United States Nuclear Regulatory Commission Official Hearing Exhibit			
In the Matter of:	CROW BUTTE RESOURCES, INC. (Marsland Expansion Area)		
ASLBP #:	13-926-01-MLA-BD01		
Docket #:	04008943		
Exhibit #:	CBR010-00-BD01	**Identified:**	10/30/2018
Admitted:	10/30/2018	**Withdrawn:**	
Rejected:		**Stricken:**	
Other:			

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

Hearing Exhibit

Exhibit Number: CBR010

Exhibit Title: Appendix AA-1 - Well Impact Analysis

AQUI-VER, INC

Hydrogeology, Water Resources & Data Services

Mr. Doug Pavlick December 10, 2013

Cameco Resources

Crow Butte Facility

P.O. Box 169

Crawford, NE 69339

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

As requested, we have completed an analysis of the potential hydrologic impacts to local irrigation wells resulting from a hypothetical shallow casing leak in the overlying aquifer at the MEA In-Situ Recovery (ISR) wellfields. Our analysis is in response to U.S. Nuclear Regulatory Commission (NRC) Technical Report RAI 15(a), which requested "an analysis of the hydraulic effects that nearby agricultural wells may have on the migration potential of MEA regulated material releases in the overlying groundwater zone toward these wells".

INTRODUCTION AND SCOPE

Cameco has conducted a local well inventory which identified local agricultural, domestic, and stock watering wells in and near the MEA (Figure 1, Appendix A, Technical Report). Of particular significance to this assessment is well 732, which is a high capacity irrigation well located in the shallow Arikaree/Brule aquifer approximately 2500 feet east of the nearest MEA ISR wellfield pattern area. This assessment focuses on the hydrologic influence of well 732 on a hypothetical material release (e.g. shallow casing leak) at the MEA ISR wellfields. In order to accomplish this task, the following basic analyses were performed:

- Hydrological and geological data for the shallow Arikaree/Brule aquifer were compiled and summarized as the basis for an analytical groundwater flow model of the shallow aquifer at the MEA and vicinity.
- The maximum average pumping rate for irrigation well 732 was computed from an annual permitted water use of 14 inches per acre (215 acres of irrigated land) and a typical 5-month irrigation season (mid-April to mid-September).
- The drawdown and capture zone of irrigation well 732 was simulated using the groundwater flow model and particle tracking techniques to assess whether a hypothetical shallow casing leak from the MEA wellfields could potentially impact the irrigation well.
- the adequacy of the current shallow groundwater monitoring well network was assessed and recommendations made to insure adequate protection of irrigation and domestic wells from a shallow release of regulated material at MEA wellfields.

IRRIGATION WELL CONSTRUCTION AND OPERATION

Well 732 supplies water to two center pivots totaling 215 acres of irrigated land. Permit documents for well 732 indicate an original pumping rate of 1300 gallons per minute (gpm). However, recent discussions with Upper Niobrara White Natural Resource District (UNWNRD) personnel indicate the actual operating pumping rate is approximately 800 gpm. The well is cased to a depth of 140 feet, with an open screened interval extending from 140 to 280 feet below grade (well bottom).

Given a permitted annual water application rate of 14 inches per acre and 215 acres of irrigated land, the maximum permitted water use for well 732 is 251 acre-ft/year. Assuming a 5-month irrigation season extending from mid-April to mid-September, this equates to a maximum continuous pumping rate of 373 gpm during the growing season. Because the actual operating pumping rate of well 732 is approximately 800 gpm, we can infer well 732 pumps at a rate of 800 gpm for a maximum of 11 hours each day during the 5-month growing season.

HYDROGEOLOGY AND GROUNDWATER MODEL PARAMETER ESTIMATES

Irrigation and domestic wells in the vicinity of the MEA are completed primarily within the shallow Arikaree/Brule aquifer, which is part of the High Plains Aquifer System of northwestern Nebraska[1]. The Arikaree/Brule aquifer at the MEA is hydraulically separated from the underlying Basal Chadron production aquifer by more than 400 feet of claystone and siltstone of the middle Chadron and upper Chadron Formations.

Water level elevation data compiled from shallow Arikaree formation monitoring wells and shallow Brule formation monitoring wells at the MEA indicate water levels and hydraulic gradients in the Arikaree and Brule are very similar, indicating a high degree of hydraulic communication and water-table (unconfined) conditions (Attachment A). Thus, the Arikaree and Brule Formations comprise a single, hydraulically-connected shallow aquifer at the MEA.

Depending on well construction and the depth of wells installed in the Arikaree/Brule aquifer, local groundwater conditions can vary from unconfined to semi-confined conditions (consistent with the observation of first water encountered at static water level depth and a hydraulically-connected shallow aquifer system). In areas with relatively deep irrigation wells that could be described as semi-confined under non-pumping conditions, groundwater becomes fully unconfined shortly after significant pumping begins (e.g. semi-confined to unconfined conversion) due to lowering of the local water table as pumping progresses. For these reasons, groundwater within the Arikaree/Brule aquifer at the MEA was simulated as an unconfined aquifer.

[1] Geohydrology of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, U.S. Geological Survey Professional Paper 1400-B, High Plains RASA project, 1984, 63p.

Aquifer properties of the Arikaree/Brule aquifer for this analysis were estimated from 1) grain-size distribution data collected from Cameco shallow Arikaree/Brule monitoring wells within the MEA, 2) specific capacity estimates from irrigation well 732, and 3) published regional hydrogeologic studies of the Arikaree/Brule aquifer. The following is a summary of hydrologic properties of the Arikaree/Brule aquifer at and near the MEA:

- the hydraulic conductivity of the Arikaree/Brule aquifer calculated from grain-size distribution analysis of sandy samples (> 45% sand by weight) obtained from shallow MEA monitoring wells varies from an average of 1.6 ft/day to a maximum of 8.2 ft/day (Attachment B).
- the hydraulic conductivity of the Arikaree/Brule aquifer was calculated from specific capacity estimates[2] for irrigation well 732, as given by:

  $T = 1500 * Q/s$, and (1)

  $K = T/b$ (2)

  where T is the aquifer transmissivity (gpd/ft), K is the hydraulic conductivity, b is the aquifer thickness (200 feet at well 732), Q is the pumping rate (800 gpm), and s is the maximum available drawdown limited by well/pump depth, (assumed to be approximately 160 feet at irrigation well 732). Given these assumptions, the hydraulic conductivity of the Arikaree/Brule aquifer is approximately 5.0 ft/day.
- regional studies[1,3] of the Arikaree/Brule aquifer indicate hydraulic conductivities near the MEA are less than 25 ft/day, consistent with grain-size and specific capacity estimates. These studies also indicate a specific yield of 0.15 to 0.20 is appropriate for the Arikaree/Brule aquifer at the MEA.
- The hydraulic gradient in the shallow Arikaree/Brule aquifer in the vicinity of well 732 is approximately 0.004 (calculated from water level maps presented in Attachment C).

IRRIGATION WELL IMPACT ANALYSIS

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) and a hypothetical shallow casing leak occurs at some time along the downgradient portion of the adjacent ISR wellfields at the MEA.

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[2] Driscoll (1986), Groundwater and Wells, second edition, equation 16.15 modified for unconfined conditions.

[3] Reed, E.C., and Pitkin, R. (unpublished). Table of hydraulic conductivity values for the High Plains Aquifer by grain-size classification, northwest Nebraska, Conservation and Survey Division, University of Nebraska.

To accomplish this task, an analytical groundwater flow model was used to simulate groundwater flow in the shallow Arikaree/Brule aquifer at the MEA. 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.

Two scenarios were simulated to ensure the range of possible hydrologic conditions at the site were adequately addressed. A high transmissivity (high K) scenario was simulated in order to produce a capture zone having the highest groundwater velocity (maximum chemical travel time). The low transmissivity (low K) scenario was simulated to produce a capture zone having the greatest width to ensure the area of potential impact was adequately addressed. Input parameters for the groundwater flow model were conservatively assigned as follows:

Hydraulic Conductivity (K) – 8.2 ft/day (high transmissivity scenario), 1.6 ft/day (low transmissivity scenario)

Aquifer Thickness - 202 feet

Regional Hydraulic Gradient (I) – 0.004 to the southeast

Specific Yield – 0.15

Aquifer Porosity – 0.15

Pumping Rate – 373 gpm for 5 months continuously, off for 7 months, each year.

RESULTS AND CONCLUSIONS

The water level drawdown in well 732 after 5 months of continuous pumping for high and low transmissivity scenarios are provided in Figures 2 and 3, respectively. Assuming maximum water use, approximately 0.1 to 0.7 feet of drawdown is predicted to occur at the end of each irrigation season in the nearest shallow monitor wells (AOW-9/BOW-9) due to operation of well 732.

The 30-year capture zone of well 732 was computed using reverse particle-tracking techniques. Figures 4 and 5 illustrate the capture zone of well 732 after 30 years for high and low transmissivity scenarios, respectively. 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.

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 (well 732), 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.

RECOMMENDATIONS

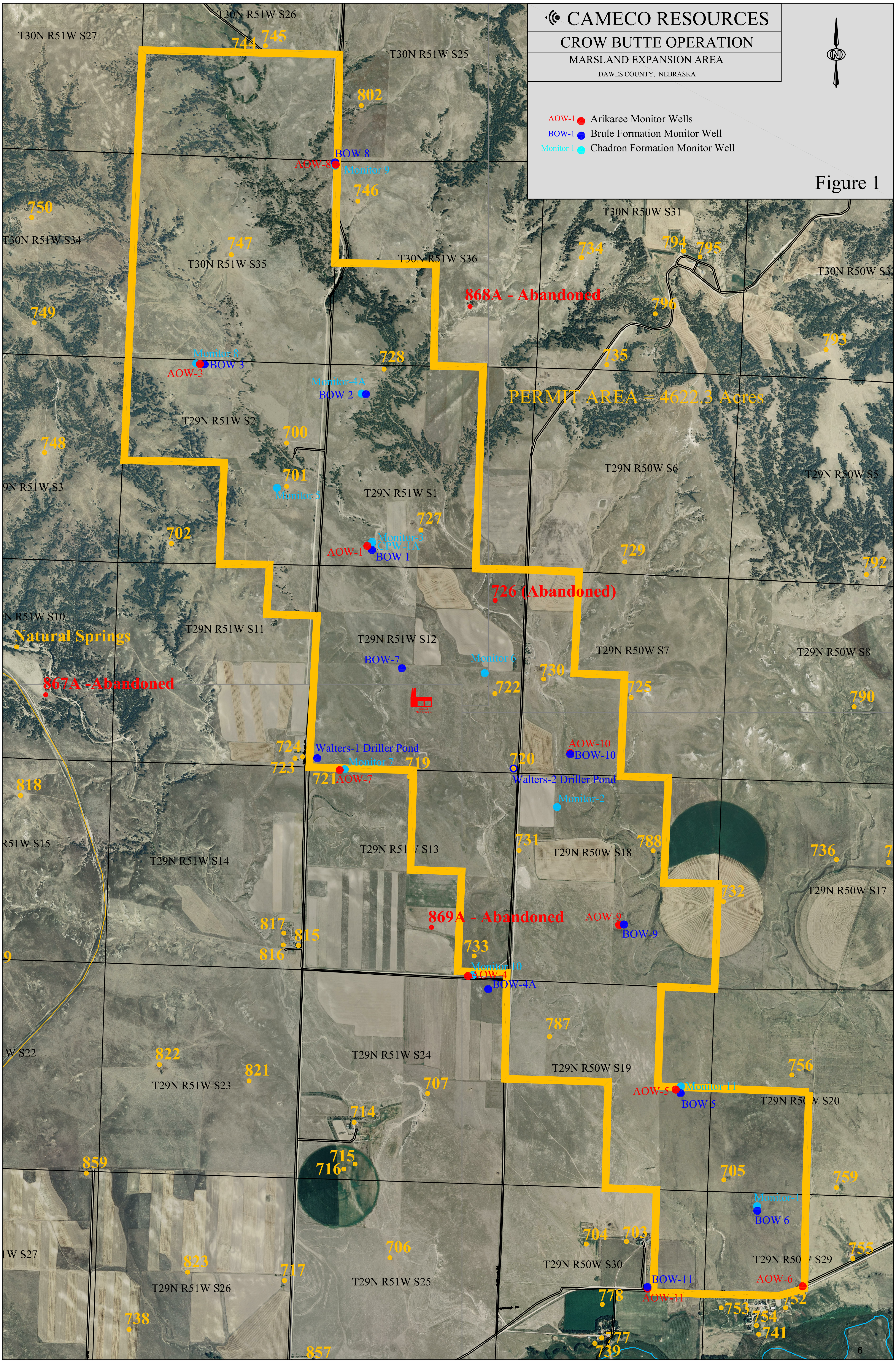
This study relies on limited information currently available concerning the hydrology of the shallow Arikaree/Brule aquifer and local irrigation well operations. Cameco currently plans to conduct continuous monitoring of groundwater elevations in shallow Arikaree/Brule monitoring wells in an effort to better characterize the shallow aquifer and quantify the hydrologic influence (e.g. drawdown) of local agricultural well pumping in the MEA during the 2014 irrigation season. At the end of the 2014 irrigation season, Cameco will use this information to calibrate and verify the groundwater model and confirm the conclusions of this study remain valid.

Please contact me directly if you have questions or comments concerning this report at 720-242-9510 Ext. 1#.

Sincerely,

AQUI-VER, INC

Robert L. Lewis, P.G.
Principal Hydrogeologist


CAMECO RESOURCES
CROW BUTTE OPERATION
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA
N
AOW-1 Arikaree Monitor Wells
BOW-1 Brule Formation Monitor Well
Monitor 1 Chadron Formation Monitor Well
Figure 1
PERMIT AREA = 4622.3 Acres
868A - Abandoned
726 (Abandoned)
867A - Abandoned
869A - Abandoned
Natural Springs
Walters-1 Driller Pond
Walters-2 Driller Pond
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
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T29N R50W S19
T29N R50W S20
T29N R51W S26
T29N R51W S25
T29N R50W S30
T29N R50W S29
AOW-3
BOW 3
Monitor 8
Monitor 4A
BOW 2
BOW 8
AOW-8
Monitor 9
Monitor 5
Monitor 3
AOW-1
BOW 1
BOW-7
Monitor 6
AOW-10
BOW-10
Monitor 7
AOW-7
Monitor-2
AOW-9
BOW-9
Monitor 10
AOW-4
BOW-4A
AOW-5
Monitor 11
BOW 5
BOW 6
BOW-11
AOW-11
AOW-6
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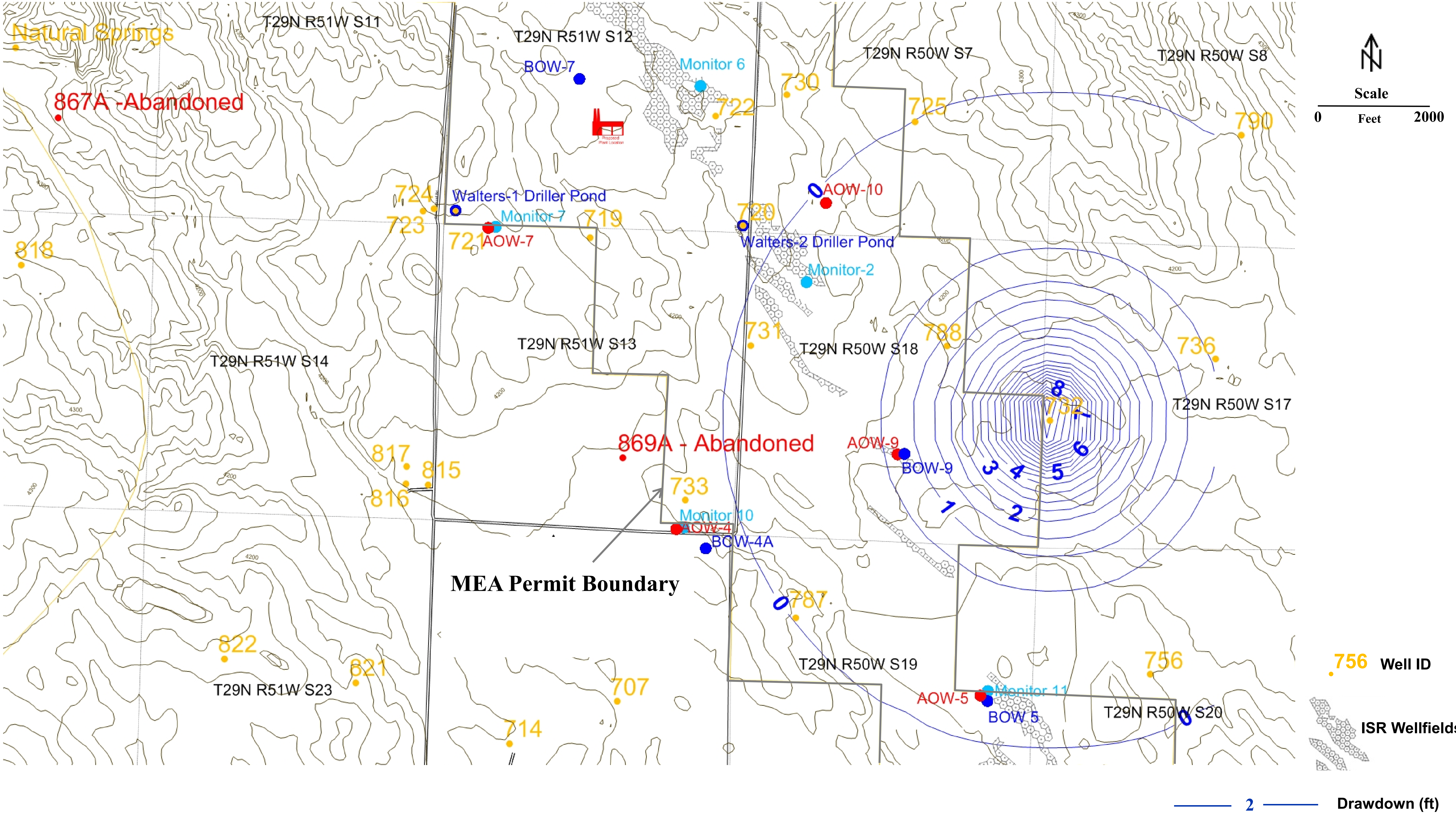
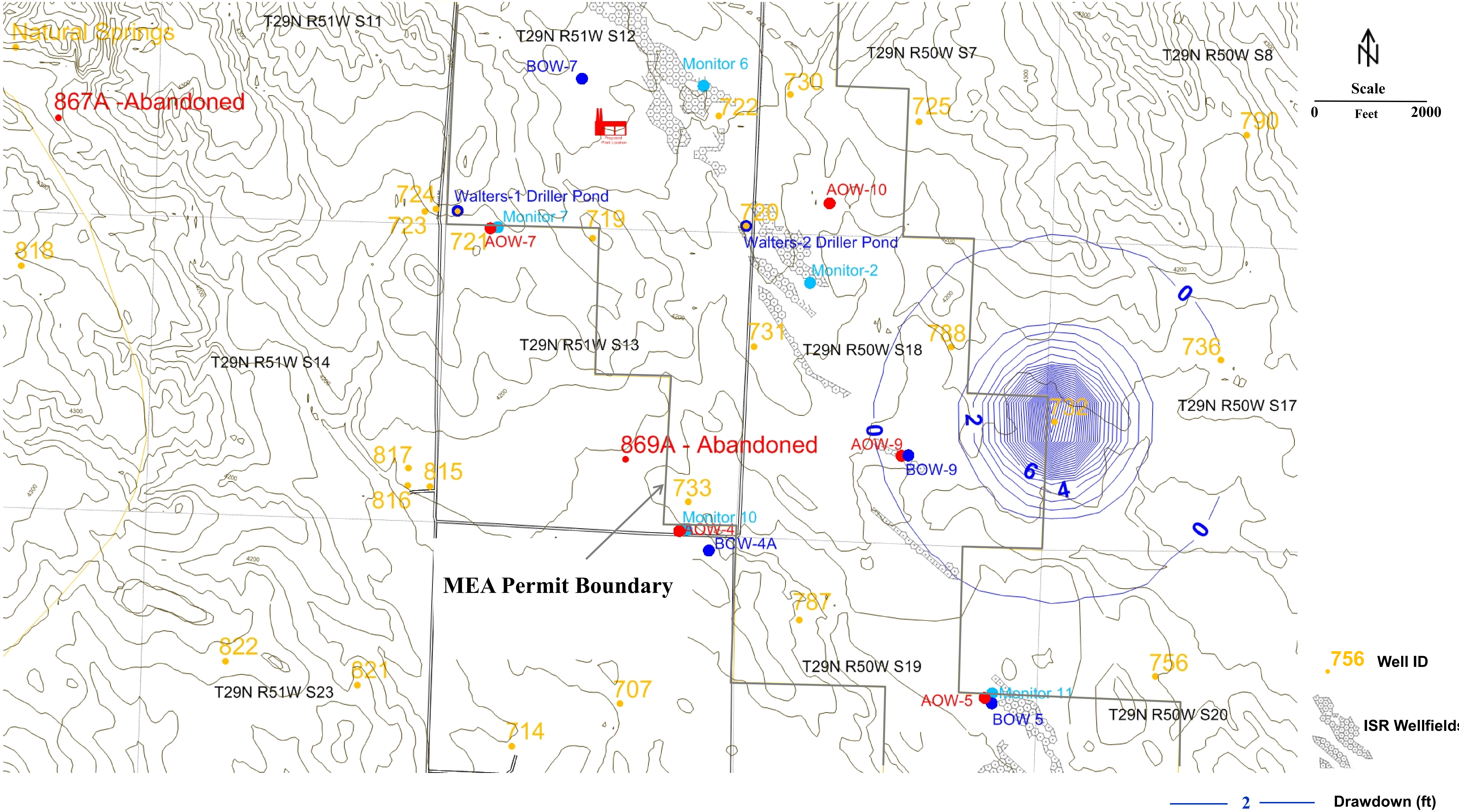


AQUI-VER, INC. *Hydrogeology, Water Resources & Data Services*	**Projected Drawdown in Arikaree/Brule Aquifer** **End of 5-month Irrigation Season** **High Transmissivity Scenario**	Crow Butte Project, Marsland Expansion Area, Dawes County, NE Cameco	FIGURE: **2**



AQUI-VER, INC.

Hydrogeology, Water Resources & Data Services

Projected Drawdown in Arikaree/Brule Aquifer
End of 5-month Irrigation Season

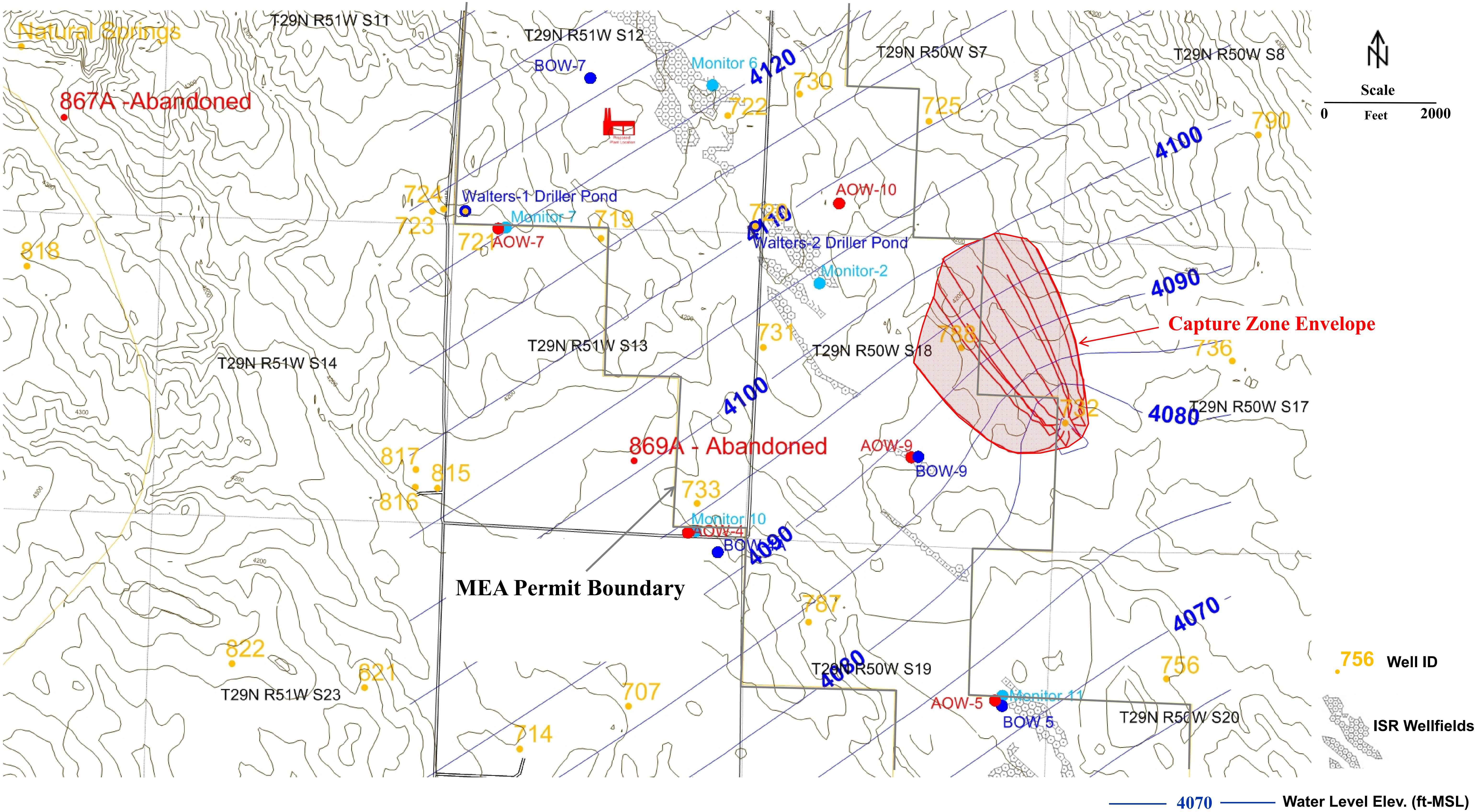
Low Transmissivity Scenario

Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

Cameco

FIGURE:

3



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Hydrogeology, Water Resources & Data Services

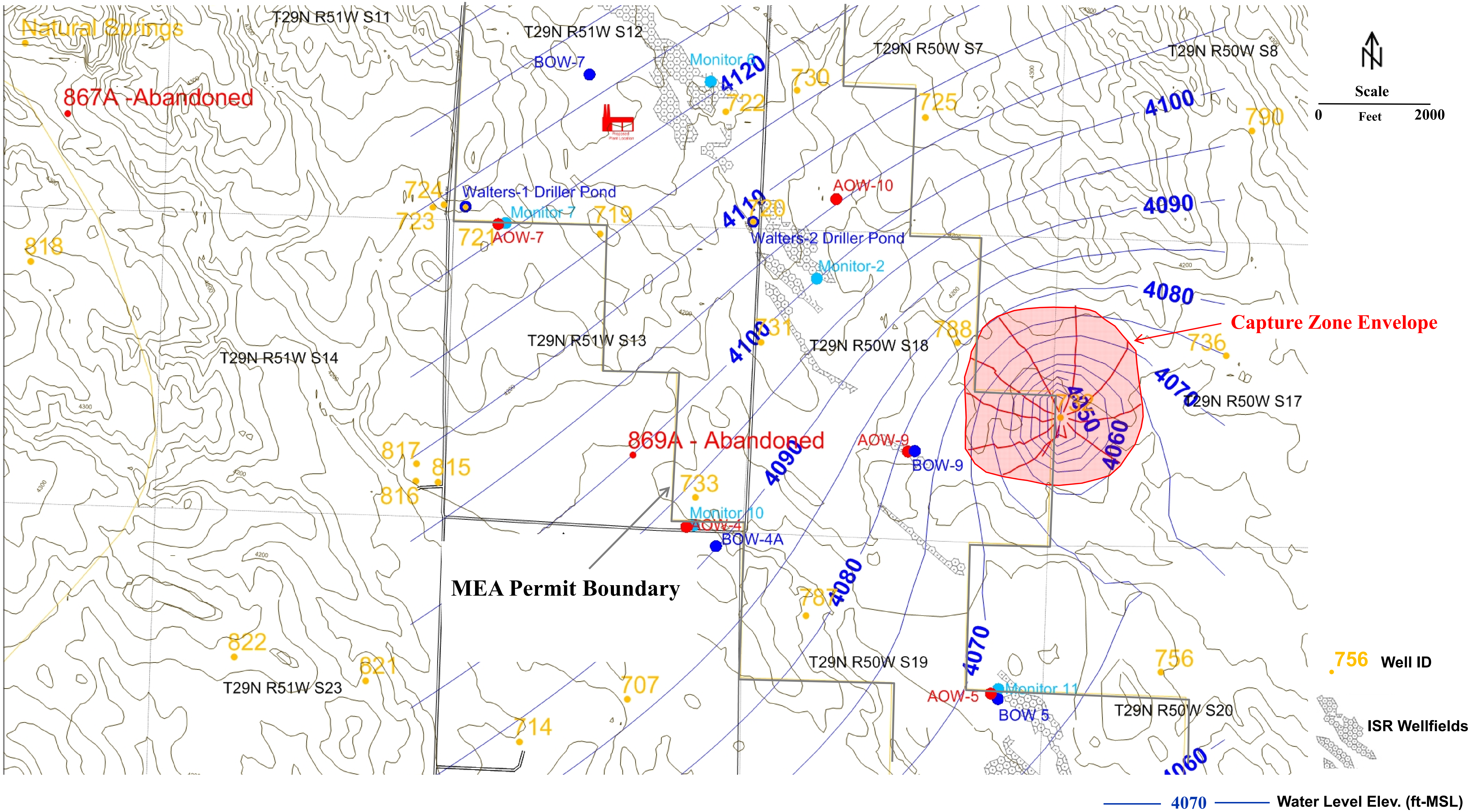
30-Year Capture Zone of Irrigation Well 732

High Transmissivity Scenario

Crow Butte Project, Marsland Expansion Area, Dawes County, NE

Cameco

FIGURE: 4



AQUI-VER, INC.
Hydrogeology, Water Resources & Data Services

30-Year Capture Zone of Irrigation Well 732
Low Transmissivity Scenario

Crow Butte Project, Marsland Expansion Area, Dawes County, NE

Cameco

FIGURE:
5

ATTACHMENT A

WATER LEVEL MONITORING DATA

Water Levels - Arikaree Group, Brule Formation and Basal Sandstone of Chadron Formation

Well	TOC Elevation (ft amsl)	2/22/11 Water Level (ft TOC)	2/22/11 Groundwater Elevation (ft amsl)	10/17/13 Water Level (ft TOC)	10/17/13 Groundwater Elevation (ft amsl)
ARIKAREE GROUP					
AOW-1	4261.64	--	--	126.4	4135.24
AOW-3	4351.97	--	--	142.2	4209.77
AOW-4	4161.91	--	--	87.3	4074.61
AOW-5	4125.42	--	--	72.0	4053.42
AOW-6	4068.60	--	--	20.0	4048.60
AOW-7	4243.94	--	--	DRY	4093.94
AOW-8	4365.02	--	--	71.7	4293.32
AOW-9	4146.41	--	--	74.9	4071.51
AOW-10	4198.60	--	--	113.3	4085.30
AOW-11	4091.02	--	--	35.4	4055.62
BRULE FORMATION					
BOW 2010-1	4260.10	125.74	4134.36	124.9	4135.20
BOW 2010-2	4324.96	150.03	4174.93	151.4	4173.56
BOW 2010-3	4352.80	137.20	4215.60	139.6	4213.20
BOW-2010-4	4163.13	86.65	4076.48	--	--
BOW 2010-4A	--	--	--	93.7	4069.43
BOW 2010-5	4127.88	71.19	4056.69	74.0	4053.88
BOW 2010-6	4100.43	49.30	4051.13	50.3	4050.13
BOW-2010-7	4248.37	--	--	155.6	4092.77
BOW-2010-8	4369.29	--	--	74.0	4295.29
BOW-2013-9	4145.90	--	--	74.6	4071.30
BOW-2013-10	4197.84	--	--	113.8	4084.04
BOW-2013-11	4091.87	--	--	37.4	4054.47
BASAL SANDSTONE OF CHADRON FORMATION					
CPW-2010-1	4261.35	551.63	3709.72	565.3	3696.05
CPW-2010-1A	4263.28	--	--	567.0	3696.28
Monitor 1	4103.28	387.65	3715.63	399.4	3703.88
Monitor 2	4199.50	484.99	3714.51	500.3	3699.20
Monitor 3	4261.40	550.90	3710.50	565.5	3695.90
Monitor 4A	4329.72	618.09	3711.64	634.3	3695.42
Monitor 5	4340.80	628.87	3711.93	645.4	3695.40
Monitor 6	4216.40	502.80	3713.60	518.2	3698.20
Monitor 7	4246.28	531.20	3715.08	548.0	3698.28
Monitor 8	4355.90	644.97	3710.93	660.5	3695.40
Monitor 9	4367.02	656.54	3710.48	669.7	3697.32
Monitor 10	4163.99	449.01	3714.98	465.0	3698.99
Monitor 11	4128.07	412.74	3715.33	427.9	3700.17

NOTES:

Groundwater elevations for the Brule Formation and Basal Chadron Sandstone are based on depth to water measurements.

TOC = top of casing

ft TOC = feet below top of casing

ft amsl = feet above mean sea level

DRY = measurable water not present in well at time of sampling

ATTACHMENT B

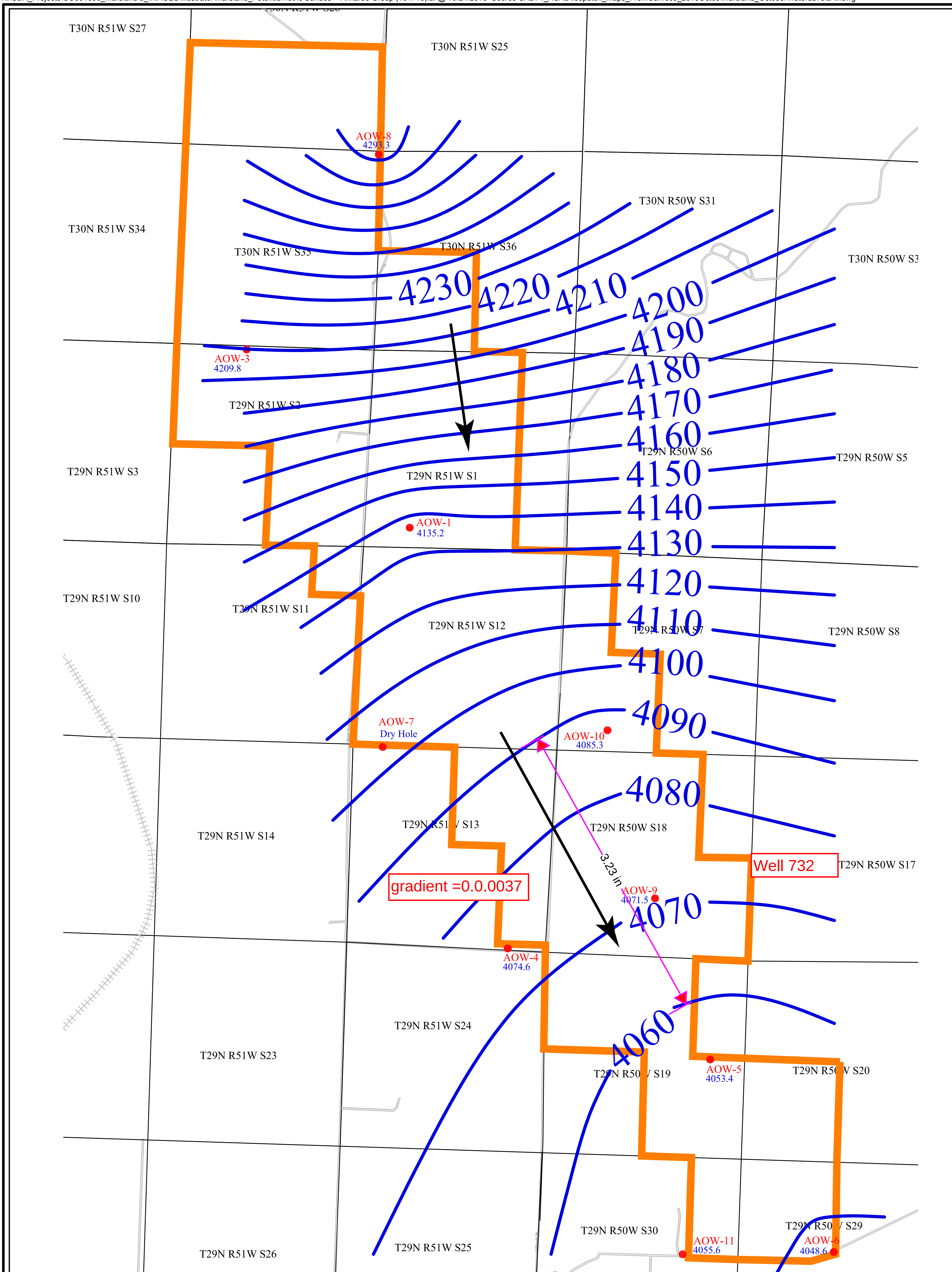
HYDRAULIC CONDUCTIVITY OF THE ARIKAREE/BRULE AQUIFER CALCULATED FROM GRAIN-SIZE ANALYSES

Hydraulic Conductivity of the Arikaree/Brule Formation Samples from Grain-Size Analyses (from ARCADIS U.S., Inc, personal communication)

	Geomean of K (cm/sec)	STD	Max K (cm/sec)	Min K (cm/sec)	# of Samples
Arikaree (all samples)	1.38E-04	9.27E-04	2.9E-03	2.3E-05	10
Arikaree (sand >45% by weight)	6.86E-04	1.22E-03	2.9E-03	1.0E-04	4
Brule (all samples)	9.22E-05	6.15E-05	2.3E-04	2.6E-05	12
Brule (sand >45% by weight)	2.31E-04	--	2.3E-04	--	1
Combined Arikaree and Brule (all samples)	1.11E-04	6.44E-04	2.9E-03	2.3E-05	22
Combined Arikaree and Brule (sand >45% by weight)	5.52E-04	1.14E-03	2.9E-03	1.0E-04	5

ATTACHMENT C

WATER LEVEL CONTOUR MAPS AND HYDRAULIC GRADIENT CALCULATIONS



LEGEND

- Proposed Marsland Expansion Area
- AOW-5 — Arikareen Group Well and Well ID
- 4053.4 — Water Level (FT-AMSL)
- Groundwater Elevation Contour (FT-AMSL)
- Groundwater Flow Direction
- Road
- Railroad

FT-AMSL = Feet Above Mean Sea Level

N

1 in

0 1,250 2,500

Feet

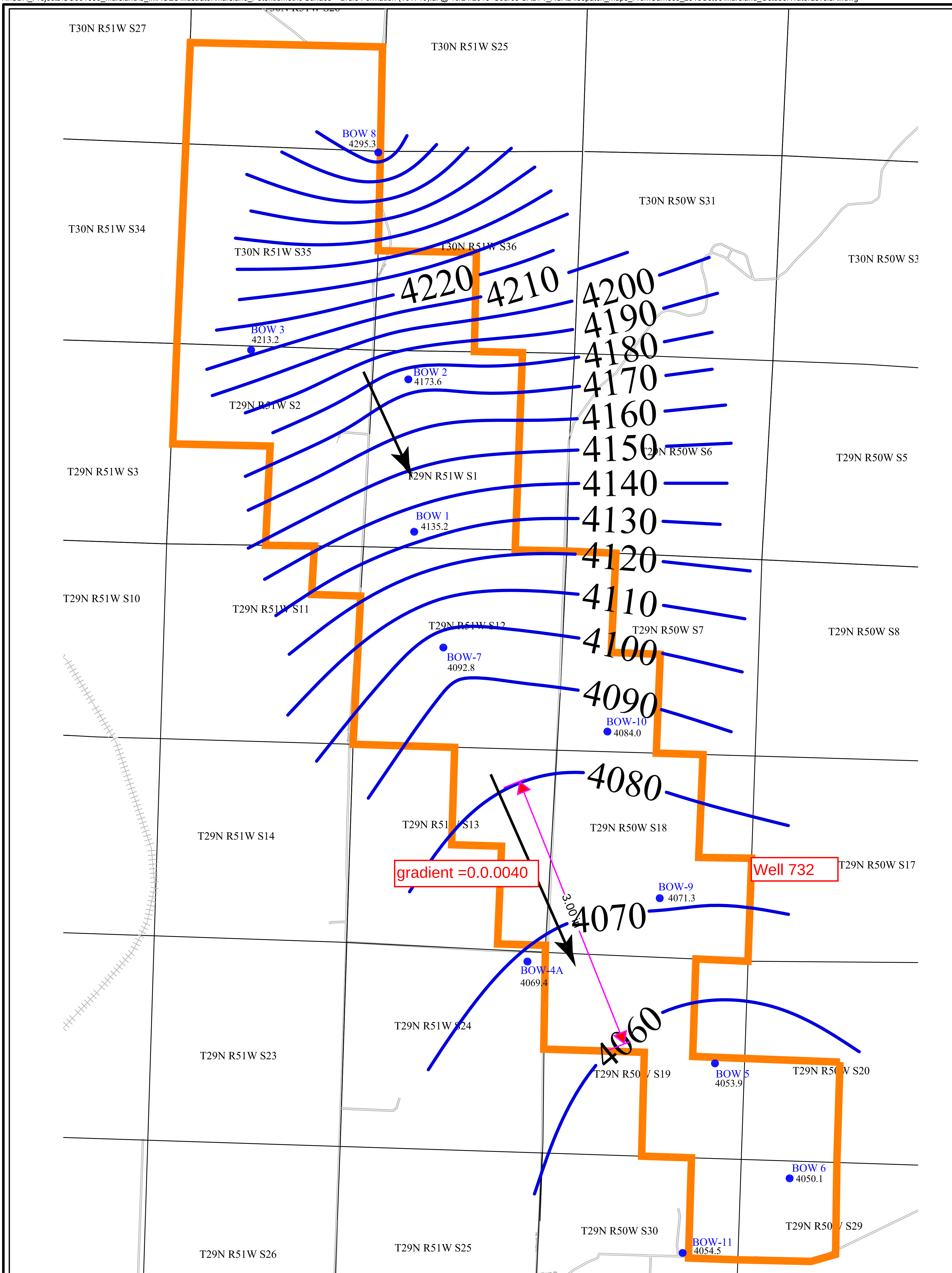
PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601

CROW BUTTE RESOURCES, INC.

FIGURE C-1
POTENTIOMETRIC SURFACE
ARIKAREE GROUP (10/17/13)

PROJECT: CO001636 FORMATTED BY: JC CHECKED BY: JA

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com



LEGEND

- Proposed Marsland Expansion Area
- BOW-5 — Brule Formation Well and Well ID
- 4053.9 — Water Level (FT-AMSL)
- Groundwater Elevation Contour (FT-AMSL)
- Groundwater Flow Direction
- Road
- Railroad

FT-AMSL = Feet Above Mean Sea Level

N

1.00 in

0 1,250 2,500

Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601

CROW BUTTE RESOURCES, INC.

FIGURE C-2
POTENTIOMETRIC SURFACE
BRULE FORMATION (10/17/13)

PROJECT: CO001636 FORMATTED BY: JC CHECKED BY: JA

ARCADIS

630 Plaza Drive, Ste. 100
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