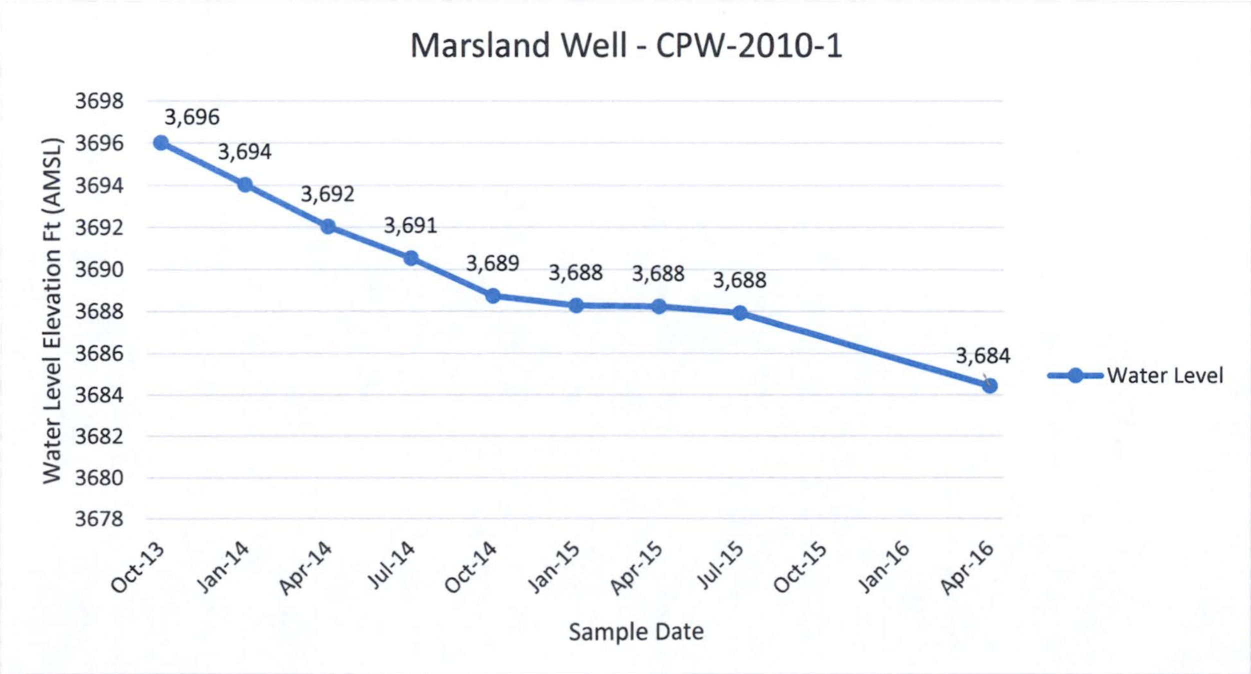
Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



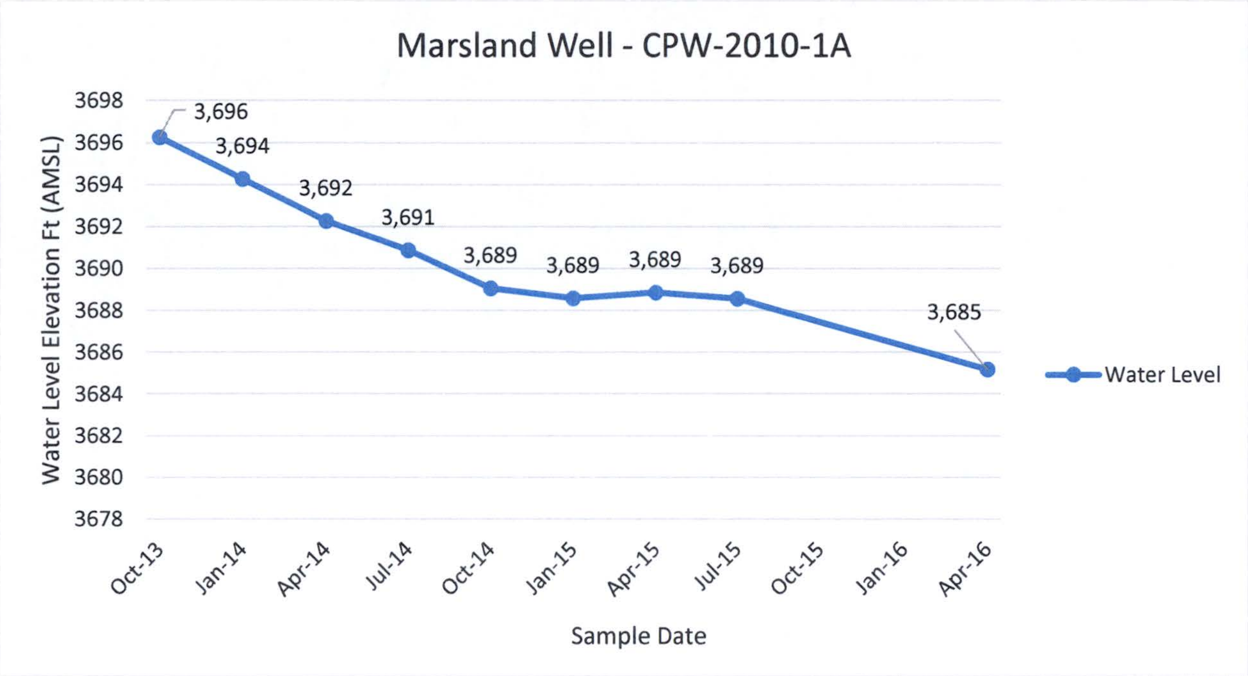


Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation





Marsland Expansion Area Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



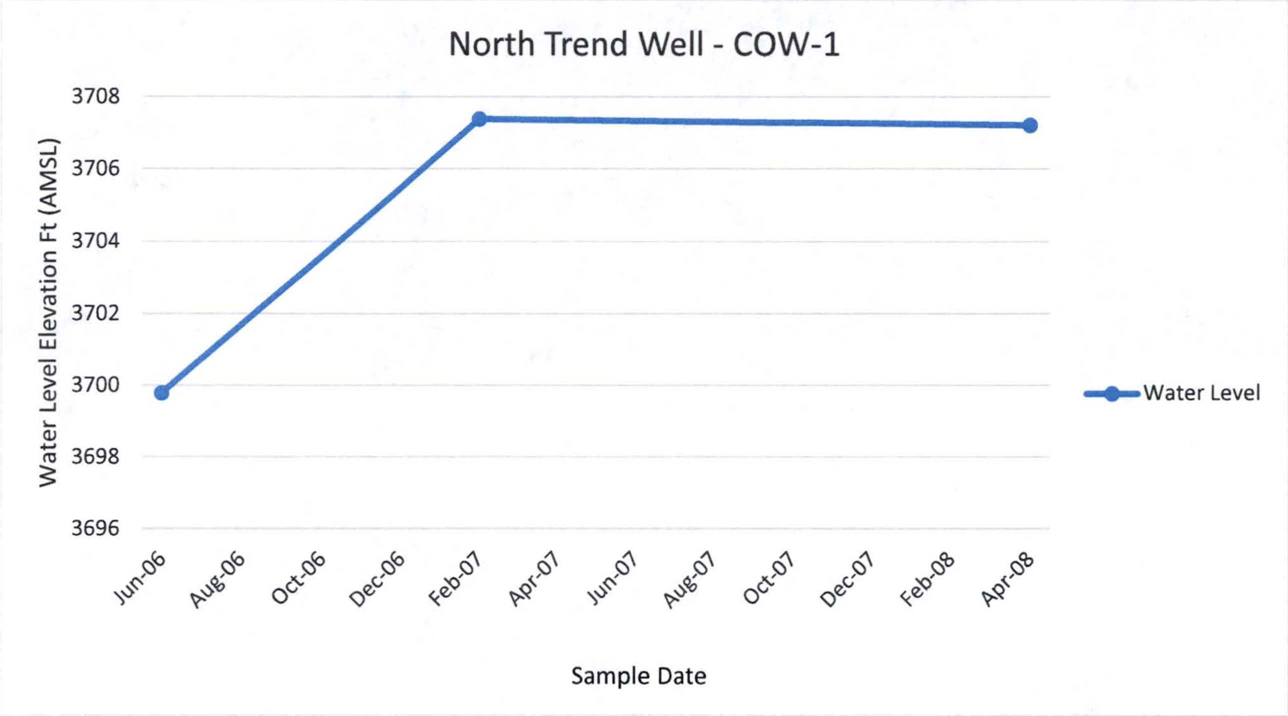
Response to Open Issues
Marsland Expansion Area
Technical Report

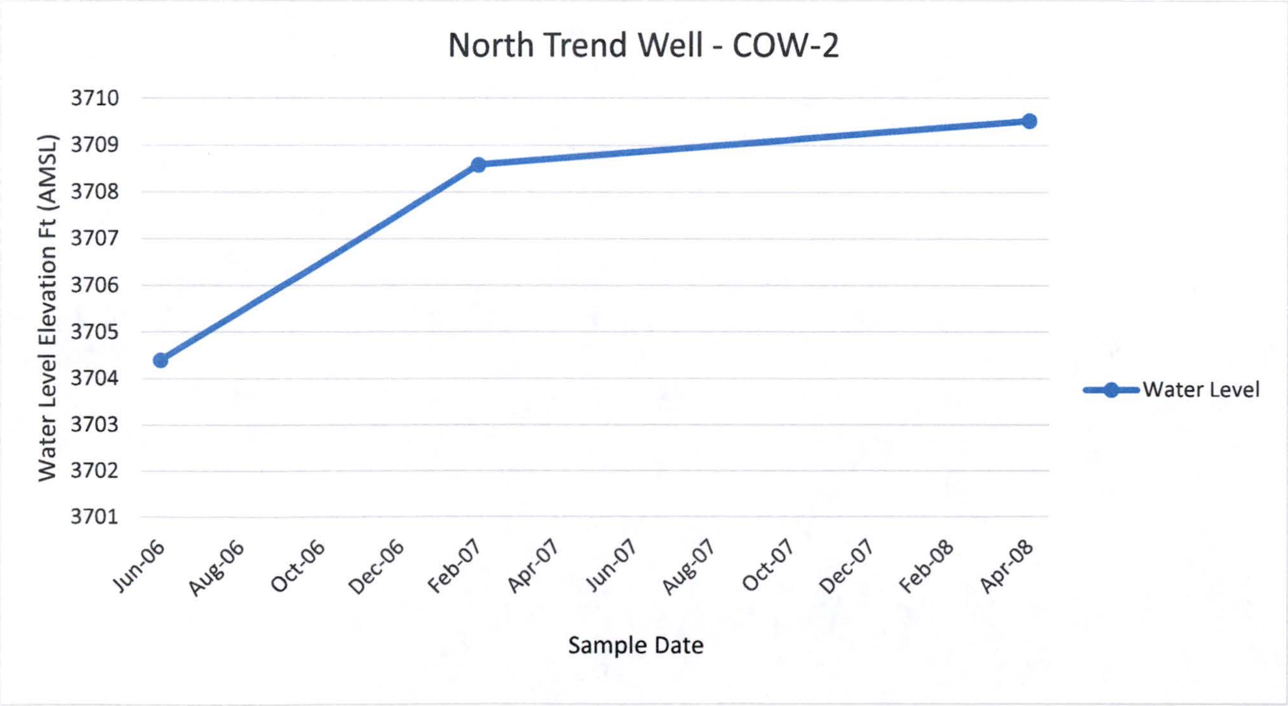
Attachment D2

Attachment D2 North Trend Expansion Area Hydrographs

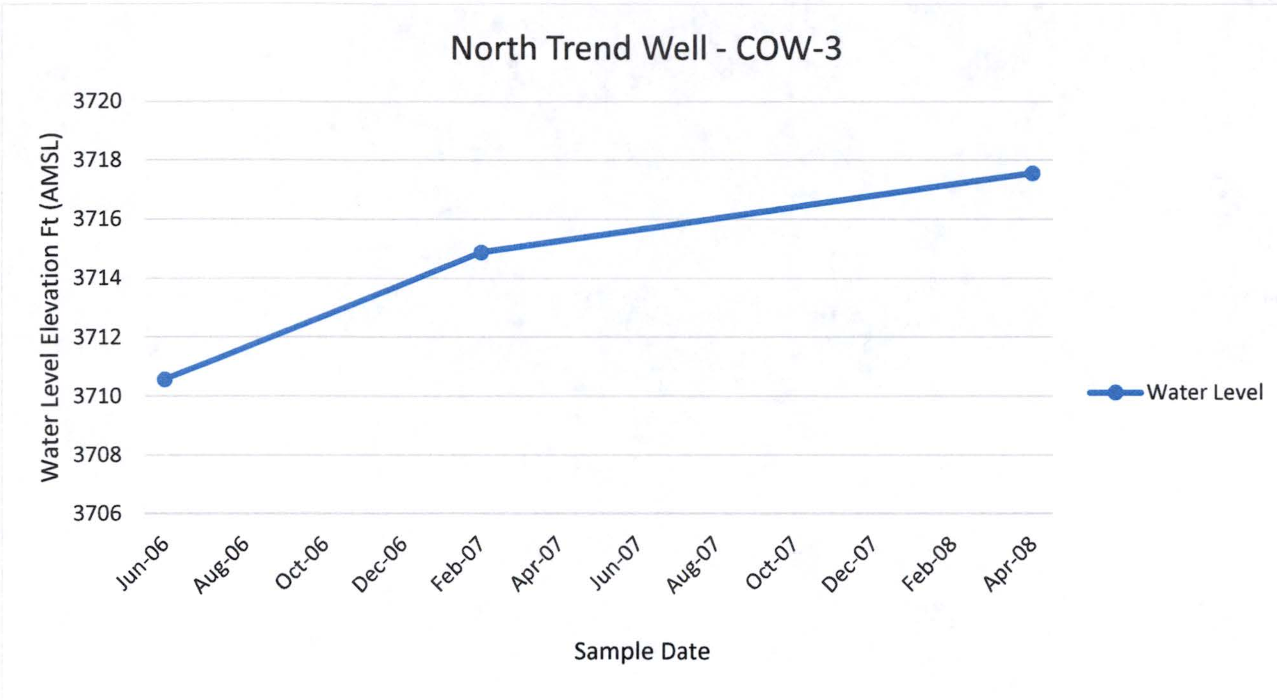
Attachment D2 Figure 1

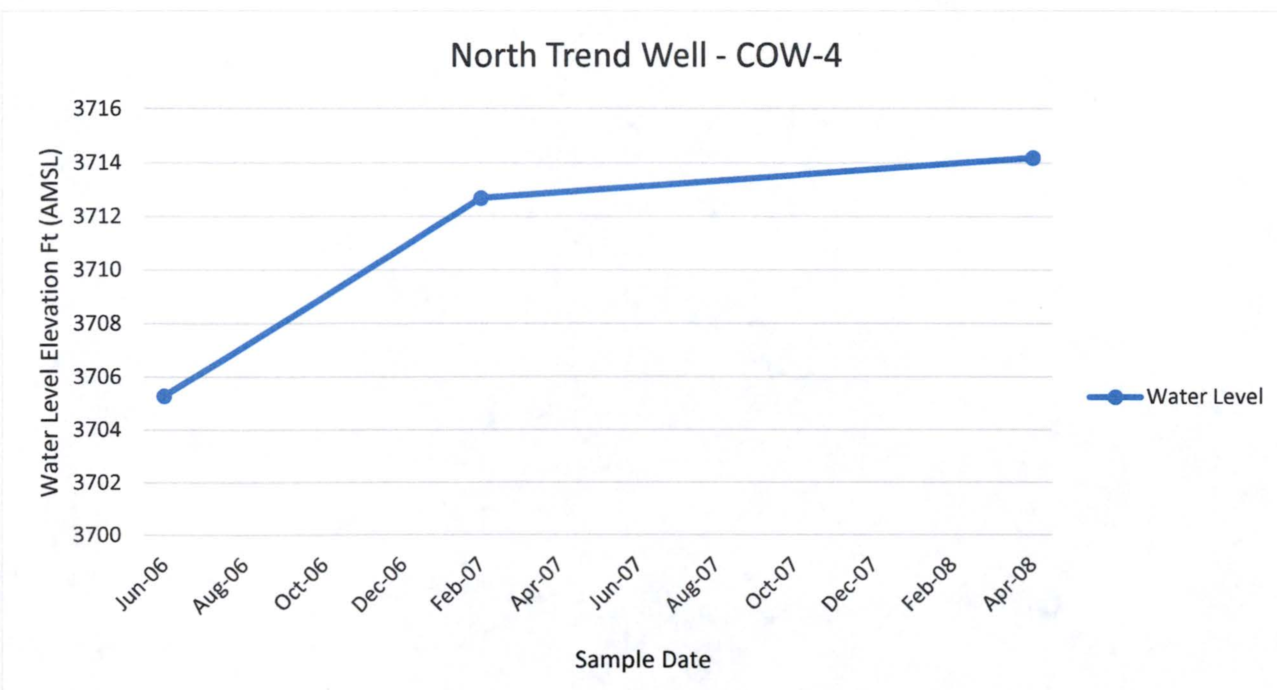
North Trend Expansion Area (NTEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



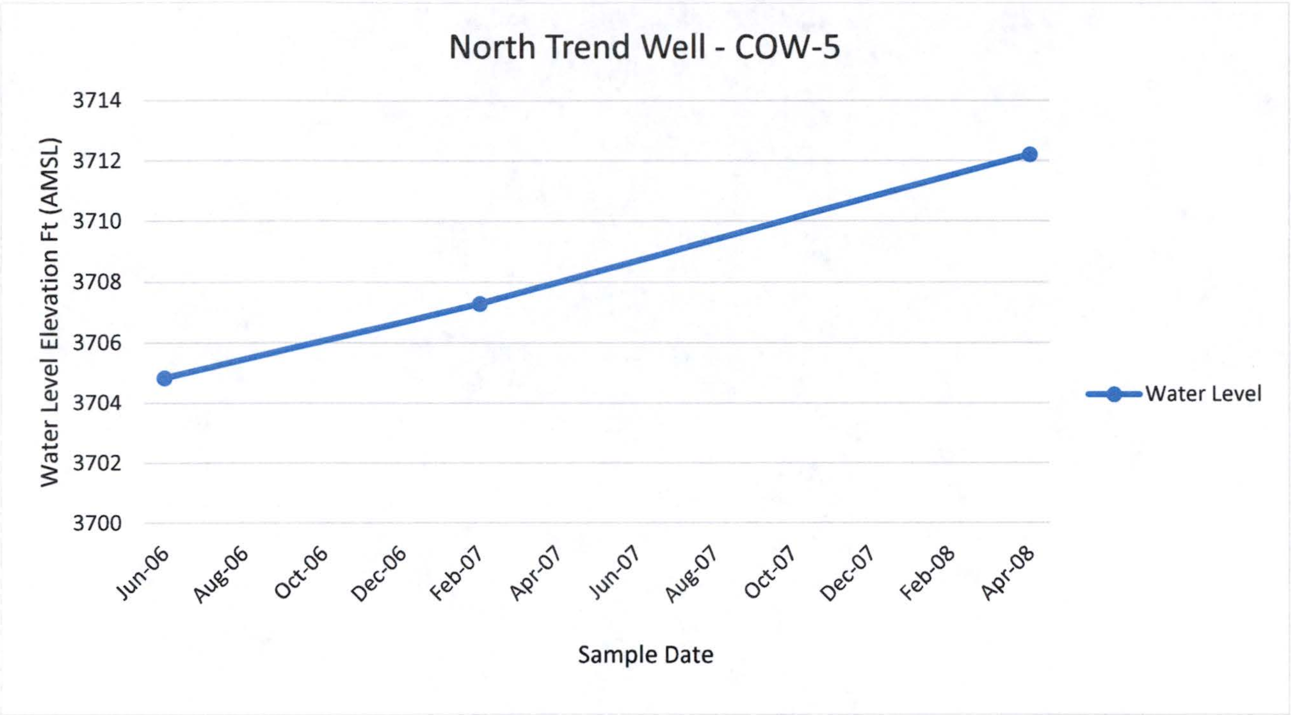


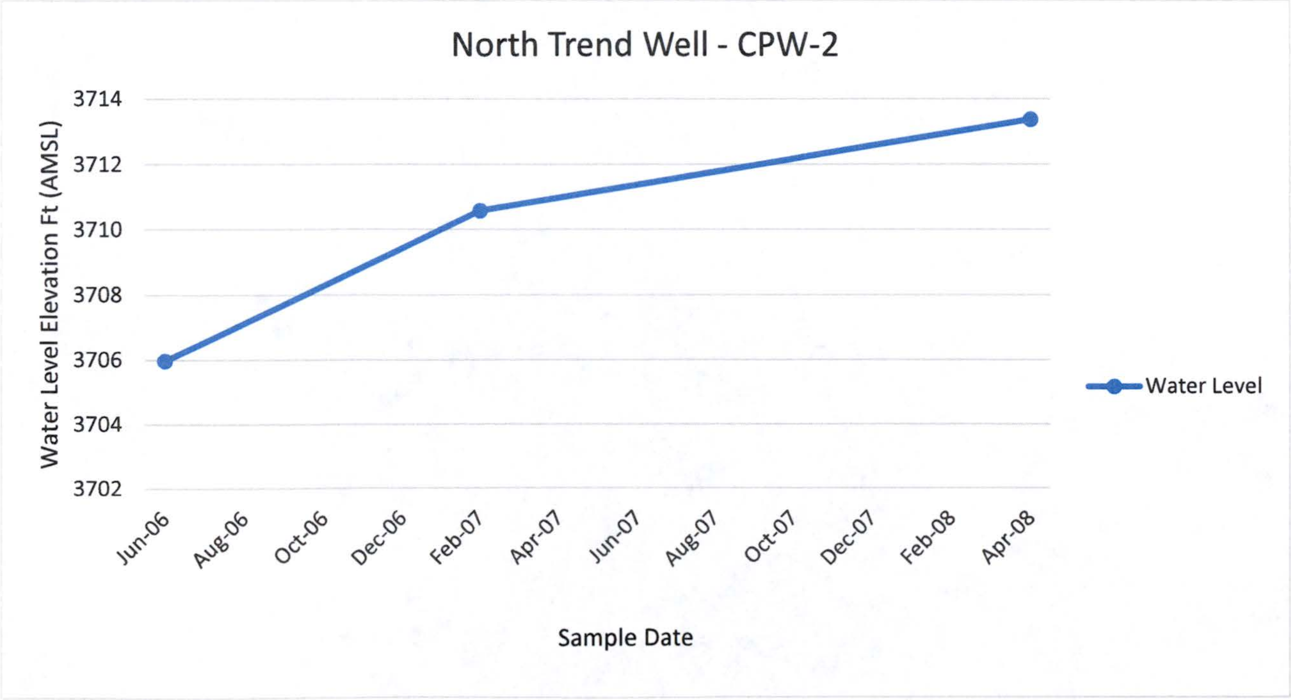
North Trend Expansion Area (NTEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



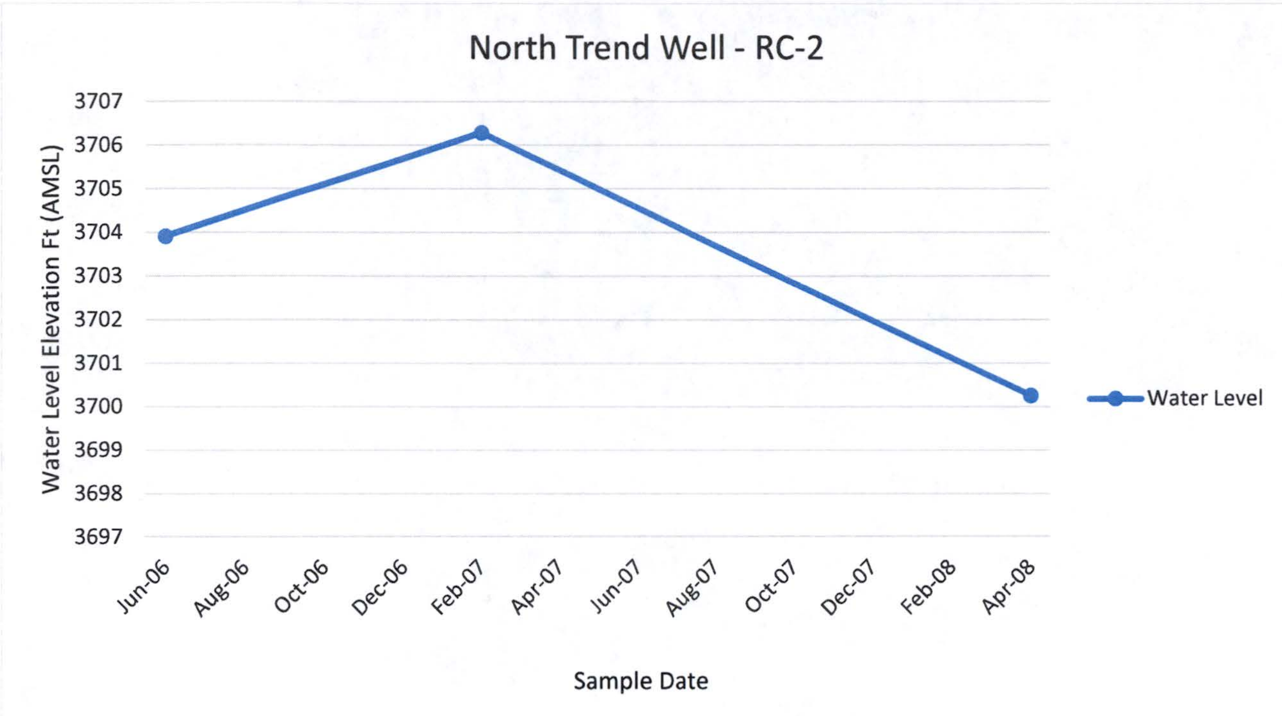


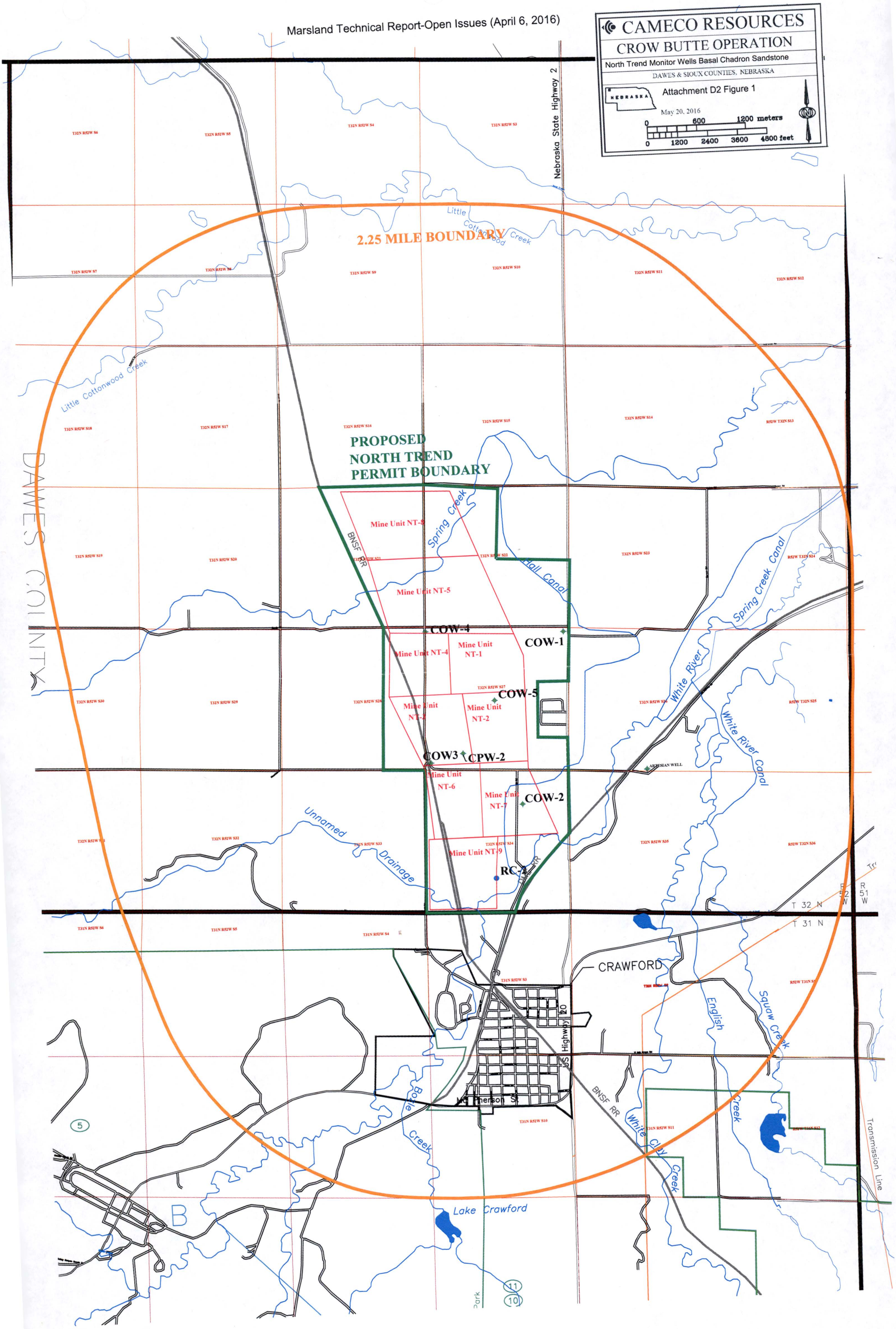
North Trend Expansion Area (NTEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation





North Trend Expansion Area (NTEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation




CAMECO RESOURCES
CROW BUTTE OPERATION
North Trend Monitor Wells Basal Chadron Sandstone
DAWES & SIOUX COUNTIES, NEBRASKA
NEBRASKA
Attachment D2 Figure 1
May 20, 2016
0 600 1200 meters
0 1200 2400 3600 4800 feet
Nebraska State Highway 2
Little Cottonwood Creek
2.25 MILE BOUNDARY
PROPOSED
NORTH TREND
PERMIT BOUNDARY
DAWES COUNTY
BNSF RR
Spring Creek
Mine Unit NT-8
Mine Unit NT-5
Mine Unit NT-4
Mine Unit NT-1
Mine Unit NT-2
Mine Unit NT-3
Mine Unit NT-6
Mine Unit NT-7
Mine Unit NT-9
COW-4
COW-1
COW-5
COW3
CPW-2
COW-2
RC-3
Hall Canal
Spring Creek Canal
White River
White River Canal
ARTESIAN WELL
Unnamed Drainage
T 32 N
T 31 N
R 52 W
R 51 W
CRAWFORD
US Highway 20
McPherson St
English Creek
Squaw Creek
Bozle Creek
White Clay Creek
Lake Crawford
Transmission Line
5
11
10

Response to Open Issues
Marsland Expansion Area
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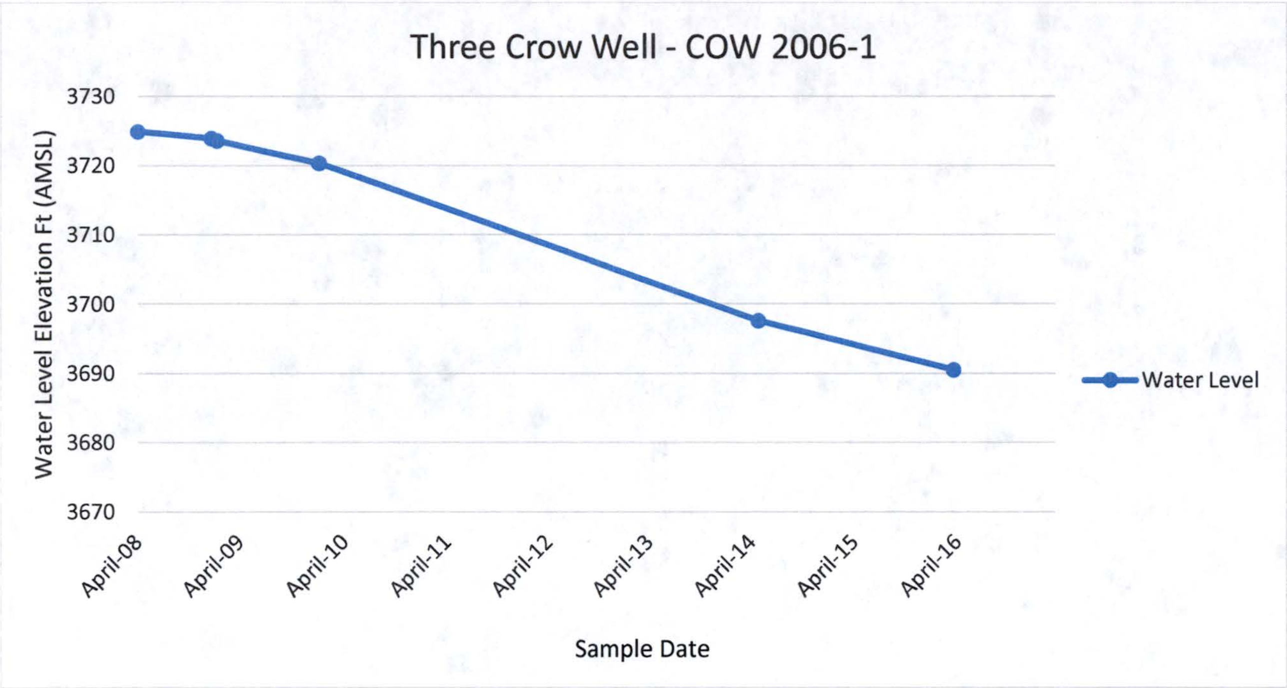
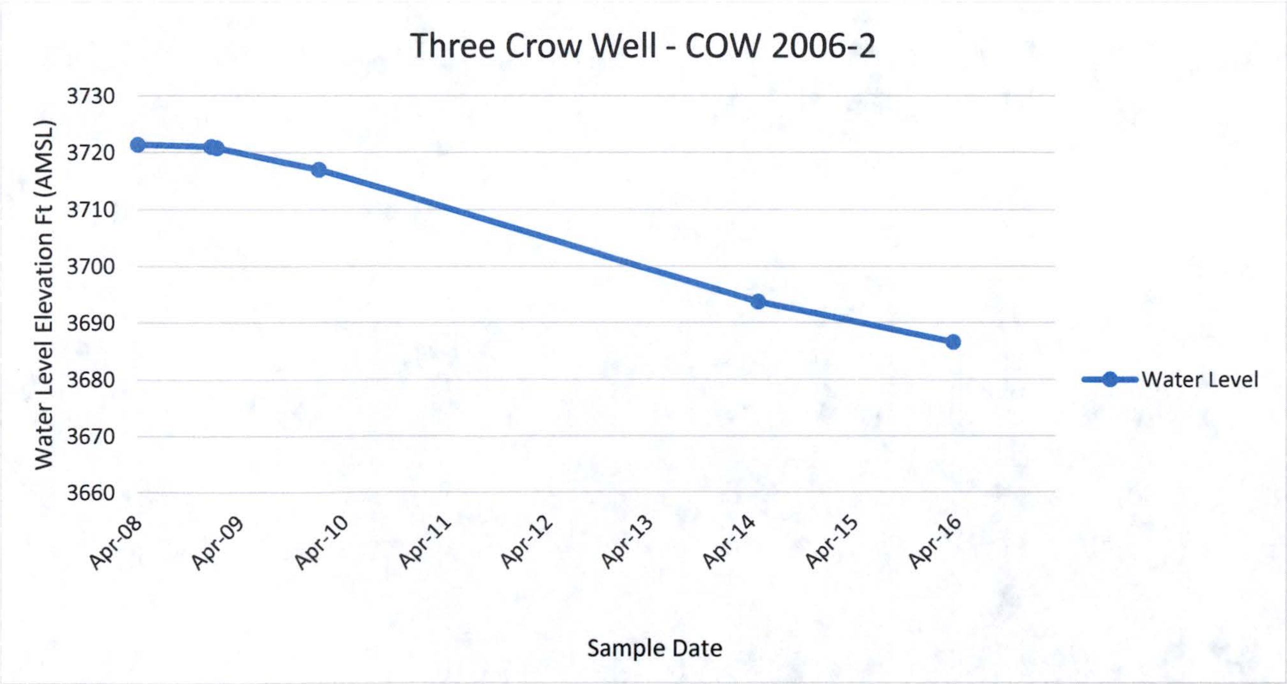
Attachment D3

Attachment D3 Three Crow Expansion Area Hydrographs

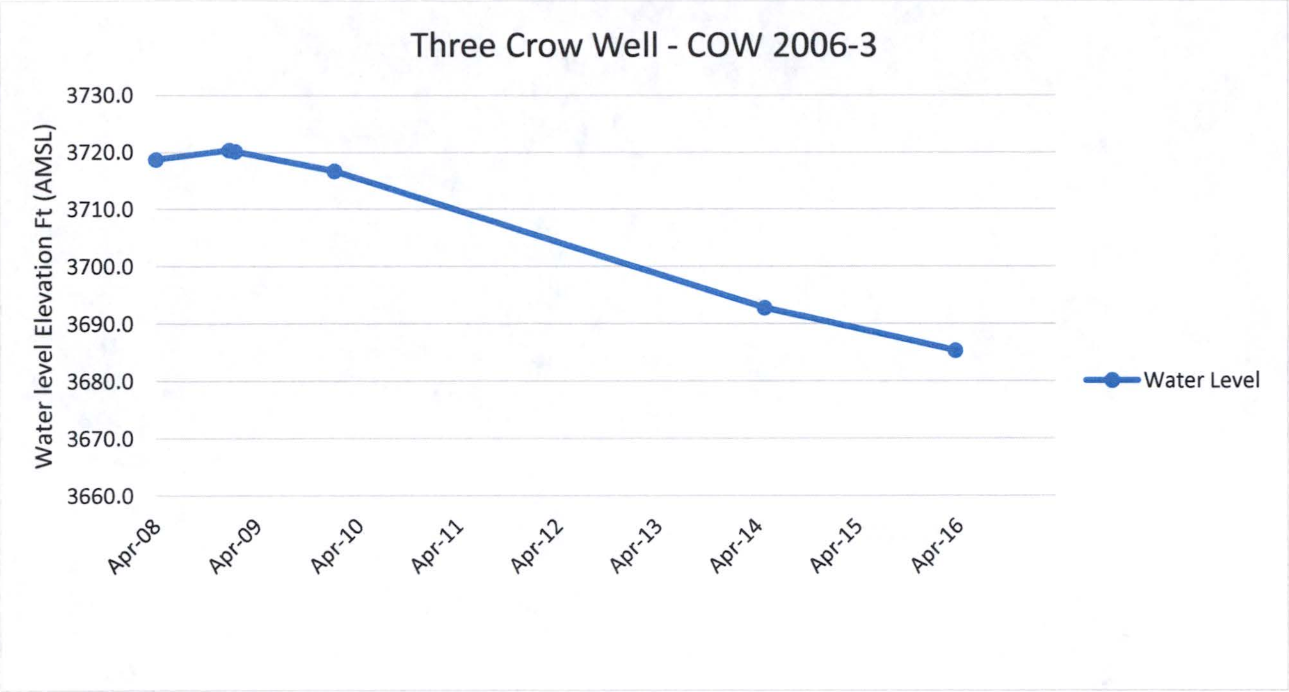
Attachment D3 Figure 1

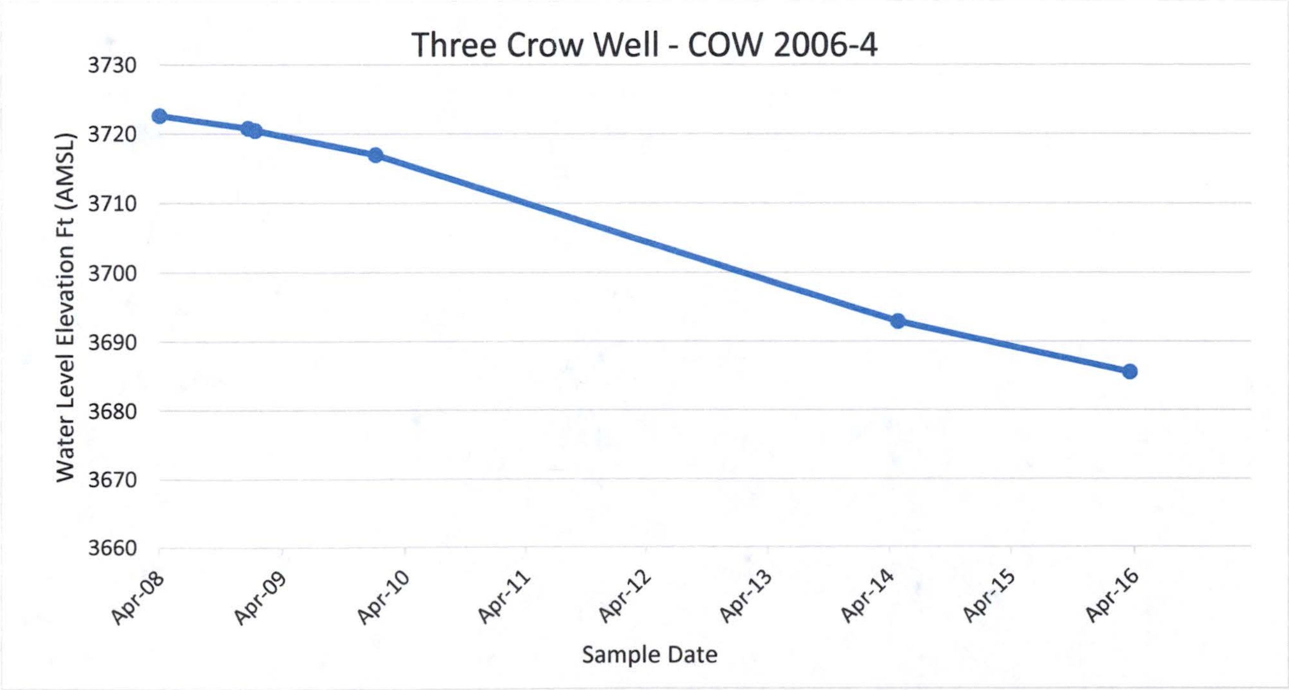
Three Crow Expansion Area (TCEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



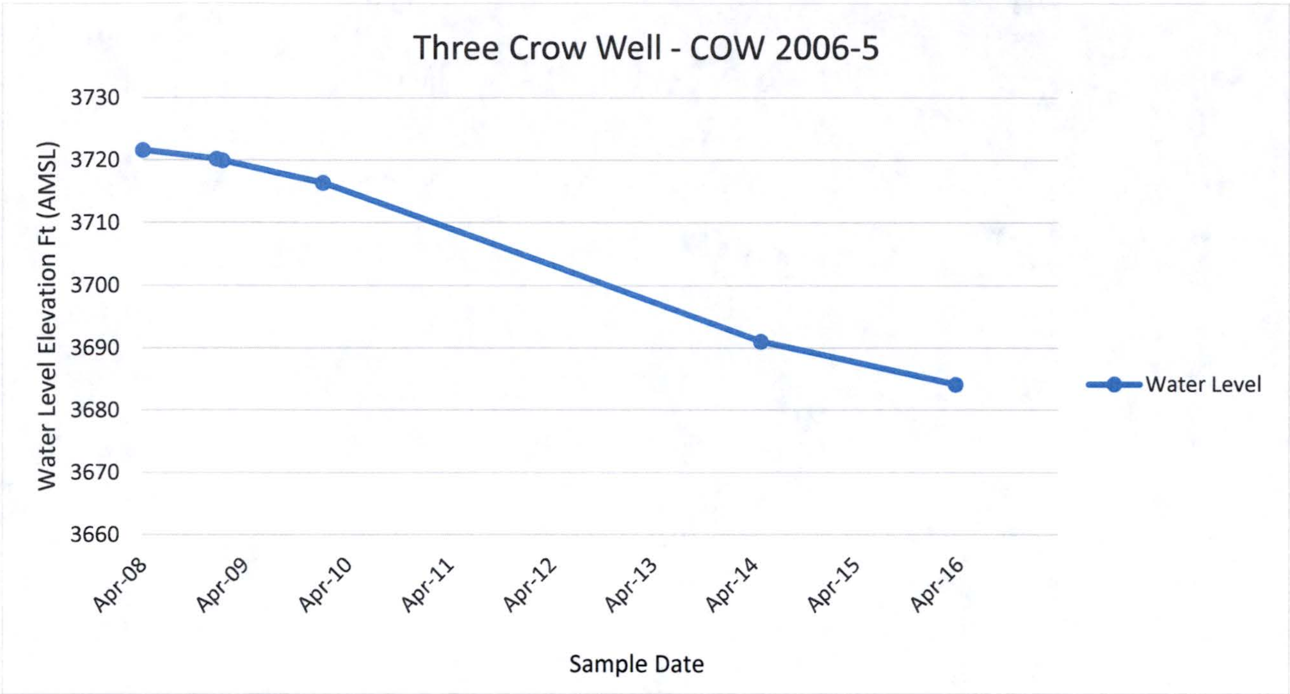


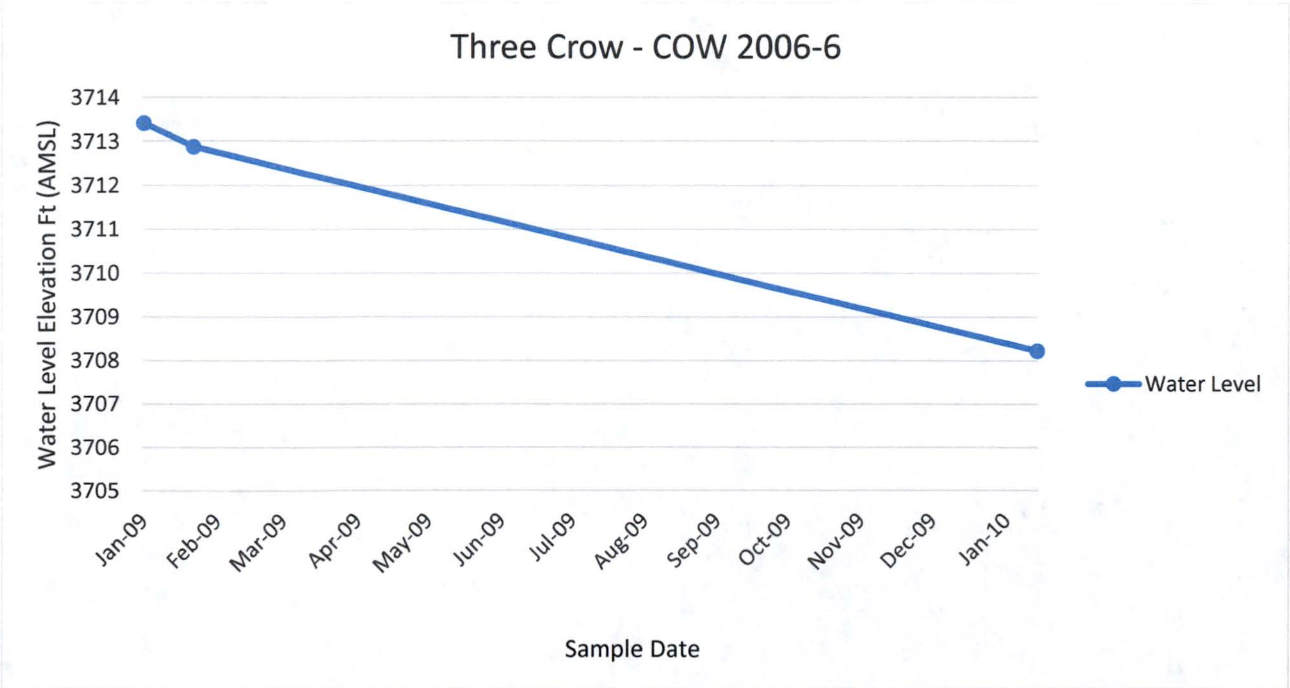
Three Crow Expansion Area (TCEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



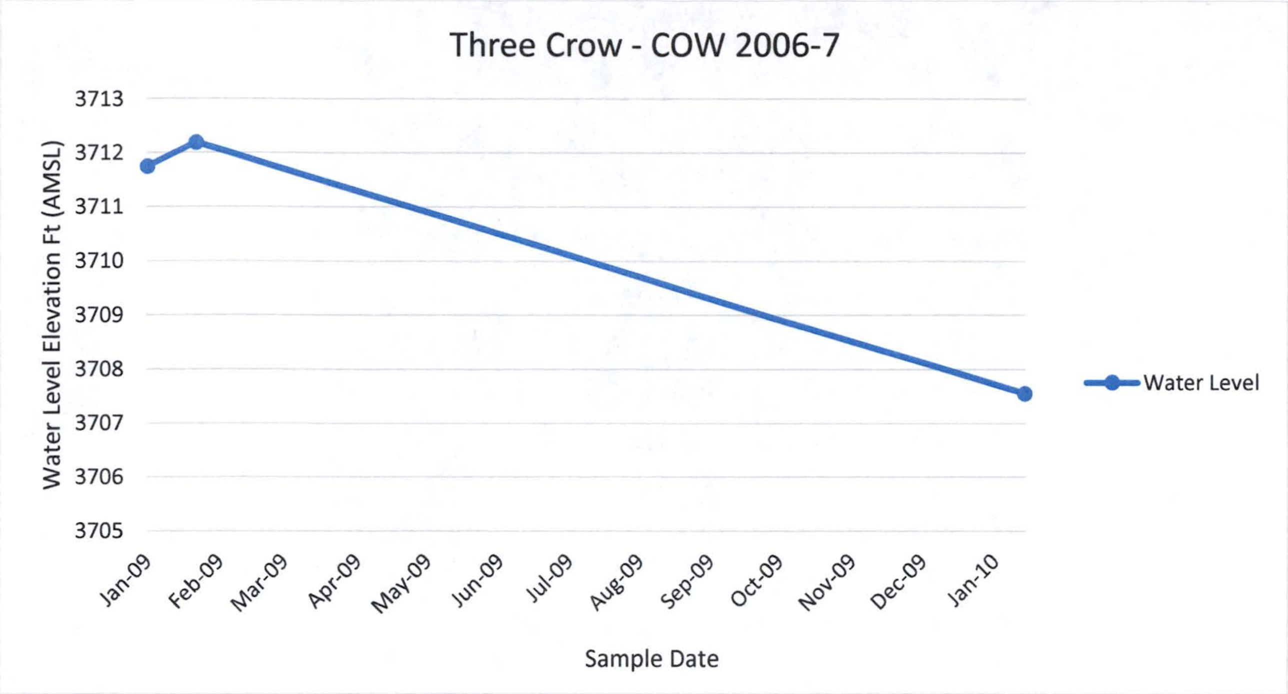


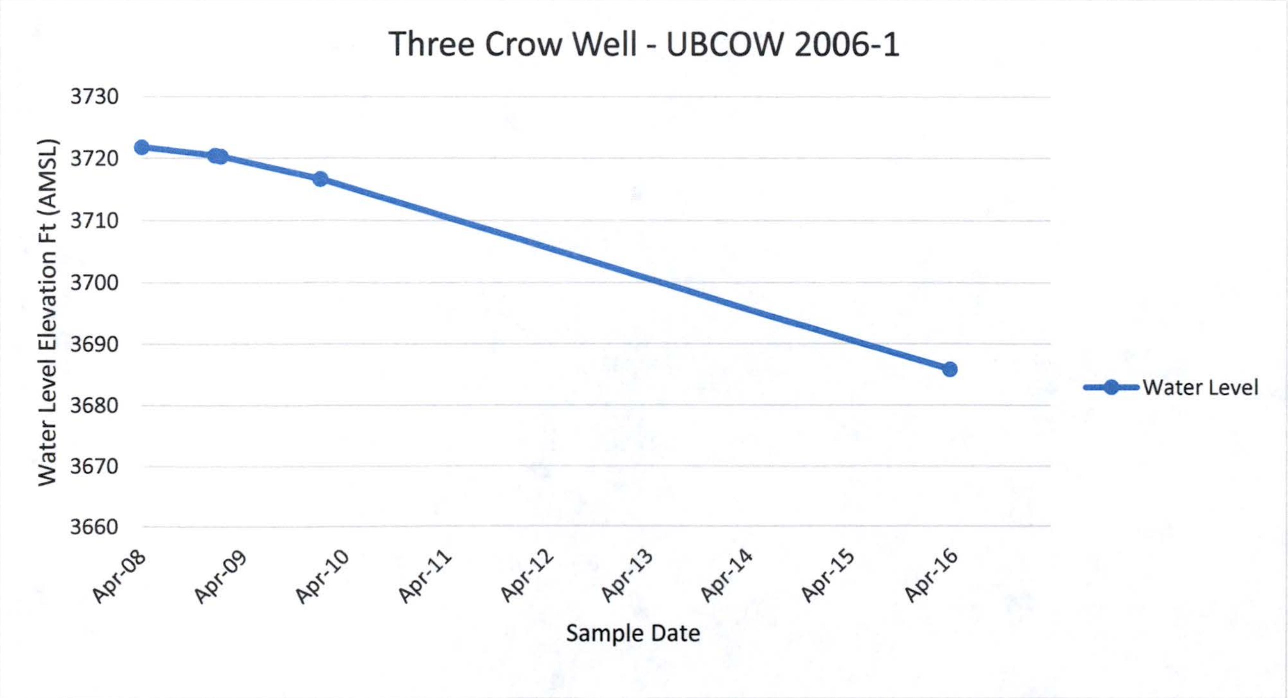
Three Crow Expansion Area (TCEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation



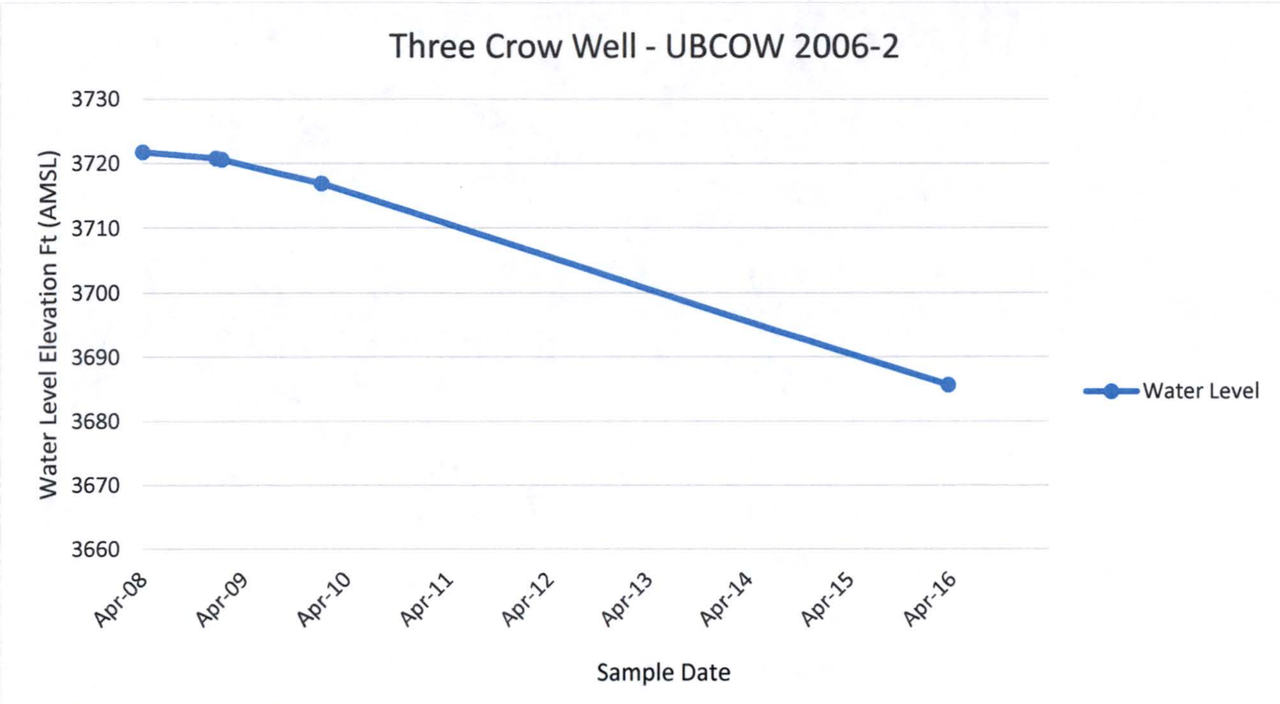


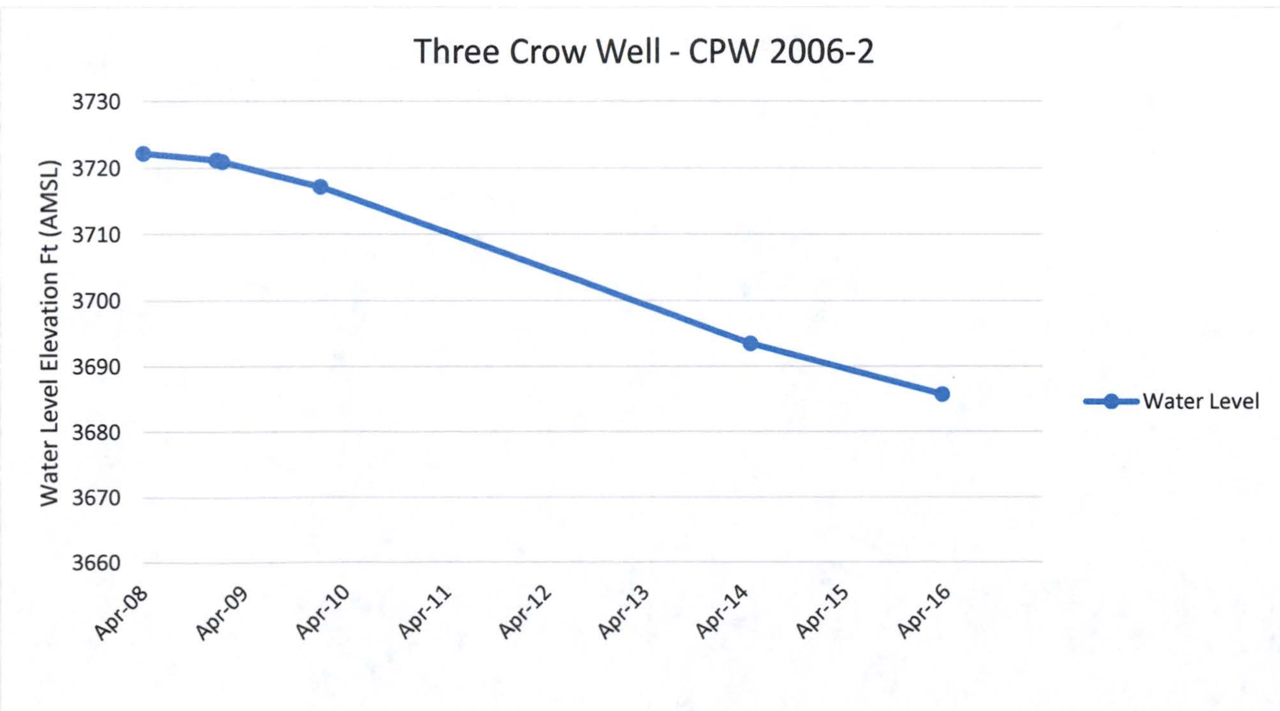
Three Crow Expansion Area (TCEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation

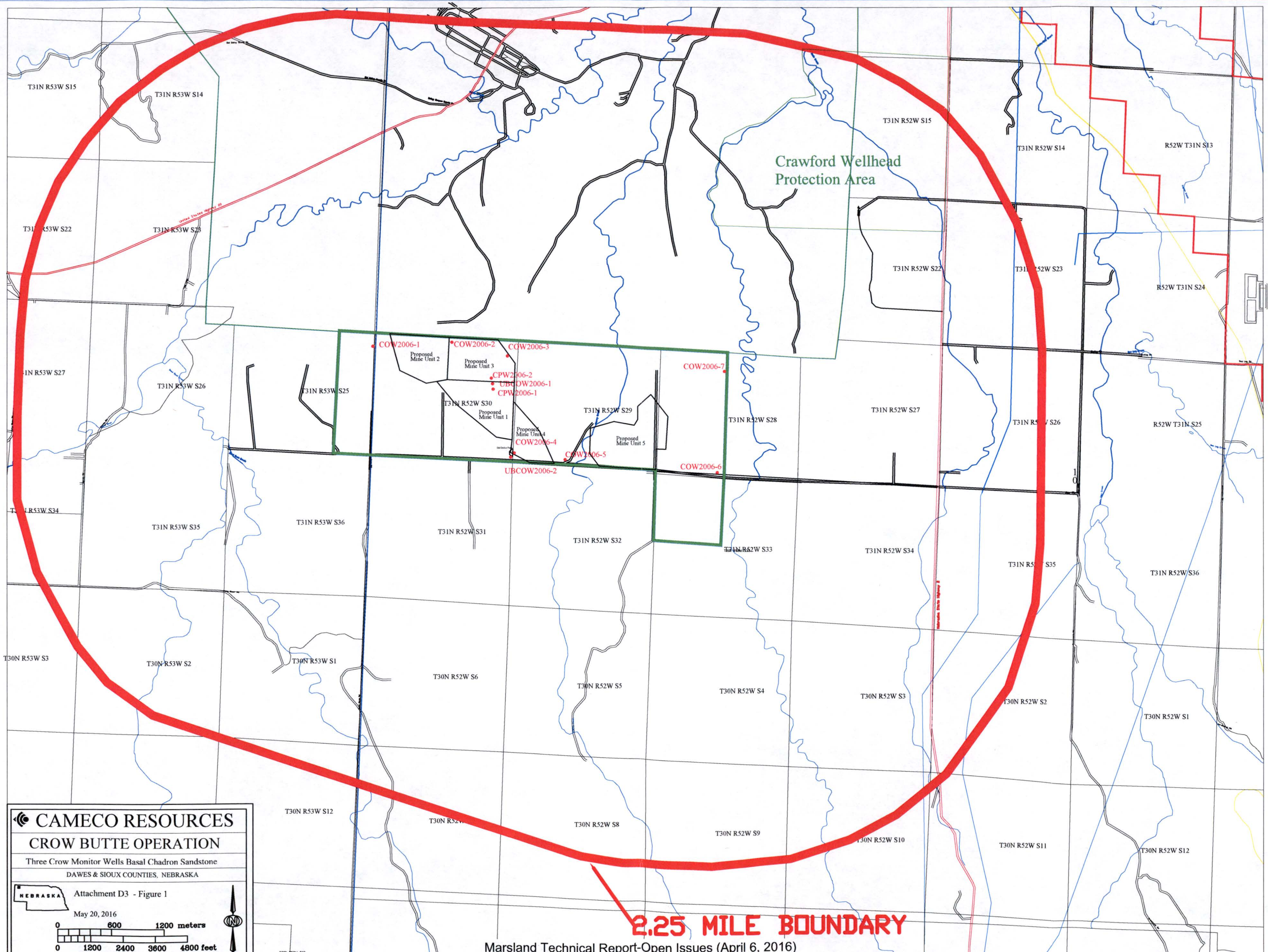




**Three Crow Expansion Area (TCEA) Monitor Well
Water Level Data
Basal Sandstone of the Chadron Formation**







Marsland Technical Report-Open Issues (April 6, 2016)

Response to Open Issues
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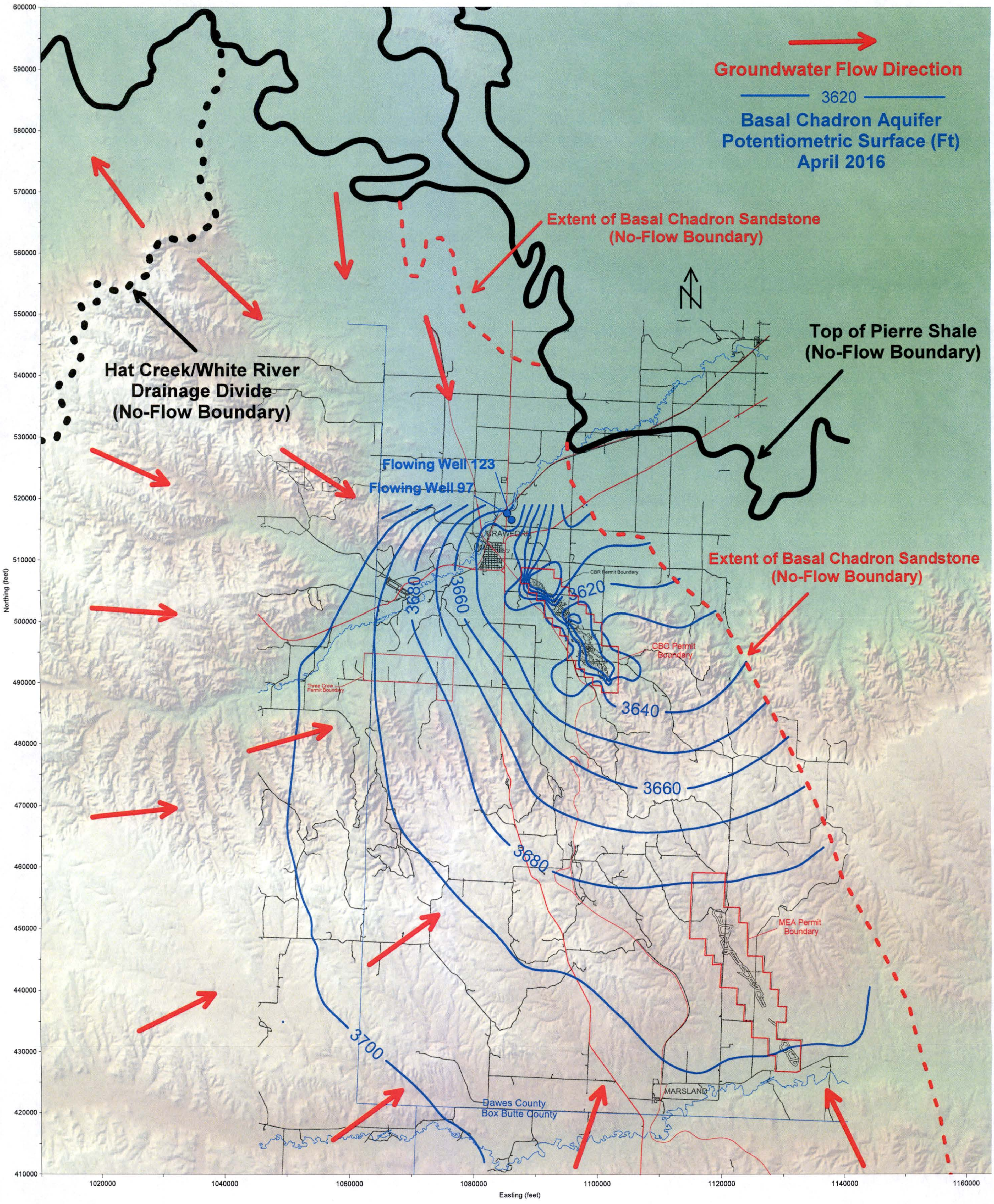
Attachment E

Conceptual Groundwater Flow Diagram
Regional Basal Chadron Sandstone

Conceptual Groundwater Flow Diagram
Basal Chadron Aquifer



May 20, 2016

Attachment E

Response to Open Issues
Marsland Expansion Area
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Attachment F

Crow Butte Water Balance 2011-2015

Crow Butte Water Balance 2011-2015

CROW BUTTE (CBO)	2011				2012				2013				2014				2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
MINE UNIT 1																				
IX Treatment/Reinjection																				
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 2																				
IX Treatment/Reinjection																				
RO Treatment	90	83	74	30	100	100	100	100	80	80										
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 3																				
IX Treatment/Reinjection																				
RO Treatment	224	220	190	130	130	165	165	165	60	60										
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 4																				
IX Treatment/Reinjection	40	221	230	250	250															
RO Treatment					36	89	81	163	122	147	223	195	261	387	456	227	400	400	400	400
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 5																				
IX Treatment/Reinjection	163	80																		
RO Treatment	0		40	40	93	41	34	79	88	76	214	208	274	300	303	321	250	250	250	250
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 6																				
IX Treatment/Reinjection	100	16	16	16	133	237	173	184	167	164	163	137	120	98	92	88	100	100	100	100
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 7	1397	1397	1397	1397	1209	1209	1209	1209	944	944	944	944	666	666	666	666	277	277	277	277
IX Treatment/Reinjection																				
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 8	743	743	743	743	671	671	671	671	771	771	771	771	887	887	887	887	773	773	773	773
IX Treatment/Reinjection																				
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 9	1671	1671	1671	1671	1452	1452	1452	1452	1368	1368	1368	1368	949	949	949	949	695	695	695	695
IX Treatment/Reinjection																				
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 10	2241	2241	2241	2241	2085	2085	2085	2085	2057	2057	2057	2057	2224	2224	2224	2224	1988	1988	1988	1988
IX Treatment/Reinjection																				
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
MINE UNIT 11	461	461	461	461	1084	1084	1084	1084	1803	1803	1803	1803	1858	1858	1858	1858	1827	1827	1827	1827
IX Treatment/Reinjection																				
RO Treatment																				
Recirculation																				
STABILIZATION SAMPLING																				
Prod Flow	6513	6513	6513	6513	6501	6501	6501	6501	6943	6943	6943	6943	6584	6584	6584	6584	5560	5560	5560	5560
Prod Bleed 1.2%	78	78	78	78	78	78	78	78	83	83	83	83	79	79	79	79	67	67	67	67
IX Bleed 2.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 1 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 2 RO Bleed (30%)	30	28	25	10	33	33	33	33	27	27	0	0	0	0	0	0	0	0	0	0
Mine Unit 3 RO Bleed (30%)	75	73	63	43	43	55	55	55	20	20	0	0	0	0	0	0	0	0	0	0
Mine Unit 4 RO Bleed (30%)	0	0	0	0	12	30	27	54	41	49	74	65	87	129	152	76	133	133	133	133
Mine Unit 5 RO Bleed (30%)	0	0	13	13	31	14	11	26	29	25	71	69	91	100	101	107	83	83	83	83
Mine Unit 6 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 7 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 8 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 9 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 10 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 11 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX Flow	303	317	246	266	383	237	173	184	167	164	163	137	120	98	92	88	100	100	100	100
RO Flow	314	303	304	200	359	395	380	507	350	363	437	403	535	687	759	548	650	650	650	650
Recirculation Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX & RO Bleed TO DDW	105	101	101	67	120	132	127	169	117	121	146	134	178	229	253	183	217	217	217	217
Total DW needed capacity	183	179	179	145	198	210	205	247	200	204	229	218	257	308	332	262	283	283	283	283

Response to Open Issues
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Attachment G

Replacement tables and figures for Volume II of the Marsland Expansion Area Technical Report

- **Table 2.2-11 – Active, Inactive, Seasonal, and Abandon Well Table**
- **Table 2.6-2 – Representative Stratigraphic Section – MEA**
- **Table 2.9-9 – Radiological Analytical Results for the Brule**
- **Figure 2.7-6 – Major Surface Features/Structures With AOR**
- **Figure 2.9-3 – Private Wells Located Within One and Two Kilometers of the MEA**

Replacement pages for Volume III of the Marsland Expansion Area Technical Report

- **Appendix A – Water User Survey**

Replacement pages for Volume IV of the Marsland Expansion Area Technical Report

- **Appendix T – Marsland Water Balance**
- **Appendix AA-2 – AquiferTek Revised MEA Agricultural Well Impact Analysis**
- **Appendix FF – MEA Quarterly Water Level Data**

New Appendix Volume IV of the Marsland Expansion Area Technical Report

- **Appendix GG – Drawdown Impact Assessment, MEA**

Table 2.2-11 **Active, Inactive, Seasonal and Abandoned Water Supply Wells in the Marsland Expansion Area and 2.25 mile AOR**

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
ACTIVE AND INACTIVE WELLS				
Wells Located Within License Boundary (10 active, 5 inactive, 1 seasonal)				
700	180-200	Brule	Livestock	Active
701	180-200	Brule	Livestock	Inactive [d]
705	Unknown	Arikaree [a]	Livestock	Active
720	240	Arikaree/Brule	Other [e]	Active
721	360	Arikaree/Brule	Other [e]	Active
722	160	Brule	Livestock	Active
727	180	Arikaree/Brule	Livestock	Active
728	260	Brule	Livestock	Active
730	Unknown	Unknown[a]	Domestic	Inactive [d]
731	180	Brule	Livestock	Inactive [d]
732	280	Brule	Agricultural	Seasonal [c]
733	Unknown	Unknown[a]	Livestock	Inactive [d]
744	80	Arikaree	Livestock	Active
747	225	Arikaree/Brule	Livestock	Active
787	130	Brule	Livestock	Inactive [d]
788	130-140	Arikaree	Livestock	Active
Wells Located Within 1 km Radius of License Boundary (18 active, 12 inactive, 3 s easonal)				
702	180-200	Brule	Livestock	Active
703	280	Brule	Domestic/Livestock	Active
704	Unknown	Unknown[a]	Livestock	Active
707	Unknown	Unknown[a]	Livestock	Active
719	160	Brule	Livestock	Active
723	220	Brule	Domestic/Livestock	Inactive [d]
724	Unknown	Unknown[a]	Domestic/Livestock	Inactive [d]
725	240	Brule	Livestock	Active
729	Unknown	Unknown[a]	Livestock	Inactive [d]
735	375	Brule[b]	Livestock	Inactive [d]
736	200	Brule[b]	Agricultural	Seasonal [c]
739	60	Arikaree	Livestock/Garden	Active
740	110	Brule	Agricultural	Seasonal [c]
741	190	Brule	Agricultural	Inactive [d]
743	140	Brule[b]	Livestock	Active
745	140[c]	Brule	Livestock	Active
746	Unknown	Unknown[a]	Livestock	Active
748	Unknown	Unknown[a]	Livestock	Active
749	Unknown	Unknown[a]	Livestock	Inactive [d]
750	Unknown	Unknown[a]	Livestock	Active
752	200-300	Brule	Domestic/Livestock	Active
753	200-300	Brule	Domestic/Livestock	Active
754	200-300	Brule	Livestock	Active
755	200-300	Brule	Livestock	Active

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
756	200-300	Brule	Livestock	Inactive [d]
759	200-300	Brule	Livestock	Inactive [d]
777	60	Arikaree	Domestic/Garden	Active
778	60	Arikaree	Livestock	Inactive [d]
802	180-200	Brule	Livestock	Active
834	300	Brule	Domestic/Livestock	Inactive [d]
843	300	Brule[b]	Livestock	Inactive [d]
869	Unknown	Unknown[a]	Livestock	Inactive [d]
Wells Located Between1 km and 2 km Radius(15 active, 5 inactive, 4 seasonal)				
706	Unknown	Unknown[a]	Livestock	Active
714	135	Brule[b]	Domestic/Livestock	Active
715	135	Arikaree	Agricultural	Seasonal [c]
716	135	Brule	Agricultural	Seasonal [c]
734	300	Brule[b]	Livestock	Active
737	340	Brule[b]	Livestock	Seasonal [c]
742	60	Arikaree	Livestock	Active
760	Unknown	Unknown[a]	Livestock	Seasonal [c]
790	Unknown	Unknown[a]	Livestock	Inactive [d]
794	300	Arikaree/Brule[b]	Domestic/Livestock	Active
795	350	Arikaree/Brule[b]	Domestic/Livestock	Active
796	350	Arikaree/Brule[b]	Domestic/Livestock	Inactive [d]
799	250	Brule	Livestock	Active
809	300	Brule	Livestock	Active
810	<300	Unknown[a]	Domestic/Livestock	Active
811	<300	Unknown[a]	Domestic/Livestock	Active
815	140	Brule	Domestic	Active
816	140	Brule	Livestock	Inactive [d]
817	160	Brule	Livestock	Inactive [d]
821	160	Brule[b]	Livestock	Active
835	300	Brule	Livestock	Inactive [d]
836	220	Brule	Livestock	Active
841	220	Brule[b]	Livestock	Active
845	Unknown	Unknown[a]	Domestic/Livestock	Active
Wells Located Between 2 km Radius and AOR Boundary (54 active, 9 inactive)				
708	200	Brule	Livestock	Active
709	Unknown	Unknown[a]	Livestock	Active
710	Unknown	Unknown[a]	Livestock	Active
711	Unknown	Unknown[a]	Livestock	Active
712	Unknown	Unknown[a]	Livestock	Active
713	Unknown	Unknown[a]	Livestock	Active
717	160	Arikaree/Brule	Livestock	Active
738	260	Arikaree/Brule[b]	Livestock	Active
751	Unknown	Unknown[a]	Livestock	Active
762	200-300	Arikaree/Brule[b]	Livestock	Active
763	200-300	Arikaree/Brule[b]	Livestock	Active
764	200-300	Arikaree/Brule[b]	Livestock	Active
765	200-300	Arikaree/Brule[b]	Livestock	Active

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
767	200-300	Arikaree/Brule[b]	Livestock	Active
768	200-300	Arikaree/Brule[b]	Domestic	Active
769	200-300	Arikaree/Brule[b]	Livestock	Active
771	200-300	Arikaree/Brule[b]	Livestock	Active
772	200-300	Arikaree/Brule[b]	Livestock	Active
773	200-300	Arikaree/Brule[b]	Livestock	Active
775	220	Arikaree/Brule[b]	Livestock	Active
776	200-300	Arikaree/Brule[b]	Livestock	Active
781	60	Arikaree/Brule	Livestock	Active
782	100	Brule[b]	Agricultural	Active
783	70	Arikaree/Brule[b]	Domestic	Active
784	40-60	Arikaree/Brule[b]	Livestock	Inactive [d]
785	140	Arikaree/Brule[b]	Livestock	Inactive [d]
786	140	Arikaree/Brule[b]	Livestock	Inactive [d]
791	Unknown	Unknown[a]	Livestock	Active
792	Unknown	Unknown[a]	Livestock	Active
793	300	Arikaree/Brule[b]	Livestock	Active
798	200	Brule	Livestock	Active
800	Unknown	Unknown[a]	Livestock	Active
801	220	Arikaree/Brule[b]	Domestic/Garden	Active
803	Unknown	Unknown[a]	Livestock	Active
804	260	Arikaree/Brule[b]	Domestic/Livestock	Active
805	Shallow	Unknown[a]	Livestock	Inactive [d]
806	Unknown	Unknown[a]	Livestock	Inactive [d]
808	160	Arikaree/Brule[b]	Domestic/Livestock	Active
812	260	Unknown[a]	Domestic/Livestock	Active
813	280	Unknown[a]	Livestock	Active
818	140	Arikaree/Brule[b]	Livestock	Active
819	140	Arikaree/Brule[b]	Livestock	Active
822	140	Brule[b]	Livestock	Active
823	100	Arikaree/Brule[b]	Livestock	Active
827	Unknown	Unknown[a]	Livestock	Active
828	160	Arikaree/Brule[b]	Domestic	Active
837	300	Brule[b]	Livestock	Active
838	300	Arikaree/Brule[b]	Livestock	Active
839	300	Arikaree/Brule[b]	Livestock	Active
840	300	Arikaree/Brule[b]	Livestock	Active
842	300	Arikaree/Brule[b]	Livestock	Active
846	Unknown	Unknown[a]	Livestock	Active
849	Unknown	Unknown[a]	Livestock	Active
850	200	Arikaree/Brule[b]	Agricultural	Active
851	140	Arikaree/Brule[b]	Agricultural	Active
852	140	Arikaree/Brule[b]	Agricultural	Inactive
853	150	Arikaree/Brule[b]	Agricultural	Active
856	Unknown	Unknown[a]	Agricultural	Inactive [d]
857	40-50	Arikaree/Brule[b]	Domestic/Agricultural	Inactive [d]
858	200	Arikaree/Brule[b]	Agricultural	Active

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
859	120	Arikaree/Brule[b]	Domestic	Inactive [d]
861	40	Arikaree/Brule[b]	Domestic/Livestock/ Agricultural	Active
862	155	Arikaree/Brule[b]	Domestic/Agricultural	Active
ABANDONED WELLS				
726A	300	Brule	Unknown	Abandoned[f]
863A	1110	Basal Chadron	Monitor	Abandoned[g]
864A	1045	Basal Chadron	Monitor	Abandoned[g]
865A	1010	Basal Chadron	Monitor	Abandoned[g]
866A	935	Basal Chadron	Monitor	Abandoned[g]
867A	60	Arikaree	Domestic	Abandoned[f]
868A	Unknown	Unknown[a]	Unknown	Abandoned[f]

[a] Discussions with land owners regarding known estimated completion depths of private water wells in the area suggest that these wells are completed within the Arikaree formation or the Brule Formation or a combination of both.

b Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.

[c] Wells are not active year-round. Wells are used seasonally and sampled when active, resulting in irregular sampling events.

[d] Well is inoperable, resulting in partial sampling events.

[e] CBR driller water supply.

[f] Abandonment record unavailable from Nebraska Department of Natural Resources.

[g] Records available in Appendix D-2.

Table 2.6-2 Representative Stratigraphic Section – Marsland Expansion Area

Elevation (ft amsl)	Average Depth (ft bgs)	Group	Formation & Member (Schultz and Stout 1955)			Formation and Member (Revised)		References (Revised)	Formation & Member (USGS)	
Varying 4,080 -4,380	15 - 135	Arikaree Group	Monroe Creek Formation			Upper Harrison Beds		Swinehart et al. (1985)	Arikaree Group	Harrison Sandstone
						Harrison-Monroe Creek Formation				Monroe Creek Sandstone
			Gering Formation			Gering Formation				Gering Formation
Varying 4,080 -3,620	135 - 460	White River Group	Brule Formation	Whitney Member		Brule Formation	Brown Siltstone Member	LaGarry (1998)	Brule Formation	Whitney Member
							Whitney Member			
				Orella Member	Orella D		Orella Member			Orella Member
					Orella C					
					Orella B					
					Orella A		Big Cottonwood Creek Member	Terry (1998) Terry and LaGarry (1998)		
3,620 – 3,480	460 – 600		Chadron Formation	Upper Chadron	Chadron C	Chadron Formation			Chadron Formation	
				Upper/Middle Chadron	Chadron B					
3,480 – 3,230	600 -850			Middle Chadron			Peanut Peak Member	Terry (1998) Terry and LaGarry (1998)		
3,230 -3,180	850 – 1,200			Upper Interior Paleosol	Chadron A	Chamberlain Pass Formation	Upper Interior Paleosol	Terry (1998)		
				basal sandstone of the Chadron Formation			Channel Sandstone	Terry (1998) Terry and LaGarry (1998)		
3,180 – 3,130	1,200 - ? (Bottom not seen in logs)	Montana Group	Pierre Shale	Interior Paleosol		Pierre Shale	Yellow Mounds Paleosol	Retallack (1983) Terry (1998)	Pierre Shale	
				Pierre Shale			Pierre Shale	Terry (1998) Terry and LaGarry (1998)		

Notes:

1) The Shultz and Stout conventions for Formation & Member are utilized throughout this document for consistency with historical permitting, with the exception of the Red Clay Horizon, which is referred to as the Upper Interior Paleosol.
2) Topsoil, colluvial and alluvial deposits are not shown, but are Quaternary in age and range in thickness from 0 to 30 ft-bgs.
3) The terms "Arikaree Group", "Arikaree Formation", and "Arikaree Sandstone" are accepted usages by USGS in Nebraska.
4) The terms "Gering Formation" and "Gering Sandstone" are both accepted usages by USGS in Nebraska.
5) Subdivisions of the Chadron Formation are not formally recognized by USGS in Nebraska.
6) ft amsl = feet above mean sea level; ft bgs = feet below ground surface.
7) Elevations are representative averages for MEA only, and based on Log M-1252.

Table 2.9-9 Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

Location ID:		BOW 2010-1		BOW 2010-1		BOW 2010-1		BOW 2010-1		BOW 2010-2		BOW 2010-2		BOW 2010-2		BOW 2010-2		BOW 2010-3	
Date Collected:		12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES-DISSOLVED																			
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	1.8E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		7E-10		NA		NA		4E-10		3E-10		NA		NA	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09
Polonium 210 precision (±)	µCi/mL	NA		1E-10		2E-10		NA		NA		2E-10		1E-10		NA		NA	
Radium 226	µCi/mL	5E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	1E-10		1E-10		1E-10		NA		NA		1E-10		1E-10		1E-10		NA	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		2E-11		1E-10		NA		NA		1E-10		1E-10		NA		NA	
Thorium 229 Tracer (30-120)	%	120		80		79		80		100		94		87		74		110	
METALS - DISSOLVED																			
Uranium	mg/L	0.0004	0.0003	0.0004	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0016	0.0003	0.0014	0.0003	0.0018	0.0003	0.0017	0.0003	0.0023	0.0003
Uranium Activity	uCi/mL	3E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	1.1E-9	2E-10	9E-10	2E-10	1.2E-9	2E-10	1.2E-9	2E-10	1.6E-9	2E-10
RADIONUCLIDES-SUSPENDED																			
Lead 210	µCi/mL	<1E-9	1E-9	1.1E-9	1E-9	1.3E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		4E-10		NA		NA		5E-10		4E-10		NA		NA	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09
Polonium 210 precision (±)	µCi/mL	NA		2E-10		2E-10		NA		NA		2E-10		1E-10		NA		NA	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		4E-11		0.0		NA		NA		1E-10		0.0		NA		NA	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	4E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		4E-11		4E-11		NA		NA		4E-11		2E-11	NA	2E-10		NA	
Thorium 229 Tracer (30-120)	%	81		92		78		73		90		96		95	74	74		90	
METALS - SUSPENDED																			
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:

uCi/mL = microcuries per milliliter

mg/L = milligrams per Liter

RL - Analyte reporting limit.

Table 2.9-9 Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

Location ID:		BOW 2010-3		BOW 2010-3		BOW 2010-3		BOW 2010-4A		BOW 2010-4A		BOW 2010-4A		BOW 2010-4A		BOW 2010-5		BOW 2010-5	
Date Collected:		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/25/2014		6/16/2014		9/17/2014		12/16/2013		2/26/2014	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES-DISSOLVED																			
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		NA		NA		4E-10		3E-10		5E-10		NA		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-10	1E-10	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	2E-10		2E-10		NA		NA		2E-10		2E-10		2E-10		NA		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	1E-9	2E-10	8E-10	2E-10	5E-10	2E-10	5E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	4E-11		3E-11		NA		1E-10		1E-10		1E-10		2E-10		NA		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	3E-11		1E-10		NA		NA		5E-11		2E-11		1E-10		NA		3E-11	
Thorium 229 Tracer (30-120)	%	97		81		89		120		98		79		79		90		77	
METALS - DISSOLVED																			
Uranium	mg/L	0.0024	0.0003	0.0032	0.0003	0.0035	0.0003	0.0008	0.0003	0.0014	0.0003	0.0017	0.0003	0.0016	0.0003	0.0067	0.0003	0.0076	0.0003
Uranium Activity	uCi/mL	1.6E-9	2E-10	2.2E-9	2E-01	2.4E-9	2E-10	5E-9	2E-10	9E-9	2E-10	1.2E-9	2E-10	1.1E-9	1E-10	4.5E-9	2E-10	5.2-9	2E-01
RADIONUCLIDES-SUSPENDED																			
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	5E-10		4E-10		NA		NA		5E-10		4E-10		5E-10		NA		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	2E-10		2E-10		NA		NA		2E-10		2E-10		2E-10		NA		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	9E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	2E-11		0.0		NA		1E-10		0.0		0.0		1E-10		NA		2E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	3E-11		2E-11		NA		NA		1E-10		4E-11		5E-11		NA		3E-11	
Thorium 229 Tracer (30-120)	%	100		95		77		80		74		94		41		82		89	
METALS - SUSPENDED																			
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:

uCi/mL = microcuries per milliliter

mg/L = milligrams per Liter

RL - Analyte reporting limit.

Table 2.9-9 Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

Location ID:		BOW 2010-5		BOW 2010-5		BOW 2010-6		BOW 2010-6		BOW 2010-6		BOW 2010-6		BOW 2010-7		BOW 2010-7		BOW 2010-7	
Date Collected:		6/17/2014		9/17/2014		12/16/2013		2/26/2014		6/19/2014		9/17/2014		12/16/2013		2/25/2014		6/16/2014	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES-DISSOLVED																			
Lead 210	μCi/mL	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	1.2E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	μCi/mL	4E-10		5E-10		NA		4E-10		NA		5E-10		NA		4E-10		4E-10	
Polonium 210	μCi/mL	<1E-9	1E-9	4E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	μCi/mL	1E-10		9E-10		NA		2E-10		NA		1E-10		NA		2E-10		3E-10	
Radium 226	μCi/mL	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	8E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	5E-10	2E-10	4E-10	2E-10	4E-10	2E-10
Radium 226 precision (±)	μCi/mL	0.0		4E-11		1E-10		1E-10		0.0		5E-11		0.1		1E-10		1E-10	
Thorium 230	μCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	μCi/mL	0.0		2E-11		NA		2E-11		NA		0.0		NA		1E-10		2E-11	
Thorium 229 Tracer (30-120)	%	85		95		85		99		90		84		77		85		88	
METALS - DISSOLVED																			
Uranium	mg/L	0.0070	0.0003	0.0070	0.0003	0.0049	0.0003	0.0056	0.0003	0.0047	0.0003	0.0052	0.0003	0.0035	0.0003	0.0041	0.0003	0.0048	0.0003
Uranium Activity	uCi/mL	4.7E-9	2E-10	4.7E-9	2E-10	3.3E-9	2E-10	3.8E-9	2E-10	3.2E-9	2E-10	3.5E-9	2E-10	2.4E-9	2E-10	2.8E-9	2E-10	3.3E-9	2E-10
RADIONUCLIDES-SUSPENDED																			
Lead 210	μCi/mL	1.5E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	μCi/mL	6E-10		5E-10		NA		4E-10		4E-10		4E-10		NA		5E-10		4E-10	
Polonium 210	μCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	μCi/mL	1E-10		2E-10		NA		3E-10		NA		2E-10		NA		2E-10		2E-10	
Radium 226	μCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	μCi/mL	0.0		3E-11		NA		3E-11		NA		3E-11		1E-10		4E-11		0.0	
Thorium 230	μCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	μCi/mL	0.0		1E-10		NA		4E-11		NA		1E-10		NA		2E-11		2E-11	
Thorium 229 Tracer (30-120)	%	83		61		81		100		91		76		87		89		86	
METALS - SUSPENDED																			
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	μCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:

uCi/mL = microcuries per milliliter

mg/L = milligrams per Liter

RL - Analyte reporting limit.

Table 2.9-9 Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

Location ID:		BOW 2010-7		BOW 2010-8		BOW 2010-8		BOW 2010-8		BOW 2010-8		BOW 9		BOW 9		BOW 9		BOW 9	
Date Collected:		9/16/2014		12/10/2013		2/26/2014		6/16/2014		9/16/2014		11/8/2013		2/26/2014		6/16/2014		9/17/2014	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES-DISSOLVED																			
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		NA		4E-10		3E-10		NA		NA		4E-10		3E-10		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		NA		2E-10		2E-10		NA		NA		2E-10		2E-10		2E-10	
Radium 226	µCi/mL	4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	1E-10		NA		3E-11		3E-11		NA		NA		4E-11		0.0		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		NA		3E-11		1E-10		NA		NA		0.0		3E-11		4E-11	
Thorium 229 Tracer (30-120)	%	78		89		87		92		64		67		94		82		89	
METALS - DISSOLVED																			
Uranium	mg/L	0.0049	0.0003	0.0034	0.0003	0.0041	0.0003	0.0043	0.0003	0.0042	0.0003	0.0073	0.0003	0.0081	0.0003	0.0076	0.0003	0.0080	0.0003
Uranium Activity	uCi/mL	3.3E-9	2E-10	2.3E-9	2E-10	2.8E-9	2E-10	2.9E-9	2E-10	2.8E-9	2E-10	4.9E-9	2E-10	5.5E-09	2E-10	5.2E-9	2E-10	5.4E-9	2E-10
RADIONUCLIDES-SUSPENDED																			
Lead 210	µCi/mL	1.5E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	2.9E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	6E-10		NA		4E-10		4E-10		7E-10		NA		4E-10		4E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		NA		2E-10		2E-10		NA		NA		2E-10		1E-10		3E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		NA		2E-11		0.0		NA		NA		3E-11		0.0		1E-10	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		NA		3E-11		2E-11		NA		NA		1E-10		3E-11		1E-10	
Thorium 229 Tracer (30-120)	%	76		110		92		87		80		71		99		92		87	
METALS - SUSPENDED																			
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:

uCi/mL = microcuries per milliliter

mg/L = milligrams per Liter

RL - Analyte reporting limit.

Table 2.9-9 Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

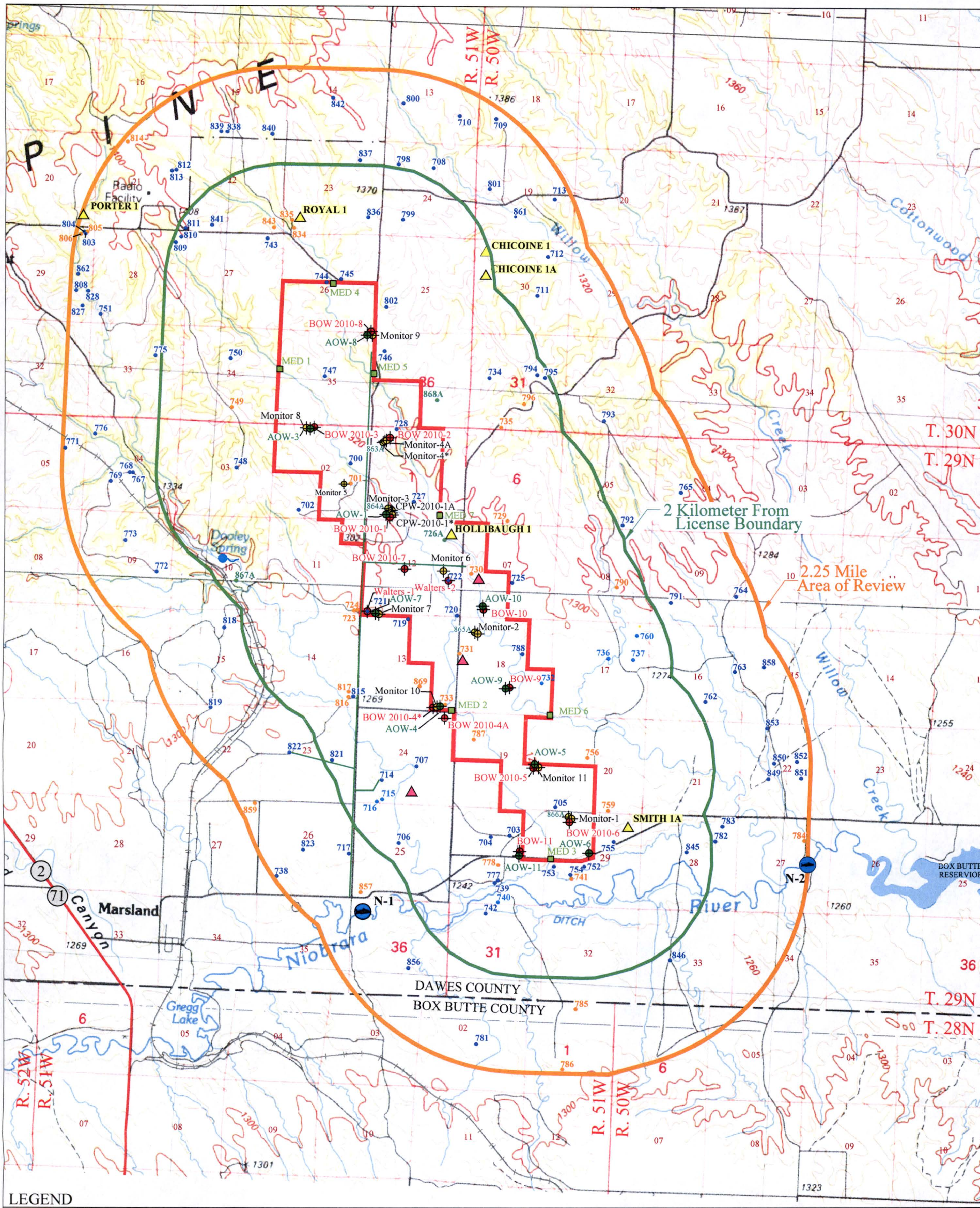
Location ID:		BOW 10		BOW 10		BOW 10		BOW 10		BOW 11		BOW 11		BOW 11		BOW 11	
Date Collected:		11/8/2013		2/25/2014		6/16/2014		9/17/2014		11/8/2013		2/26/2014		6/17/2014		9/17/2014	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES-DISSOLVED																	
Lead 210	µCi/mL	<1E-9	1E-9	1.4	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		3E-10		5E-10		NA		4E-10		3E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		2E-10		1E-10		NA		2E-10		2E-10		3E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		3E-11		0.0		4E-11		NA		5E-11		0.0		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		5E-11		3E-11		4E-11		NA		4E-11		0.0		1E-10	
Thorium 229 Tracer (30-120)	%	55		82		81		70		65		95		82		54	
METALS - DISSOLVED																	
Uranium	mg/L	0.0075	0.0003	0.0074	0.0003	0.0073	0.0003	0.0071	0.0003	0.0053	0.0003	0.0050	0.0003	0.0051	0.0003	0.0051	0.0003
Uranium Activity	uCi/mL	5.1E-9	2E-10	5E-9	2E-10	4.9E-9	2E-10	4.8E-9	2E-10	3.6E-9	2E-10	3.4E-9	2E-10	3.5E-9	2E-10	3.5E-9	2E-10
RADIONUCLIDES-SUSPENDED																	
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	1.6E-9	1E-9	<1E-9	1E-9	2.5E-9	1E-9	<1E-9	1E-9	1.3E-9	1E-9	1.5E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		6E-10		4E-10		1.3E-10		4E-10		4E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		1E-10		2E-10		NA		3E-10		2E-10		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		3E-11		0.0		5E-11		NA		2E-11		0.0		3E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		5E-11		3E-11		1E-10		NA		3E-11		4E-11		1E-10	
Thorium 229 Tracer (30-120)	%	60		94		93		51		70		91		92		73	
METALS - SUSPENDED																	
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0007	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	5E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:

uCi/mL = microcuries per milliliter

mg/L = milligrams per Liter

RL - Analyte reporting limit.



LEGEND

- Proposed Marsland Expansion Area
- Area of Review (AOR)
- 2 Kilometer Boundary From License Boundary
- Surface Water/Fish Sampling Location
- Ephemeral Drainage Sediment Sampling Point
- Natural Spring

Pumping Test Monitoring Wells

- Monitor-1 — Basal Sandstone of the Chadron Formation Well and Well ID
- BOW-2010-1 — Brule Formation Well and Well ID
- AOW-1 — Arikaree Group Well and Well ID
- 866A — Abandoned Chadron Monitor Well and Well ID
- Sand/Gravel pit, Inactive
- Oil/Gas Test holes

Private Water Supply Wells

- 781 Active Well and Well ID
- 786 Inactive Well and Well ID
- 732 Seasonal Well and Well ID
- 726A Abandoned Well and Well ID
- Powerline
- Railroad

* BOW-2010-4 and Monitor 4 are inactive and scheduled to be abandoned.

N

0 2000 4000 6000 FEET

PROJECTION: NAD 1983, STATE PLANE NEBRASKA NORTH, FIPS 2600
SOURCES: US TOPO MAPS – USGS

CAMECO RESOURCES
CROW BUTTE OPERATIONS

Figure 2.7-6

MAJOR SURFACE FEATURES/STRUCTURES WITHIN AOR AS PER TITLE 122, CHAPTER 11, SECTION 006.09

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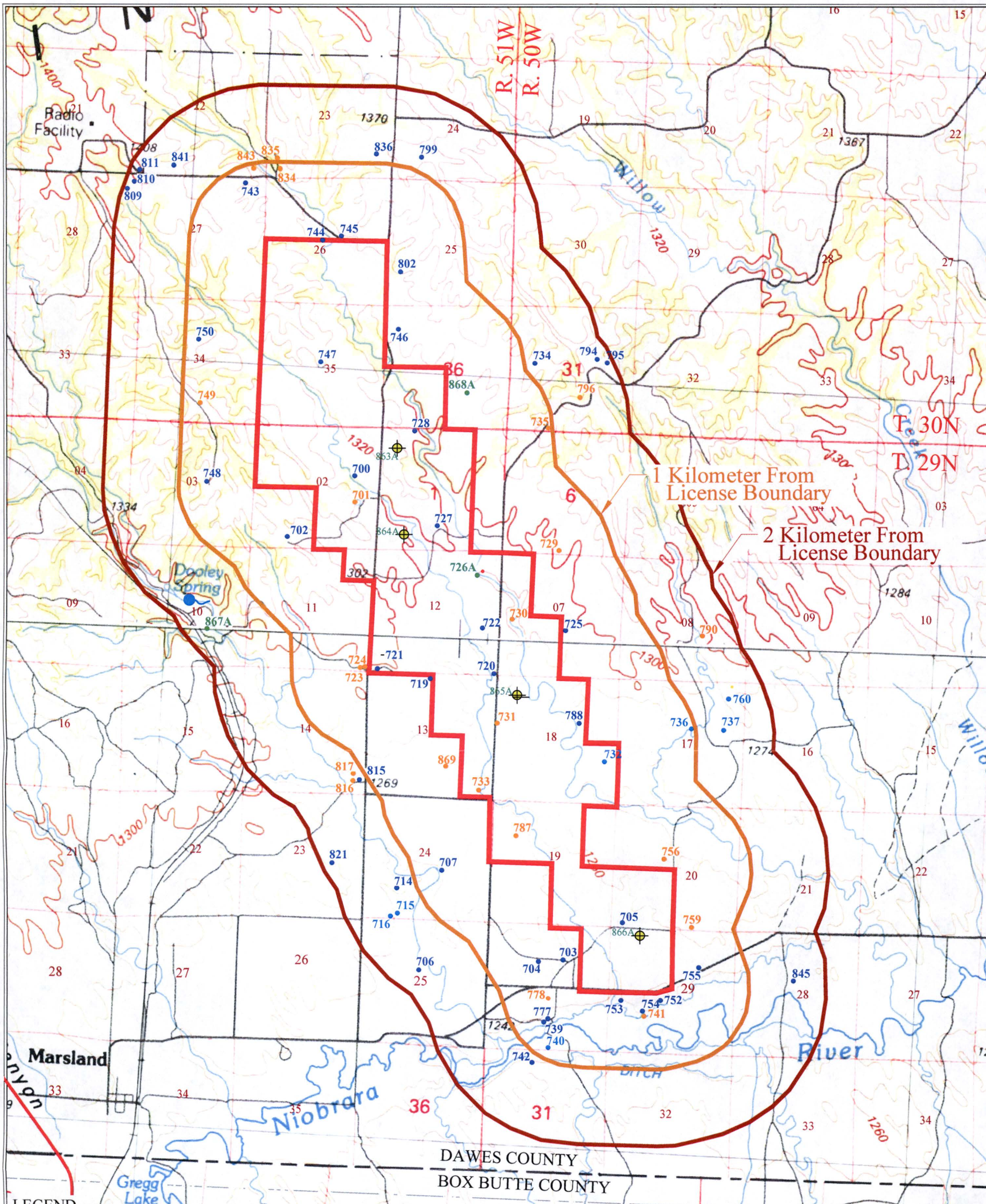

LEGEND

- Proposed Marsland Expansion Area (MEA)
- 1 Kilometer Radius of MEA
- 2 Kilometer Radius of MEA
- Natural Spring

Private Water Supply Wells

- 781 Active Well and Well ID
- 786 Inactive Well and Well ID
- 732 Seasonal Well and Well ID
- 726A Abandoned Well and Well ID

N

0 2000 4000 6000 FEET

PROJECTION: NAD 1983, STATE PLANE NEBRASKA NORTH, FIPS 2600
SOURCES: US TOPO MAPS – USGS

CAMECO RESOURCES
CROW BUTTE OPERATIONS

Figure 2.9-3

PRIVATE WELLS LOCATED WITHIN ONE AND TWO KILOMETERS OF THE MEA LICENSE BOUNDARY

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Response to Open Issues
Marsland Expansion Area
Technical Report

Attachment G

Replacement tables and figures for Volume II of the Marsland Expansion Area Technical Report

- **Table 2.2-11 – Active, Inactive, Seasonal, and Abandon Well Table**
- **Table 2.6-2 – Representative Stratigraphic Section – MEA**
- **Table 2.9-9 – Radiological Analytical Results for the Brule**
- **Figure 2.7-6 – Major Surface Features/Structures With AOR**
- **Figure 2.9-3 – Private Wells Located Within One and Two Kilometers of the MEA**

Replacement pages for Volume III of the Marsland Expansion Area Technical Report

- **Appendix A – Water User Survey**

Replacement pages for Volume IV of the Marsland Expansion Area Technical Report

- **Appendix T – Marsland Water Balance**
- **Appendix AA-2 – AquiferTek Revised MEA Agricultural Well Impact Analysis**
- **Appendix FF – MEA Quarterly Water Level Data**

New Appendix Volume IV of the Marsland Expansion Area Technical Report

- **Appendix GG – Drawdown Impact Assessment, MEA**

Appendix A

Water User Survey Information
[Active, Inactive, Seasonal and Abandoned Water Supply Wells within 2.25-Mile Area of Review]

APPENDIX A
Water User Survey Information for Water Supply Wells in 2.25 Mile Area of Review

Well Id	NDNR Registration Number	Township Location	Range Location	Section Location	Screen Interval (ft)	Name of Strata	Water Quality	Owner Type	Survey Date	Permit Area	Supply Source	Water Use Type	Well Status	Estimated Rate (gpm)	History	Total Depth (ft)	Static Level (ft)	Drill Date	Casing Depth (ft)	Diameter (inches)	Pumping Method	Driller	Casing Type	Remarks	Easting	Northing
0700	*	29	51	2		Brule		Private Landowner	16-Aug-10	Marsland	Well	livestock	active		old well	180-200ft					submersible		galvanized	old homestead-not inhabitable	1119330.5	448886.2
0701	*	29	51	2		Brule		Private Landowner	16-Aug-10	Marsland	Well	livestock	inactive		off; do not use well; old well	180-200ft					submersible		galvanized	follow REA (SW) line; 1/4 mile from house	1119336.8	447762.1
0702	*	29	51	2		Brule		Private Landowner	16-Aug-10	Marsland	Well	livestock	active		old well	180-200ft					submersible		galvanized	(W) 3/4 mile from house-follow well traveled trail	1116343.1	446281.0
0703	*	29	50	30		Brule		Private Landowner	23-Aug-10	Marsland	Well	domestic/livestock	active	10gpm	drill date-old	280ft	120ft				submersible		steel		1128170.1	428142.3
0704	*	29	50	30		Unknown	good	Private Landowner	23-Aug-10	Marsland	Well	livestock	active										pvc	Formation: estimated Arikaree/Brule	1127118.2	428075.3
0705	*	29	50	20		Arikaree		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								Windmill	Panhandle Drilling		fairly shallow	113691.0	429745.1
0706	A004714	29	51	25		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								solar submersible			Formation: estimated Arikaree/Brule	1122016.7	427725.7
0707	*	29	51	24		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1122999.9	431994.5
0708	*	30	51	24		Brule		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								submersible				1123856.7	465439.8
0709	*	30	50	18		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								submersible			Formation: estimated Arikaree/Brule	1127322.8	468166.0
0710	*	30	51	13		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1125293.1	468311.7
0711	*	30	50	30		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1129643.0	458314.5
0712	*	30	50	30		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1130223.6	460507.4
0713	*	30	50	19		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1130589.8	463714.3
0714	*	29	51	24		Brule		Private Landowner	24-Aug-10	Marsland	Well	domestic/livestock	active			135ft	55-60ft				submersible		steel		1121088.7	431237.4
0715	G-173791	29	51	25		Arikaree		Private Landowner	24-Aug-10	Marsland	Well	Agricultural	seasonal	350	Previously G-001417B	135	55	01-Apr-56			submersible		steel		Lat: 42 28' 6.03"	Long: 103 15' 23.05"
0716	G-001417A	29	51	24		Brule		Private Landowner	24-Aug-10	Marsland	Well	Agricultural	seasonal	350		135	55-60	01-Jan-55			turbine		steel	slits cut in casing for screen	1120822.4	430022.8
0717	*	29	51	26		Arikaree/Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active			160					submersible		pvc & steel	pvc slid inside old steel casing	1119281.0	427121.2
0719	*	29	51	13		Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active			160		01-Jan-60			submersible		steel	drilled before 1962	1122515.2	440218.3
0720	*	29	51	12	85-225	Arikaree/Brule		Private Landowner	24-Aug-10	Marsland	Well	Other	active		drillers pond	240		01-Jul-07	79	4.95	submersible	Landrill Exploration	White Certalok	CBO drillers pond off of Hollibaugh Rd.	1125236.9	440341.4
0721	*	29	51	12		Arikaree/Brule		Private Landowner	24-Aug-10	Marsland	Well	Other	active		drillers pond	360		06-Jul-06	79	4.95	submersible	Landrill Exploration	White Certalok	CBO drillers pond; off Squaw Mound Rd.	112014.8	440485.1
0722	*	29	51	12		Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active			160					submersible			follow REA poles	1124745.2	442385.0
0723	G-100831	29	51	11	180-220	Brule		Private Landowner	24-Aug-10	Marsland	Well	domestic/livestock	inactive	10		220	150	19-May-99	180	9	submersible	Chubb	pvc	Well is behind house	1119554.2	440690.5
0724	*	29	51	11		Unknown		Private Landowner	24-Aug-10	Marsland	Well	domestic/livestock	inactive											Formation: estimated Arikaree/Brule	1119753.9	440732.5
0725	G-094856	29	50	7	180-240	Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active	3		240	139	01-Jan-97	240	1	Windmill	Nelson	pvc		1128286.3	442274.9
0727	*	29	51	1		Arikaree/Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active			180					submersible/Windmill		pvc/steel	pvc inside steel casing	1122822.4	446628.1
0728	G-088070	29	51	1	180-260	Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active	10		260	112	01-Jan-96	200	1	submersible	Nelson	pvc		1121872.0	450812.2
0729	*	29	50	6		Unknown		Private Landowner	10-Nov-10	Marsland	Well	livestock	inactive	10-15			180	01-Jan-60			Windmill			Formation: estimated Arikaree/Brule	1128117.7	445802.1
0730	*	29	50	7		Unknown		Private Landowner	24-Aug-10	Marsland	Well	Domestic	inactive								submersible			Formation: estimated Arikaree/Brule	1126008.5	442756.2
0731	G-090120	29	50	18	120-180	Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	inactive	3		180	106	01-Jan-96	147	1	submersible	Nelson	pvc	Leased	1125370.9	438301.7
0732	G-043958	29	50	18		Brule		Private Landowner	10-Nov-10	Marsland	Well	Agricultural	seasonal	1300		280	78	01-Jan-74	171	8	Turbine pump			pivot	1130680.7	436970.7

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Well Id	NDNR Registration Number	Township Location	Range Location	Section Location	Screen Interval (ft)	Name of Strata	Water Quality	Owner Type	Survey Date	Permit Area	Supply Source	Water Use Type	Well Status	Estimated Rate (gpm)	History	Total Depth (ft)	Static Level (ft)	Drill Date	Casing Depth (ft)	Diameter (inches)	Pumping Method	Driller	Casing Type	Remarks	Easting	Northing
0733	*	29	51	13		Unknown		Private Landowner	23-Aug-10	Marsland	Well	livestock	inactive								Windmill			Formation: estimated Arikaree/Brule	1124205.4	435560.2
0734	G-094138	30	50	31	240-300	Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active			300	1	01-Jan-98	300	9	cylinder pump	Nelson	pvc		1126994.5	453703.9
0735	G-148049	30	50	31	355-375	Brule		Private Landowner	01-Sep-10	Marsland	Well	livestock	inactive			375	210	01-Jan-07	375	9		Prosser	pvc		1127652.4	450927.5
0736	G-068634	29	50	17		Brule		Private Landowner	05-Nov-10	Marsland	Well	Agricultural	seasonal	900		200	115	01-Jan-68	200	8				pivot	1133618.8	438066.8
0737	G-068635	29	50	17		Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	seasonal	1200		340	110	01-Jan-73	340	8					1134975.2	437990.2
0738	G-097537	29	51	26	240-260	Arikaree/Brule		Private Landowner	24-Aug-10	Marsland	Well	livestock	active	3		260	178	01-Jan-98	260	9	Windmill	Chubb	pvc		1115236.8	425854.9
0739	G-113923	29	50	30	30-60	Arikaree		Private Landowner	08-Nov-10	Marsland	Well	livestock/garden	active	10		60	14	08-Nov-01		9	submersible	Chubb	pvc		1127342.4	425486.4
0740	G-108894	29	50	30	50-100	Brule		Private Landowner	08-Nov-10	Marsland	Well	Agricultural	seasonal	850		110	8	02-Feb-01		6		Nelson	pvc	pivot	1127519.8	424396.8
0741	G-081600	29	50	29	50-170 170-190	Brule		Private Landowner	05-Nov-10	Marsland	Well	domestic/livestock	active	20		190	42	01-Jan-94		2		Chubb	pvc	house well; between the two houses	1131600.1	425727.9
0742	G-086157	29	50	31	40-60	Arikaree		Private Landowner	08-Nov-10	Marsland	Well	livestock	active	20		60	18	01-Jan-95		2	submersible	Chubb	pvc		1126845.0	423771.4
0743	*	30	51	27	120-140	Brule		Private Landowner	03-Nov-10	Marsland	Well	livestock	active			140	70	05-May-99	120	9	submersible	Chubb	pvc		1114725.2	461481.1
0744	*	30	51	26		Arikaree		Private Landowner	03-Nov-10	Marsland	Well	livestock	active			80	30	01-Jan-70	80	5	windmill/submersible	Chubb	pvc		1117989.3	459031.5
0745	G-106423	30	51	26		Brule		Private Landowner	03-Nov-10	Marsland	Well	livestock	active			140		05-May-99	140	4.95	submersible	Chubb	pvc		1118781.9	459206.3
0746	*	30	51	36		Unknown		Private Landowner	03-Nov-10	Marsland	Well	livestock	active								Windmill		State Land	Formation: estimated Arikaree/Brule. State Land	1121182.9	455178.1
0747	*	30	51	35		Arikaree		Private Landowner	03-Nov-10	Marsland	Well	livestock	active			225	200				submersible/Windmill				1117899.2	453783.8
0748	*	29	51	3		Unknown		Private Landowner	03-Nov-10	Marsland	Well	livestock	active								submersible			Formation: estimated Arikaree/Brule	1113046.1	448639.2
0749	*	30	51	34		Unknown		Private Landowner	03-Nov-10	Marsland	Well	livestock	inactive								Windmill			Formation: estimated Arikaree/Brule	1112776.7	452017.4
0750	*	30	51	34		Unknown		Private Landowner	03-Nov-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1112710.4	454753.1
0751	*	30	51	28		Unknown		Private Landowner	03-Nov-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1105386.1	457186.6
0752	*	29	50	29		Brule		Private Landowner	05-Nov-10	Marsland	Well	domestic/livestock	active	10-20		200-300					submersible			barns	1132300.5	426415.9
0753	*	29	50	29		Brule		Private Landowner	05-Nov-10	Marsland	Well	domestic/livestock	active	50		200-300					submersible			by houses and barn	1130626.6	426414.2
0754	*	29	50	29		Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					submersible			by houses and barn	1131539.7	425961.1
0755	*	29	50	29		Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					submersible				1134050.4	427697.6
0756	*	29	50	20		Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	inactive		old windmill fell over	200-300					Pump Jack				1132462.9	432469.1
0759	*	29	50	20		Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	inactive	10-20		200-300					submersible				1133622.5	429537.5
0760	*	29	50	17		Unknown		Private Landowner	05-Nov-10	Marsland	Well	livestock	seasonal	1000							submersible				1135189.3	439343.3
0762	*	29	50	16		Arikaree/Brule		State of NE	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					submersible			state land	1138960.3	435635.4
0763	*	29	50	16		Arikaree/Brule		State of NE	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					submersible			state land	1140565.5	437331.7
0764	*	29	50	9		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill				1140646.2	441535.3
0765	*	29	50	4		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill				1137611.0	447306.0
0767	*	29	51	4		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill			not far from house	1107246.0	448328.8

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0768	*	29	51	4		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	Domestic	active		pumps good	200-300	60-120				submersible			house well	1107063.9	448333.0
0769	*	29	51	4		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill				1105995.9	447845.8
0771	*	29	51	5		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill				1103426.3	449697.7
0772	*	29	51	9		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill				1108613.8	442822.8
0773	*	29	51	9		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		200-300					Windmill				1106844.2	444555.1
0775	G-095954	30	51	33		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10		220	117	06-Apr-98	200	9	submersible/Wind mill	Chubb	pvc	submersible under windmill	1108495.3	454893.0
0776	G-167918	29	51	4		Arikaree/Brule		Private Landowner	05-Nov-10	Marsland	Well	livestock	active	10-20		280	195	07-Jul-13	280	5.563	submersible	Prosser	pvc		1105105.1	450500.5
0777	*	29	50	30		Arikaree		Private Landowner	08-Nov-10	Marsland	Well	domestic/garden	active	10-20		60					submersible				1127520.1	425634.3
0778	*	29	50	30		Arikaree		Private Landowner	08-Nov-10	Marsland	Well	livestock	inactive	10-20		60					submersible				1127537.2	426508.6
0781	*	28	51	2		Arikaree/Brule		Private Landowner	08-Nov-10	Marsland	Well	livestock	active			60					windmill					
0782	G-134034	29	50	28		Brule		Private Landowner	08-Nov-10	Marsland	Well	Agricultural	active	700		100	20	01-Jan-60			submersible	Midwest Farm Service			1139522.2	427841.1
0783	G-150312	29	50	28	50-70	Arikaree/Brule		Private Landowner	08-Nov-10	Marsland	Well	Domestic	active	15		70	24	01-Jan-08	70	9	submersible	Chubb	pvc		1139916.9	428674.7
0784	*	29	50	27		Arikaree/Brule		Private Landowner	08-Nov-10	Marsland	Well	livestock	inactive	10-20		40-60					Windmill			useable but not being used	1144451.6	427879.5
0785	*	28	51	1		Arikaree/Brule		Private Landowner	08-Nov-10	Marsland	Well	livestock	inactive	3		140					Windmill				1131834.3	418463.8
0786	*	28	51	1		Arikaree/Brule		Private Landowner	08-Nov-10	Marsland	Well	livestock	inactive	3		140					Windmill				1131089.0	415095.5
0787	*	29	50	19		Brule		Private Landowner	10-Nov-10	Marsland	Well	livestock	inactive	10		130		01-Jan-60			Windmill		pvc		1126168.2	433468.9
0788	*	29	50	18		Arikaree		Private Landowner	10-Nov-10	Marsland	Well	livestock	inactive	10		130-140		01-Jan-40			Windmill		steel		1128858.0	438296.6
0790	*	29	50	8		Unknown		Private Landowner	10-Nov-10	Marsland	Well	livestock	inactive	10-20			160				Windmill		pvc	Formation: estimated Arikaree/Brule	1134081.7	442038.2
0791	*	29	50	9		Unknown		Private Landowner	10-Nov-10	Marsland	Well	livestock	active	10-20			160-170				Windmill		steel	Formation: estimated Arikaree/Brule	1137066.2	441191.8
0792	*	29	50	5		Unknown		Private Landowner	10-Nov-10	Marsland	Well	livestock	active	10			180				Windmill		steel	Formation: estimated Arikaree/Brule	1134397.3	445473.0
0793	*	30	50	32		Arikaree/Brule		Private Landowner	10-Nov-10	Marsland	Well	livestock	active	8-10		300					Windmill		pvc	windmill is not working	1133348.7	451314.8
0794	*	30	50	31		Arikaree/Brule		Private Landowner	10-Nov-10	Marsland	Well	domestic/livestock	active	10-15		300					submersible		pvc	well drilled between 1925-1930, house well	1129656.3	453879.2
0795	*	30	50	31		Arikaree/Brule		Private Landowner	10-Nov-10	Marsland	Well	domestic/livestock	active	10-15		350		01-Jan-90			submersible		pvc	well drilled in the 1990's, house well	1130072.5	453722.8
0796	*	30	50	31		Arikaree/Brule		Private Landowner	10-Nov-10	Marsland	Well	domestic/livestock	inactive	15		350		01-Jan-80			submersible		pvc	not in use, well drilled in the 1980's	1128914.6	452242.4
0798	*	30	51	24		Brule		Private Landowner	11-Nov-10	Marsland	Well	livestock	active	10-20		200		01-Jan-00			submersible	Chubb	pvc	Between Anderson and Franey-share well	1121934.8	465639.5
0799	*	30	51	24		Brule		Private Landowner	11-Nov-10	Marsland	Well	livestock	active	10-20		250					Windmill			1/4 mile south of Hough Rd. in middle of property,	1122179.9	462541.3
0800	*	30	51	13		Unknown		Private Landowner	12-Nov-10	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1122174.9	469011.5
0801	G-116402	30	50	19		Arikaree/Brule		Private Landowner	11-Nov-10	Marsland	Well	domestic/garden	active	15		220	70	06-Jul-02	220	9	submersible	Chubb	pvc		1126978.9	464282.7
0802	*	30	51	25		Brule		Private Landowner	15-Nov-10	Marsland	Well	livestock	active	10-20		180-200	80				Windmill	Chubb		started out being a domestic well in 1945	1121275.9	457656.7
0803	*	30	51	29		Unknown		Private Landowner	14-Jan-11	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1104542.3	461686.1
0804	G-113903	30	51	29		Arikaree/Brule		Private Landowner	14-Jan-11	Marsland	Well	domestic/livestock	active			260	140	02-Oct-01		4.95	submersible	Chubb	pvc		1104468.4	461791.2

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0805	•	30	51	29		Unknown		Private Landowner	14-Jan-11	Marsland	Well	livestock	inactive	not good		shallow					Pump Jack			Formation: estimated Arikaree/Brule	1104640.5	461790.0
0806	•	30	51	29		Unknown		Private Landowner	14-Jan-11	Marsland	Well	livestock	inactive								Windmill	Chubb		Formation: estimated Arikaree/Brule	1104273.2	461660.7
0808	•	30	51	29		Arikaree/Brule		Private Landowner	14-Jan-11		Well	Agricultural	Active								submersible					
0809	•	30	51	28		Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	active	fairly good		300					Windmill			well drilled before 1947, located by barn	1109635.8	461243.9
0810	•	30	51	28		Unknown		Private Landowner	14-Jan-11	Marsland	Well	domestic/livestock	active	1		<300		01-Jan-90			submersible	Prosser		Formation: estimated Arikaree/Brule	1109942.6	461542.5
0811	•	30	51	21		Unknown		Private Landowner	14-Jan-11	Marsland	Well	domestic/livestock	active	1/2		<300		01-Jan-90			Windmill	Panhandle Drilling		Formation: estimated Arikaree/Brule	1110187.6	462030.2
0812	•	30	51	21		Unknown		Private Landowner	14-Jan-11	Marsland	Well	domestic/livestock	active	good		260		01-Jan-71	220		submersible	Chubb		Formation: estimated Arikaree/Brule	1109662.5	465283.8
0813	•	30	51	21		Unknown		Private Landowner	14-Jan-11	Marsland	Well	livestock	active			280		01-Jan-39			Windmill		steel	Formation: estimated Arikaree/Brule	1109411.4	465224.8
0815	•	29	51	14		Brule		Private Landowner	14-Jan-11	Marsland	Well	Domestic	active	5-6		140		01-Jan-55			submersible	Chubb	steel	house well, drill in 1955 or 1956	1119645.0	435833.7
0816	•	29	51	14		Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	inactive	4-6		140					submersible		steel	old well	1119247.7	435853.5
0817	•	29	51	14		Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	inactive	1-4		160			not cased to bottom		Windmill		steel		1119264.0	436157.5
0818	•	29	51	15		Arikaree/Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	active	1-2		140		01-Jan-50			Windmill	Chubb	steel		1112421.6	439735.3
0819	•	29	51	22		Arikaree/Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	active	1-2		140		02-Jan-00	cased to butte rock		Windmill	Pellren	steel	drilled in the early 1900's	1111644.7	435252.1
0821	•	29	51	23		Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	active	3		160		01-Jan-80			submersible	Peterson	pvc		1118356.5	432321.7
0822	•	29	51	23		Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	active	6-7		140		01-Jan-60			submersible	Chubb	steel		1116025.6	432731.4
0823	•	29	51	26		Arikaree/Brule		Private Landowner	14-Jan-11	Marsland	Well	livestock	active	1-2		100		01-Jan-50			Windmill	Chubb	steel		1116762.1	427344.1
0827	•	30	51	29		Unknown		Private Landowner	29-Oct-08	Marsland	Well	livestock	active		inherited land from grandfather									Formation: estimated Arikaree/Brule	1104365.7	457644.6
0828	G-103966	30	51	29	140-160	Arikaree/Brule		Private Landowner	14-Jan-11	Marsland	Well	Domestic	active	10		160	31	10-Jul-99	100	9	submersible	Chubb	pvc	house well	1104688.8	458477.1
0834	•	30	51	23		Brule		Private Landowner	25-Feb-11	Marsland	Well	domestic/livestock	inactive	good		300		01-Jan-76			submersible		pvc	not used	1116192.0	462067.9
0835	•	30	51	23		Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	inactive	average		300					Windmill		pvc	windmill not standing anymore	1116080.4	462504.7
0836	G-100106	30	51	23	200-220	Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	active	average		220	145	26-Mar-98		9	submersible		pvc		1120265.4	462677.2
0837	•	30	51	23		Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	active	average		300		01-Jan-69			submersible		pvc		1119802.0	465856.2
0838	•	30	51	15		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	active	average		300		01-Jan-64	20-30	6	Windmill		galvanized	tubular pipe	1112499.0	467397.3
0839	•	30	51	15		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	active	average		300		01-Jan-58			Windmill		galvanized		1112156.6	467406.7
0840	•	30	51	15		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	active	average		300		01-Jan-73		5	Windmill	Chubb	pvc		1114985.4	467289.5
0841	G-100105	30	51	22		Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	active	average		220	155	25-Mar-99	220	9	submersible	Chubb	pvc		1111665.6	462209.9
0842	•	30	51	14		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	inactive	average		300							pvc	cased hole, will be used for livestock,	1118307.0	469291.8
0843		30	51	22		Brule		Private Landowner	25-Feb-11	Marsland	Well	livestock	inactive	average		300					Windmill		pvc	well drilled before 1955	1115080.5	462090.2
0845	•	29	50	28		Unknown		Private Landowner	25-Feb-11	Marsland	Well	domestic/livestock	active								submersible			Formation: estimated Arikaree/Brule	1137941.5	427243.4
0846		29	50	33		Unknown		Private Landowner	25-Feb-11	Marsland	Well	livestock	active								Windmill			Formation: estimated Arikaree/Brule	1137048.9	421179.0
0849		29	50	22		Unknown		Private Landowner	25-Feb-11	Marsland	Well	livestock	active								submersible			Formation: estimated Arikaree/Brule	1142423.3	431322.9

APPENDIX A
Water User Survey Information for Water Supply Wells in 2.25 Mile Area of Review

Well Id	NDNR Registration Number	Township Location	Range Location	Section Location	Screen Interval (ft)	Name of Strata	Water Quality	Owner Type	Survey Date	Permit Area	Supply Source	Water Use Type	Well Status	Estimated Rate (gpm)	History	Total Depth (ft)	Static Level (ft)	Drill Date	Casing Depth (ft)	Diameter (inches)	Pumping Method	Driller	Casing Type	Remarks	Easting	Northing
0850	G-022646	29	50	22		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	Agricultural	active	840		200	71	01-Jan-62		8	Turbine pump			vertical shaft	1142735.9	432181.9
0851	G-000345A	29	50	22		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	Agricultural	active	500		140	60	15-Jul-55	140	8	submersible		steel		144241.1	431350.1
0852	G-000345B	29	50	22		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	Agricultural	inactive		No driling log avaliable on NDNR.	140	60	15-Jul-55	140	8	submersible		steel	All information per landowner & G-000345A	11454555.9	432362.8
0853	G-126273	29	50	22		Arikaree/Brule		Private Landowner	25-Feb-11	Marsland	Well	Agricultural	active	600		160	63	05-Nov-03	160	8	submersible	Kelly-Deines Irrigation	steel		1142384.3	434389.8
0856	*	29	51	36		Arikaree/Brule		Private Landowner		Marsland		Agricultural	inactive								Windmill			Formation: estimated Arikaree/Brule	112255.5	420726.5
0857	*	29	51	25		Arikaree/Brule		Private Landowner	01-Mar-11	Marsland	Well	domestic/livestock	inactive	10		40-50				8	submersible		galvanized	Greater than 100 yrs. Old.	1119931.4	424946.6
0858	G-068633	29	50	15		Arikaree/Brule		Private Landowner	01-Mar-11	Marsland	Well	Agricultural	active	1000		200	105	01-Jan-68		8					1142168.8	437589.0
0859	*	29	51	27		Arikaree/Brule		Private Landowner	01-Mar-11	Marsland	Well	Domestic	inactive			120	no water	01-Jan-20			no pump		galvanized	cement block on top of well, cased down to butte	1114131.2	429920.5
0861	*	30	50	19		Arikaree/Brule		Private Landowner	02-Mar-11	Marsland	Well	domestic/livestock/agri culture	active			40			6	6	submersible		galvanized	information as per certified letter		
0862	G-89968	30	51	29	135-155	Arikaree/Brule		Private Landowner	21-Mar-11	Marsland	Well	domestic/livestock	active	16		155	98	06-Aug-96		4.5	submersible	Chubb	pvc		1104113.1	459435.5
0869	*	29	51	13		Arikaree/Brule		Private Landowner	08-Oct-14	Marsland	Well	Livestock	inactive		Originally reported as abandoned.									Per Landowner Oct. 2014 Casing Bent Over		
Abandoned																										
0726A	*	29	51	12		Brule		Private Landowner	24-Aug-10	Marsland	Well	unknown	abandoned			300	70-80							abandoned-old oil test well, caved in		
0863A	*	29	51	1		Basal Chadron		Private Landowner		Marsland		Monitoring	Abandoned			1110										
0864A	*	29	51	1		Basal Chadron		Private Landowner		Marsland		Monitoring	Abandoned			1045										
0865A	*	29	50	18		Basal Chadron		Private Landowner		Marsland		Monitoring	Abandoned			1010										
0866A	*	29	50	29		Basal Chadron		Private Landowner		Marsland		Monitoring	Abandoned			935										
0867A	*	29	51	10		Arikaree		Private Landowner		Marsland	Well	Domestic	Abandoned		Hand Dug	60								Filled in		
0868A	*	30	51	36		Unknown		Private Landowner		Marsland	Well	Livestock	Abandoned													

* This well is not registered in the Nebraska Department of Natural Resources (NDNR) database.

Response to Open Issues
Marsland Expansion Area
Technical Report

Attachment G

Replacement tables and figures for Volume II of the Marsland Expansion Area Technical Report

- **Table 2.2-11 – Active, Inactive, Seasonal, and Abandon Well Table**
- **Table 2.6-2 – Representative Stratigraphic Section – MEA**
- **Table 2.9-9 – Radiological Analytical Results for the Brule**
- **Figure 2.7-6 – Major Surface Features/Structures With AOR**
- **Figure 2.9-3 – Private Wells Located Within One and Two Kilometers of the MEA**

Replacement pages for Volume III of the Marsland Expansion Area Technical Report

- **Appendix A – Water User Survey**

Replacement pages for Volume IV of the Marsland Expansion Area Technical Report

- **Appendix T – Marsland Water Balance**
- **Appendix AA-2 – AquiferTek Revised MEA Agricultural Well Impact Analysis**
- **Appendix FF – MEA Quarterly Water Level Data**

New Appendix Volume IV of the Marsland Expansion Area Technical Report

- **Appendix GG – Drawdown Impact Assessment, MEA**

Appendix T

Marsland Water Balance (Production, Restoration and Stabilization Sampling)

Appendix T MARSLAND WATER BALANCE (GPM) - PRODUCTION, RESTORATION AND STABILIZATION SAMPLING

	2015				2016				2017				2018				2019				2020			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
MINE UNIT 1	1100	1700	1700	1600	1500	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700	600	500	400	400				
IX Treatment/Reinjection																					800	800	800	200
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT 2			400	500	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700	600	500	400	300
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT 3							400	500	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT 4											400	500	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT 5															400	500	600	1200	1600	1700	1600	1500	1400	1400
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT A																						400	500	600
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT B																								
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT C																								
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT D																								
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT E																								
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT F																								
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
Prod Flow	1100	1700	2100	2100	2100	2700	3400	3600	3500	3900	4500	4700	4500	4800	5300	5400	5100	5300	5300	5300	4500	4500	4200	4100
Prod Bleed 1.2%	13	20	25	25	25	32	41	43	42	47	54	56	54	58	64	65	61	64	64	64	54	54	50	49
IX Bleed 2.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	16	4
Mine Unit 1 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 2 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 3 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 4 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 5 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit A RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit B RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit C RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit D RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit E RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit F RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	800	800	800	200
RO Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recirculation Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX & RO Bleed TO DDW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	16	4
Total DW needed capacity	13	20	25	25	25	32	41	43	42	47	54	56	54	58	64	65	61	64	64	64	70	70	66	53

	2021				2022				2023				2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
MINE UNIT 1																								
IX Treatment/Reinjection																								
RO Treatment	500	500	500	500	500	500	500	500	500															
Recirculation										800	800													
STABILIZATION SAMPLING																								
MINE UNIT 2																								
IX Treatment/Reinjection	800	800	800	400																				
RO Treatment					250	250	250	250	250	500	500	500	500	500	500	500								
Recirculation																	800	800						
STABILIZATION SAMPLING																								
MINE UNIT 3	600	500	400	300																				
IX Treatment/Reinjection					800	800	800	800																
RO Treatment									250	250	250	250	250	250	250	500	500	500	500	500	500			
Recirculation																						800	800	
STABILIZATION SAMPLING																								
MINE UNIT 4	1000	900	800	700	600	500	400	300																
IX Treatment/Reinjection									400	400	400	400	400	400	400									
RO Treatment																250	250	250	250	250	250	500	500	500
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT 5	1300	1200	1100	1100	1000	900	800	700	600	500	400	300												
IX Treatment/Reinjection													400	400	400	400	400	400	400	400	400			
RO Treatment																						250	250	250
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT A	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700	600	500	400	300	200	200			
IX Treatment/Reinjection																						400	400	400
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT B		400	500	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700	600	500	400	300	200
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT C						400	500	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700	600
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT D										400	500	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT E														400	500	600	1200	1600	1700	1600	1500	1400	1400	1300
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
MINE UNIT F																							400	500
IX Treatment/Reinjection																								
RO Treatment																								
Recirculation																								
STABILIZATION SAMPLING																								
Prod Flow	4100	4600	4500	4300	4300	4800	4800	4500	4500	5000	5100	4800	4800	5300	5400	5100	5300	5300	5200	4700	4300	3700	3900	3600
Prod Bleed 1.2%	49	55	54	52	52	58	58	54	54	60	61	58	58	64	65	61	64	64	62	56	52	44	47	43
IX Bleed 2.0%	16	16	16	8	16	16	16	16	8	8	8	8	16	16	16	8	8	8	8	8	8	8	8	8
Mine Unit 1 RO Bleed (30%)	150	150	150	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 2 RO Bleed (30%)	0	0	0	0	75	75	75	75	75	150	150	150	150	150	150	150	0	0	0	0	0	0	0	0
Mine Unit 3 RO Bleed (30%)	0	0	0	0	0	0	0	0	75	75	75	75	75	75	75	150	150	150	150	150	150	0	0	0
Mine Unit 4 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	150	150	150
Mine Unit 5 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75
Mine Unit A RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit B RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit C RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit D RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit E RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit F RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX Flow	800	800	800	400	800	800	800	800	400	400	400	400	800	800	800	400	400	400	400	400	400	400	400	400
RO Flow	500	500	500	500	750	750	750	750	1000	750	750	750	750	750	750	1250	750	750	750	750	750	750	750	750
Recirculation Flow	0	0	0	0	0	0	0	0	0	800	800	0	0	0	0	0	800	800	0	0	0	800	800	0
IX & RO Bleed TO DDW	166	166	166	158	241	241	241	241	308	233	233	233	241	241	241	383	233	233	233	233	233	233	233	233
Total DW needed capacity	215	221	220	210	293	299	299	295	362	293	294	291	299	305	306	444	297	297	295	289	285	277	280	276

May 2016

Appendix T MARSLAND WATER BALANCE (GPM) - PRODUCTION, RESTORATION AND STABILIZATION SAMPLING

	2027				2028				2029				2030				2031				2032				2033				2034				2035				2036				2037				2038				2039	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
MINE UNIT 1																																																		
IX Treatment/Reinjection																																																		
RO Treatment																																																		
Recirculation																																																		
STABILIZATION SAMPLING																																																		
MINE UNIT 2																																																		
IX Treatment/Reinjection																																																		
RO Treatment																																																		
Recirculation																																																		
STABILIZATION SAMPLING																																																		
MINE UNIT 3																																																		
IX Treatment/Reinjection																																																		
RO Treatment																																																		
Recirculation																																																		
STABILIZATION SAMPLING																																																		
MINE UNIT 4																																																		
IX Treatment/Reinjection																																																		
RO Treatment	500	500	500																																															
Recirculation				800	800																																													
STABILIZATION SAMPLING																																																		
MINE UNIT 5																																																		
IX Treatment/Reinjection																																																		
RO Treatment	250	250	250	500	500	500	500	500	500																																									
Recirculation										800	800																																							
STABILIZATION SAMPLING																																																		
MINE UNIT A																																																		
IX Treatment/Reinjection	400	400	400																																															
RO Treatment				250	250	250	250	250	250	500	500	500	500	500	500																																			
Recirculation																800	800																																	
STABILIZATION SAMPLING																																																		
MINE UNIT B	200	200	200																																															
IX Treatment/Reinjection				400	400	400	400	400	400																																									
RO Treatment										250	250	250	250	250	250	500	500	500	500	500	500																													
Recirculation																						800	800																											
STABILIZATION SAMPLING																																																		
MINE UNIT C	500	400	300	200	200	200	200	200	200																																									
IX Treatment/Reinjection										400	400	400	400	400	400																																			
RO Treatment																250	250	250	250	250	250	500	500	500	500	500	500																							
Recirculation																												800	800																					
STABILIZATION SAMPLING																																																		
MINE UNIT D	900	800	700	600	500	400	300	200	200	200	200	200	200	200	200																																			
IX Treatment/Reinjection																400	400	400	400	400	400																													
RO Treatment																						250	250	250	250	250	250	500	500	500	500	500	500																	
Recirculation																																		800	800															
STABILIZATION SAMPLING																																																		
MINE UNIT E	1200	1100	1100	1000	900	800	700	600	500	400	300	200	200	200	200	200	200	200	200	200	200																													
IX Treatment/Reinjection																						400	400	400	400	400	400																							
RO Treatment																												250	250	250	250	250	250	500	500	500	500	500	500											
Recirculation																																								800	800									
STABILIZATION SAMPLING																																																		
MINE UNIT F	600	1200	1600	1700	1600	1500	1400	1400	1300	1200	1100	1100	1000	900	800	700	600	500	400	300	200	200	200	200	200	200	200																							
IX Treatment/Reinjection																												400	400	400	400	400	400																	
RO Treatment																																		250	250	250	250	250	250	750	750	750	750							
Recirculation																																												800	800					
STABILIZATION SAMPLING																																																		
Prod Flow	3400	3700	3900	3500	3200	2900	2600	2400	2200	1800	1600	1500	1400	1300	1200	900	800	700	600	500	400	200	200	200	200	200	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prod Bleed 1.2%	41	44	47	42	38	35	31	29	26	22	19	18	17	16	14	11	10	8	7	6	5	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IX Bleed 2.0%	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 1 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 2 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 3 RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 4 RO Bleed (30%)	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit 5 RO Bleed (30%)	75	75	75	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit A RO Bleed (30%)	0	0	0	75	75	75	75	75	75	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit B RO Bleed (30%)	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit C RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit D RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mine Unit E RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0
Mine Unit F RO Bleed (30%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	75	75	75	75	75	225	225	225	225	0	0	0	0	0	0	0
IX Flow	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RO Flow	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	500	500	500	500	500	500	0	0	0	0	0	0	0	0	0	0	0
Recirculation Flow	0	0	0	800	800	0	0	0	0	800	800	0	0	0	0	800	800	0	0	0	0	800	800	0	0	0	0	800	800	0	0	0	0	800	800	0	0	0	0	800	800	0	0	800	800	0	0	0	0	0
IX & RO Bleed TO DDW	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	225	225	225	225	225	225	150	150	150	150	150	150	0	0	0	0	0	0	0	0	0	0	0
Total DW needed capacity	274	277	280	275	271	268	264	262	259	255	252	251	250	249	247	244	243	241	240	239	238	235	235	235	235	235	235	233	233	233	233	233	233	225	225	225	225	225	225	225	225	225	225	0	0	0	0	0	0	0

Appendix T MARSLAND WATER BALANCE (GPM) - PRODUCTION, RESTORATION AND STABILIZATION SAMPLING

			PV size	Surety PV	Flow GPM	Days	PV Needed	Total Days	Total Gal Needed
MINE UNIT 1									
IX Treatment/Reinjection	MU1	IX	95017565	95017565	800	82	3	247	285052695
RO Treatment	MU1	RO	95017565	95017565	500	132	6	792	570105390
Recirculation	MU1	RC	95017565	95017565	800	82	2	165	190035130
STABILIZATION SAMPLING									
MINE UNIT 2									
IX Treatment/Reinjection	MU2	IX	95017565	95017565	220	300	3	900	285052695
RO Treatment	MU2	RO	95017565	95017565	225	293	6	1760	570105390
Recirculation	MU2	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT 3									
IX Treatment/Reinjection	MU3	IX	95017565	95017565	220	300	3	900	285052695
RO Treatment	MU3	RO	95017565	95017565	225	293	6	1760	570105390
Recirculation	MU3	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT 4									
IX Treatment/Reinjection	MU4	IX	95017565	95017565	172	384	3	1151	285052695
RO Treatment	MU4	RO	95017565	95017565	250	264	6	1584	570105390
Recirculation	MU4	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT 5									
IX Treatment/Reinjection	MU5	IX	95017565	95017565	350	189	3	566	285052695
RO Treatment	MU5	RO	95017565	95017565	225	293	6	1760	570105390
Recirculation	MU5	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT A									
IX Treatment/Reinjection	MUA	IX	95017565	95017565	1000	66	3	198	285052695
RO Treatment	MUA	RO	95017565	95017565	800	82	6	495	570105390
Recirculation	MUA	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT B									
IX Treatment/Reinjection	MUB	IX	95017565	95017565	1000	66	3	198	285052695
RO Treatment	MUB	RO	95017565	95017565	800	82	6	495	570105390
Recirculation	MUB	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT C									
IX Treatment/Reinjection	MUC	IX	95017565	95017565	1000	66	3	198	285052695
RO Treatment	MUC	RO	95017565	95017565	800	82	6	495	570105390
Recirculation	MUC	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT D									
IX Treatment/Reinjection	MUD	IX	95017565	95017565	1000	66	3	198	285052695
RO Treatment	MUD	RO	95017565	95017565	800	82	6	495	570105390
Recirculation	MUD	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT E									
IX Treatment/Reinjection	MUE	IX	95017565	95017565	1000	66	3	198	285052695
RO Treatment	MUE	RO	95017565	95017565	800	82	6	495	570105390
Recirculation	MUE	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
MINE UNIT F									
IX Treatment/Reinjection	MUF	IX	95017565	95017565	1000	66	3	198	285052695
RO Treatment	MUF	RO	95017565	95017565	800	82	6	495	570105390
Recirculation	MUF	RC	95017565	95017565	400	165	2	330	190035130
STABILIZATION SAMPLING									
Prod Flow									
Prod Bleed 1.2%									
IX Bleed 2.0%									
Mine Unit 1 RO Bleed (30%)									
Mine Unit 2 RO Bleed (30%)									
Mine Unit 3 RO Bleed (30%)									
Mine Unit 4 RO Bleed (30%)									
Mine Unit 5 RO Bleed (30%)									
Mine Unit A RO Bleed (30%)									
Mine Unit B RO Bleed (30%)									
Mine Unit C RO Bleed (30%)									
Mine Unit D RO Bleed (30%)									
Mine Unit E RO Bleed (30%)									
Mine Unit F RO Bleed (30%)									
IX Flow									
RO Flow									
Recirculation Flow									
IX & RO Bleed TO DDW									
Total DW needed capacity									

AA-2

Validation of Agricultural Well Impact Analysis
(AquiferTek, May 2016)

AquiferTek

Mr. Doug Pavlick
Larry Teahon
Cameco Resources
Crow Butte Facility
P.O. Box 169
Crawford, NE 69339

May 11, 2016

Re: Revised Validation of Marsland Expansion Area (MEA) Agricultural Well Impact Analysis

As requested, we have completed a revision to the Marsland Expansion Area (MEA) Agricultural Well Impact Analysis and Validation Report dated November 7, 2014. This report corrects the location of irrigation well 732, which was originally located approximately 600 feet east of the correct well location (**Figure 1**). Our analysis included calibration of the groundwater flow model using water level data collected during the 2014 irrigation season, and calculation of the calibrated 30-year capture zone of irrigation well 732.

WATER LEVEL MONITORING

Water level elevation data was collected from eight shallow monitoring wells (AOW-4, AOW-5, AOW-9, AOW-10, BOW-4A, BOW-5, BOW-9, and BOW-10) at the MEA from 12/11/2013 to 10/9/2014. Water level data were collected using downhole in-situ Troll® dataloggers equipped with pressure transducers. Water levels were collected once per day from each monitoring well over the monitoring period, and are plotted in **Attachment A**.

Results of water level monitoring indicate the operation of irrigation well 732 caused a maximum of 2.2 feet of drawdown in the nearest monitoring well cluster (AOW-9/BOW-9) over a 100-day (3.3 month) irrigation well pumping period. Drawdown in other shallow monitoring wells was not significant and less than 0.5 feet. Drawdown measured in AOW-9 and BOW-9 was very similar, indicating the shallow Arikaree and Brule aquifers are in hydraulic communication as previously noted in the December 2013 summary report.

IRRIGATION WELL 732 OPERATING CONDITIONS

Pump operating and monitoring data collected during the 2014 irrigation season indicates irrigation well 732 pumped 57,742,980 gallons of groundwater over an approximate 100-day (3.3 month) period from late April to early August 2014. This equates to an average continuous pumping rate of 401 gpm over the 3.3 month operating period. Because the actual operating

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pumping rate of well 732 is approximately 800 gpm, we can infer well 732 pumped at a rate of 800 gpm for 12 hours each day during operating period. The observed 2014 irrigation operating conditions differed somewhat from the estimated operating conditions used in our December 2013 impact analysis (well 732 operating 11 hours per day for 5-months, or an average continuous pumping rate of 373 gpm).

GROUNDWATER FLOW MODEL CALIBRATION

The groundwater flow model used in the original December 2013 impact analysis was calibrated by simulating observed changes in water level elevation (drawdown) in shallow monitoring wells AOW-9/BOW-9 during the 2014 irrigation season using the updated irrigation well 732 operating conditions.

Aquifer parameters used in the "high transmissivity scenario" of the December 2013 irrigation well impact analysis were used as initial conditions for the model calibration. In order to calibrate the flow model and achieve a reasonable match between observed and simulated drawdown, the specific yield of the shallow Arikaree/Brule aquifer was lowered slightly from 0.15 to 0.10. A summary of calibrated flow model parameters and irrigation well operating conditions is summarized below:

Hydraulic conductivity - 8.2 ft/day.

Transmissivity - 1656 ft^2/day (aquifer thickness 202 feet).

The hydraulic gradient – 0.004, 300 degrees (NW)

Porosity – 0.15

Specific Yield – 0.10 (adjusted downward from 0.15 to calibrate the model)

Pumping rate – 401 gpm for 3.3 months (100 days).

Results of the flow model calibration are shown in **Figures 2 and 3**. Observed and simulated drawdowns in wells AOW-9/BOW-9 are very similar, and simulated drawdown in other shallow monitoring wells is less than 0.5 feet as observed. Given these results, the model has been adequately calibrated and can be used to make predictions with a reasonable degree of accuracy.

REVISED IRRIGATION WELL IMPACT ANALYSIS

The calibrated groundwater flow model was used to calculate the 30-year capture zone of irrigation well 732. Particle-tracking techniques were used to illustrate the 30-year capture zone of irrigation well 732 to assess whether a hypothetical shallow casing leak from the MEA wellfields could potentially impact the irrigation well.

For purposes of this analysis, we have assumed a conservative (worse-case) scenario in which irrigation well 732 pumps the maximum allowable amount of groundwater (251 acre-ft/year, 373 gpm for 5-months) and a hypothetical shallow casing leak occurs at some time along the downgradient portion of the adjacent ISR wellfields at the MEA. These are the same operating conditions assumed in the original December 2013 impact analysis, which are considered to be more conservative than conditions observed during the 2014 growing season (e.g. 3.3 month operating period, 70% of permitted water right).

RESULTS AND CONCLUSIONS

The revised 30-year capture zone of irrigation well 732 is illustrated in **Figure 4**. Based on the results of this analysis, MEA wellfields are not located within the capture zone of irrigation well 732. A shallow casing leak within the MEA wellfields will not impact irrigation well 732 at any time in the future given similar operating conditions. This conclusion is identical to the original December 2013 impact analysis.

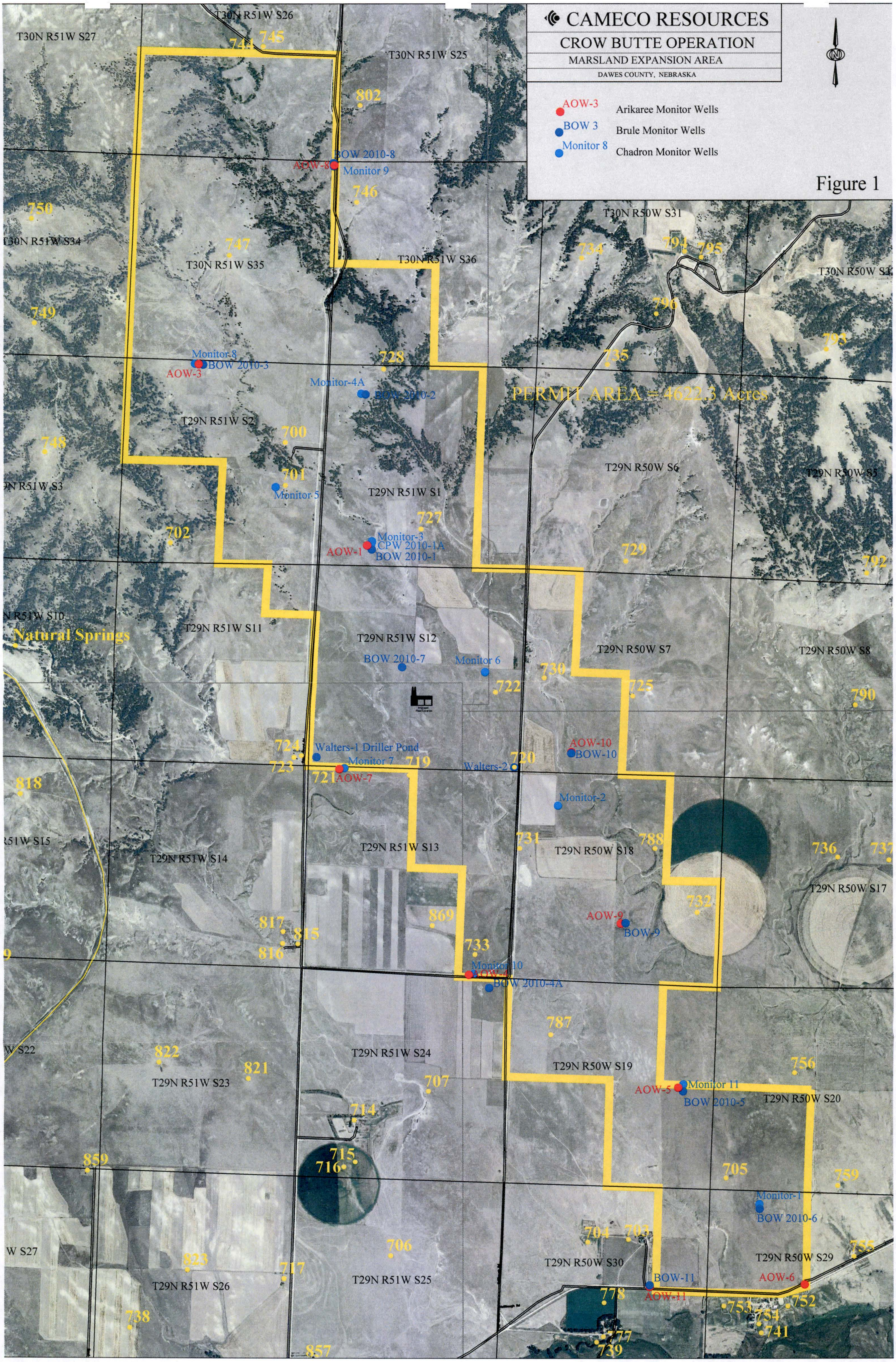
Given the location of other irrigation and domestic wells in the area (Figure 1, Appendix A Technical Report) and configuration of the worse-case capture zone, it is reasonable to conclude there are no other wells outside the MEA boundary that will be impacted by a potential release of MEA regulated material to the shallow aquifer. Therefore, the current MEA shallow groundwater monitoring network is adequate to ensure the protection of human health and environment.

If you have any questions or comments concerning this report, please contact me directly at 303-522-1118.

Sincerely,
AquiferTek

Robert Lewis

Robert L. Lewis, P.G.
Principal Hydrogeologist


CAMECO RESOURCES
CROW BUTTE OPERATION
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA
AOW-3 Arikaree Monitor Wells
BOW 3 Brule Monitor Wells
Monitor 8 Chadron Monitor Wells
Figure 1
PERMIT AREA = 4622.3 Acres
Natural Springs
T30N R51W S26
T30N R51W S27
T30N R51W S25
T30N R51W S34
T30N R51W S35
T30N R51W S36
T30N R50W S31
T29N R51W S2
T29N R51W S1
T29N R50W S6
T29N R50W S5
T29N R51W S11
T29N R51W S12
T29N R50W S7
T29N R50W S8
T29N R51W S14
T29N R51W S13
T29N R50W S18
T29N R50W S17
T29N R51W S23
T29N R51W S24
T29N R50W S19
T29N R50W S20
T29N R51W S26
T29N R51W S25
T29N R50W S30
T29N R50W S29
AOW-8
BOW 2010-8
Monitor 9
Monitor 8
BOW 2010-3
AOW-3
Monitor-4A
BOW 2010-2
Monitor 5
Monitor-3
CPW 2010-1A
BOW 2010-1
AOW-1
BOW 2010-7
Monitor 6
Walters-1 Driller Pond
Monitor 7
AOW-7
Walters-2
AOW-10
BOW-10
Monitor-2
AOW-9
BOW-9
Monitor 10
AOW-4
BOW 2010-4A
AOW-5
Monitor 11
BOW 2010-5
Monitor-1
BOW 2010-6
BOW-11
AOW-11
AOW-6
744
745
802
746
750
747
749
748
728
700
701
702
727
734
794
795
796
793
735
729
792
730
722
725
790
724
723
721
719
720
818
731
788
736
737
732
817
815
816
869
733
787
822
821
707
756
714
715
716
859
705
759
704
703
755
823
717
706
778
752
753
754
741
738
777
739
857

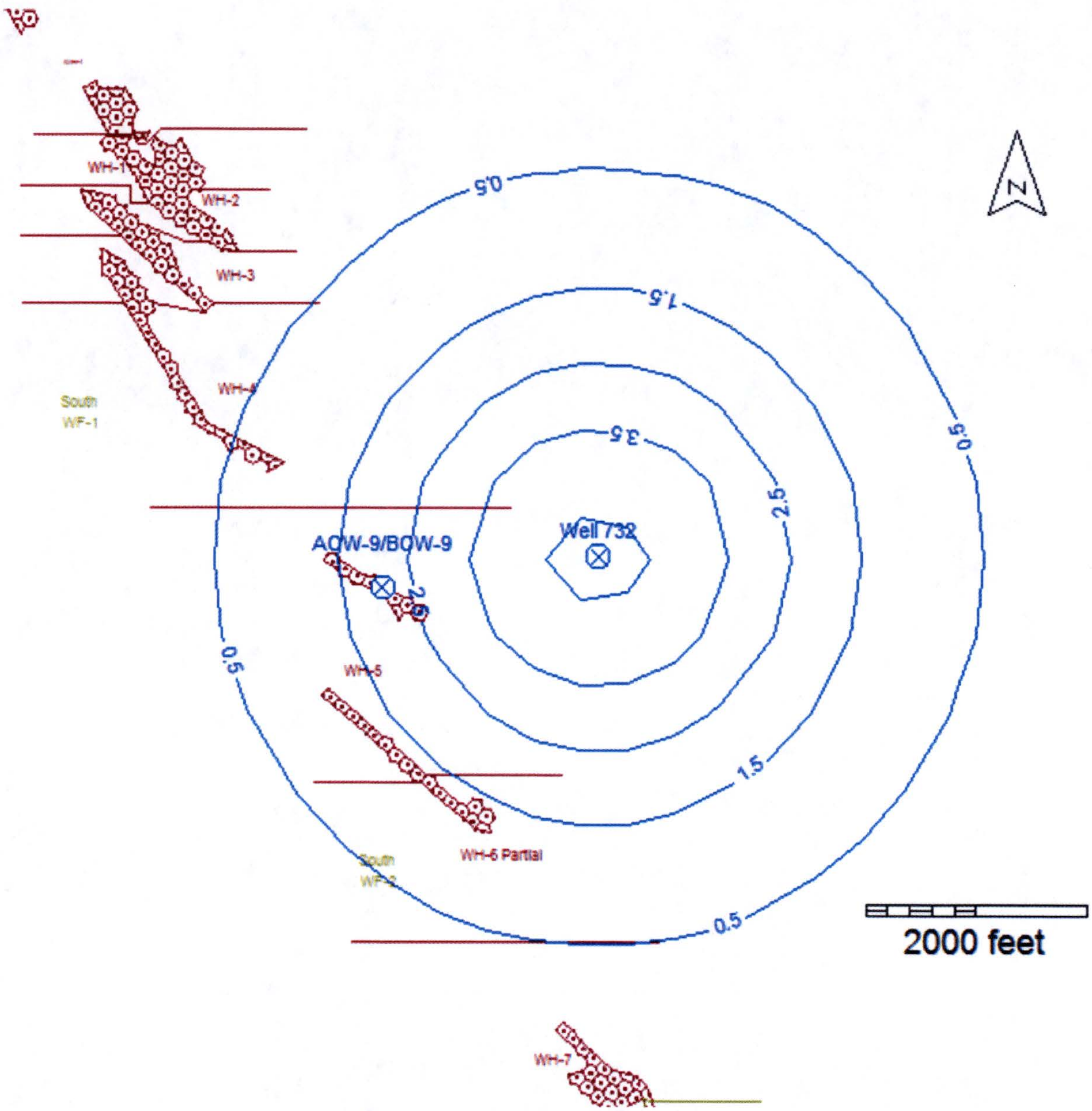


Figure 2. Calibrated maximum drawdown contour map, 2014 Irrigation Season.

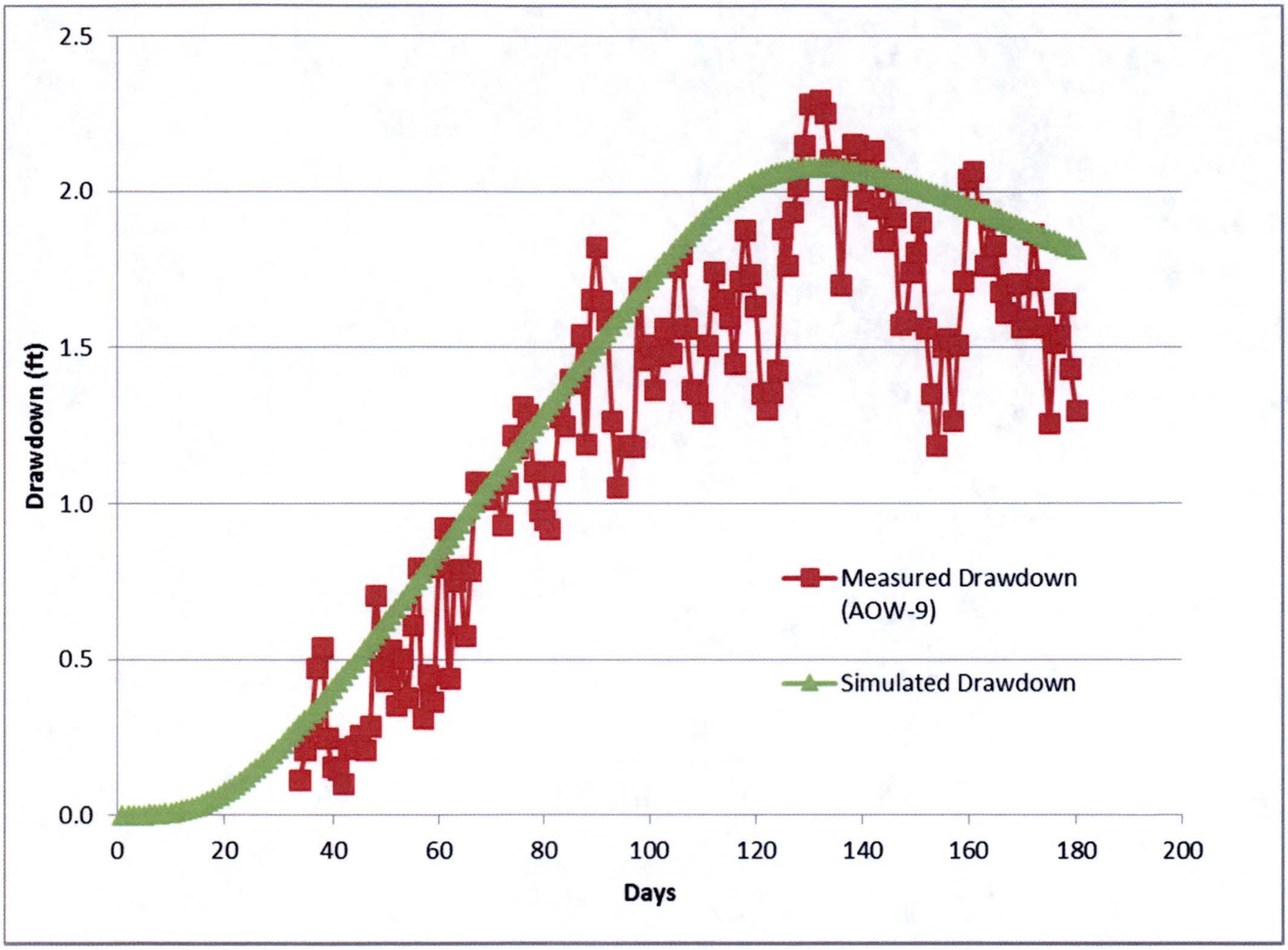


Figure 3. Simulated vs. Observed Drawdown in shallow monitoring well AOW-09, Irrigation Well 732 calibration.

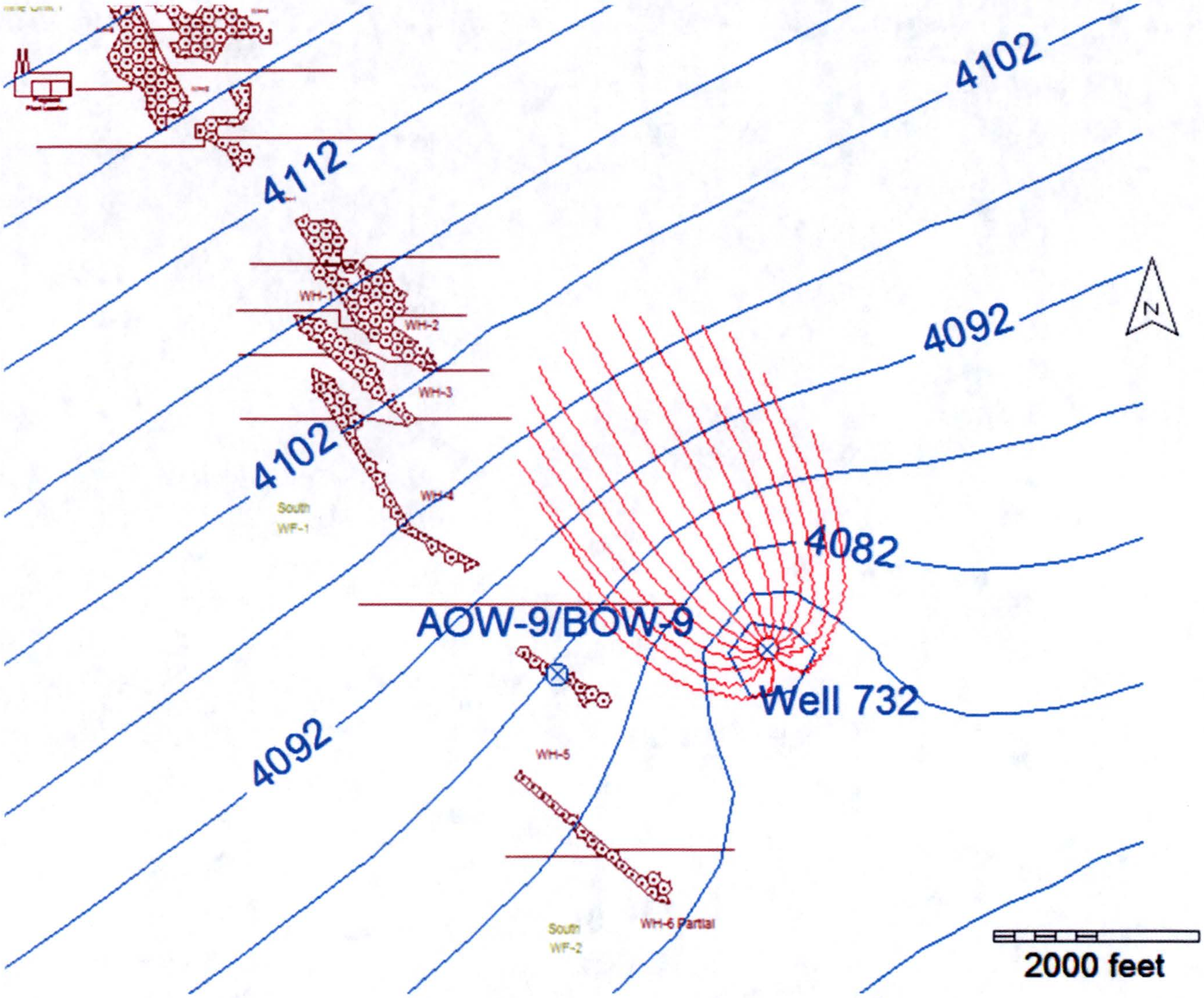
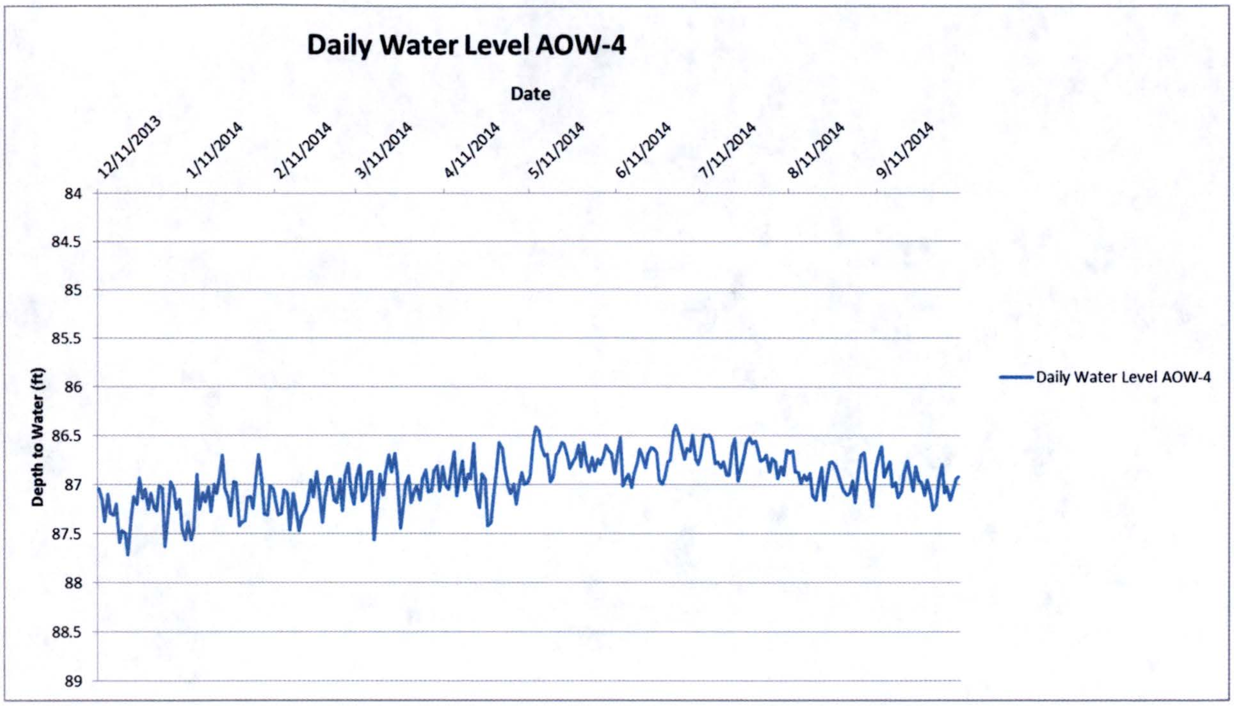


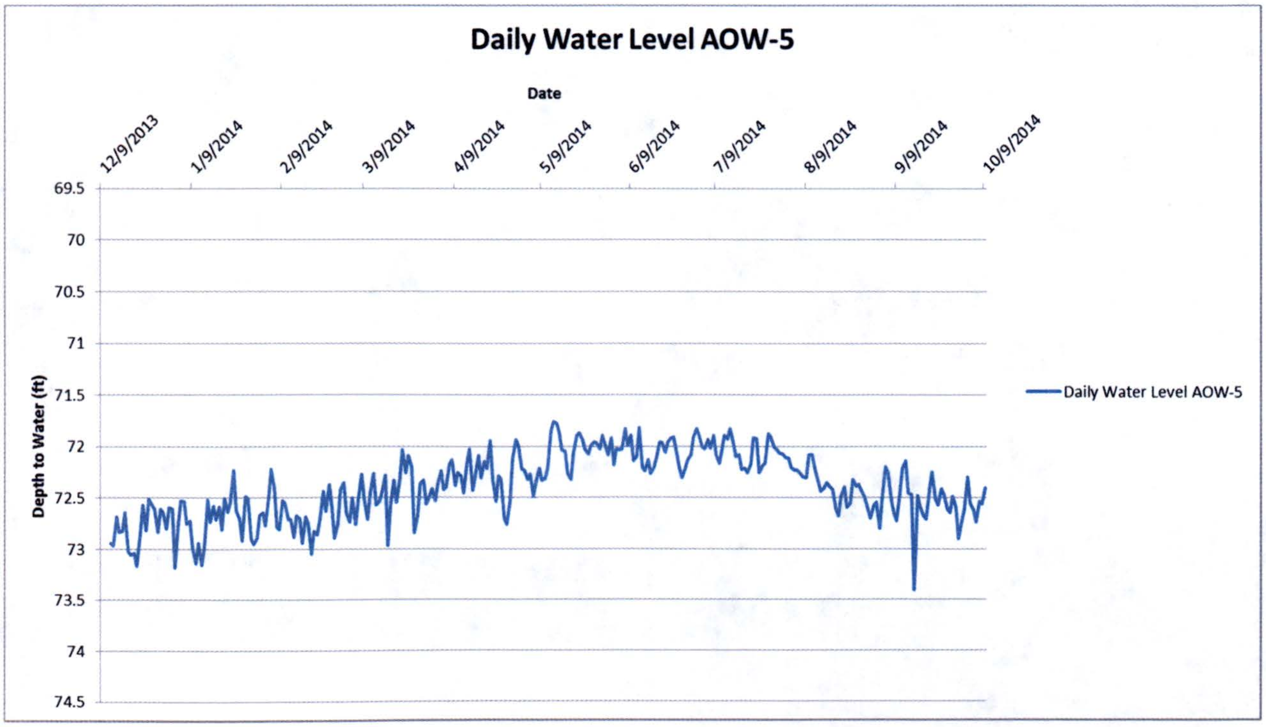
Figure 4. 30-year capture zone of Irrigation Well 732.

ATTACHMENT A

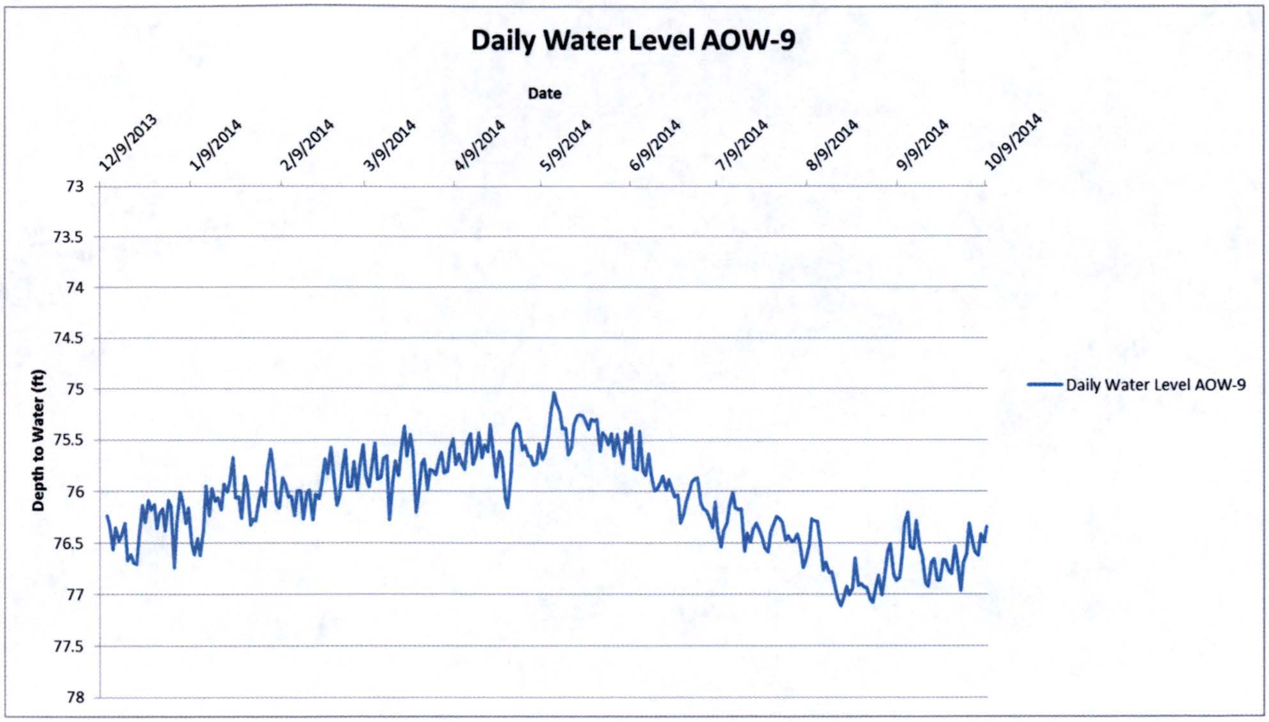
WATER LEVEL MONITORING DATA



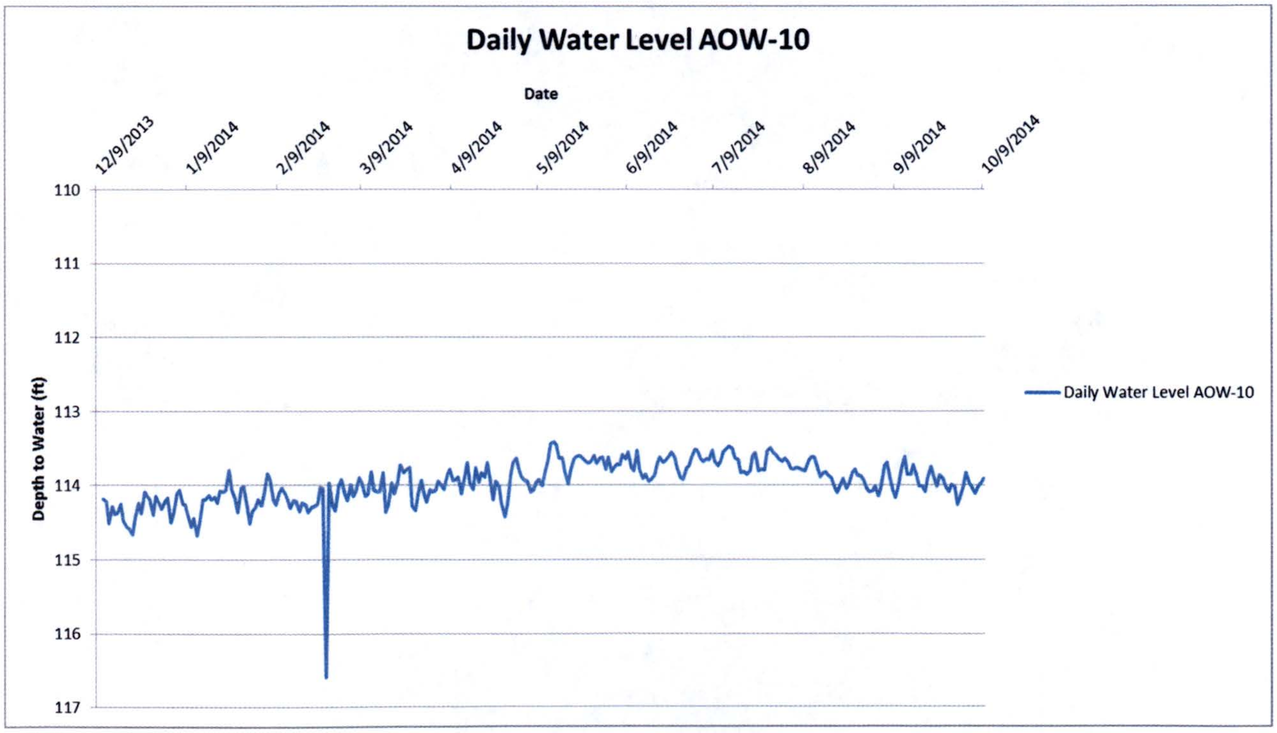
Daily Water Level AOW-4
Date
12/11/2013
1/11/2014
2/11/2014
3/11/2014
4/11/2014
5/11/2014
6/11/2014
7/11/2014
8/11/2014
9/11/2014
84
84.5
85
85.5
86
86.5
87
87.5
88
88.5
89
Depth to Water (ft)
Daily Water Level AOW-4



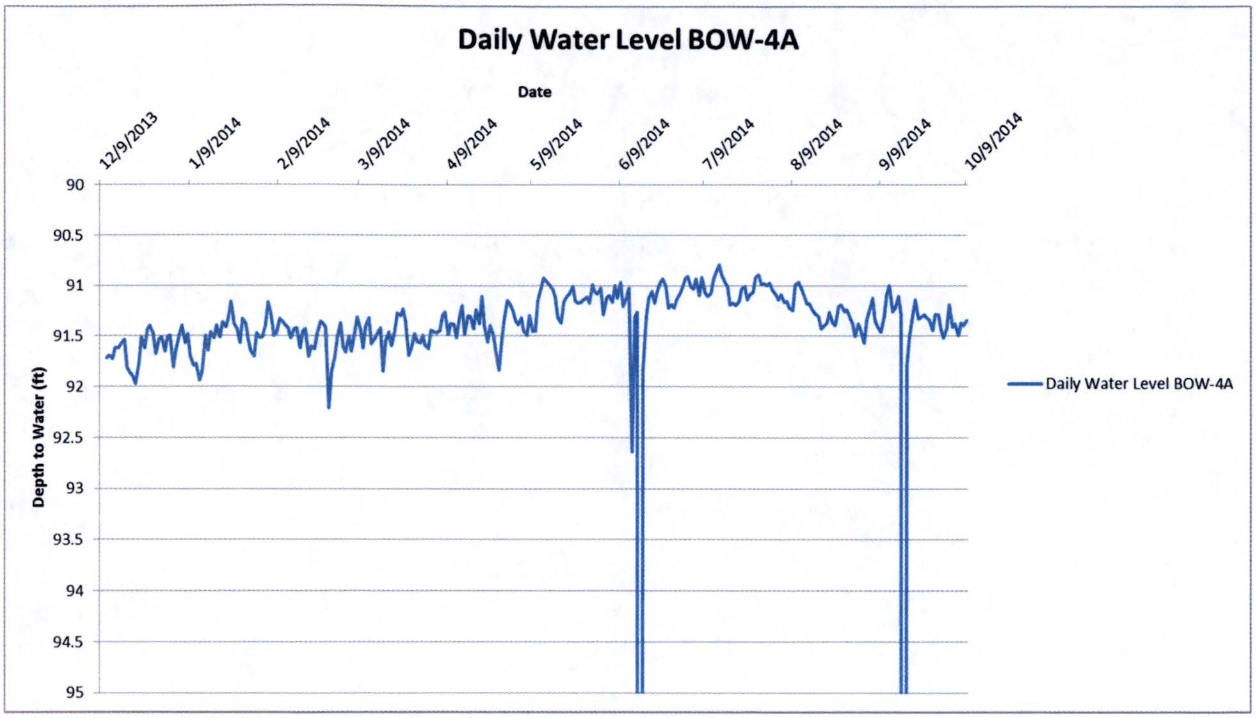
Daily Water Level AOW-5
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
69.5
70
70.5
71
71.5
72
72.5
73
73.5
74
74.5
Depth to Water (ft)
Daily Water Level AOW-5

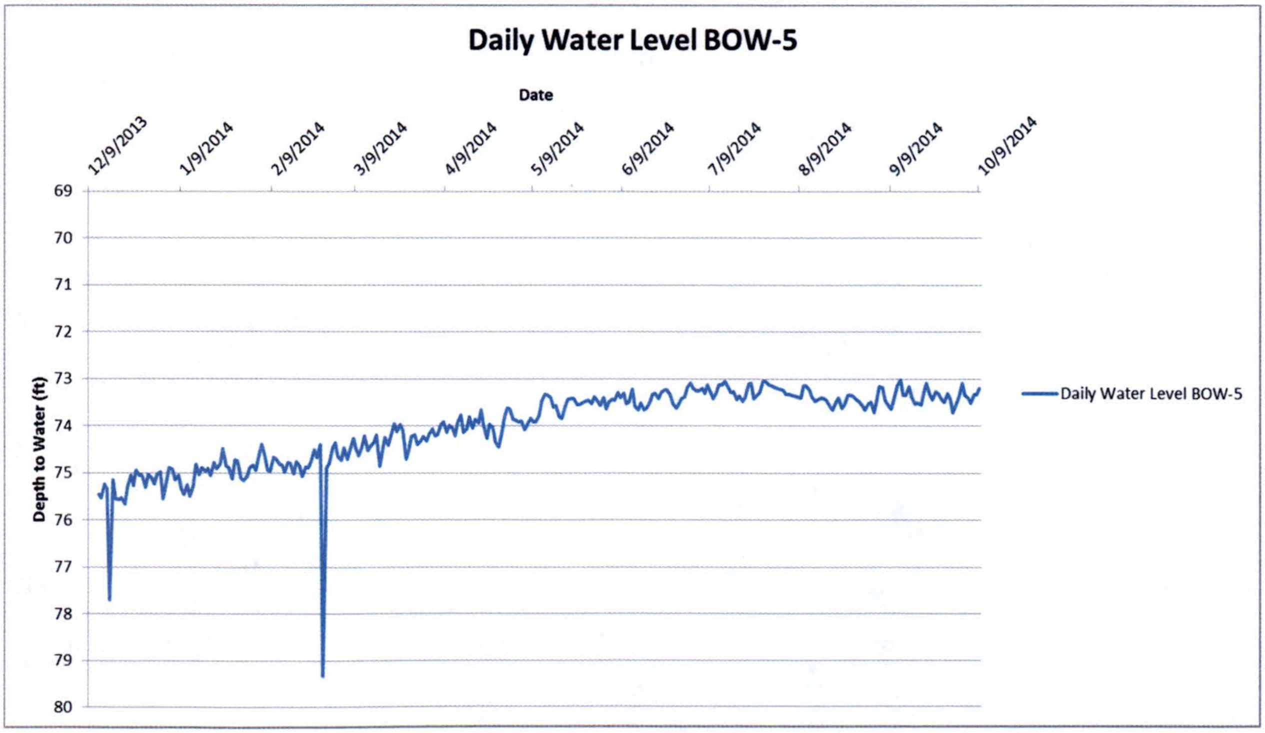


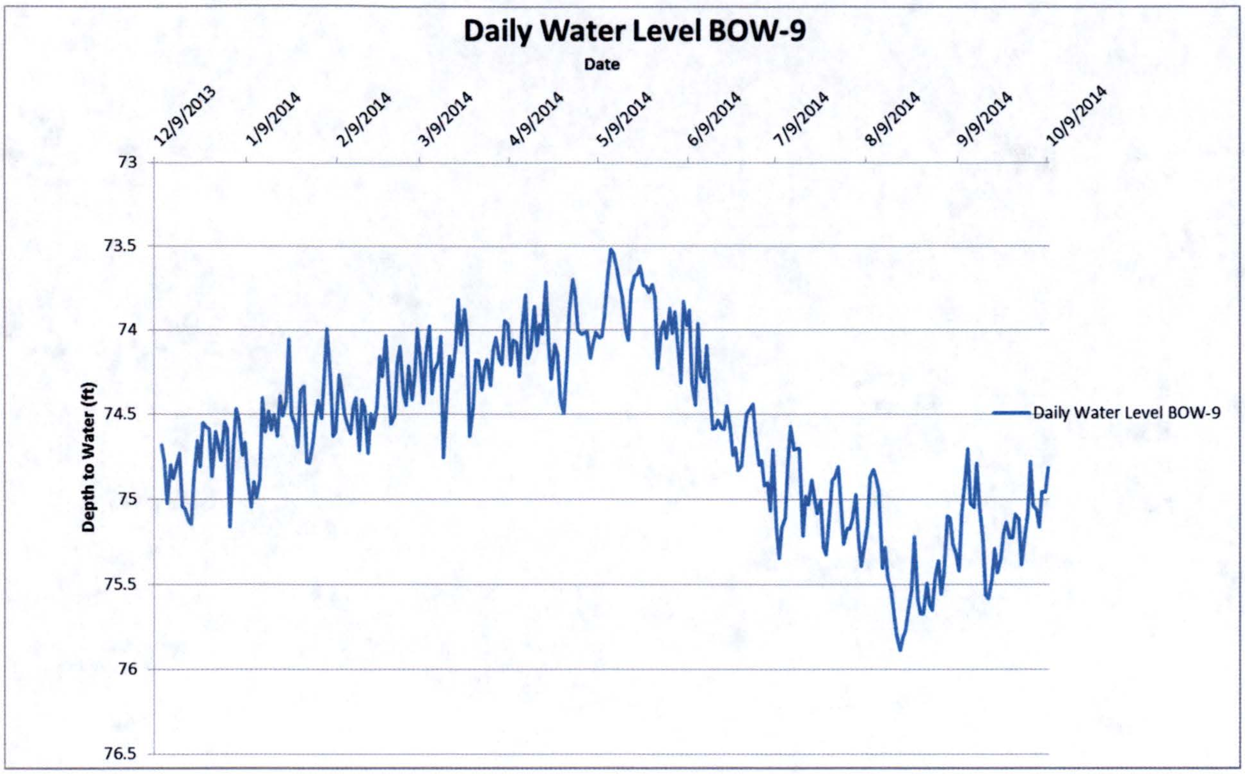
Daily Water Level AOW-9
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
Depth to Water (ft)
73
73.5
74
74.5
75
75.5
76
76.5
77
77.5
78
Daily Water Level AOW-9

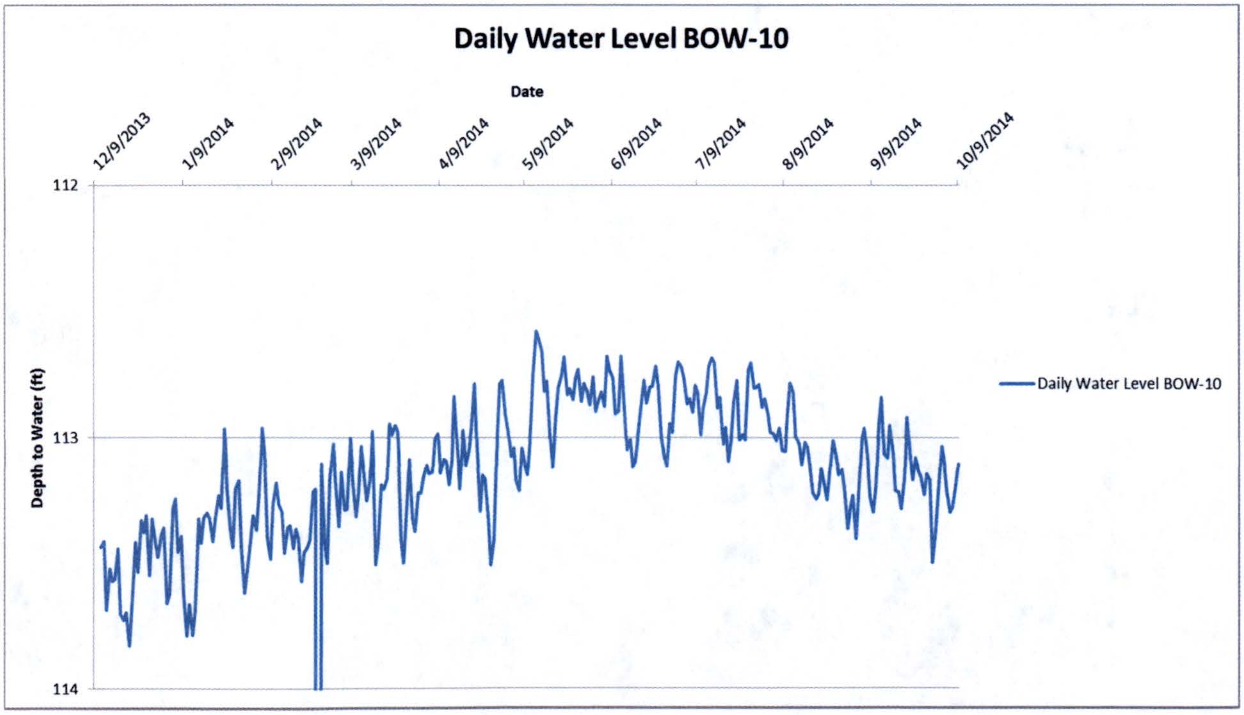


Daily Water Level AOW-10
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
Depth to Water (ft)
110
111
112
113
114
115
116
117
Daily Water Level AOW-10


Daily Water Level BOW-4A
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
Depth to Water (ft)
90
90.5
91
91.5
92
92.5
93
93.5
94
94.5
95
Daily Water Level BOW-4A


Daily Water Level BOW-5
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
Depth to Water (ft)
69
70
71
72
73
74
75
76
77
78
79
80
Daily Water Level BOW-5


Daily Water Level BOW-9
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
73
73.5
74
74.5
75
75.5
76
76.5
Depth to Water (ft)
Daily Water Level BOW-9


Daily Water Level BOW-10
Date
12/9/2013
1/9/2014
2/9/2014
3/9/2014
4/9/2014
5/9/2014
6/9/2014
7/9/2014
8/9/2014
9/9/2014
10/9/2014
112
113
114
Depth to Water (ft)
Daily Water Level BOW-10

Appendix FF

Quarterly Water Level Data

MARSLAND WATER LEVELS

October 17, 2013

General Well ID	Ground Level Elevation	Distance from Ground To Measurement Point	Water Level Depth At Measurement Point	Water Level Elevation	Surveyed Top East Coordinate	Surveyed Top North Coordinate	Notes
Monitor 1	4101.5	1.8	399.4	3703.9	1131520.7	429027.9	
Monitor 2	4197.2	2.3	500.3	3699.2	1126362.4	439439.1	
Monitor 3	4260.2	1.2	565.5	3695.9	1121518.7	446287.7	
Monitor 4A	4326.3	3.4	634.3	3695.4	1121344.1	450083.5	
Monitor 5	4337.4	3.4	645.4	3695.4	1119235.5	447734.4	
Monitor 6	4213.8	2.6	518.2	3698.2	1124385.2	442856.5	
Monitor 7	4243.2	3.1	548.0	3698.3	1120757.2	440358.4	
Monitor 8	4352.4	3.5	660.5	3695.4	1117004.9	450973.8	
Monitor 9	4364.6	2.4	669.7	3697.3	1120642.7	456122.8	
Monitor 10	4160.5	3.5	465.0	3699.0	1124017.9	435031.4	
Monitor 11	4124.2	3.9	427.9	3700.2	1129466.6	432062.9	
CPW-2010-1	4259.8	1.6	565.3	3696.1	1121527.7	446224.8	
CPW-2010-1A	4261.1	2.2	567.0	3696.3	1121450.2	446202.0	
BOW-2010-1	4259.2	0.9	124.9	4135.2	1121572.0	446250.5	
BOW-2010-2	4322.3	2.7	151.4	4173.6	1121367.4	450154.1	
BOW-2010-3	4349.8	3.0	139.6	4213.2	1117056.4	450973.9	
BOW-2010-4A	4162.4	0.7	93.7	4069.4	1124588.9	434717.3	
BOW-2010-5	4125.0	2.9	74.0	4053.9	1129467.0	432093.7	
BOW-2010-6	4099.2	1.2	50.3	4050.1	1131536.4	429001.7	
BOW-2010-7	4247.6	0.8	155.6	4092.8	1122449.2	442906.1	
BOW-2010-8	4366.4	2.9	74.0	4295.3	1120638.9	456205.1	
BOW-9	4144.9	1.0	74.6	4071.3	1128100.5	436375.6	
BOW-10	4196.7	1.1	113.8	4084.0	1126708.4	440807.5	
BOW-11	4091.0	0.9	37.4	4054.5	1128708.9	426957.2	
AOW-1	4260.6	1.0	126.4	4135.2	1121484.3	446205.9	
AOW-3	4351.1	0.9	142.2	4209.8	1117032.7	450950.3	
AOW-4	4161.0	0.9	87.3	4074.6	1124044.4	435036.8	
AOW-5	4124.3	1.1	72.0	4053.4	1129444.7	432092.1	
AOW-6	4067.6	1.0	20.0	4048.6	1132761.2	426945.1	
AOW-7	4242.9	1.0	DRY HOLE	N/A	1120713.3	440391.7	
AOW-8	4364.2	0.8	71.7	4293.3	1120636.6	456107.5	
AOW-9	4145.3	1.1	74.9	4071.5	1127974.4	436369.7	
AOW-10	4197.7	0.9	113.3	4085.3	1126707.0	440838.5	
AOW-11	4090.2	0.8	35.4	4055.6	1128712.0	426919.7	
Collected by TJ, LE							

MARSLAND WATER LEVELS

January 21, 2014

General Well ID	Ground Level Elevation	Distance from Ground To Measurement Point	Water Level Depth At Measurement Point	Water Level Elevation	Surveyed Top East Coordinate	Surveyed Top North Coordinate	Notes
Monitor 1	4101.5	1.8	402.3	3701.0	1131520.7	429027.9	
Monitor 2	4197.2	2.3	502.1	3697.4	1126362.4	439439.1	
Monitor 3	4260.2	1.2	566.6	3694.8	1121518.7	446287.7	
Monitor 4A	4326.3	3.4	636.6	3693.1	1121344.1	450083.5	
Monitor 5	4337.4	3.4	647.4	3693.4	1119235.5	447734.4	
Monitor 6	4213.8	2.6	520.2	3696.2	1124385.2	442856.5	
Monitor 7	4243.2	3.1	549.9	3696.4	1120757.2	440358.4	
Monitor 8	4352.4	3.5	663.6	3692.3	1117004.9	450973.8	
Monitor 9	4364.6	2.4	674.0	3693.0	1120642.7	456122.8	
Monitor 10	4160.5	3.5	466.8	3697.2	1124017.9	435031.4	
Monitor 11	4124.2	2.5	428.3	3698.4	1129466.6	432062.9	
CPW-2010-1	4259.8	1.6	567.3	3694.1	1121527.7	446224.8	
CPW-2010-1A	4261.1	2.2	569.0	3694.3	1121450.2	446202.0	
BOW-2010-1	4259.2	0.9	125.0	4135.1	1121572.0	446250.5	
BOW-2010-2	4322.3	1.4	150.1	4173.6	1121367.4	450154.1	
BOW-2010-3	4349.8	0.7	137.2	4213.3	1117056.4	450973.9	
BOW-2010-4A	4162.4	0.7	93.4	4069.7	1124588.9	434717.3	
BOW-2010-5	4125.0	2.9	74.9	4053.0	1129467.0	432093.7	*
BOW-2010-6	4099.2	1.2	49.9	4050.5	1131536.4	429001.7	
BOW-2010-7	4247.6	0.8	155.5	4092.9	1122449.2	442906.1	
BOW-2010-8	4366.4	0.5	71.6	4295.3	1120638.9	456205.1	
BOW-9	4144.9	1.0	74.5	4071.4	1128100.5	436375.6	*
BOW-10	4196.7	1.1	113.2	4084.6	1126708.4	440807.5	*
BOW-11	4091.0	0.9	37.1	4054.8	1128708.9	426957.2	
AOW-1	4260.6	1.0	126.3	4135.3	1121484.3	446205.9	
AOW-3	4351.1	0.9	142.4	4209.6	1117032.7	450950.3	
AOW-4	4161.0	0.9	87.1	4074.8	1124044.4	435036.8	*
AOW-5	4124.3	1.1	72.6	4052.8	1129444.7	432092.1	*
AOW-6	4067.6	1.0	19.7	4048.9	1132761.2	426945.1	
AOW-7	4242.9	1.0	DRY HOLE	N/A	1120713.3	440391.7	
AOW-8	4364.2	0.9	71.8	4293.3	1120636.6	456107.5	
AOW-9	4145.3	1.1	73.7	4072.7	1127974.4	436369.7	
AOW-10	4197.7	0.9	114.1	4084.5	1126707.0	440838.5	*
AOW-11	4090.2	0.8	35.2	4055.8	1128712.0	426919.7	

* Water Level Measured using Level-trol instrumentation

Collected by TJ, LE

MARSLAND WATER LEVELS

April 22, 2014

General Well ID	Ground Level Elevation	Distance from Ground To Measurement Point	Water Level Depth At Measurement Point	Water Level Elevation	Surveyed Top East Coordinate	Surveyed Top North Coordinate	Notes
Monitor 1	4101.5	1.8	404.1	3699.2	1131520.7	429027.9	
Monitor 2	4197.2	2.3	503.9	3695.6	1126362.4	439439.1	
Monitor 3	4260.2	1.2	568.6	3692.8	1121518.7	446287.7	
Monitor 4A	4326.3	3.4	638.7	3691.0	1121344.1	450083.5	
Monitor 5	4337.4	3.4	649.3	3691.5	1119235.5	447734.4	
Monitor 6	4213.8	2.6	522.1	3694.3	1124385.2	442856.5	
Monitor 7	4243.2	3.1	551.8	3694.5	1120757.2	440358.4	
Monitor 8	4352.4	3.5	665.7	3690.2	1117004.9	450973.8	
Monitor 9	4364.6	2.4	678.8	3688.2	1120642.7	456122.8	
Monitor 10	4160.5	3.5	467.8	3696.2	1124017.9	435031.4	
Monitor 11	4124.2	2.5	430.1	3696.6	1129466.6	432062.9	
CPW-2010-1	4259.8	1.6	569.3	3692.1	1121527.7	446224.8	
CPW-2010-1A	4261.1	2.2	571.0	3692.3	1121450.2	446202.0	
BOW-2010-1	4259.2	0.9	124.8	4135.3	1121572.0	446250.5	
BOW-2010-2	4322.3	1.4	149.9	4173.8	1121367.4	450154.1	
BOW-2010-3	4349.8	0.7	137.1	4213.4	1117056.4	450973.9	
BOW-2010-4A	4162.4	0.7	91.3	4071.8	1124588.9	434717.3	*
BOW-2010-5	4125.0	2.9	73.8	4054.1	1129467.0	432093.7	*
BOW-2010-6	4099.2	1.2	49.4	4051.0	1131536.4	429001.7	
BOW-2010-7	4247.6	0.8	155.1	4093.3	1122449.2	442906.1	
BOW-2010-8	4366.4	0.5	71.4	4295.5	1120638.9	456205.1	
BOW-9	4144.9	1.0	73.8	4072.1	1128100.5	436375.6	*
BOW-10	4196.7	1.1	112.8	4085.0	1126708.4	440807.5	*
BOW-11	4091.0	0.9	36.5	4055.4	1128708.9	426957.2	
AOW-1	4260.6	1.0	126.0	4135.6	1121484.3	446205.9	
AOW-3	4351.1	0.9	141.9	4210.1	1117032.7	450950.3	
AOW-4	4161.0	0.9	86.6	4075.3	1124044.4	435036.8	*
AOW-5	4124.3	1.1	71.9	4053.5	1129444.7	432092.1	*
AOW-6	4067.6	1.0	19.7	4048.9	1132761.2	426945.1	
AOW-7	4242.9	1.0	DRY HOLE	N/A	1120713.3	440391.7	
AOW-8	4364.2	0.9	71.6	4293.5	1120636.6	456107.5	
AOW-9	4145.3	1.1	75.5	4070.9	1127974.4	436369.7	*
AOW-10	4197.7	0.9	113.7	4084.9	1126707.0	440838.5	*
AOW-11	4090.2	0.8	34.6	4056.4	1128712.0	426919.7	

* Water Level Measured using Level-trol instrumentation
Collected by TJ, LE, WB

MARSLAND WATER LEVELS

July 14, 2014

General Well ID	Ground Level Elevation	Distance from Ground To Measurement Point	Water Level Depth At Measurement Point	Water Level Elevation	Surveyed Top East Coordinate	Surveyed Top North Coordinate	Notes
Monitor 1	4101.5	1.8	405.6	3697.7	1131520.7	429027.9	
Monitor 2	4197.2	2.3	505.5	3694.0	1126362.4	439439.1	
Monitor 3	4260.2	1.2	570.0	3691.4	1121518.7	446287.7	
Monitor 4A	4326.3	3.4	640.1	3689.6	1121344.1	450083.5	
Monitor 5	4337.4	3.4	650.7	3690.1	1119235.5	447734.4	
Monitor 6	4213.8	2.6	523.3	3693.1	1124385.2	442856.5	
Monitor 7	4243.2	3.1	553.3	3693.0	1120757.2	440358.4	
Monitor 8	4352.4	3.5	667.1	3688.8	1117004.9	450973.8	
Monitor 9	4364.6	2.4	680.1	3686.9	1120642.7	456122.8	
Monitor 10	4160.5	3.5	469.3	3694.7	1124017.9	435031.4	
Monitor 11	4124.2	2.5	431.7	3695.0	1129466.6	432062.9	
CPW-2010-1	4259.8	1.6	570.8	3690.6	1121527.7	446224.8	
CPW-2010-1A	4261.1	2.2	572.4	3690.9	1121450.2	446202.0	
BOW-2010-1	4259.2	0.9	124.9	4135.2	1121572.0	446250.5	
BOW-2010-2	4322.3	1.4	150.0	4173.7	1121367.4	450154.1	
BOW-2010-3	4349.8	0.7	137.2	4213.3	1117056.4	450973.9	
BOW-2010-4A	4162.4	0.7	90.4	4072.7	1124588.9	434717.3	*
BOW-2010-5	4125.0	2.9	73.0	4054.9	1129467.0	432093.7	*
BOW-2010-6	4099.2	1.2	49.6	4050.8	1131536.4	429001.7	
BOW-2010-7	4247.6	0.8	155.2	4093.2	1122449.2	442906.1	
BOW-2010-8	4366.4	0.5	71.3	4295.6	1120638.9	456205.1	
BOW-9	4144.9	1.0	74.6	4071.3	1128100.5	436375.6	*
BOW-10	4196.7	1.1	112.7	4085.1	1126708.4	440807.5	*
BOW-11	4091.0	0.9	36.9	4055.0	1128708.9	426957.2	
AOW-1	4260.6	1.0	126.3	4135.3	1121484.3	446205.9	
AOW-3	4351.1	0.9	142.2	4209.8	1117032.7	450950.3	
AOW-4	4161.0	0.9	86.5	4075.4	1124044.4	435036.8	*
AOW-5	4124.3	1.1	71.8	4053.6	1129444.7	432092.1	*
AOW-6	4067.6	1.0	19.4	4049.2	1132761.2	426945.1	
AOW-7	4242.9	1.0	DRY HOLE	N/A	1120713.3	440391.7	
AOW-8	4364.2	0.9	71.5	4293.6	1120636.6	456107.5	
AOW-9	4145.3	1.1	76.0	4070.4	1127974.4	436369.7	
AOW-10	4197.7	0.9	113.5	4085.1	1126707.0	440838.5	*
AOW-11	4090.2	0.8	34.8	4056.2	1128712.0	426919.7	

* Water Level Measured using Level-trol instrumentation

Collected by LE, WB

Response to Open Issues
Marsland Expansion Area
Technical Report

Attachment G

Replacement tables and figures for Volume II of the Marsland Expansion Area Technical Report

- **Table 2.2-11 – Active, Inactive, Seasonal, and Abandon Well Table**
- **Table 2.6-2 – Representative Stratigraphic Section – MEA**
- **Table 2.9-9 – Radiological Analytical Results for the Brule**
- **Figure 2.7-6 – Major Surface Features/Structures With AOR**
- **Figure 2.9-3 – Private Wells Located Within One and Two Kilometers of the MEA**

Replacement pages for Volume III of the Marsland Expansion Area Technical Report

- **Appendix A – Water User Survey**

Replacement pages for Volume IV of the Marsland Expansion Area Technical Report

- **Appendix T – Marsland Water Balance**
- **Appendix AA-2 – AquiferTek Revised MEA Agricultural Well Impact Analysis**
- **Appendix FF – MEA Quarterly Water Level Data**

New Appendix Volume IV of the Marsland Expansion Area Technical Report

- **Appendix GG – Drawdown Impact Assessment, MEA**

Appendix GG

Drawdown Impact Assessment MEA

AquiferTek

Mr. Robert Tiensvold May 11, 2016
Mine Manager
Cameco Resources
Crow Butte Facility
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Re: Drawdown Impact Assessment, Marsland Expansion Area (MEA)

This report has been prepared in response to a request by the U.S. Nuclear Regulatory Commission (NRC) for an analysis of the drawdown impacts resulting from Marsland Expansion Area (MEA) operations, and the cumulative drawdown impacts resulting from the simultaneous operation of the MEA, Crow Butte (CBO), and Three Crow Expansion Area (TCEA) facilities. The scope of work for this analysis is provided in a summary of the April 6, 2016 teleconference between the NRC and Crow Butte Resources.

METHODOLOGY

Drawdown of the potentiometric surface of the Basal Chadron Aquifer was computed using the Theis solution for confined aquifers (Theis, 1935) included in AquiferWin32® analytical modeling software by Environmental Simulations Inc. Drawdown impacts were computed over the period 2011 through 2052, corresponding to the approximate historical groundwater monitoring period at MEA, future ISR facility operations, and aquifer recovery period. Cumulative drawdown impacts from multiple ISR facilities were computed by summing the drawdown impacts of individual facilities using the principal of superposition. Additional drawdown resulting from a lateral no-flow boundary was computed using image well theory (e.g. Ferris and others, 1962).

MODEL INPUT PARAMETERS

Aquifer transmissivity and storativity for MEA, CBO, and TCEA were obtained from results of site-specific aquifer testing (Aqui-Ver, 2015). Representative values of aquifer transmissivity and storativity for each facility were input into the analytical flow model as follows:

MEA: Transmissivity = 1012 ft^2/day

Storage Coefficient = 7.46×10^{-5}

CBO: Transmissivity = 479 ft^2/day (Initial Estimate)

Storage Coefficient = 8.8 x 10^{-5} (Initial Estimate)

TCEA: Transmissivity = 480 ft^2/day

Storage Coefficient = 8.8 x 10^{-5}

Transmissivity and storativity values for the CBO facility were lowered from initial estimates cited above as part of the model calibration process (described in more detail later in this report).

Pumping rates for the drawdown impact assessment were assigned based on future annual average consumptive use estimates provided by Cameco Resources for MEA, CBO, and TCEA (**Attachment A**). Future consumptive use estimates assume 25% Reverse Osmosis (RO) efficiency at CBO based on historical performance, and 30% RO efficiency at MEA and TCEA (conservative estimate). For the period 2011-2015, actual consumptive use rates were used for the CBO facility (**Attachment A**).

Simulated pumping well locations for MEA, CBO and TCEA are shown in **Figures 1 and 2**. The total discharge rate for each mine unit at MEA was distributed evenly between six wells per mine unit in order to provide a more detailed assessment of drawdown within ISR wellfields at MEA. Discharge from mine units at CBO and TCEA was assigned to a single well location in each mine unit given the regional nature of drawdown impacts from these facilities upon the MEA.

DRAWDOWN IMPACT ASSESSMENT (THEIS ANALYSIS)

ISR operations at MEA were initially projected to begin in 2015 (e.g. Appendix T of the MEA Technical Report). The projected start of ISR operations at MEA is assumed to be January 2020 for purposes of this assessment. Drawdown impacts resulting from MEA operations were computed over the period 2020 to 2042, the expected duration of MEA ISR operations. A 10-year aquifer recovery period was also simulated over the period 2042 through 2052.

The projected drawdown impact due to MEA operations using the Theis solution is illustrated on the drawdown contour map in **Figure 3** for the year 2028 (time of maximum cumulative drawdown impacts at MEA). Projected drawdown impacts resulting from MEA operations in site monitoring wells, wellfields, and at a 2.25-mile radius from the MEA permit boundary (Area of Review) using the Theis solution are provided in **Figures 4 thru 16**. Maximum drawdown impacts within ISR wellfields and monitor wells due to MEA operations are projected to be less than 54 feet using the Theis solution.

Drawdown impacts at MEA resulting from CBO and TCEA operations were also computed using the Theis solution. Drawdown impacts from CBO operations were simulated over the historical operating period through the expected end of CBO operations in 2028. Drawdown impacts resulting from TCEA operations were computed from 2023 to 2042, the expected duration of TCEA ISR operations. Aquifer recovery at CBO and TCEA was simulated from the end of operations through 2052.

Drawdown impacts at MEA resulting from CBO and TCEA operations using the Theis solution are illustrated in **Figures 4 thru 16**. Maximum drawdown in MEA wellfields and monitor wells resulting from CBO and TCEA operations is projected to be less than 28 and 14 feet, respectively, over the period 2011 through 2042 using the Theis solution.

Cumulative drawdown impacts resulting from the simultaneous operation of MEA, CBO, and TCEA facilities were computed by summing drawdown impacts using the Theis solution from individual facilities (principal of superposition). Maximum cumulative drawdown (in year 2028) at the MEA is illustrated on the drawdown contour map in **Figure 17,** and on hydrographs in **Figures 4 thru 16**. Maximum cumulative drawdown within MEA wellfields and monitor wells is projected to be less than 77 feet over the period 2011 through 2042 using the Theis solution.

DRAWDOWN IMPACT ASSESSMENT INCLUDING NO-FLOW BOUNDARY

The predicted drawdown in MEA monitor wells over the period 2011-2015 is approximately 9 to 11 feet using the Theis solution and initial estimates of aquifer transmissivity (**Figures 4 thru 16**). The observed drawdown in MEA monitoring wells from 2011-2015, presumably due to CBO operations, is approximately 20 to 23 feet. Thus, the Theis drawdown impact model under-predicts observed drawdown at the MEA using initial estimates of aquifer parameters (and assuming no other sources of drawdown impacts). Adjusting initial estimates of transmissivity and storativity at CBO over a range of reasonable values does not significantly improve the under-prediction of drawdown at MEA.

Degraw (1969, 1982) and Sibray (2010) presented geological data from regional boreholes and oil and gas wells that illustrated the distribution of the Basal Chadron Sandstone in northwestern Nebraska. The Basal Chadron Sandstone was deposited in a fluvial stream environment within a regional paleochannel possessing lateral boundaries (corresponding to zero sandstone thickness). The eastern MEA and CBO permit boundaries are located approximately 3 miles west of the lateral flow boundary, which trends northwest-southeast parallel to the main mineralized trend at MEA and CBO. The finite extent of the Basal Chadron Sandstone to the east of the MEA and CBO forms a lateral no-flow boundary that would act to increase drawdown and is not accounted for using the conventional Theis drawdown solution.

Lateral groundwater flow boundaries can be accounted for using analytical modeling techniques (e.g. Theis solution) and image well theory (e.g. Ferris, 1962). To account for a no-flow

boundary using image well theory, a mirror image of the actual wellfield is created with the "mirror" located at the presumed location of the no-flow boundary. Drawdowns resulting from the actual and image wellfields are then added together using the principal of superposition.

Image well theory was applied to predict the drawdown resulting from a lateral no-flow boundary at MEA and CBO. To accomplish this, the drawdown predicted using the Theis solution for MEA and CBO were first added together using the principal of superposition. The resulting drawdown distribution was then transposed uniformly by a distance of 39,000 feet east and 9,000 feet north to create a mirror image of the drawdown resulting from CBO and MEA on the opposite side of the no-flow boundary. The image wellfield drawdown was then added to the cumulative Theis drawdown distribution. **Figure 18** illustrates the projected cumulative drawdown at MEA including a lateral no-flow boundary in the year 2028 (corresponding to the period of maximum cumulative drawdown at MEA and CBO). **Figure 19** is a hydrograph of the Mine Unit 1 wellfield showing the maximum cumulative drawdown including a lateral no-flow boundary. The maximum cumulative drawdown in MEA wellfields and monitor wells is projected to be less than 111 feet over the period of ISR operations (2011 to 2042).

In order for model projected drawdown to closely match observed drawdown at the MEA over the period 2011-2015 (e.g. model calibration), the transmissivity and storativity of the CBO drawdown model was reduced slightly (in addition to the inclusion of a lateral no-flow boundary). The resulting calibrated transmissivity and storativity of the CBO drawdown model is 360 ft^2/day and 4.0 x 10^{-5}, respectively (values are similar to results of aquifer tests 1 thru 3 at CBO).

Results of model drawdown calculations including a lateral no-flow boundary and calibrated transmissivity are in close agreement with observed drawdown in MEA monitor wells over the period 2011-2015 (approximately 20 feet of observed drawdown and model calculated drawdown). The drawdown model can therefore be considered calibrated for purposes of drawdown prediction.

REGIONAL DRAWDOWN IMPACTS

The NRC has requested an assessment of regional drawdown impacts due to simultaneous operation of CBO, MEA, and TCEA facilities. Regional drawdown impacts, including a lateral no-flow boundary, were calculated in a manner identical to MEA drawdown calculations (e.g. Theis drawdown, image well theory, and superposition). The resulting cumulative regional drawdown in 2028 (time of maximum cumulative drawdown at CBO and MEA) is provided on the drawdown contour map in **Figure 20.**

PROJECTED AVAILABLE HEAD AND POTENTIOMETRIC SURFFACE

The NRC has requested an analysis of the available hydraulic head above the top of the Basal Chadron Sandstone at the MEA at the time of maximum projected cumulative drawdown. To accomplish this task, the available head in February 2011 was computed by subtracting the elevation of the top of the Basal Chadron Sandstone from the February 2011 water level elevation. The available head at MEA in February 2011 is illustrated in **Figure 21**. The projected available head at MEA in 2028 (time of maximum cumulative drawdown) was then computed by subtracting the projected drawdown in 2028 (**Figure 18**) from the available head in February 2011 (**Figure 21**). The resulting projected available head at MEA in 2028 is provided in **Figure 22**. The available head at MEA is projected to be greater than 320 feet within MEA wellfields and greater than 270 feet within the MEA permit boundary during ISR operations (2011-2042).

The projected Basal Chadron potentiometric surface at the time of maximum cumulative drawdown was computed by subtracting the projected maximum drawdown in 2028 (**Figure 18**) from the February 2011 water level elevation (**Figure 23**). The resulting projected potentiometric surface at MEA in 2028 is shown in **Figure 24**.

RESULTS AND CONCLUSIONS

A drawdown impact assessment has been completed for the Basal Chadron Aquifer at the MEA and for the simultaneous operation of MEA, CBO, and TCEA ISR facilities (e.g. cumulative drawdown assessment). An assessment of the projected available head and Basal Chadron potentiometric surface at the time of maximum cumulative drawdown has also been completed.

Results of the impact assessment indicates maximum cumulative drawdown at the MEA will be less than 111 feet over the period of combined ISR operations (2011-2042). Minimum available head at the MEA is projected to be greater than 320 feet within MEA ISR wellfields, and greater than 270 feet within the MEA permit area for the duration of combined ISR operations.

Model drawdown projections can be considered conservative because they do not include the impact of groundwater recharge on the Basal Chadron aquifer over a large radius of influence, and because consumptive use for the MEA and TCEA are based in part on a conservative 30% Reverse Osmosis (RO) efficiency during wellfield restoration (25% RO efficiency has been routinely achieved at the CBO facility).

The drawdown impact assessment does not include potential drawdown impacts resulting from groundwater withdrawals other than Cameco ISR operations, including large seasonal agricultural groundwater withdrawals from a tributary arm of the Basal Chadron Aquifer approximately 35 to 50 miles southwest of MEA in the North Platte drainage. Irrigation wells in

the North Platte Irrigation District have been operating for over 40 years. Although there may not be a direct hydraulic connection between the tributary arm of the Basal Chadron Aquifer in the North Platte drainage and the MEA (e.g. Sibray, 2010), there does appear to be less direct flow paths (on the order of 60 to 100 miles in length) that may hydraulically connect the MEA and the North Platte basin. Given the large reported seasonal groundwater withdrawals in excess of 1000 gpm from the Basal Chadron Aquifer in the North Platte drainage, some measurable drawdown impact at the MEA would not be unexpected in a confined aquifer over a long period of time. Some of the historical drawdown observed at the MEA may therefore be attributable to irrigation withdrawals southwest of the MEA, and not entirely due to CBO operations.

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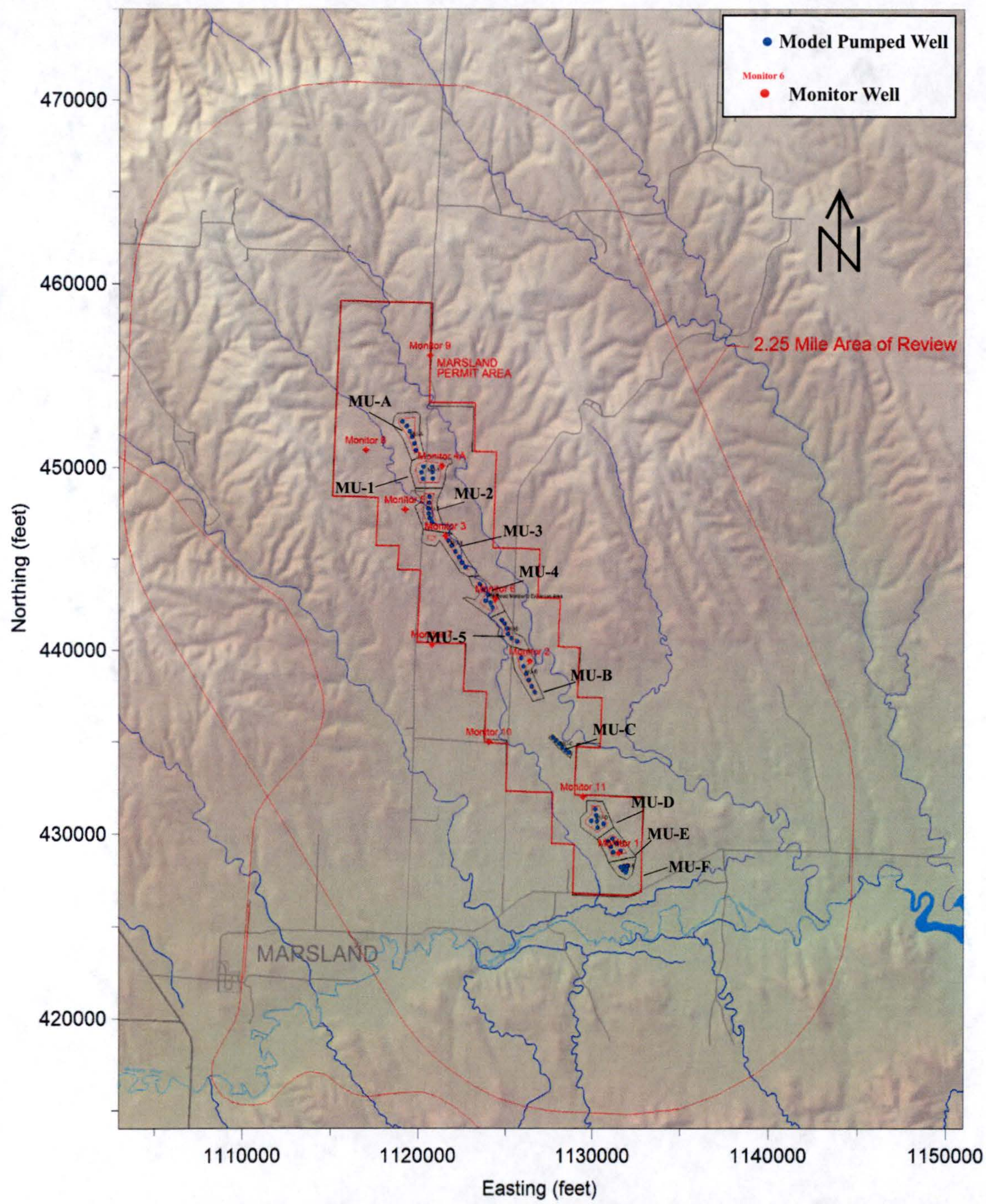
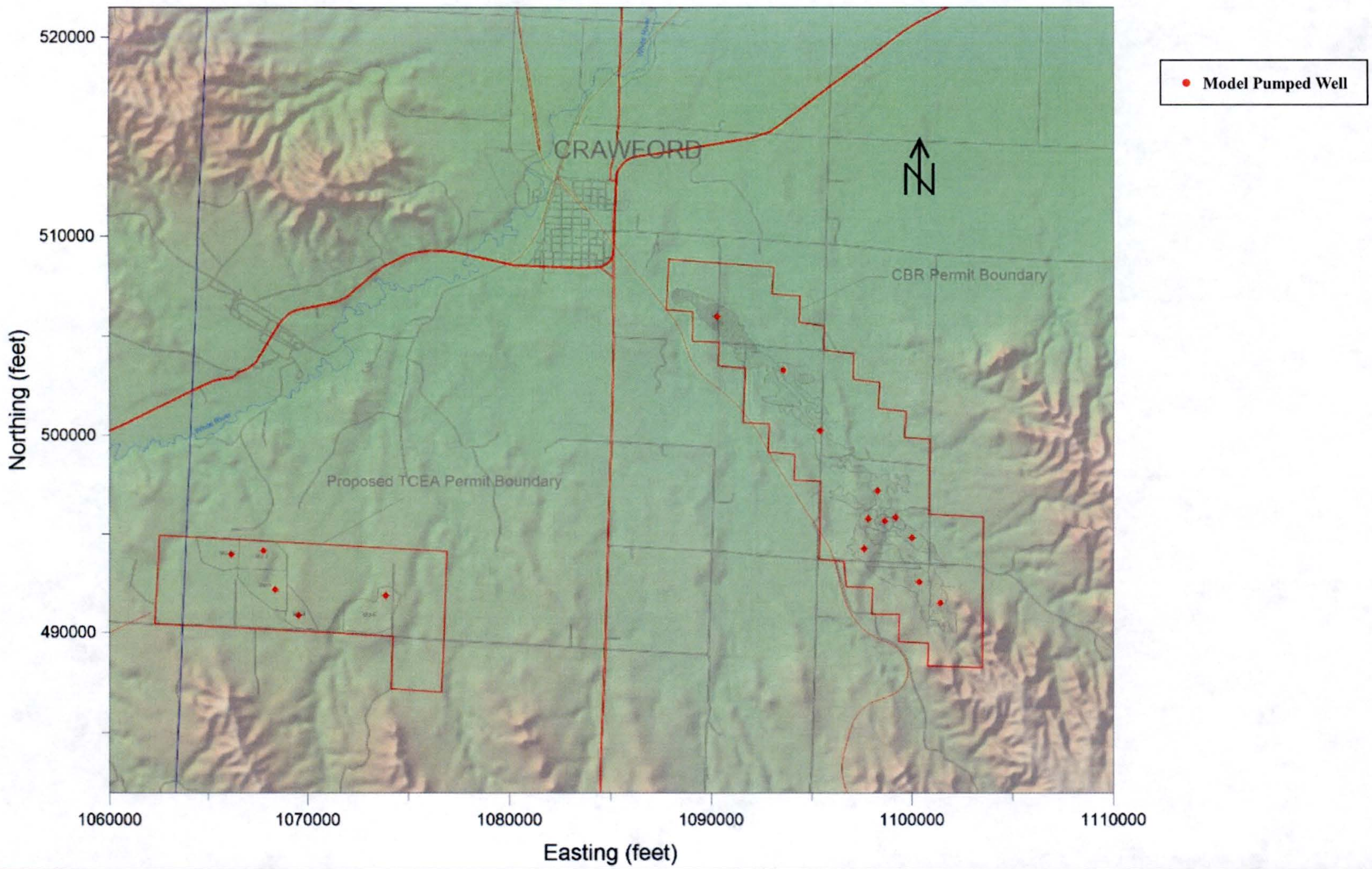
Theis, C.V. (1935). The relation between lowering the potentiometric surface and the rate and duration of discharge of a well using groundwater storage, American Geophysical Union Transactions, vol. 16, pp. 519-524.

FIGURES



AquiferTek	**MEA Well Locations**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **1**



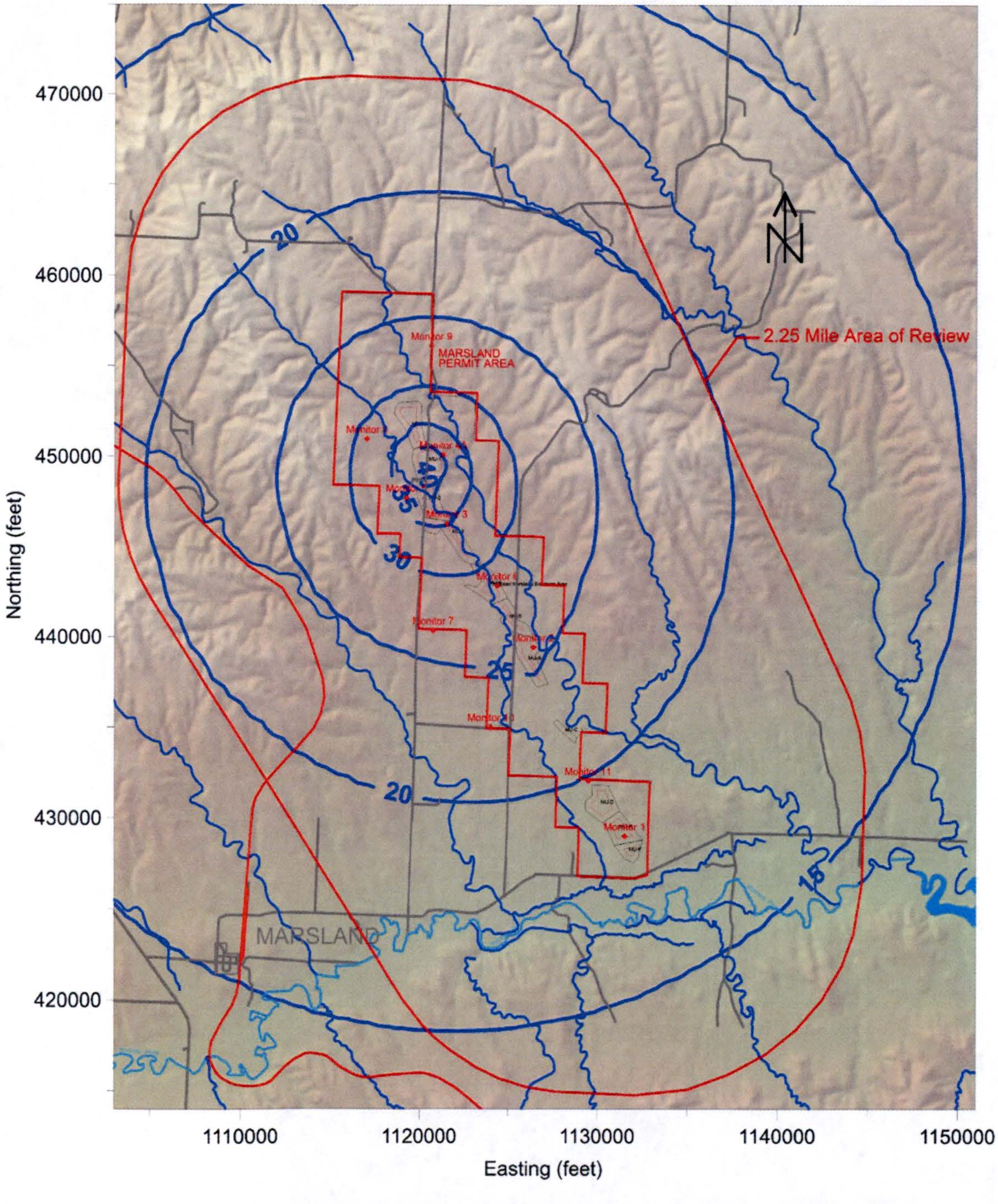
AquiferTek

CBO and TCEA Model Pumped Well Locations

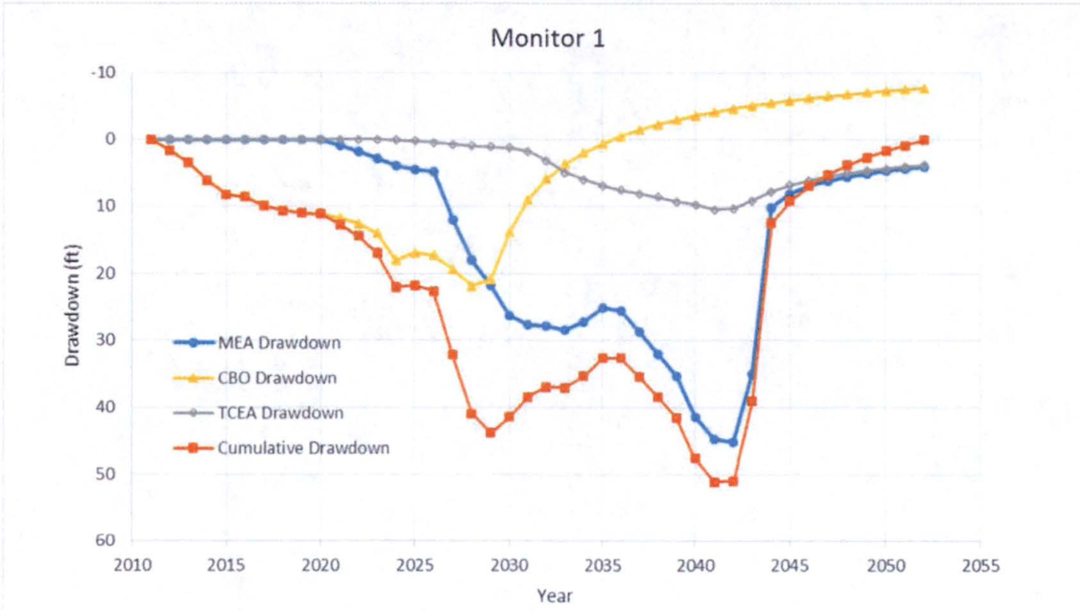
Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

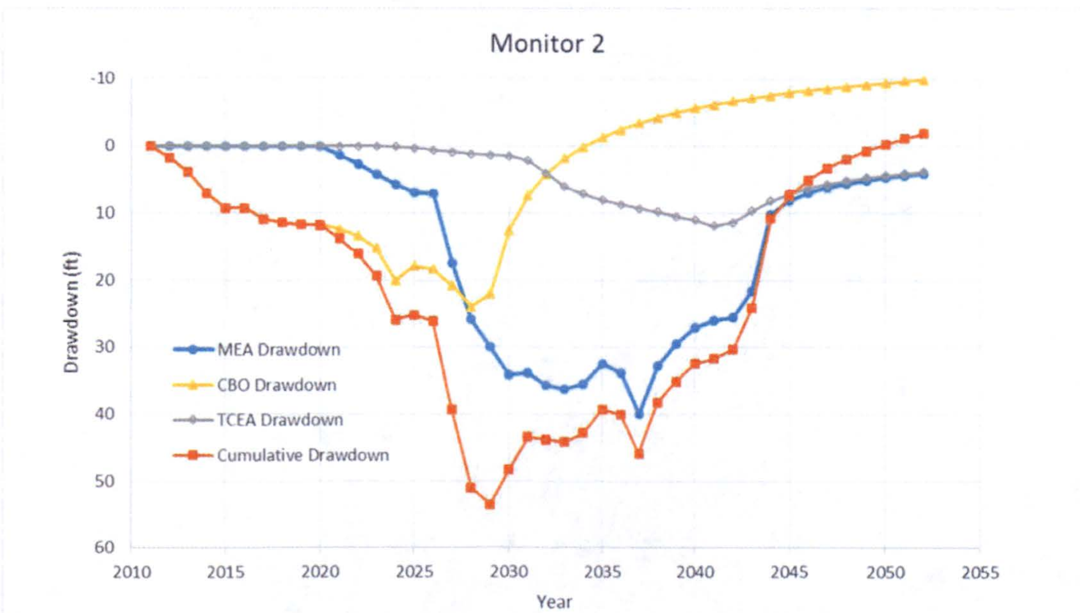
Cameco

Figure
2

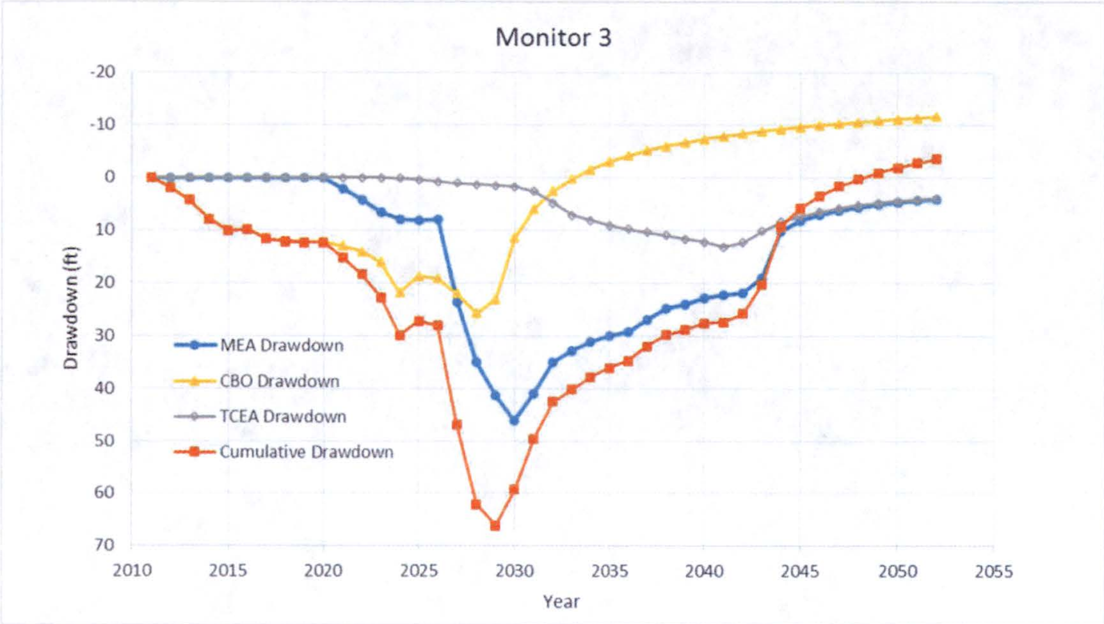


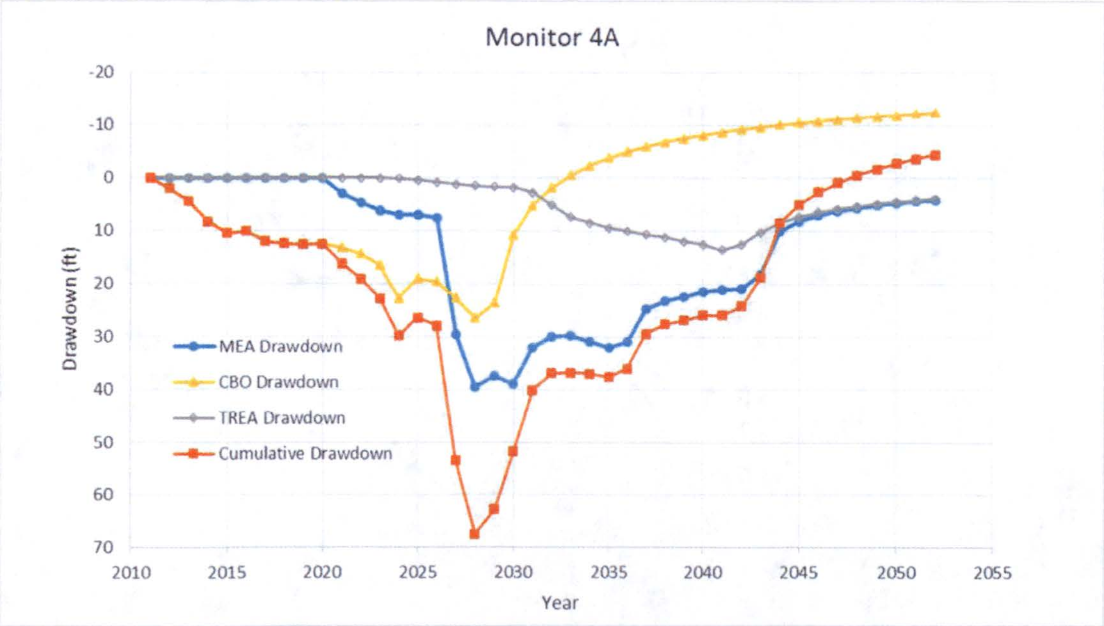
AquiferTek	**Model Projected Drawdown (feet)** **MEA Operations Year 2028** **Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **3**





AquiferTek	**Model Drawdown Hydrographs** **MEA Monitor 1 and Monitor 2** **Theis Analysis**	Drawdown *Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **4**





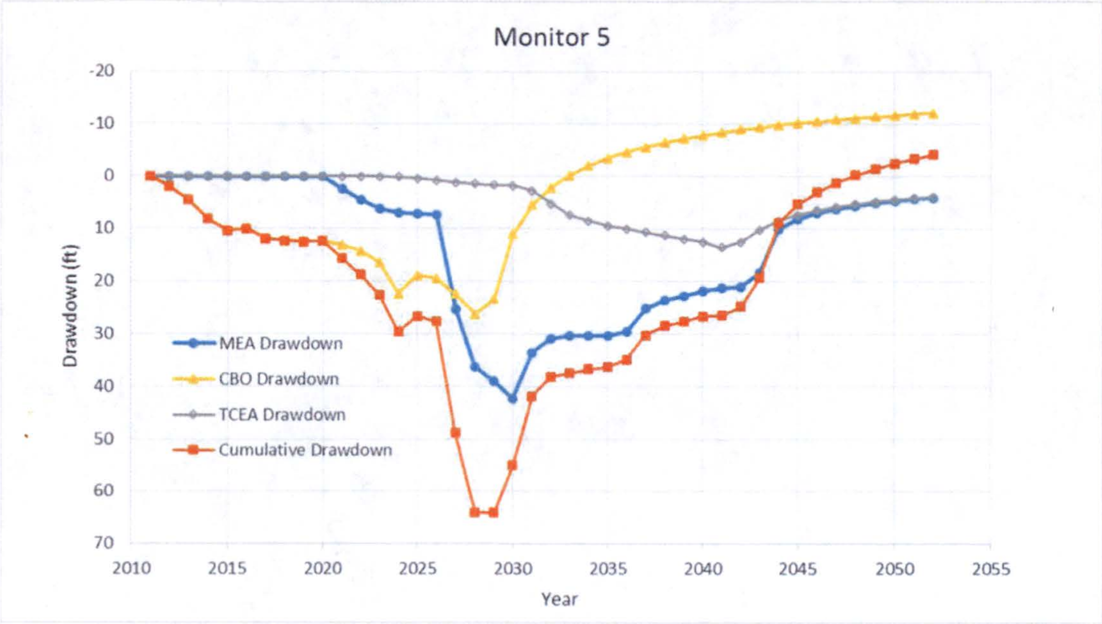
AquiferTek

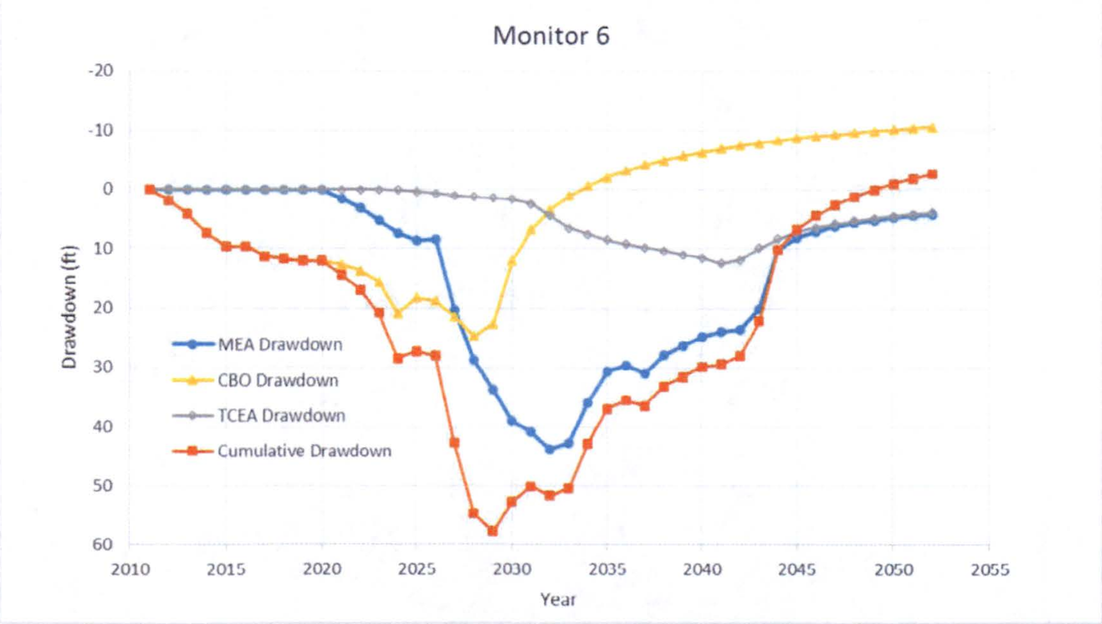
Model Drawdown Hydrographs MEA Monitor 3 and Monitor 4A Theis Analysis

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

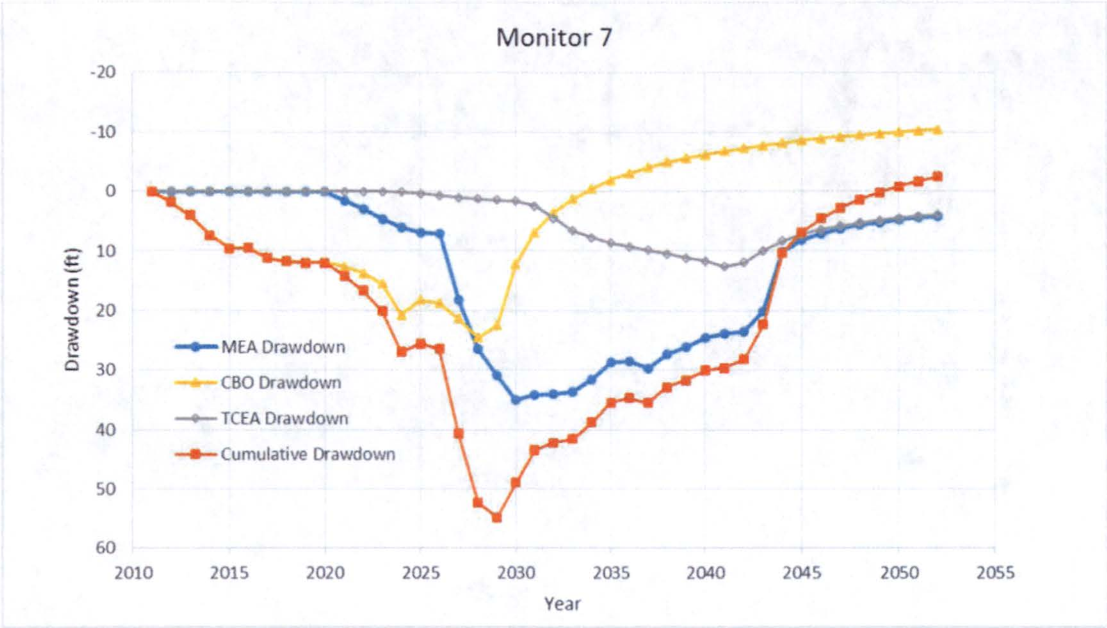
Cameco

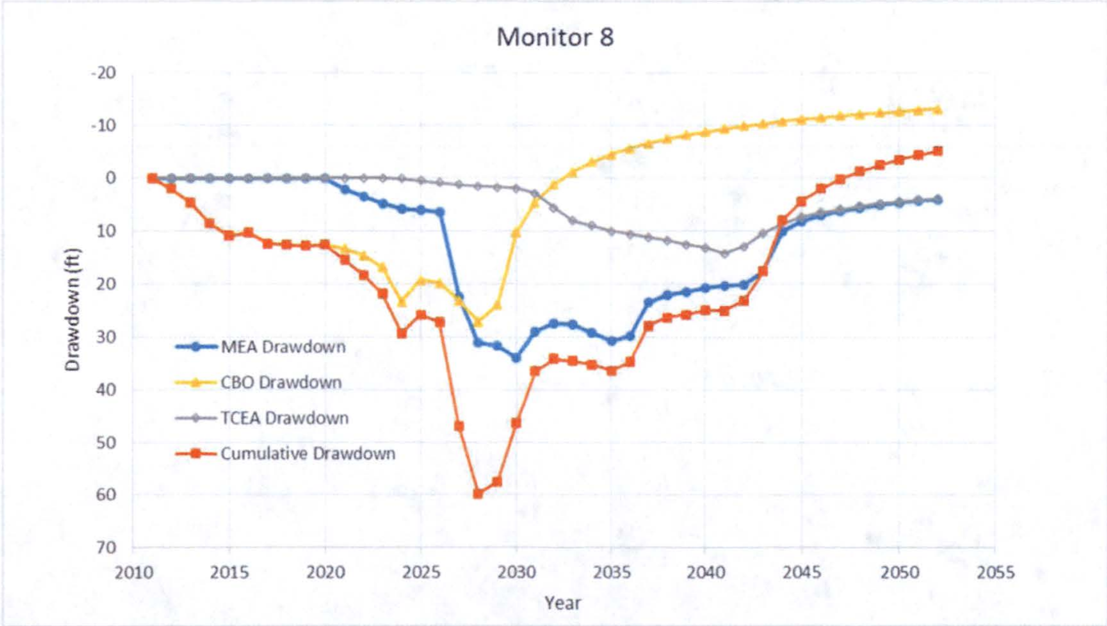
Figure 5



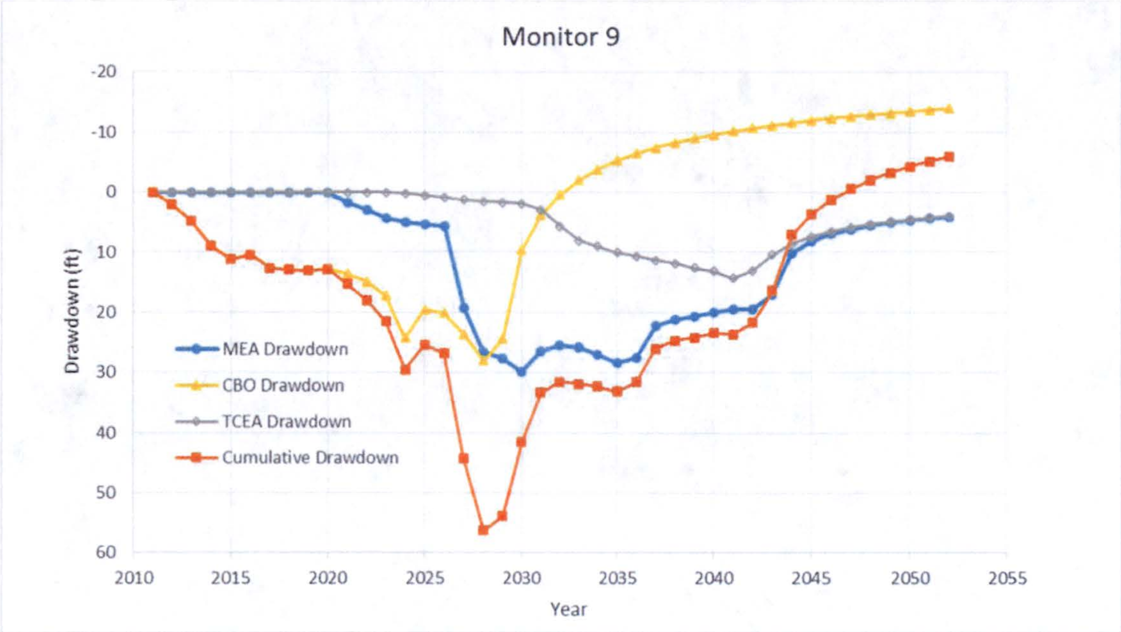


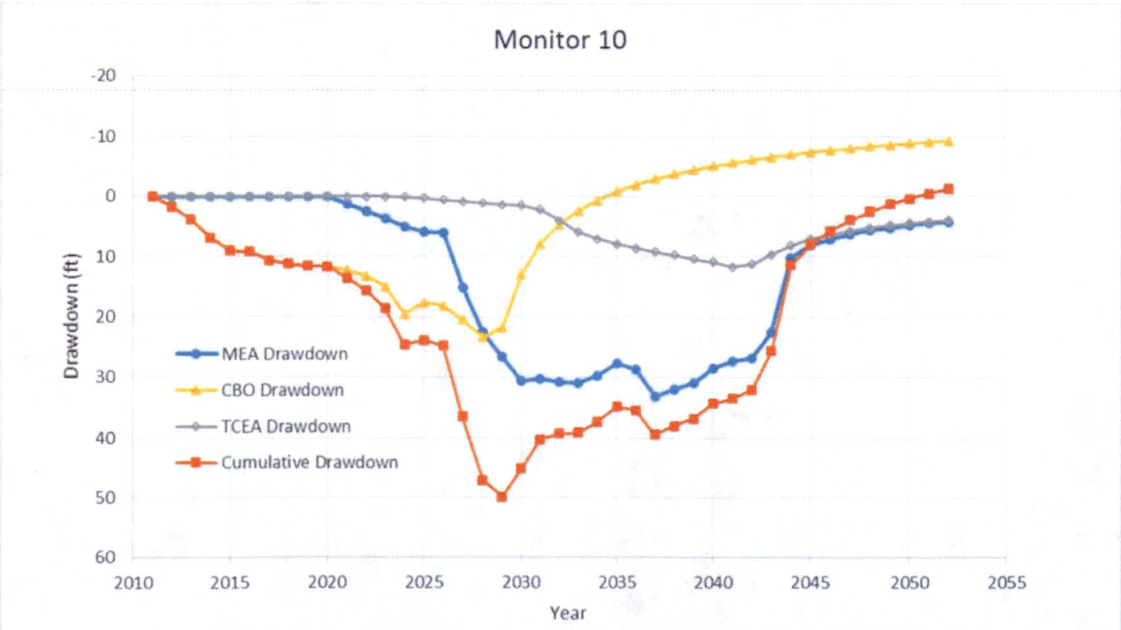
AquiferTek	**Model Drawdown Hydrographs MEA Monitor 5 and Monitor 6 Theis Analysis**	*Drawdown Impact Assessment Marsland Expansion Area Dawes County, Nebraska* Cameco	**Figure 6**





AquiferTek	**Model Drawdown Hydrographs** **MEA Monitor 7 and Monitor 8** **Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **7**





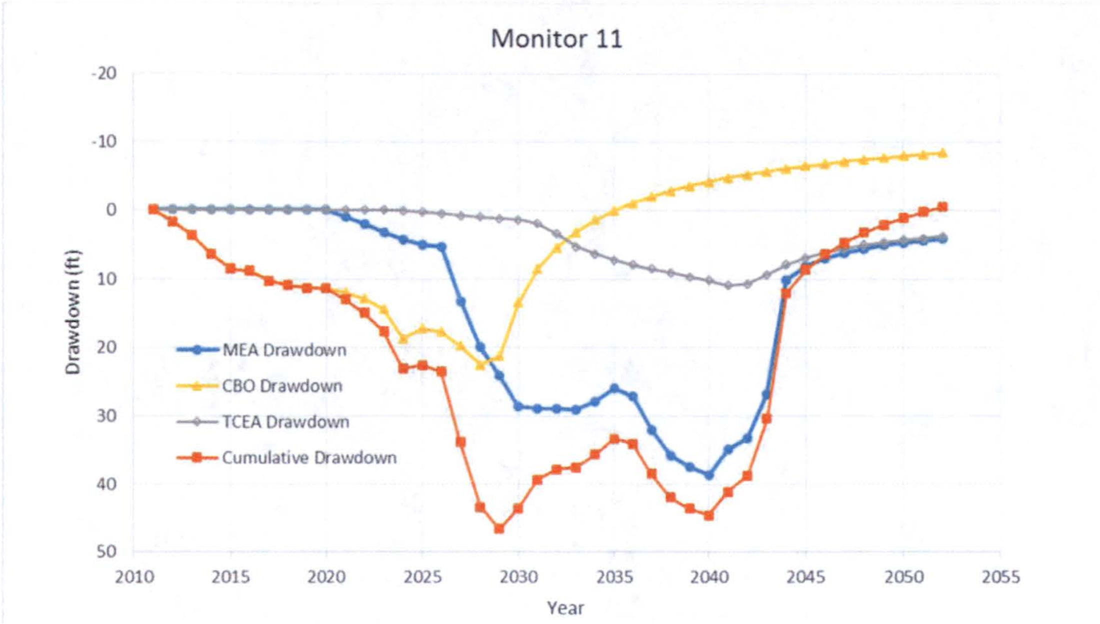
AquiferTek

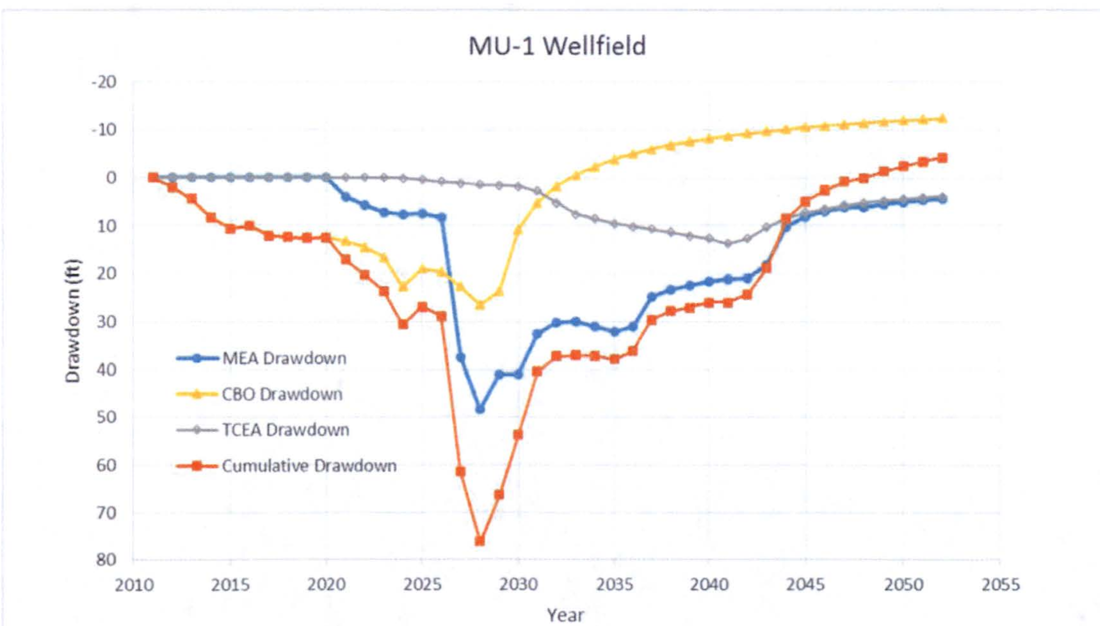
Model Drawdown Hydrographs
MEA Monitor 9 and Monitor 10
Theis Analysis

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

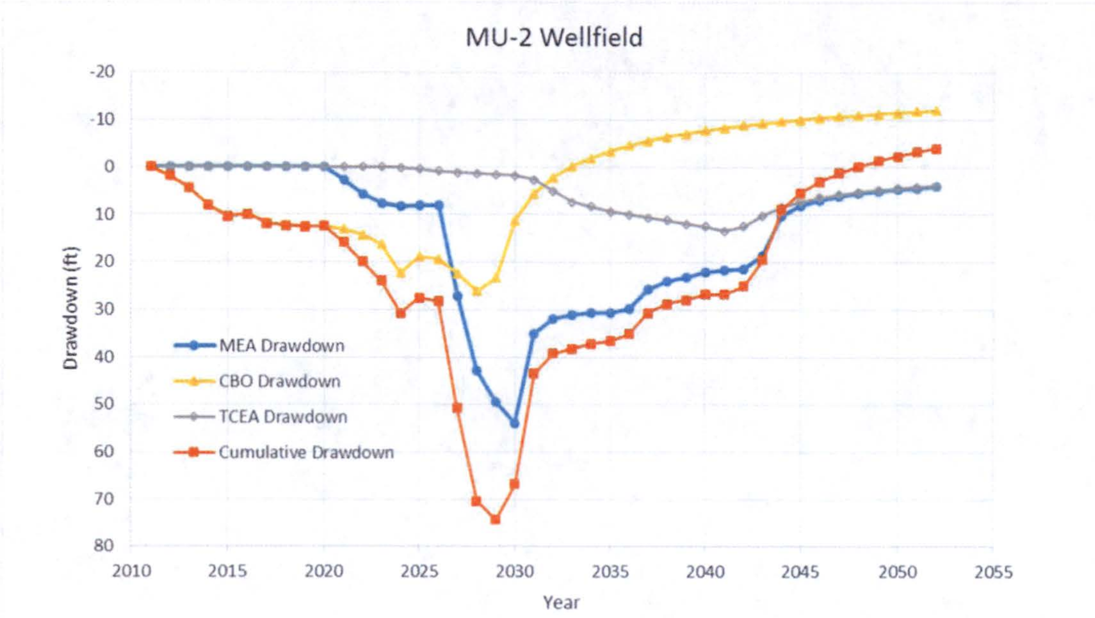
Cameco

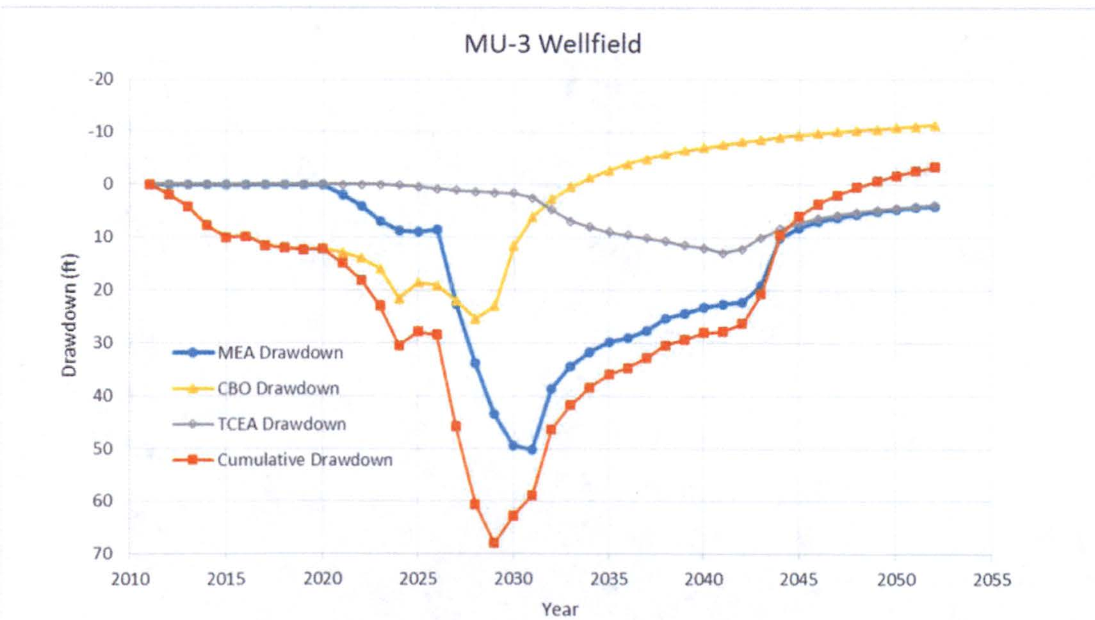
Figure
8



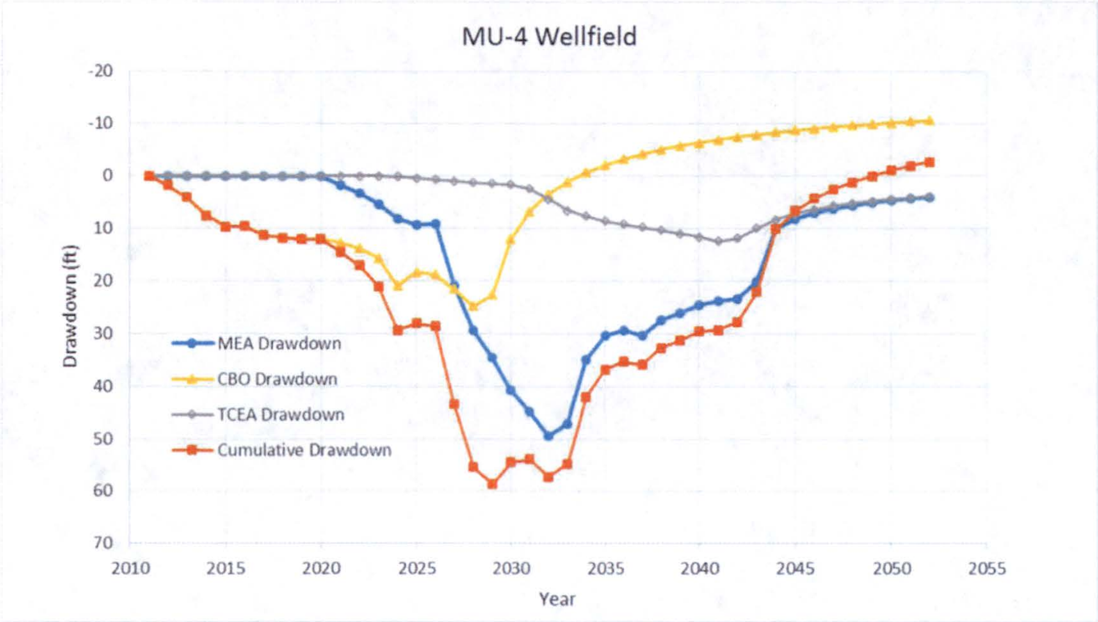


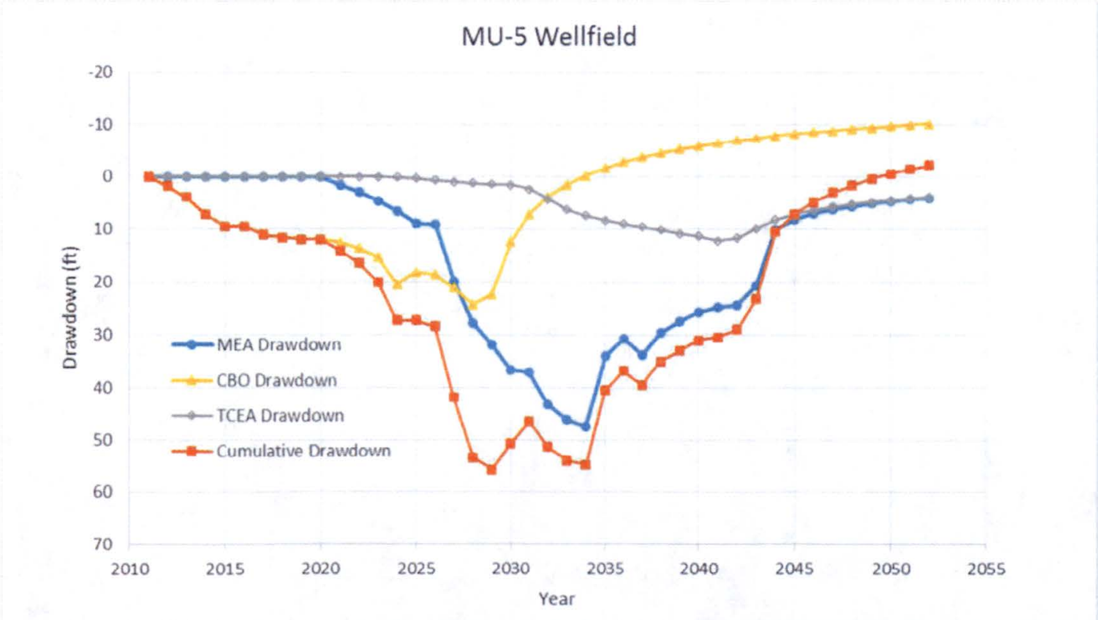
AquiferTek	**Model Drawdown Hydrographs MEA Monitor 11 and MU-1 Wellfield Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **9**



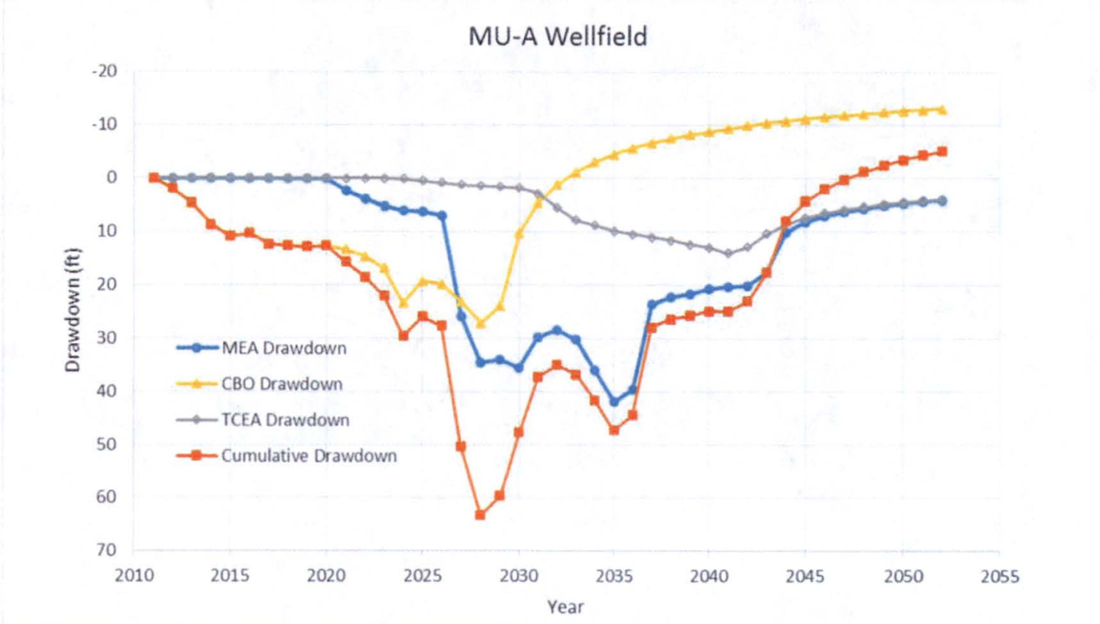


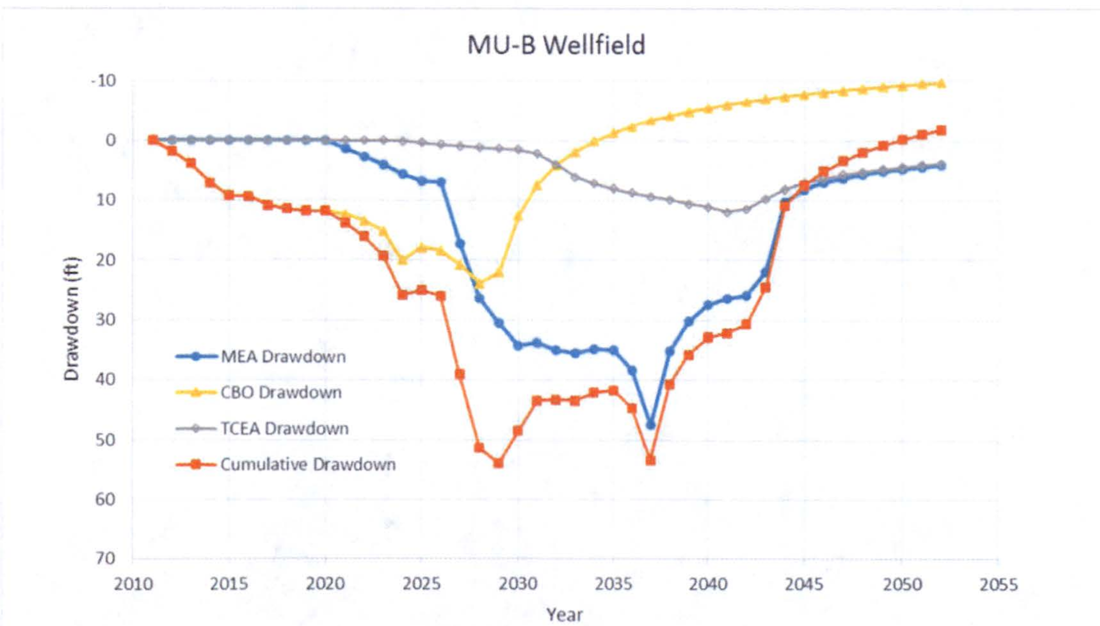
AquiferTek	**Model Drawdown Hydrographs MEA MU-2 and MU-3 Wellfields Theis Analysis**	*Drawdown Impact Assessment Marsland Expansion Area Dawes County, Nebraska* Cameco	**Figure 10**



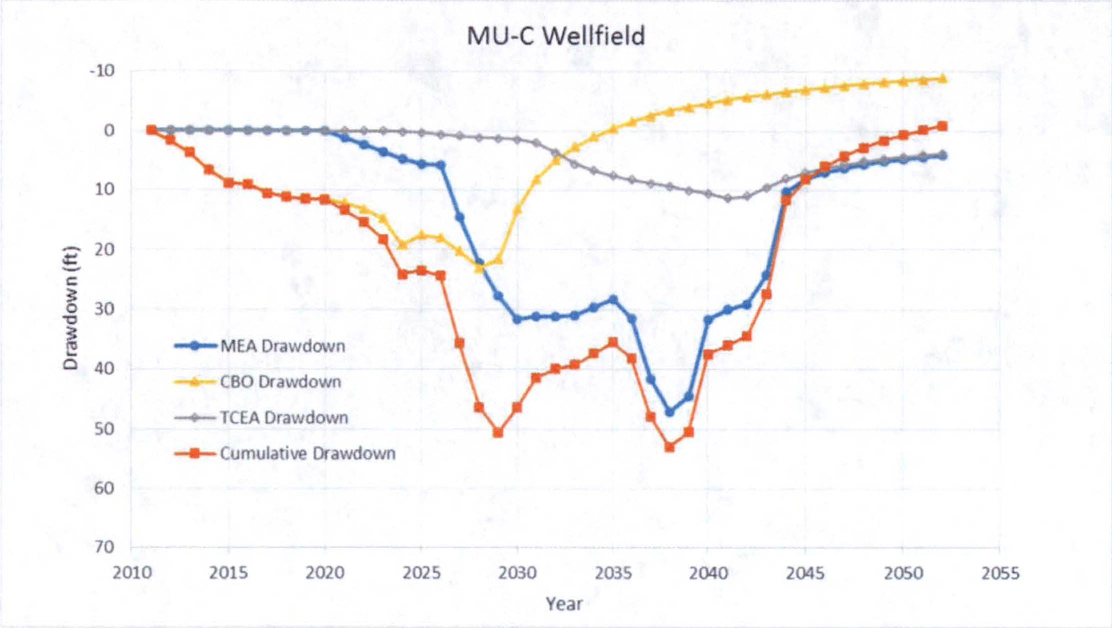


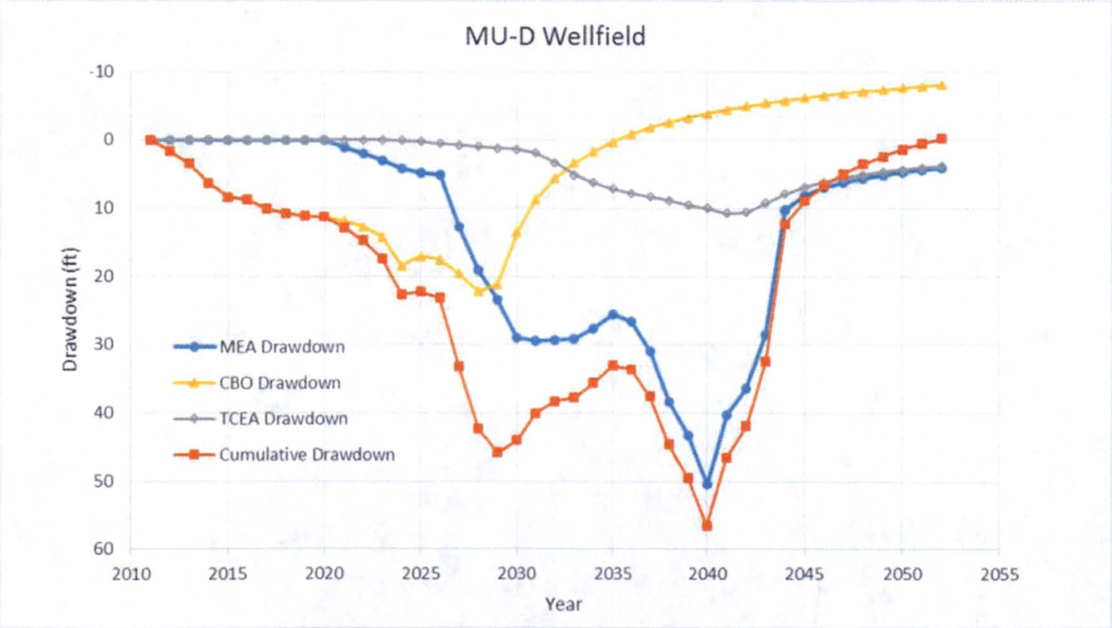
AquiferTek	**Model Drawdown Hydrographs MEA MU-4 and MU-5 Wellfields Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **11**



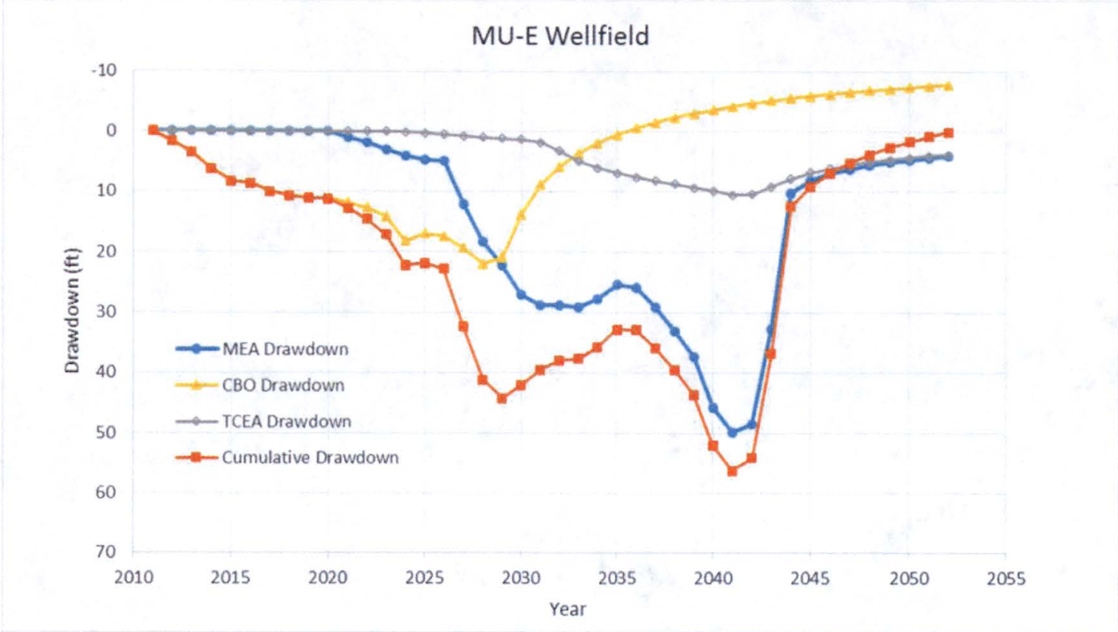


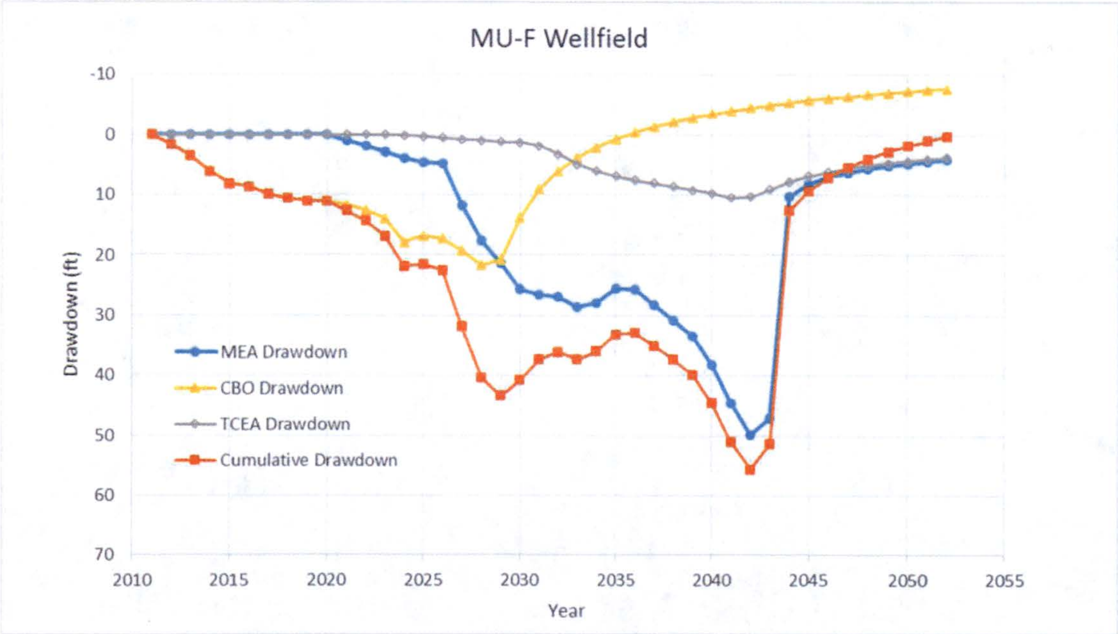
AquiferTek	**Model Drawdown Hydrographs** **MEA MU-A and MU-B Wellfields** **Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **12**





AquiferTek	**Model Drawdown Hydrographs MEA MU-C and MU-D Wellfields Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **13**





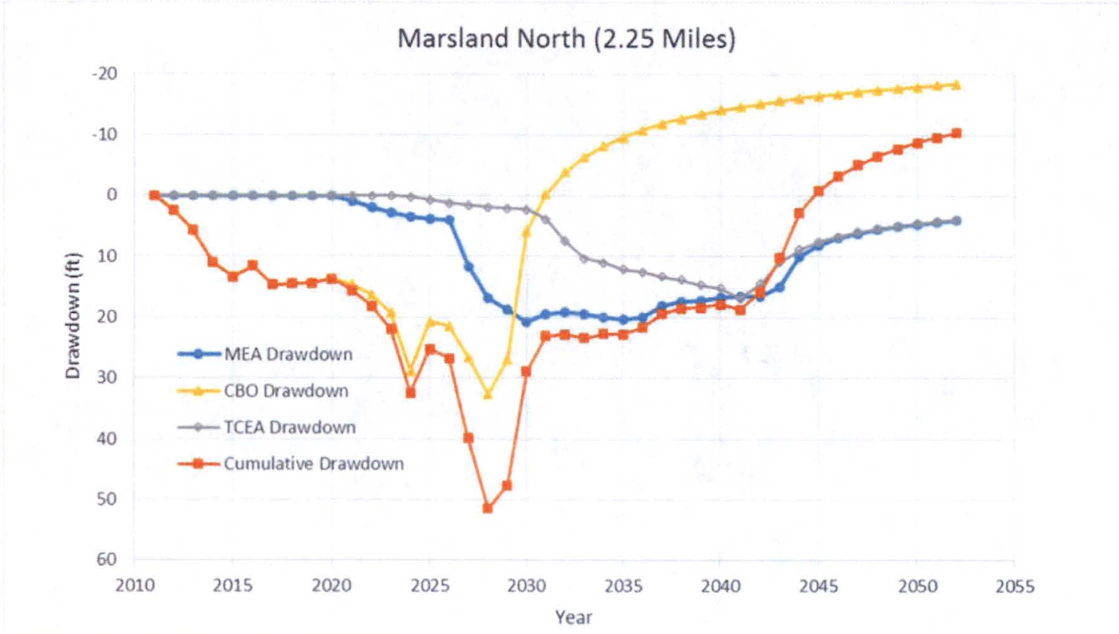
AquiferTek

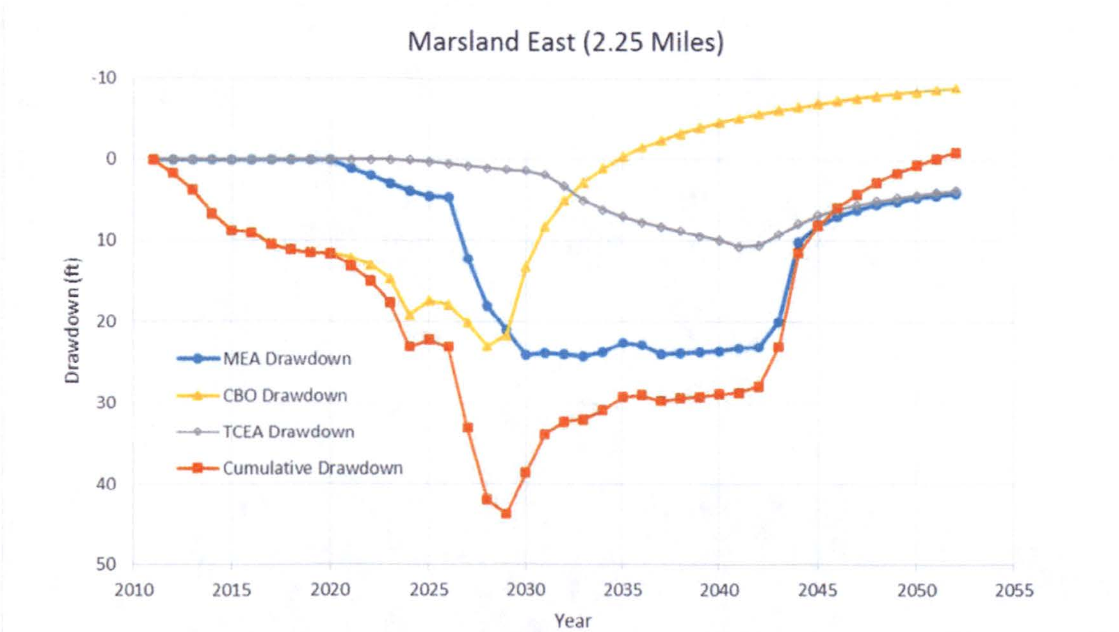
Model Drawdown Hydrographs
MEA MU-E and MU-F Wellfields
Theis Analysis

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

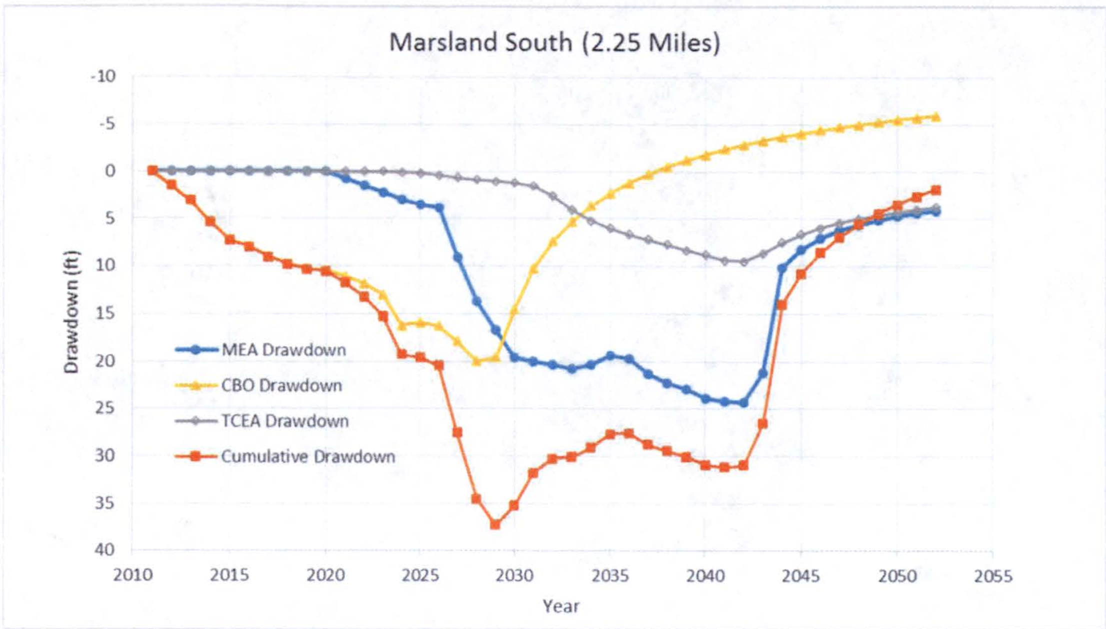
Cameco

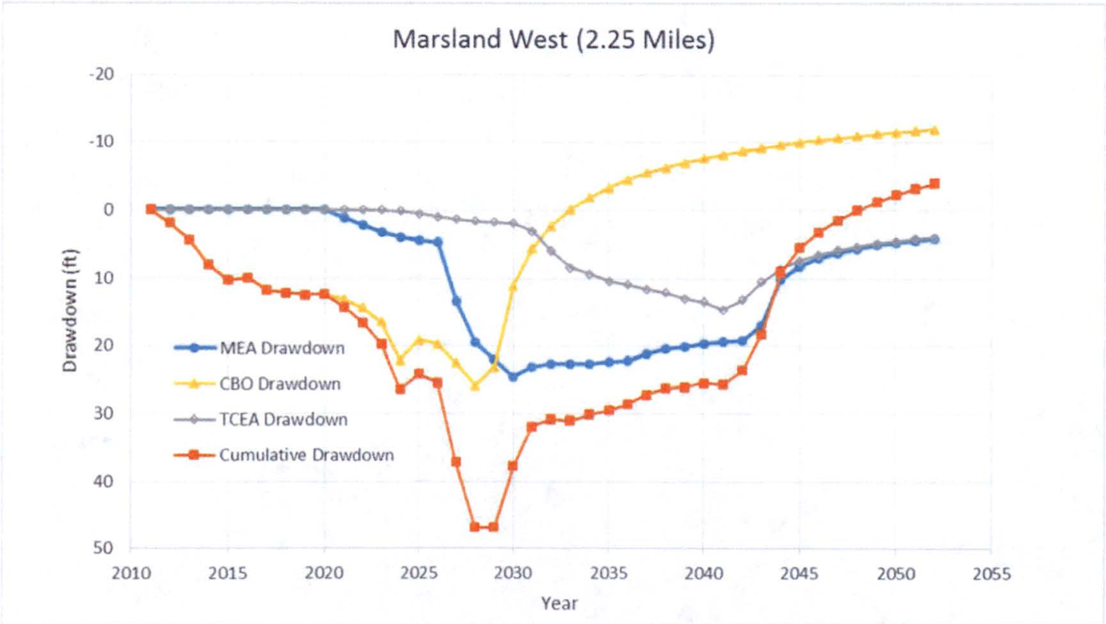
Figure
14



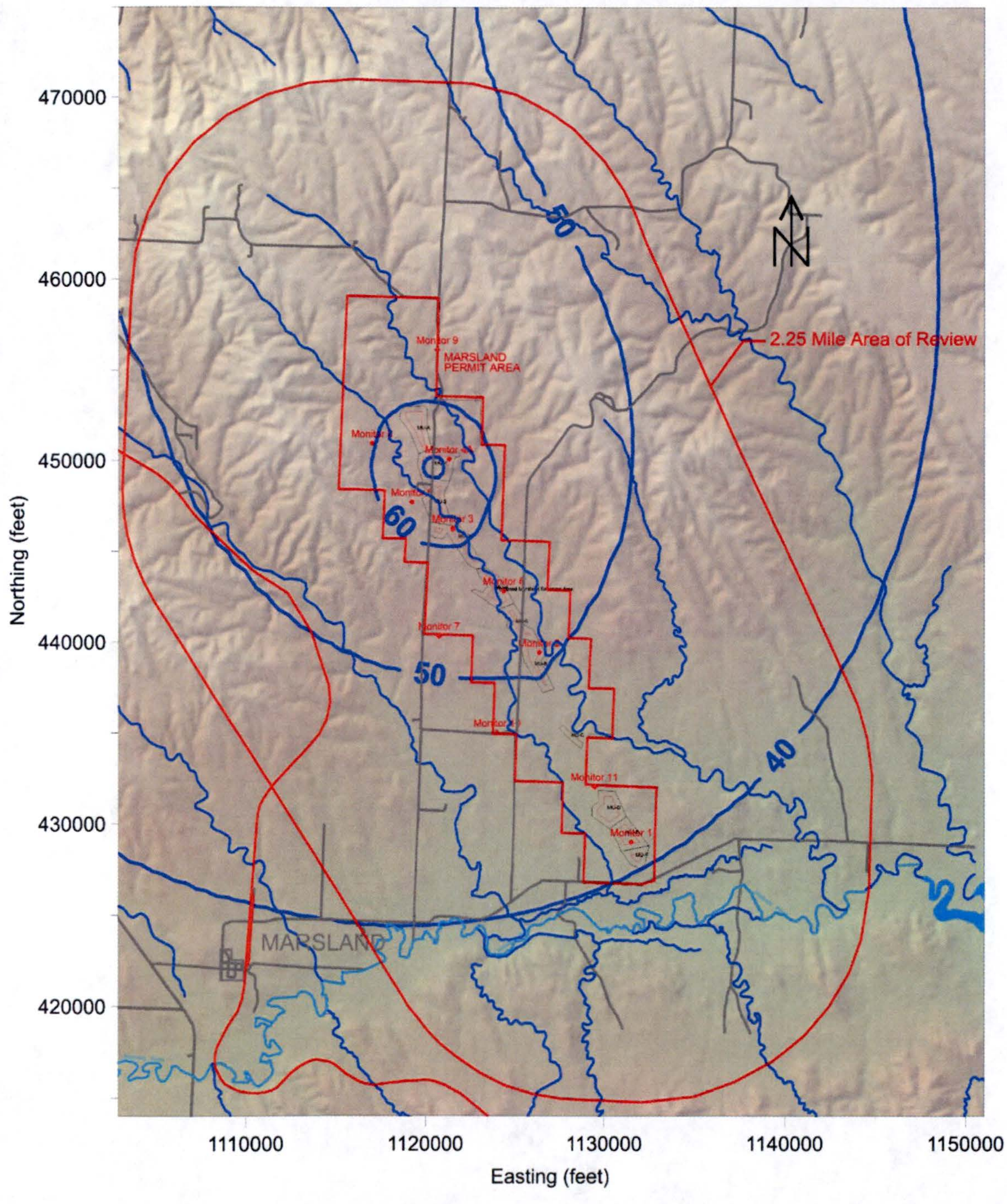


AquiferTek	**Model Drawdown Hydrographs MEA North and East 2.25 Mile Radius Theis Analysis**	*Drawdown Impact Assessment Marsland Expansion Area Dawes County, Nebraska* Cameco	**Figure 15**





AquiferTek	**Model Drawdown Hydrographs** **MEA South and West 2.25 Mile Radius** **Theis Analysis**	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska* Cameco	**Figure** **16**



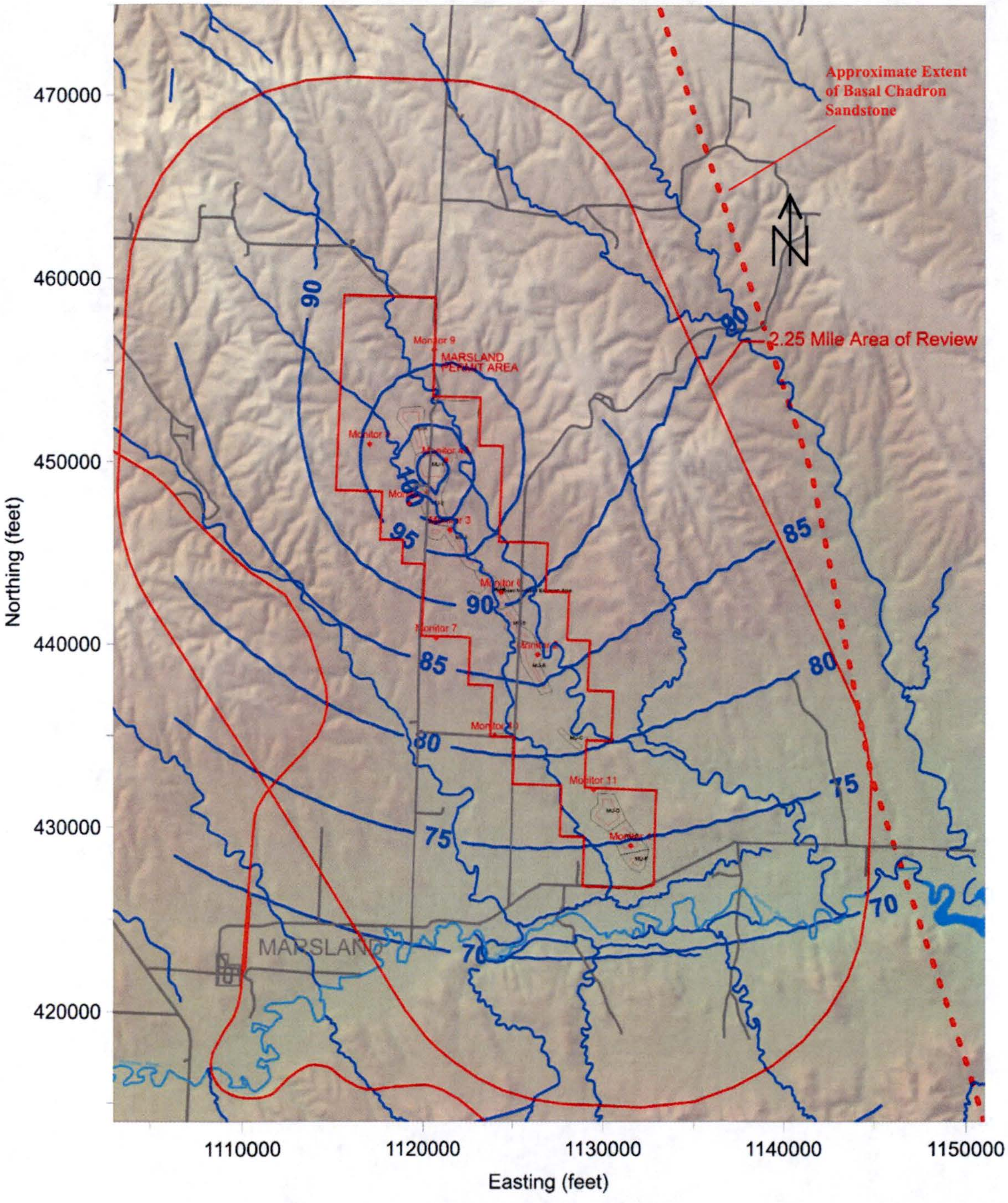
AquiferTek

Projected Cumulative Drawdown
Year 2028
Theis Analysis

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

Cameco

Figure
17



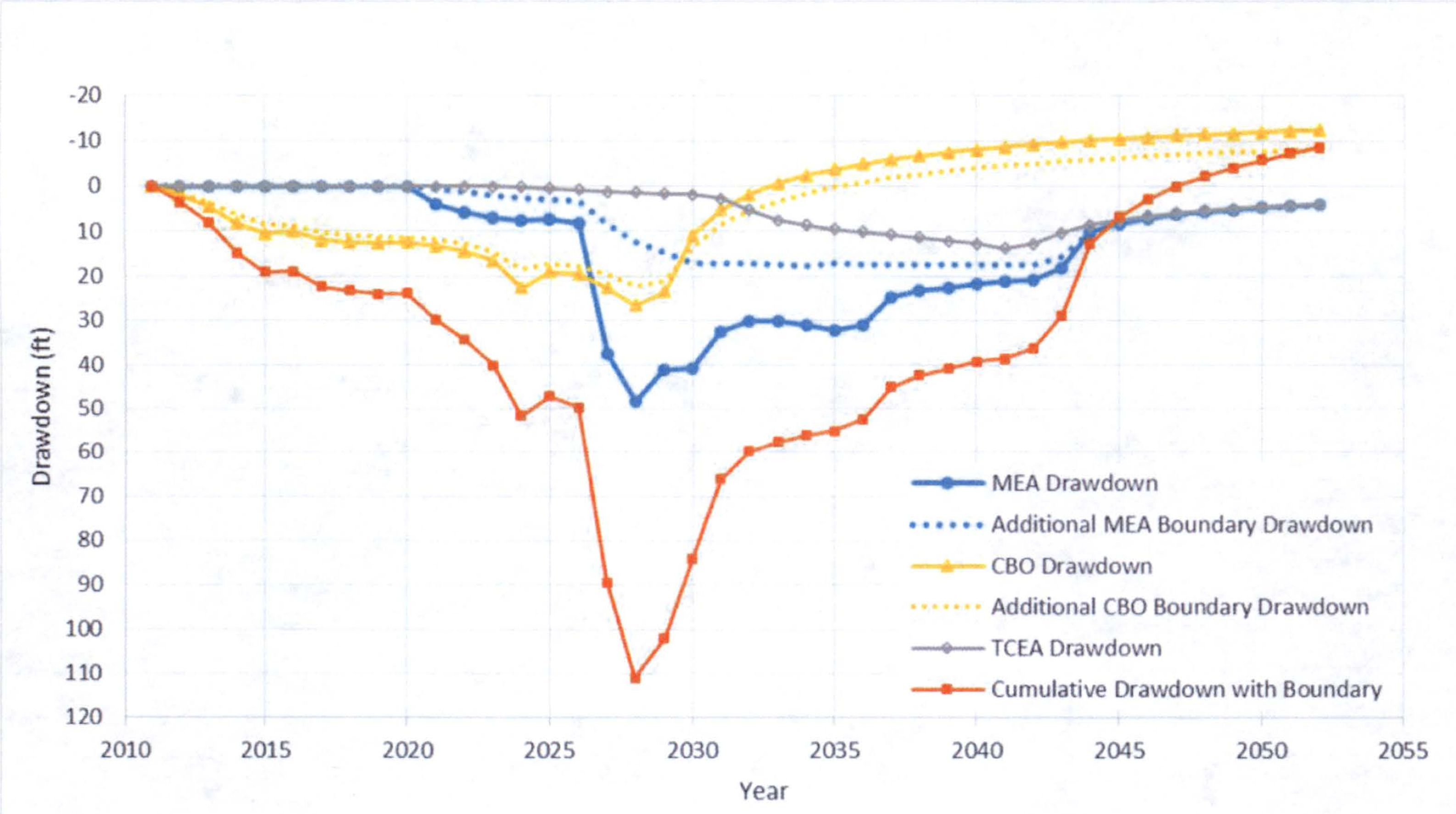
Projected Cumulative Drawdown
Year 2028
Including No-Flow Boundary

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

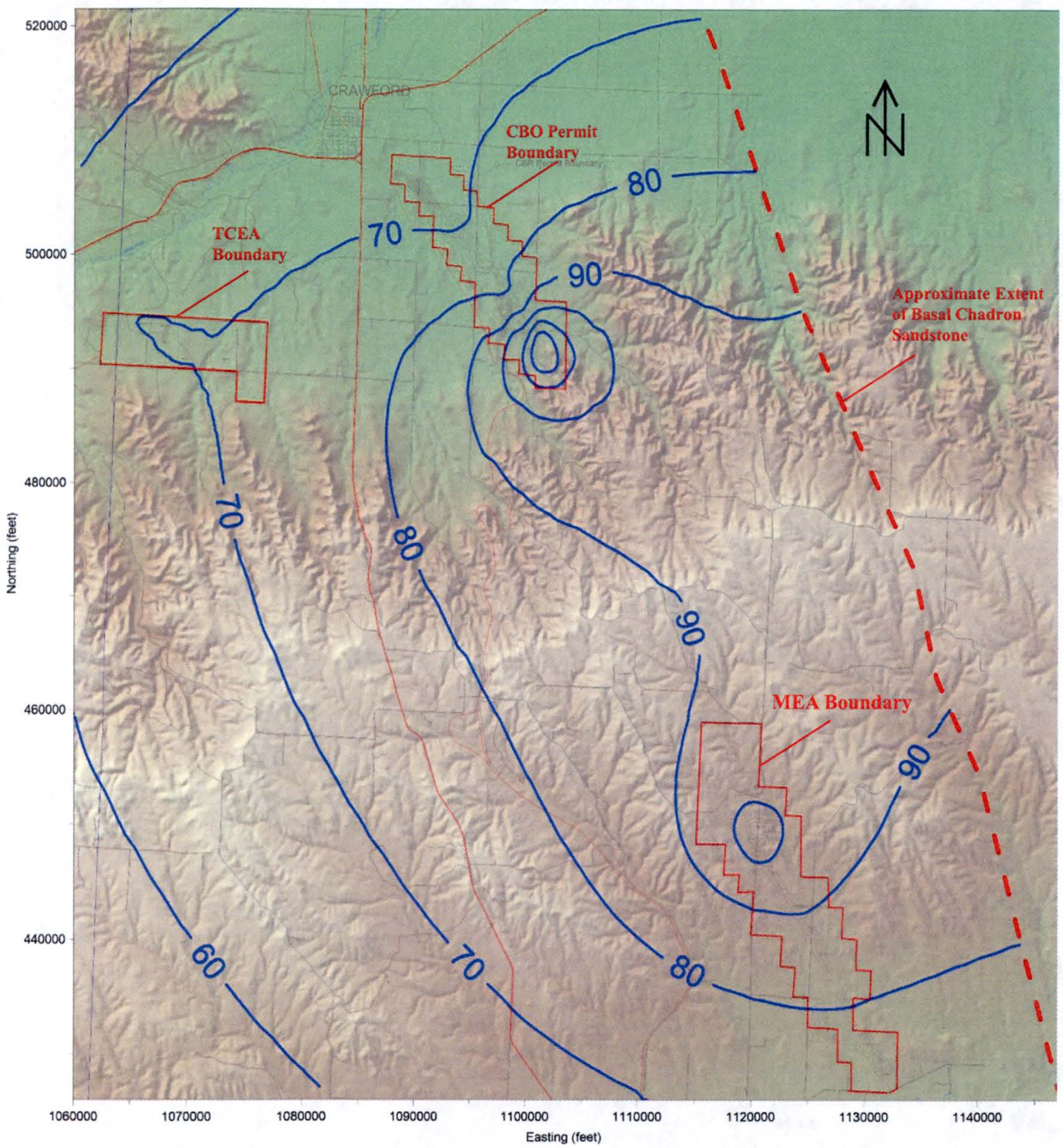
AquiferTek

Cameco

Figure 18



AquiferTek	Model Drawdown Hydrograph MEA MU-1 Wellfield Including No-Flow Boundary (Image Well Analysis)	*Drawdown Impact Assessment* *Marsland Expansion Area* *Dawes County, Nebraska*	Cameco	Figure 19



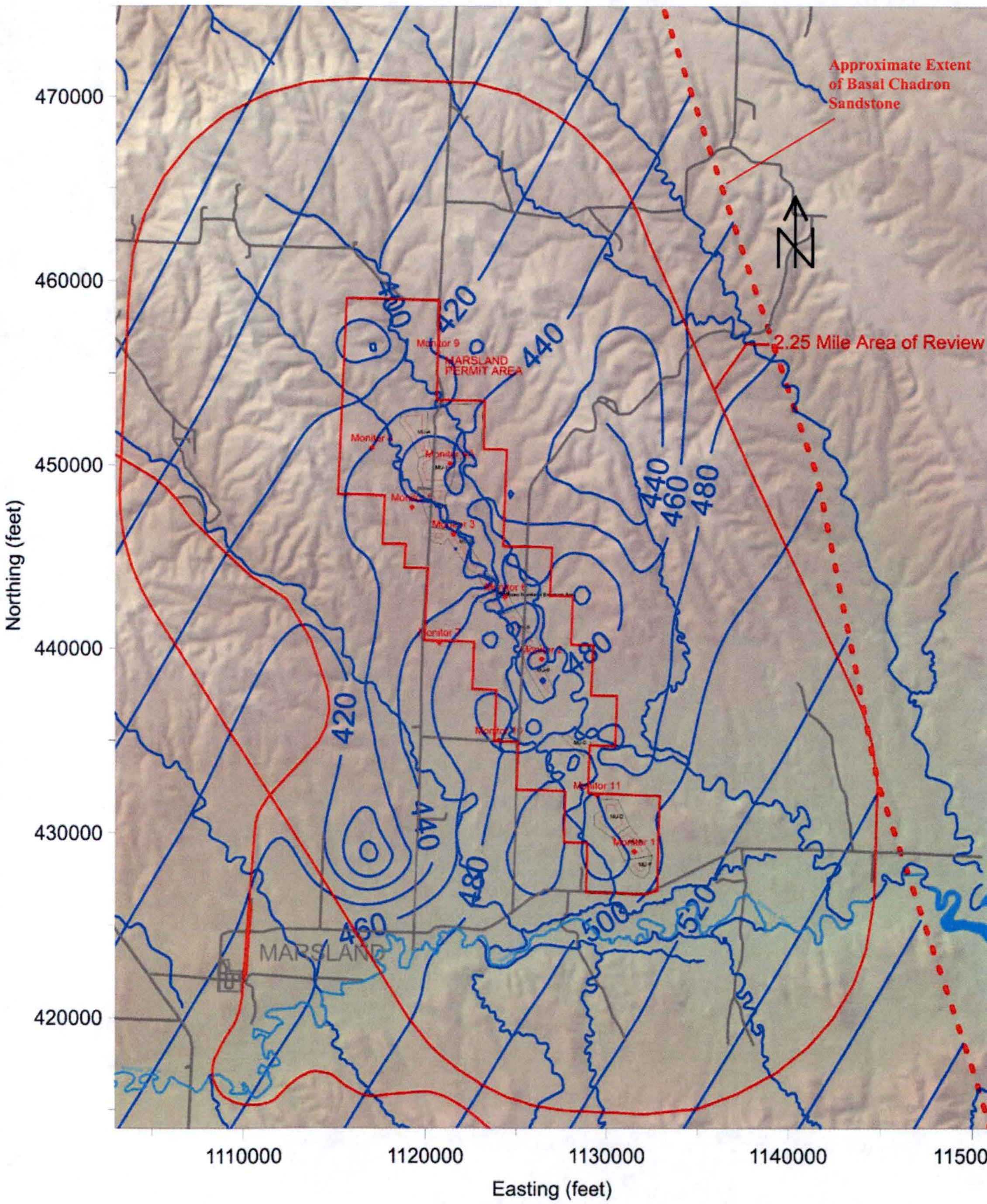
Regional Cumulative Drawdown
Year 2028
Including No-Flow Boundary

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

AquiferTek

Cameco

Figure 20



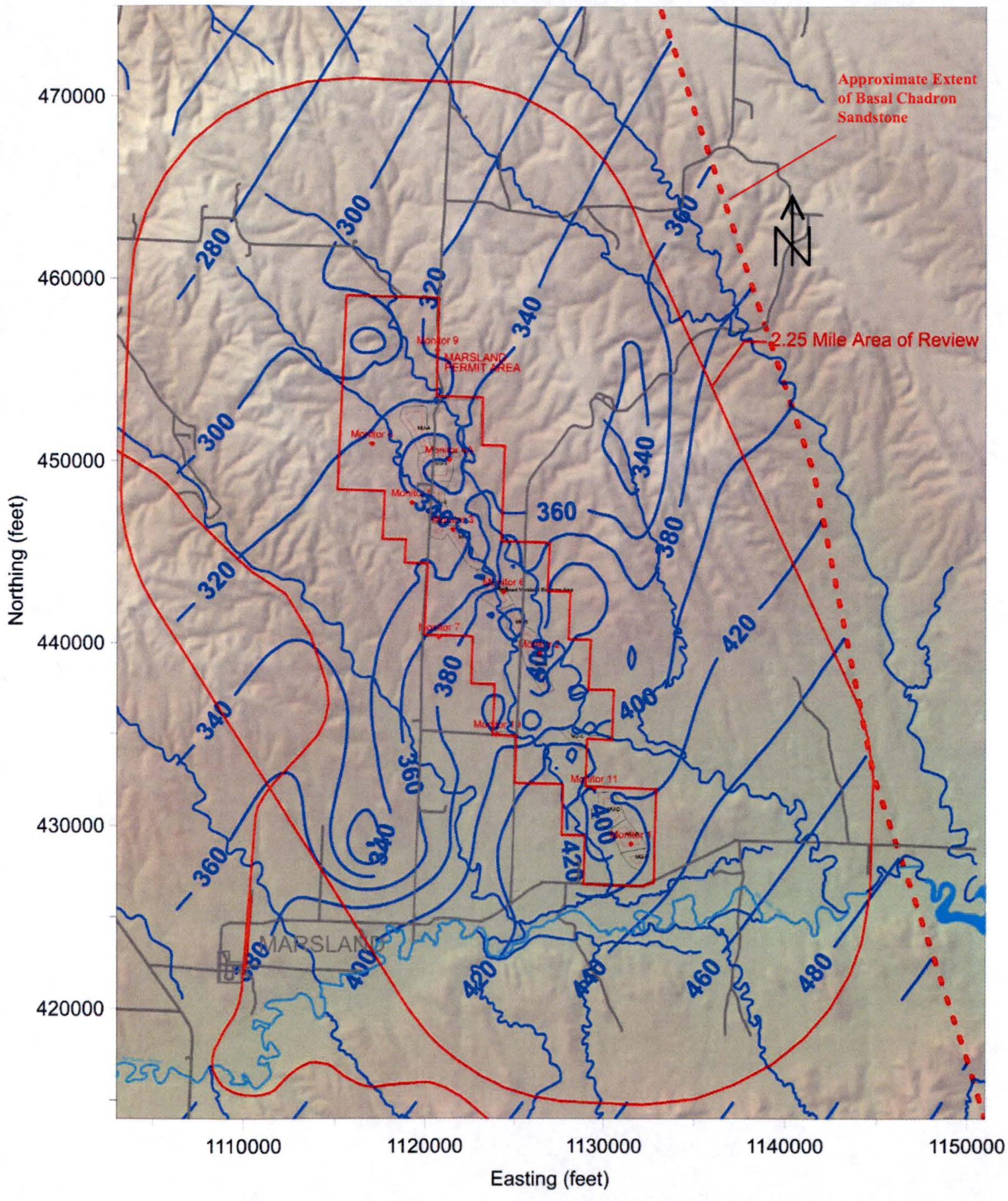
AquiferTek

MEA Available Head
Year 2011

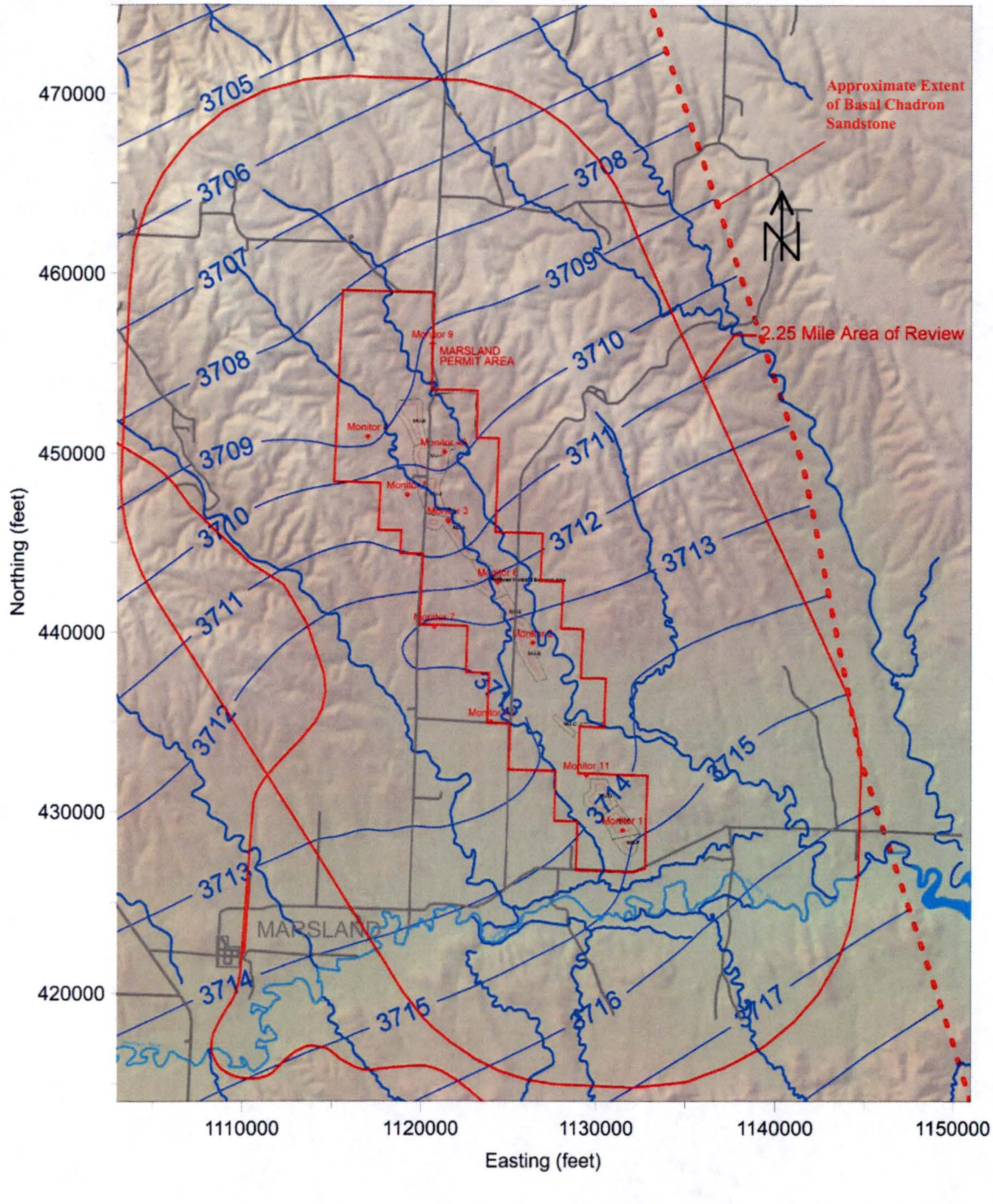
Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

Cameco

Figure 21



AquiferTek	**Projected Minimum Available Head Year 2028**	*Drawdown Impact Assessment Marsland Expansion Area Dawes County, Nebraska* Cameco	**Figure 22**



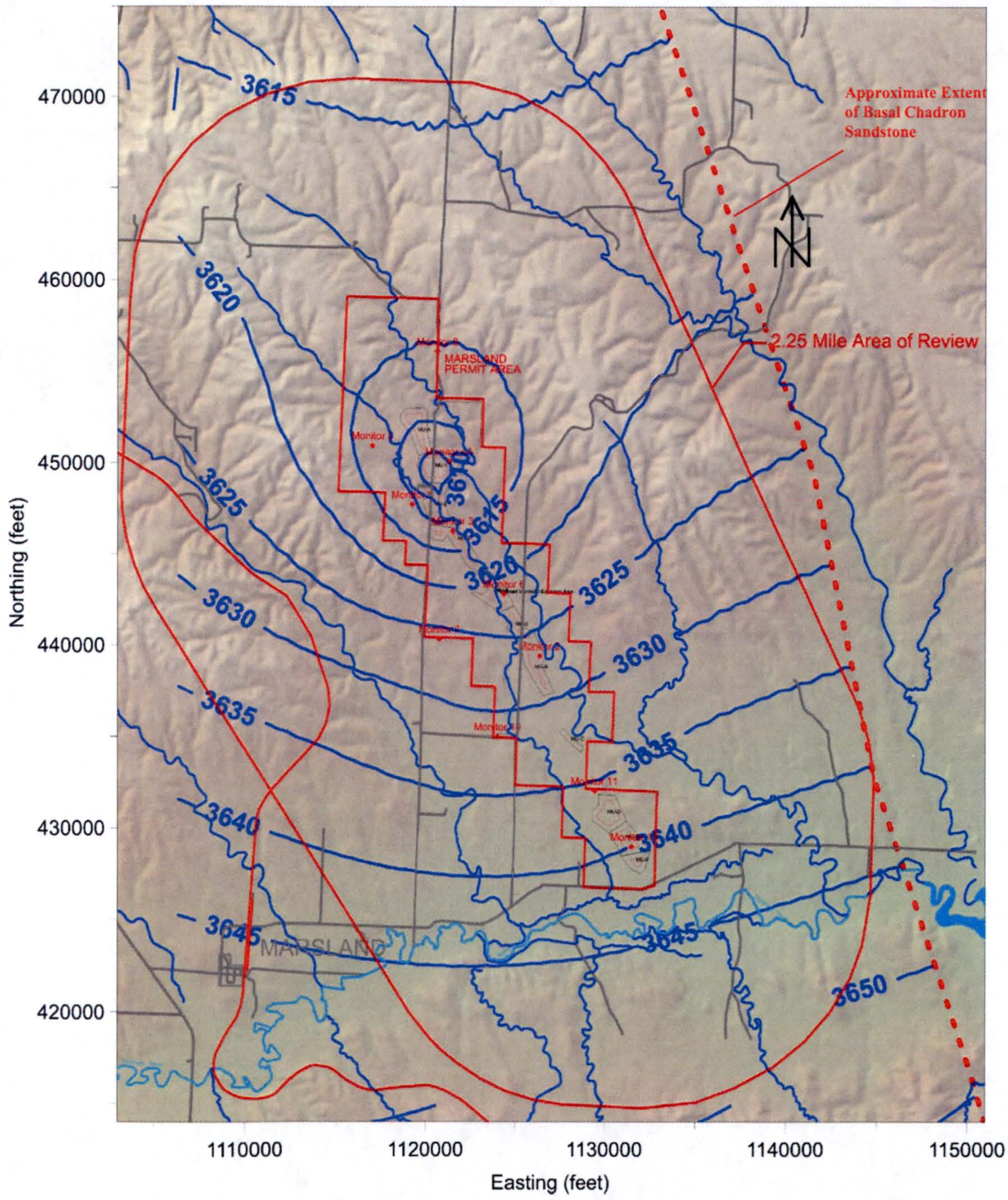
AquiferTek

MEA Basal Chadron Water Level Elevation February 2011

Drawdown Impact Assessment
Marsland Expansion Area
Dawes County, Nebraska

Cameco

Figure 23



AquiferTek	**Projected MEA Basal Chadron Water Level Elevation Year 2028**	*Drawdown Impact Assessment Marsland Expansion Area Dawes County, Nebraska* Cameco	**Figure 24**

ATTACHMENT A

WATER BALANCE AND CONSUMPTIVE USE DATA

CBO Consumptive Use (gpm)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
MU-1	20.00	10.00	8.33	7.50	8.75	8.10	10.56	8.16	6.99																													
MU-2		10.00	8.33	7.50	8.75	8.10	10.56	8.16	6.99	10.37	8.96	9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51																
MU-3			8.33	7.50	8.75	8.10	10.56	8.16	6.99	10.37	8.96	9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76													
MU-4				7.50	8.75	8.10	10.56	8.16	6.99	10.37	8.96	9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	75.00												
MU-5						8.10	10.56	8.16	6.99	10.37	8.96	9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	87.50	162.50	162.50	31.25									
MU-6								8.16	6.99	10.37	8.96	9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	2.00	2.00	2.00	131.25	59.40								
MU-7									6.99	10.37	8.96	9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	3.60	2.40	1.20	10.00	105.60	121.90							
MU-8												9.45	10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	7.20	6.00	4.80	4.30	8.60	73.13	246.90						
MU-9													10.09	8.31	9.72	14.04	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	8.10	6.00	4.80	4.70	4.70	10.00	20.00	262.50					
MU-10																	12.17	12.51	15.07	16.35	17.28	19.51	26.72	26.43	21.76	20.40	18.00	15.60	12.00	10.80	9.00	9.80	20.00	262.50	262.50	143.75		
MU-11																				16.35	17.28	19.51	26.72	26.43	21.76	20.40	16.20	13.20	10.80	8.80	4.20	4.20	4.20	8.60	10.00	123.75	262.50	196.90
Total CBO Consumptive Use (gpm)	**20.0**	**20.0**	**25.0**	**30.0**	**35.0**	**40.5**	**52.8**	**49.0**	**48.9**	**62.2**	**53.7**	**66.2**	**80.7**	**66.5**	**77.7**	**112.3**	**109.5**	**112.6**	**135.6**	**163.5**	**172.8**	**195.1**	**240.4**	**237.9**	**195.9**	**224.2**	**213.1**	**204.1**	**204.3**	**197.9**	**218.2**	**280.9**	**286.7**	**271.1**	**272.5**	**267.5**	**262.5**	**196.9**

MEA Consumptive Use (gpm)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MU-1	18.3	17.4	14.1	10.2	5.7	13	150	150	37.5														
MU-2	2.7	15.3	17.7	14.1	10.2	5.4	14	75	131.5	150													
MU-3		2.7	15.3	17.7	14.1	10.2	5.4	16	75	93.75	150	37.5											
MU-4			2.7	15.3	17.7	14.1	10.2	5.4	8	24.75	75	131.25	112.5										
MU-5				2.7	15.3	17.7	14.1	10.2	5.4	8	8	58.25	93.75	150	37.5								
MU-A						4.5	18.3	16.8	13.2	9	4.2	6.6	24.75	75	131.25	112.5							
MU-B							4.5	18.3	16.8	13.2	9	4.2	3.8	8	58.25	93.75	150	37.5					
MU-C								4.5	18.3	16.8	13.2	9	4.2	2.4	6.6	24.75	75	131.25	112.5				
MU-D									4.5	18.3	16.8	13.2	9	4.2	2.4	3.8	8	58.25	93.75	150	37.5		
MU-E										4.5	18.3	16.8	13.2	9	4.2	2.4	2.4	6.6	24.75	75	131.25	112.5	
MU-F												2.7	15.3	17.7	14.1	10.2	5.4	2.4	3.8	8	58.25	112.5	168.75
Total MEA Consumptive Use (gpm)	**21**	**35.4**	**49.8**	**60**	**63**	**64.9**	**216.5**	**296.2**	**310.2**	**338.3**	**294.5**	**279.5**	**276.5**	**266.3**	**254.3**	**247.4**	**240.8**	**236**	**234.8**	**233**	**227**	**225**	**168.75**

TCEA Consumptive Use (gpm)	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MU-1	8.7	19.5	19.8	16.2	11.4	4.8	0.96	50.5	150	150										
MU-2		1.5	9	15.6	17.7	13.8	9	4.5	0.9	13	131.25	150	75							
MU-3					3.3	12.6	15.3	12.3	9.06	4.2	0.9	8	64.25	150	150					
MU-4							5.4	14.4	17.4	13.8	9.9	4.8	0.9	6	8	150	150	37.5		
MU-5									5.1	13.2	17.4	15.3	11.4	6.6	1.8	8	8	114.5	150	75
Total TCEA Consumptive Use (gpm)	**8.7**	**21**	**28.8**	**31.8**	**32.4**	**31.2**	**30.66**	**81.7**	**182.46**	**194.2**	**159.45**	**178.1**	**151.55**	**162.6**	**159.8**	**158**	**158**	**152**	**150**	**75**

Notes: Future consumptive use estimates assume 25% Reverse Osmosis (RO) efficiency at CBO based on historical performance, and 30% RO efficiency at MEA and TCEA as a conservative estimate.
Historical consumptive use at CBO (1991-2015) use actual disposal volumes evenly distributed over active mine units.