Dave Heineman
Governor

STATE OF NEBRASKA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Michael J. Linder
Director
Suite 400, The Atrium
1200 'N' Street
P.O. Box 98922
Lincoln, Nebraska 68509-8922
Phone (402) 471-2186
FAX (402) 471-2909
website: www.deq.state.ne.us

MAY 23 2013

Tom Lancaster
Marsland Project Manager
US Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Dear Mr. Lancaster:

On April 22, 2013, NDEQ received a Class I Injection Well Application for the Marsland Expansion Area of Crow Butte Operations. Please find a copy of the application enclosed.

Sincerely,

Nancy Harris

Nancy Harris
UIC/ME Program Coordinator
Groundwater Unit
Water Quality Assessment Section
Ph: (402) 471-4290

Cameco

CAMECO RESOURCES
Corporate Office
2020 Carey Avenue
Suite 600
Cheyenne, WY
82001 USA

Tel: (307) 316-7600
Fax: (307) 635-9949
www.cameco.com

April 19, 2013

Mr. Michael Linder, Director
Nebraska Department of Environmental Quality
P.O. Box 98922
Lincoln, NE 68509-8922

Re : Application for a Class I Underground Injection Control Permit, Cameco Marsland Expansion Area

Dear Mr. Linder:

Crow Butte Resources is submitting this application for a Class I Underground Injection Control Permit to develop additional uranium in-situ recovery resources. The proposed development is called the Marsland Expansion Area and will be a satellite facility to the main Crow Butte Resources plant in Crawford Nebraska.

Enclosed are the permit application, a check for $25,000 payable to the State of Nebraska and seven copies of the permit application to facilitate review. The check is located on the inside of the front cover of the binder marked "original".

If you or your staff has any questions regarding the petition please contact John Schmuck at 307-316-7587.

Sincerely,

J.P. Schmuck for JOSH LEFTWICH

Josh Leftwich
Director of Safety Health Environment and Quality

Enclosures
Ec:

SUBSURFACE

AREA PERMIT APPLICATION
CLASS I NONHAZARDOUS WASTE INJECTION WELLS

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

SUBSURFACE PROJECT NO. 60D6753

SUBMITTED:
APRIL 2013

PREPARED BY

SUBSURFACE TECHNOLOGY, INC.
BATON ROUGE, LOUISIANA

SUBSURFACE

AREA PERMIT APPLICATION
CLASS I NONHAZARDOUS WASTE INJECTION WELLS

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

SUBSURFACE TECHNOLOGY, INC.
8212 KELWOOD AVENUE
BATON ROUGE, LOUISIANA
(225) 753-2561
pfbr@subsurfacegroup.com

SUBMITTED:
APRIL 2013

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INTRODUCTION

Crow Butte Resources, Inc. (dba Cameco Resources) is applying for an Area Permit to install and operate Class I Nonhazardous Waste Injection Wells at the company's Marsland Expansion Area (MEA) located in southwestern Dawes County, Nebraska, approximately 11.5 miles southeast of the City of Crawford, Nebraska and approximately 4 miles northeast of Marsland, Nebraska. The purpose of establishing an Area Permit is to allow for multiple injection wells to be installed at the facility over the expected multi-year life of the project. This permit application is for the initial two Class I Nonhazardous Waste Injection Wells to be installed under the Area Permit. Cameco is aware that a permit modification would be required for any additional wells added to the Area Permit at a later date.

This application has been prepared in accordance with the regulatory requirements presented in Nebraska Department of Environmental Quality Assessment Section, Title 122 Rules and Regulations for Underground Injection and Mineral Production Wells (Effective April 2, 2002). The application includes a table of contents, a completed *NDEQ Application for a Class I Non-Hazardous Injection Well Permit Form*, required certifications, and a supporting detailed technical report.

FOR AGENCY USE ONLY	APPLICATION NUMBER		
	N E		
	DATE RECEIVED		
	YEAR	MO.	DAY

NEBRASKA DEPARTMENT OF ENVIRONMENTAL QUALITY
APPLICATION FOR A CLASS I NON-HAZARDOUS INJECTION WELL PERMIT

This application is required in accordance to Title 122, Chapter 7, Section 001. This application must be submitted at least 180 days prior to any testing, drilling, or planned construction at the application site. Every item on this application must be completed. **An incomplete application will be returned.** If you have questions while filling out this application, please refer to Title 122, Chapter 11 or call **(402) 471-4290** and someone will assist you.

1. **Did you include the $25,000.00 non-refundable permit fee Made payable to the State of Nebraska?** Yes

2. **Describe the activities conducted at the facility and the nature of the business (Attach if necessary):**

The Marsland Expansion Area is an in-situ mining operation to recover uranium from the Chadron Sand. Uranium enriched groundwater is extracted and processed to recover the uranium. Wastewaters from the process are disposed deep underground into non-freshwater sands via Class I injection wells.

3. **List up to 4 Standard Industrial Classification (SIC) codes that best reflect the facility or process:**

1094	NAICS 212291		

4.

Name of Facility:	Marsland Expansion Area		
Operator's Name:	Crow Butte Resources, Inc.		
Street Address:	86 Crow Butte Road	City/Zip:	Crawford 69339
Telephone Number:	308-665-2215	County:	Dawes
Signatory Status:	(i.e. President, Partner, Executive Officer)		President
Entity Status:	(i.e. Federal, State, Private, Other)		Private
Operator's Signature (printed and signed)			

5.

Owner's Name:	William P. Goranson		
Mailing Address:	2020 Carey Ave Ste 600	City/Zip:	Cheyenne WY 82006
Telephone Number:	303-316-7601	County:	Laramie
Signatory Status:	(i.e. President, Partner, Executive Officer)		President
Entity Status:	(i.e. Federal, State, Private, Other)		Private
Owner's Signature (printed and signed):	[signature] William P. Goranson		

6. **Legal location of the Injection well, including county:** County: Dawes

(i.e. NW ¼ of the SE ¼ of Section 27, Township 14 North, Range 1 East)

WDW #1 SE/SE of Section 12, Township 29 North, Range 51 West

WDW #2 SW/SW of Section 7, Township 29 North, Range 50 West

7. **Is the facility located on Indian lands, historic and/or archaeological sites? If yes, please list them below (Attach if necessary):** No

The MEA facility is located on private lands in southwestern Dawes Cunty, Nebraska.

Refer to Sections 1.5 and 1.6 of the Permit Application for information on Surrounding Land Use and Cultural Resources

8. **List all environmental permits, construction approval, or any other relevant permit received or applied for from the Department or any other federal, state, or local regulatory agency for this site (Attach if necessary):**

Refer to Table 1.7-1 in the Permit Application for a listing of applicable regulatory permits.

9. **Proposed Operating Data:**

9a. Average and maximum daily volume of fluid to be injected:
Average: To be reported Maximum: To be reported

9b. Average and maximum injection pressure:
Average: 50 psi/well Maximum: 800 psi/well

10. **The zone of endangering influence:** (Refer to Title 122, Chapter 14) 0 feet
Attach all calculations and assumptions used in calculations.

11. **Name of person completing this form:** Jerry W. Taylor, P.G.
Telephone number: 225-753-2561
Signature:

CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

William P. Goranson
President
Crow Butte Resources, Inc.

4-12-13
Date

ENGINEERING CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

T. Walter Cook
Subsurface Technology, Inc.
Nebraska PE #E-13475

Date

GEOLOGICAL CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Jerry W. Taylor, PG
Subsurface Technology, Inc.
Nebraska PG #G-0365
4/2/13
Date

1.0 SITE DESCRIPTION

The following sections provide information pertaining to the location of the MEA, relevant site operations, surrounding land use patterns, cultural resources of the area, and related Underground Injection Control (UIC) project operated by Crow Butte Resources, Inc. (CBR).

1.1 Site Location

The MEA is located in southwestern Dawes County, Nebraska, approximately 12 miles southeast of the city of Crawford, Nebraska. The site is situated in Sections 26 and 35 of Township 30 North, Range 51 West, Sections 1, 2, 11, 12 and 13 of Township 29 North, Range 51 West and Sections 7,18,19, 20, 29 and 30 of Township 29 North, Range 50 West as depicted on Figure 1.1-1. The current CBO Area is approximately six miles northwest of the MEA and the planned TCEA is approximately eight miles northwest of the MEA, as depicted on the Site Location Map (Figure 1.1-1). Figure 1.1-2 presents a plan view of the MEA.

1.2 Facility Owner and Operator

MEA is wholly owned by CBR, a subsidiary of CBO (dba Cameco). Cameco is one of the world's largest publicly traded uranium companies.

Operator:	
	Crow Butte Resources, Inc. dba Cameco Resources
	86 Crow Butte Road
	P.O. Box 169
	Crawford, NE 69339-0169
Contacts:	
	Doug Pavlick
	General Manager
	308-665-2215
Owner:	
	Crow Butte Resources, Inc. dba Cameco Resources
	2020 Carey Avenue, Suite 600
	Cheyenne, WY 82001
Contacts:	
	William P. Goranson
	President
	307-316-7601

1.3 Relevant Site Operations

The nearby Crow Butte Project Research and Development Facility commenced operations in 1986, e.g., CBO. Following successful restoration of the R&D Project, commercial in-situ recovery (ISR) operations for uranium were initiated in 1991. In 2007, Cameco Resources was registered as a trade name with the Nebraska Secretary of State, with Crow Butte Resources, Inc. operating under the Cameco Resources trade name. The name of the facility was then referred to as the Crow Butte Operation, with the operator's and owner's name being Crow Butte Resources, Inc. dba Cameco Resources. The project continues to produce uranium.

The ISR mining process for uranium removal is a proven technology that has been successfully demonstrated commercially in Wyoming, Texas, and at the nearby CBO in Nebraska. ISR mining of uranium is environmentally superior to conventional open pit and underground uranium mining as evidenced by the following:

- ISR mining results in significantly less surface disturbance as mine pits, waste dumps, haul roads, and tailings ponds are not needed.
- ISR mining requires much less water demand than conventional mining and milling, avoiding the water usage associated with pit dewatering, conventional milling, and tailings transport.
- The lack of heavy equipment, haul roads, waste dumps, etc. result in very little air quality degradation at ISR mines.
- Fewer employees are needed at ISR mines, thereby reducing transportation and socioeconomic concerns.
- Aquifers are not excavated, but remain intact during and after ISR mining.
- Tailings ponds are not used, thereby eliminating a major ground water pollution concern.
- State of the art lined evaporation ponds and/or deep disposal wells are used to manage liquid waste streams.

ISR uranium mining results in the majority of other contaminants (e.g., heavy metals) being left in the subsurface environment where they naturally occur, instead of moving them to waste dumps and tailings ponds where their presence is of more environmental concern.

ISR entails the extraction of the uranium-enriched groundwater (leachate) from the subsurface mineralized zone, processing of the leachate to recover the naturally occurring uranium, and then mixing of the process stream with a complexing agent and oxidant with re-injection of the stream back into the mineralized zone to repeat the process.

A small amount of bleed water (approximately 0.5 to 1.5 percent of the total mining flow) is generated during the in-situ leaching process. This bleed water and a small volume of process water and wastewater generated by groundwater restoration activities will be disposed via the proposed Class I nonhazardous injection wells.

The MEA will be an expansion of ISR uranium mining operations for CBR in Dawes County, with operations already ongoing at the CBO area approximately six miles to the northwest.

At MEA, uranium will be recovered from the Basal Chadron Sand (same source formation as at CBO and TCEA), which ranges in depth from 800 to 1,250 feet below ground surface (bgs). The width of the ore body varies from 1,000 feet to 4,000 feet as depicted on Figure 1.3-1. The ore body ranges in grade from less than 0.11 percent to 0.33 percent U_3O_8, with an average grade estimated at 0.17 percent U_3O_8. The MEA ISR well fields will be designed in a manner consistent with the existing well fields at CBO.

Extracted uranium will be processed in a satellite facility located within the MEA or will be piped directly to CBO for uranium recovery. The satellite facility will operate at an average flow rate of 6,000 gpm (excluding 1,500 gpm for restoration) with an expected annual production rate of 600,000 pounds U_3O_8. Total reserves for the MEA are estimated to be approximately 9,551,197 pounds U_3O_8.

The uranium extracted from the MEA will be loaded onto ion exchange resin in the Satellite Plant, which will then be transported by tanker truck to the main plant at the CBO area for elution, precipitation, drying and packaging. Barren resin will be returned to the MEA satellite plant by tanker truck.

1.4 Proposed Injection Wells

CBR is seeking an Area Permit for the MEA. The two wells being permitted under this application (WDW #1 and WDW #2) will be installed at the following locations as shown on Figure 1.4-1:

- WDW #1: SE/SE of Section 12, Township 29 North, Range 51 West
- WDW #2: SW/SW of Section 7, Township 29 North, Range 50 West

The purpose of the injection wells is to dispose of well field bleed water and a small volume of process water from ISR mining operations and wastewater generated by groundwater restoration activities. Additional injection wells would be permitted and installed under the Area Permit at later dates as the MEA ISR mining operations expand if they are deemed necessary.

1.5 Surrounding Land Use

Land use in the vicinity of the MEA is dominated by agricultural uses. Livestock grazing on rangeland comprises the greatest portion of land use. Figure 1.5-1 provides land use patterns in the area of the MEA.

Residential and commercial land uses in Dawes County are concentrated within the city limits of Crawford and Chadron. Industrial land uses within the city limits of Crawford are generally associated with railroad facilities.

Within the MEA, rangeland accounts for 82.3 percent of the land use. Additional minor land uses (cropland 9.9 percent and forestland 7.7 percent) occur within the MEA.

No surface water impoundments are located within the MEA. The Niobrara River, located just south of the MEA is the prominent drainage in the vicinity of the MEA.

1.6 Cultural Resources

Recreational opportunities provided by federal and state lands in Dawes County have become an increasingly important component of the local economy. There are no developed recreation facilities within the MEA. Nearby recreational facilities in Dawes County include the Fort Robinson State Park, Ponderosa Wildlife Management Area (WMA), Chadron State Park, Soldier Creek Wilderness Area, the Red Cloud Picnic Area and several trails in the Nebraska National Forest.

Habitat lands are those dedicated wholly or partially to the production, protection, or management of species of fish or wildlife. Significant areas classified as habitat nearest to the MEA include the Peterson WMA, located nearly 15 miles northwest of the MEA boundary; the Fort Robinson WMA, located 14 miles north-northwest of the MEA boundary; and the Ponderosa State WMA, which is 7 miles north of the MEA boundary. There is no land within the MEA that is used primarily for wildlife habitat. Wildlife habitat is a secondary use of rangeland and forestland within the MEA and surrounding area.

The proposed MEA is on private lands immediately south of the Nebraska National Forest-Pine Ridge Ranger District.

ARCADIS (ARCADIS 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 National Historic Preservation Act, NHPA) 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 DW00-243 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 (construction and operations) 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.

1.7 Site Regulatory Permits

Applicable permits received (or applied for if not yet received) for the MEA and related CBR projects are listed in Table 1.7-1.

1.8 Description of Related UIC Projects

The MEA project, for which this Area Permit application is being submitted, is the third project to be developed by CBR in Nebraska that utilizes underground injection wells to dispose of a nonhazardous waste stream associated with ISR uranium mining operations from the basal sand of the Chadron Formation.

CBR currently operates such a project approximately six miles to the northwest of MEA at the CBO which includes the original Crow Butte ISR mining operation and two associated Class I nonhazardous waste injection wells. A Class I UIC Application for Class I nonhazardous waste injection wells at the second TCEA project, located approximately four miles west of the CBO will be submitted to the Nebraska Department of Environmental Quality (NDEQ).

CBR has also received a Class III UIC Permit for the North Trend Expansion Area (NTEA) located northwest of the initially developed CBO site.

The current CBO area is located in Sections 11, 12, 13, and 24 Township 31 North, Range 52 West and Sections 18, 19, 20, 29, and 30 Township 31 North, Range 51 West. The permit area consists of approximately 2,875 acres. The MEA location in relation to the current CBO is shown in Figure 1.1-1.

Injection Well #1 at CBO has been in operation since 1994. The last major permit modification request for Well #1 was made in 2010 to increase vanadium disposal criteria to 100 milligrams per liter (mg/L). This modification was subsequently approved by NDEQ, and the permit expires July 2, 2014. Injection Well #2 has more recently been installed at CBO following NDEQ approval of a permit application. Injection Well #1 is completed in the Cretaceous age Morrison Formation and Injection Well #2 is completed in the Morrison and Sundance formations.

The proposed injection zone for the planned injection wells at MEA will include the Lower Dakota, Morrison, and Sundance formations similar to the injection zone at CBO. The specific injection interval at MEA will be determined based on site-specific data acquired when the first two injection wells are drilled. It is anticipated that the Morrison or the underlying Sundance Formation will be the injection interval at MEA.

2.0 GEOLOGIC AND HYDROGEOLOGIC INFORMATION

The following sections present information related to the geologic and hydrogeologic setting at the MEA.

2.1 Physiography

The MEA is located near the northern limits of the High Plains section of the Great Plains physiographic province. The most prominent physiographic feature in the region is the Pine Ridge Escarpment, which rises roughly 300 to 900 feet above the basal plain. The escarpment bounds three sides of the Crawford Basin (refer to Section 2.3.2). Colluvial and alluvial deposits originating from this escarpment cover the permit area.

Topography of the area includes gently sloping, rolling hills with outlying, broad ridges which are dissected by intermittent and perennial streams. Land surface elevation in the area ranges from approximately 3,880 to 4,400 feet above mean sea level (amsl). Surface topography is depicted on the topographic map used for Figure 1.1-1.

2.2 Regional Geology

MEA is located in Dawes County in northwestern Nebraska. Table 2.2-1 presents a published generalized geologic and hydrostratigraphic framework for Nebraska. A portion of the geologic map of bedrock in northwest Nebraska is provided on Figure 2.2-1. A regional geologic cross-section orientated west to east from the Rocky Mountains to the Omaha area is shown on Figure 2.2-2. As described in Section 2.3 below, the local geologic setting is consistent with the regional geologic setting depicted on Table 2.2-1 and Figure 2.2-2.

All geologic units encountered during the drilling of oil and gas exploration wells in the vicinity of the MEA are consistent with known regional stratigraphy. Geologic units that are consistently identified in oil and gas wells include the Brule Formation, Chadron Formation, Pierre Shale, Niobrara Formation, Carlisle Shale, Greenhorn Limestone, Graneros Shale, "D" and "J" sands of the Upper Dakota Group, the Lower Dakota Group, Morrison Formation, Sundance Formation and Satanka Shale.

2.3 Local Geology

The following subsections provide discussions concerning the geology in the area of the MEA.

2.3.1 Stratigraphy

The subsurface stratigraphy in the vicinity of the MEA is provided in Table 2.2-1 which shows the stratigraphic sequence from land surface down to the Precambrian basement rocks.

The local stratigraphy of interest within the MEA consists of the following geological units in descending order: Brule Formation, Chadron Formation, Pierre Shale, Niobrara Formation, Lower Dakota Formation, Morrison Formation, Sundance Formation, and Satanka Shale.

The formations of primary importance to underground injection operations at the MEA are the Lower Cretaceous/Upper Jurassic sequence which includes the Lower Dakota, Morrison, and Sundance.

The following is a detailed description of the shallow stratigraphy at the MEA based on an extensive review of existing site-specific drilling logs and published literature. Geological units are described from stratigraphically youngest to stratigraphically oldest. Revised nomenclature for these stratigraphic units is discussed, where applicable, and referred to throughout this application. To be consistent with historical permitting, the stratigraphic nomenclature used in previous submittals to the Nuclear Regulatory Commission and the NDEQ has been preserved. Table 2.3-1 accompanies the following text.

Quaternary

Alluvium

Quaternary alluvium as much as 30 feet in thickness overlies the Arikaree Group along drainages in the study area. In general, the alluvium consists of fragments of locally outcropping Oligocene-Miocene sedimentary rocks, sand, gravel and sandy soil horizons, and may include weathered fragments of the Arikaree Group. Because alluvium is unconsolidated and may incorporate one or both of the vadose and phreatic (shallow groundwater) zones, log signatures within this unit vary in comparison with those geologic units in the deeper subsurface underlying units. On most MEA logs, resistivity values for alluvium are very high (beyond the log scale), indicating the presence of either soil vapor or fresh water. In general, shallow zones with elevated resistivity are also distinguished by a negatively deflected SP curve, suggesting the presence of a permeable zone and formation fluid with lower resistivity than the fluid within the borehole. Although these log signatures suggest the base of the alluvium can be readily identified in geophysical logs, this relationship has not been verified and the alluvium Arikaree Group contact is not depicted on cross-sections.

The weathered upper part of the Arikaree Group that is in direct contact with overlying alluvium exhibits signatures in geophysical logs that are similar to those of the overlying alluvium. Therefore, interpretation of the contact between the two mapped units is only tentative.

Oligocene-Miocene

Arikaree Group

The Oligocene – Miocene aged Arikaree Group is typically a water bearing unit overlain by alluvium. Within the MEA permit boundary, the Arikaree Group has limited occurrence and is deposited at shallow depths. The thickness varies from 50 to 210 feet, depending upon the degree of erosion. The Arikaree Group lies unconformably above the Brule Formation and is comprised of the Upper Harrison Beds, Harrison-Monroe Creek and Gering Formations, aged youngest to oldest, respectively (Collings and Knode, 1984; Swinehart et al., 1985; LaGarry, H. E., 1998; McFadden and Hunt, Jr., 1998).

In the literature, the Upper Harrison beds are referred to as the Marsland Formation or are grouped with the upper portion of the Harrison-Monroe Creek Formation to create separate Harrison and Monroe Creek formations. This permit will use the nomenclature presented in Swinehart et al. (1985) which uses the Upper Harrison beds, Harrison-Monroe Creek and Gering Formations.

Contained within the Arikaree are numerous channel and flood plain deposits. In some locations crossbedding is observed. Grain size increases from very fine to fine to medium. The coarsest materials are epiclasts from the White River Group and the Rocky Mountains (Bradley and Rainwater, 1956; Tedford et al., 1985; Hoganson, J.W., et al., 1998).

Upper Harrison Beds

The Upper Harrison beds are comprised of buff and gray fine sand without abundant silt and clay, white sand with abundant silt and clay and a siliceous pedogenic horizon. Convolute laminae are formed from the fine sand and contain very little silt or clay. The white sand was formed from sheet flow following rains and/or flooding after a heavy ash fall and formed a massive unlaminated layer. The lower part of the Upper Harrison contains large blocks formed from underlying strata indicating deposition from channel and floodplains. Cross stratified beds are also found within the Upper Harrison (Witzel, 1974; Vicars and Breyer, 1981).

Harrison - Monroe Creek Formation

The upper portion of the Harrison-Monroe Creek Formation is comprised of fine, unconsolidated grey sand. The lower portion is comprised of compact fine sandy silt and clay, pinkish to buff in color and a fine to medium grained gray sand (Witzel, 1974; McFadden and Hunt, Jr., 1998).

Concretions are found in the upper and lower portions of the Harrison-Monroe Creek Formation. Concretions within the upper beds are typically smaller than those found within the lower portion of the formation. The concretions are comprised of long irregular cylindrical masses which are fine grained and grey in color (Lugn, 1939; Witzel, 1974; Collings and Knode, 1984).

Gering Formation

The Gering Formation consists of gray, grayish brown volcaniclastic fine to medium grained sandstones, silty sandstones, silt and local beds of ash, coarse sand and fine gravel. The unconformable contact between the Brule and Gering Formations is readily observed when the sediments of the Gering Formation were deposited by channels and proximal flood plains. When the sediments of the Gering are fine grained, the contact is harder to discern (Witzel, 1974; Collings and Knode, 1984; McFadden and Hunt, Jr., 1998).

Eocene-Oligocene

White River Group

The White River Group consists of the Chamberlain Pass Formation overlain by the Chadron Formation, which is, in turn, overlain by the Brule Formation. Strata assigned to this group were deposited within fluvial, lacustrine, and eolian environments (Terry and LaGarry, 1998). In northwest Nebraska, it rests unconformably on weathered Pierre Shale. The bulk of the White River Group consists of airfall and reworked volcaniclastics derived from sources in Nevada and Utah (Larson and Evanoff, 1998; Terry and LaGarry, 1998).

The history of stratigraphic nomenclature for the White River Group of Nebraska and South Dakota has had various interpretations as described by Harksen and Macdonald (1969). The following stratigraphic nomenclature retains the formal and informal members based on nomenclature by Schultz and Stout (1955) but also includes more recent nomenclature (Terry and LaGarry, 1998; Terry, 1998; LaGarry, 1998; Hoganson et al., 1998).

Brule Formation

The Brule Formation (Oligiocene) is the stratigraphically-lowest unit within the White River Group that crops out extensively in the study area; underlying and older units of the same group are unexposed (Gutentag et al., 1984). The Brule Formation was originally subdivided by Swinehart, et al. (1985) and later revised by LaGarry (1998) into three members, from youngest to oldest: the "brown siltstone" member, the Whitney Member, and underlying Orella Member. The "brown siltstone" member consists of pale brown and brown, nodular, cross-bedded eolian volcaniclastic siltstones and sandy siltstones.

The contact with the underlying Whitney Member varies from a gradational contact to a sharp disconformity where the "brown siltstone" fills valleys incised into the older stata of the Whitney Member. The Whitney Member consists mostly of pale brown, massive, typically nodular eolian siltstones with rare thin interbeds of brown and bluish-green sandstone, and volcanic ash. The lowest 10 meters of the Whitney Member, however, consist of white or green laminated fluvial siltstones, sheet sandstones, and channel sandstones. The contact between the Whitney Member and the underlying Orella Member is intertonguing. The Orella Member consists of pale brown, brown, and brownish-orange volcaniclastic overbank clayey siltstones and silty claystones, brown and bluish-green overbank sheet sandstones, and thin volcanic ashes. Rare thick, fine- to medium-grained, channelized sandstones appear throughout the Orella Member. These sandstones appear to have very limited lateral extent. The overall thickness of the Brule Formation within the MEA is generally less than 400 feet and ranges from approximately 50 to 350 feet.

The contact between the Brule Formation and underlying Chadron Formation is difficult to identify in some places, as the contact between the two formations is inter tonguing (LaGarry 1998). Regionally, the contact is recognized as the lithologic change from thinly interbedded and less pedogenically-modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member to pedogenically-modified green, red, and pink volcaniclastic silty claystones of the Big Cottonwood Creek Member in the upper Chadron Formation (Terry and LaGarry 1998). The Brule Formation is characterized by rapidly fluctuating geophysical log curves, or "log chatter". This response is recognized in resistivity curves, and to a lesser extent in SP curves, throughout the MEA. Such fluctuations result from resistivity contrasts between the thinly interbedded siltstones and sandstones of the Orella Member. Because the sandstones are porous and constitute a part of the regional aquifer, the contacts with the interbedded, dry siltstones are sharp and easily recognized on logs (Gutentag et al., 1984). Lateral correlation of beds within the Brule Formation is very difficult due to generally thin bed thicknesses and limited lateral extent.

The contact between the interbedded siltstones and sandstone of the Brule Formation and the silty claystones of the Upper Chadron Formation is distinguished by a drop off of "log chatter" and establishment of relatively flat or straight curves (i.e., the shale baseline) on both resistivity and SP logs. Because of the intertonguing nature of the Lower Brule and Upper Chadron Formations, thin, isolated sandstones and siltstones may be present in the Upper Chadron, making it appear that the formation contact is deeper in some wells.

Chadron Formation

The Eocene-Oligocene Chadron Formation is the lower part of the White River Group. The Chadron Formation conformably overlies the basal sandstone of the Chadron Formation and is conformably overlain by the Brule Formation. From top to bottom, the Chadron Formation historically consists of the following stratigraphic units: Big Cottonwood Creek Member (herein referred to as the upper Chadron and upper/middle Chadron to be consistent with historical permitting), Peanut Peak Member (herein referred to as the middle Chadron to also be consistent with historical permitting), and basal sandstone of the Chadron Formation. The basal sandstone of the Chadron Formation represents the production zone and target of ISL mining within the MEA.

Upper Chadron and Upper/Middle Chadron Formation

The Upper Chadron Formation and Upper/Middle Chadron Formation are composed primarily of volcaniclastic overbank silty claystones interbedded with tabular and lenticular channel sandstones, lacustrine limestones, pedogenic calcretes, marls, volcanic ashes, and gypsum (Terry and LaGarry 1998). Tuffs in the Toadstool Park area that occur in the Upper Chadron were dated by 40Ar/39Ar methods as late Eocene (~34 Ma) in age (Terry and LaGarry 1998). The lower boundary of this member is an intertonguing contact with the underlying Middle Chadron of the Chadron Formation, or is a local unconformity where the Upper/Middle Chadron fills valleys and depressions (Terry and LaGarry 1998). The upper boundary is recognized by a lithologic change from pedogenically modified green, red, and pink volcaniclastic silty claystones of the Upper Chadron to thinly interbedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member of the Brule Formation (Terry and LaGarry, 1998).

The Upper Chadron is the youngest member of the Chadron Formation. The upper part of the Upper Chadron is light green-gray bentonitic clay grading downward to green and frequently red clay, though interbedded sandstones also occur. Based on the predominance of fine-grained lithologies that comprise the Upper Chadron, this unit represents a distinct and rapid facies change from the sandstones present in the underlying Upper/Middle Chadron and Basal Chadron Sandstone. On the basis of aviailable well control data, the Upper Chadron is continuous under the MEA. The Upper Chadron ranges in stratigraphic thickness from approximately 410 to 650 feet in the MEA.

Two core samples (M-1454c, Run 1 and M-1624c, Run 1) were collected from the Upper Chadron by CBR at boreholes M-1454c and M1624c, Sections 1 and 12, T29N, R51W of the MEA. X-ray diffraction analyses of M-1454c Run 1 and M-1624c Run 1 samples indicate varied compositions. M-1454c Run 1 was primarily comprised of calcite, montmorillonite and quartz. Minor amounts of plagioclase, potassium feldspar and illite/mica were recorded. M-1624c was primarily comprised of mixed layered illite/smectite, calcite and quartz. Minor amounts of plagioclase, potassium feldspar, magnetite and illite/mica were recorded. Particle size distribution analyses of M-1454c Run 1 and M-1624c Run 1 give median grain sizes of 0.056 mm (silt) and 0.049 mm (silt), respectively. Both samples are dominated by silt-sized grains, however M-1454c Run 1 contained more medium sand than M-1624c, which increased the median grain size. M-1454c Run 1 contained 47.25% silt and 9.64% clay. M-1624c Run 1 contained 54.65% silt and 8.73% clay. As M-1454c Run 1 and M-1624c Run 1 both contain greater than 50% combined silt and clay-sized particles, and because greater than 67% of the silt+clay component is silt, they are classified as siltstones (Brown and Harrell, 1991).

Typical GR, SP, and resistivity log signatures for the Upper Chadron exhibit curves representative of the relatively flat shale baseline. Fluctuations are present among Upper Chadron log curves, representing interbedded siltstones, sandstones, limestones, and volcanic ash deposits that occur less commonly than in the overlying Brule Formation.

The Upper/Middle Chadron is directly overlain by the Upper Chadron. At some locations, the Upper/Middle Chadron is similar in appearance to the channel sandstone facies of the upper portion of the basal sandstone of the Chadron Formation (described later in this section) and is typically very fine to fine grained, well-sorted, poorly cemented sandstone. However, within the MEA permit boundaries, the water-bearing sandstones of the upper/middle Chadron Formation that are recognized in other locations such as TCEA are not present within the MEA. Geophysical logs (discussed below) and core samples indicate the presence of a finer-grained facies than is present at TCEA. Therefore, because the sandstones of the upper/middle Chadron are absent, the upper Chadron and middle Chadron Formation comprise a thick continuous mudstone and siltstone sequence within the MEA.

Review of geophysical logs from within the permit boundaries indicates that the upper/middle Chadron has poor reservoir characteristics and minimal water saturation. When compared to aquifers of the Brule Formation and basal sandstone of the Chadron Formation (discussed below), inflections in resistivity, neutron and SP curves are almost wholly unseen within the upper/middle Chadron. At TCEA, the upper/middle Chadron was recognized and correlated primarily on the basis of decreased neutron counts (indicating increased porosity), increased resistivity (indicating the possible presence of relatively fresh water) and other log signature combinations. Correlation of the upper/middle Chadron at MEA using GR log signatures is problematic due to the presence of bentonitic deposits throughout the upper and middle Chadron Formation. Occasional, very minor increases in resistivity are present at the stratigraphic level likely to represent the upper/middle Chadron, but are not consistent across the MEA. These comparatively muted log signatures indicate that water may be intermittently present within the upper/middle Chadron. However, water saturations are not significant enough to create strong log responses as recognized in other known aquifers within the MEA. Therefore, a continuous sandstone aquifer within the upper/middle Chadron is interpreted to be absent within the MEA.

Middle Chadron Formation

The Middle Chadron is a clay-rich interval that grades from brick red to grey in color with interbedded bentonitic clay and sands. Light green-gray "sticky" clay within this unit serves as an excellent marker bed in drill cuttings and has been observed in virtually all regional test holes both within the MEA, TCEA, NTEA and the current CBO. The Middle Chadron unconformably overlies the Basal Chadron Sandstone (Chamberlain Pass Formation) in South Dakota and

Nebraska (Terry 1998). As described above, the upper boundary is variable and is overlain either by the Upper/Middle Chadron, where present, or by the Upper Chadron. The Middle Chadron differs from the overlying Upper/Middle and Upper Chadron in that the Middle Chadron is composed of bluish-green, smectite-rich mudstone and claystone, weathers into hummocky, "haystack-shaped" hills and slopes with a popcorn-like surface, is less variegated in color, and has less silt (Terry 1998). The predominantly clay lithology of the Middle Chadron represents a distinct and rapid facies change from the underlying Basal Chadron Sandstone. Within the MEA, the unit ranges in stratigraphic thickness from about 20 to 290 feet.

Two core samples (M-1454c Run 2 and M-1624c, Run 2) were collected from the Middle Chadron by CBR at boreholes M-1454c and M-1624c, Sections 1 and 12, T29N, R51W of the MEA. X-ray diffraction analysis of the M-1454c Run 2 and M-1624 Run 2 samples indicate varied composition. Samples M1454c Run 2 and M-1624c Run 2 are primarily comprised of mixed-layered illite/smectite; however, M-1454c Run 2 also contains a high amount of calcite. Other minor minerals found within the samples include quartz plagioclase, potassium, feldspar, chlorite and illite/mica. Particle size distribution analysis of M-1454c Run 2 and M-1624c Run 2 give median grain sizes of 0.0027 mm (silt) and 0.065 mm (very fine sand), respectively. Both were mainly comprised of silt sized particles, however, M-1624c Run 2 contained more medium sand than M-1454c Run 2, which increased the median grain size. M-1454c Run 2 contained 46.36% silt and 20.65% clay. M-1624c Run 2 contained 34.6% silt and 16.54% clay. Both are classified as siltstones (Brown and Harrell, 1991).

Typical GR, SP, and resistivity log signatures for the Middle Chadron exhibit curves representative of the shale baseline. The contact between the top of the Middle Chadron and the overlying upper Chadron is difficult to ascertain due to similarities in grain size. At MEA, due to like lithology and geophysical log responses between the upper/middle and middle Chadron Formation, it is difficult to define the contact between these units.

Basal Sandstone of the Chadron Formation – Mining Unit

The basal sandstone of the Chadron Formation is the oldest unit in the White River Group. The lower part is a coarse-grained, arkosic sandstone with common, discontinuous interbedded thin silt and clay lenses of varying thickness. The basal Chadron sandstone overlies a marked regional unconformity with the underlying Yellow Mounds Paleosol (Terry 1998). The lower contact is easily recognized as change from the underlying black or bright yellow, pedogenically modified surface of the Pierre Shale (i.e., the Yellow Mounds Paleosol) to white channel sandstone. In places,, the basal sandstone of the Chadron Formation grades upward to fine sandstone containing varying amounts of interstitial clay and persistent clay interbeds. Vertebrate fossils from the Basal Chadron Sandstone in northwestern Nebraska and South Dakota indicate a late Eocene age (Chadronian) (Clark et al. 1967; LaGarry 1996; Lillegraven 1970; Vondra 1958). The Upper Interior Paleosol, occurring as a persistent clay horizon, typically brick red in color, developed on top of the Basal Chadron Sandstone and generally marks the upper limit of the Basal Chadron Sandstone.

The basal Chadron sandstone occurs at depths ranging from about 817 to 1,130 feet bgs and was encountered at all exploration holes. Stratigraphic thickness of the unit within the MEA ranges from approximately 20 to 110 feet. The thickest sections of the unit occur in the western portions of the MEA. Up to four distinct sandstone horizons are present in the thickest portions of this unit and are separated by variable amounts of interbedded clay. Regionally, the unit ranges in thickness from 0 to 250 feet.

The greenish-white channel sandstones of the Basal Chadron Sandstone that overlie the Yellow Mounds Paleosol are the target of ISR mining activities in the MEA. Regionally, deposition of the Basal Chadron Sandstone has been attributed to large, high-energy braided streams (Collings and Knode, 1984; Hansley et al., 1989). In this regard, the Basal Chadron Sandstone is lenticular with numerous facies changes occurring within short distances. The interbedded thin silt and clay lenses most likely represent flood plain or low velocity deposits normally associated with fluvial sedimentation.

Core samples (M-1454c Runs 3 and 4 and M-1624c Runs 3 and 4) were collected from the basal sandstone of the Chadron Formation by CBR at boreholes M-1454c and M-1624c in Sections 1 and 7, T29N, R51W. X-ray diffraction analysis of the M-1454c sample indicates a varied composition. Run 3 is mainly comprised of quartz whereas Run 4 is mainly comprised of mixed-layered smectite. Minor amounts of plagioclase feldspar, potassium feldspar, kaolinite and illite/mica were found in both samples. Run 3 also had trace amounts of calcite, siderite, pyrite, magnetite and magnesium vanadium oxide, while Run 4 had minor amounts of dolomite and chlorite. Particle size distribution analysis of M-1454c Run 3 and M-1624c Run 4 give median grain sizes of 0.075 mm (very fine sand) and 0.711 mm (coarse sand), respectively. M-1454c Run 3 contained 29.85% silt and 19.92% clay. M-1624c Run 4 contained 11.56% silt and 4.5% clay. Both are classified as sandstones (Brown and Harrell,1991).

The sandstones of the basal sandstone of the Chadron Formation within the CBO are dominated by quartz (50% monocrystalline) and feldspar (30 – 40% undifferentiated feldspar) with the remainder made up of chert, pyrite and various heavy metals and polycrystalline and chalcedonic quartz (Collings and Knode, 1984). X-ray diffraction analyses indicate that the basal sandstone of the Chadron Formation within the area of the CBO is 75 percent quartz and the remaining 25% consisting of a combination of potassium feldspar, plagioclase, illite, smectite, expandable mixed layer illite-smectite and kaolinite (Collings and Knode, 1984).

Geophysical logs record a unique signature for the Basal Chadron Sandstone. A distinct GR spike is present at the base of the unit in most of the MEA exploration boreholes, indicating an abundance of radioactive material. Increased resistivity (i.e., log curve shift to the right), decreased N-N count (i.e., log curve shift to the left), and decreased SP (i.e., log curve shift to the left) are typically associated with GR spikes. These log signatures support interpretations of a uranium-bearing, fluid-filled sandstone interval. Overlying channel sandstone intervals that are present in the middle and upper portions of the unit typically have lower GR readings, indicative of both lower amounts of radioactive materials and potentially non-uranium bearing intervals. Such intervals are typically marked by increased resistivity (i.e., higher porosity and fluid-filled) and lower N-N counts and, in contrast to the uranium-bearing units, typically have positive SP curve deviations. This log response indicates that within the higher uranium-bearing units, mud filtrate resistivity is higher than formation water resistivity, which may be the result of the presence of higher salinity waters in uranium-bearing units. Pervasive interbedded clay intervals are indicated by high GR responses accompanied by lower resistivity (i.e., reduced porosity and decrease in water content), an interpretation that is further supported by driller or geologist's notes. The high radioactivity of these clay-rich units suggests the presence of rhyolitic ash (Hansley and Dickenson, 1990). The top of the formation is marked by a gradual return of SP and resistivity curves to the shale baseline.

Near surface sediments consist of the Tertiary age White River Group which includes the Brule and Chadron formations. The Brule is the main source of fresh water in the area. The basal sand unit of the Chadron Formation, typically 40 to 80 feet in thickness, is the target of uranium extraction operations.

Cretaceous Age Sediments

The Cretaceous age Pierre Shale, Niobrara Formation, Carlisle Shale, Greenhorn Limestone, Graneros Shale and the upper portion of the Dakota Group comprise a confining interval approximately 2,100 feet thick which provides an excellent aquitard between the shallow water in the Brule and Chadron Sands and the proposed Injection Zone.

The Pierre Shale is thick regionally continuous homogenous black marine shale with low permeability that represents one of the most laterally extensive formations of northwest Nebraska. Regional geologic data indicate that this formation can be up to 1,500 feet thick in the Dawes County area (Figure 2.2-2).

The Pierre Shale is not a water-bearing unit, exhibits very low permeability, and is considered a regional aquiclude. Regional estimates of hydraulic conductivity for the Pierre Shale range from 10^{-7} to 10^{-12} centimeters per second (cm/sec). The Pierre Shale has a measured vertical hydraulic conductivity at the current CBO of less than 1×10^{-10} cm/sec, which is consistent with other studies in the region. Particle grain-size analyses of two samples collected from the Pierre Shale within the MEA indicate low permeability silty clay and clayey silt compositions. Regional studies also indicate there is no observed transmissivity between vertical fractures in the Pierre Shale, which appear to be short and unconnected.

The Pierre Shale is underlain by the Niobrara Formation consisting of organic-rich shale and marl with minor amounts of sandstone, siltstone, limestone, and chalk. The Niobrara, another regional aquiclude, is similar to the Pierre Shale in that it is laterally extensive and exhibits low permeability.

The Niobrara Formation is underlain by a sequence of shale with intermixed sand and limestone, most notably the Greenhorn limestone, the D Sand and the J Sand. The D and J sands are known to be petroleum producers in some areas but not in the MEA.

The Dakota Group comprises the basal Cretaceous sediments overlying the Morrison Formation. The Dakota is approximately 100 to 150 feet thick and consists of interbedded siltstones and sandstones separated by layers of mudstone and shale.

Jurassic Age Sediments

The Jurassic age Morrison Formation is described as a white, very fine to fine grained non-calcareous sand interbedded with siltstone and calcareous shale. The Sundance Formation underlies the Morrison and consists of very dark to black occasionally reddish brown shale interbedded with light gray to off white very fine grained sandstones. The Sundance is typically on the order of 300 feet thick

The Sundance has been divided into upper, lower, and basal units, with the basal unit separated from the overlying units by a regionally continuous limestone and shale layer.

Permian Age Sediments

The Sundance is underlain by the Permian age Satanka Shale which consists of impermeable limestone, shale and anhydrite. The Satanka forms an excellent aquiclude below the proposed Injection Zone consisting of the Lower Dakota, Morrison and Sundance.

2.3.2 Structure

The most prominent structural expression in northwest Nebraska is the Chadron Arch. It is an anticline striking northwest-southeast along the northeastern boundary of Dawes County (Figure 2.3-1).

The MEA area is situated just outside the southern boundary of the Crawford Basin along the Cochran Arch. The Crawford Basin is structurally folded into a westward-plunging syncline that trends roughly east-west. The basin is a triangular asymmetrical basin about 50 miles long in an east-west direction and 25 to 30 miles wide that is bounded by the Hat Creek Anticline to the west, the Chadron Arch to the east, and the Cochran Arch to the south (Figure 2.3-2).

Regional dip on the formations of primary importance to underground injection operations at the MEA (Pierre Shale down through the Satanka Shale), is generally towards the west.

Approximately five miles north of the MEA is the inferred Pine Ridge Fault, located along the northern edge of the Pine Ridge escarpment (Figure 2.3-2). The 230-mile long Pine Ridge escarpment exhibits an average of 1,200 feet of topographic relief (Nixon 1995). The Pine Ridge escarpment is an arc roughly concentric to the Black Hills Dome, which suggests an apparent structural relationship. The escarpment has been interpreted to represent the southern outermost cuesta of the Black Hills Dome (Nixon 1995). The escarpment is capped by sandstone of the Arikaree Group with exposed deposits of the White River Group mapped along the topographically lower, northern side of the escarpment. The Pine Ridge fault trends east to west across both Sioux and Dawes Counties, is sub-parallel to the Cochran Arch, and has a reported normal, north side down displacement of roughly 300 feet. This fault is believed to be post-early Miocene.

The planned subsurface injection operations at MEA will have no affect on this fault nor will the injection operations be affected by the faulting.

2.3.3 Seismic Activity

The USGS updated the National Seismic Hazard Maps in 2008, which includes changes in the methodology used to model potential seismicity in any given region (Petersen, M.D. 2008). Wheeler and Crone, 2001 described Quaternary fault zones and their potential seismic activity. Their findings were used in the prior National Seismic Hazard Map. The revised maps incorporate new seismic, geologic, and geodetic information on earthquake rates and associated ground shaking. The maps supersede versions released in 1996 and 2002. The National Hazard Maps show the distribution of earthquake shaking levels that have a certain probability of occurring in the U.S. (Figure 2.3-3). The hazard ranking ranges from the lowest hazard (0.4 %g) to the highest (64+ %g), with the City of Crawford area and the majority of Nebraska being located in a low hazard ranking level of 4 to 8 %g. The term "%g" is a unit of acceleration (movement of earth) measured in terms of gravity (g), i.e., acceleration due to gravity. Peak acceleration refers to the maximum acceleration (movement) experienced during a non-uniform earthquake event (i.e., starts off small, achieves a maximum and then decreases).

The seismic hazard map for Nebraska (Figure 2.3-4) represents the peak acceleration (%g) with a 2% probability of exceedance in 50 years (USGS 2009a), meaning that in a given 50-year period, there is only a 2% chance of seismic shaking exceeding any given equivalent percentage of acceleration due to Earth's gravity. Figure 2.3-4 also shows that the modeled peak acceleration due to seismic shaking in the City of Crawford area is very low: 6 to 8 %g for the majority of the immediate area, and 8 to 10 %g in a much smaller area, meaning that the maximum shaking due to any given earthquake in the region during a 50 year period would be equivalent to only 10% or less of the force of gravity at the Earth's surface. These estimates demonstrate that the Marsland and City of Crawford area are at the low end of the USGS hazard ranking system for earthquake risks. Note that the difference between Figures 2.3-3 and 2.3-4 as to the hazard ranking values are due to the use of different scales, i.e., 4 to 8 versus 6 to 8, respectively.

Earthquakes release different amounts of energy and the strength of this energy can be measured by magnitude and intensity. The Richter Scale is used to measure the magnitude of an earthquake and is a measure of the physical energy released or the vibrational energy associated with the earthquake. In general, earthquakes below 4.0 on the Richter scale do not cause damage, and earthquakes below 2.0 usually can't be felt. Earthquakes over 5.0 on the Richter scale can cause damage. An earthquake of a magnitude 6.0 is considered strong and a magnitude of 7.0 is considered a major earthquake.

A seismicity map of Nebraska that shows the distribution of earthquakes from 1990 to 2006 is shown in Figure 2.3-5. Appendix 2.3-1 includes a NEIC listing of seismic events within a 200 mile radius of the centerpoint of the MEA site.

The risk of major earthquakes in Dawes County and the state of Nebraska is low. Based on the preceedings information, and historical records for the proposed MEA in northwest Nebraska, no major effects would be expected from earthquakes on the ISR mining operations planned at the MEA.

2.3.4 Injection Zone

The planned injection wells at the MEA will inject liquids into an Injection Zone comprised of the Lower Dakota, Morrison and Sundance Formations as shown on Figure 2.3-6.

Drawings 2.3-1 and 2.3-2 are geologic cross-sections that shows the lateral continuity of the formations comprising the Injection Zone. Drawing 2.3-3 is a structure contour map on top of the Injection Zone. Note that previous artificial penetrations near the MEA did not fully penetrate the Injection Zone. However, the formations comprising the Injection Zone are expected to be present beneath the MEA given the laterally consistent geology of the region as indicated on Drawings 2.3-1 and 2.3-2.

The specific injection interval within the Injection Zone will be selected in the field based on open-hole logging and post-drilling injectivity testing activities as described in Section 7.0. To assure a successful well installation, the plan calls for drilling through the Sundance Formation approximately 100 feet into the underlying Santanka Shale.

Formation testing and actual injection operations at CBO have determined that the Morrison Formation is highly permeable and behaves as an infinite reservoir.

The Morrison Formation is currently utilized exclusively for injection at the CBR and is expected to be the injection interval at MEA.

2.3.5 Confining Zone

The Upper Confining Zone is comprised predominantly of Cretaceous age low permeability formations from the top of the Pierre Shale down to the top of the Lower Dakota Formation. Together, these formations provide over 2,100 feet of low permeability units overlying the Injection Zone (refer to Drawings 2.3-1 and 2.3-2).

The Sundance is underlain by the Satanka Shale which consists of impermeable limestone, shale and anhydrite forming an excellent Lower Confining Zone below the Injection Zone (refer to Drawings 2.3-1 and 2.3-2).

Drawings 2.3-1 and 2.3-2 show the lateral continuity of the formations comprising the Upper Confining Zone and the Lower Confining Zone. Drawing 2.3-4 is a structure contour map on top of the Upper Confining Zone. Hydraulic resistance to vertical flow is expected to be very good due to the significant thickness of the Upper Confining Zone.

2.4 Local Hydrogeology

The water table is typically encountered at less than 200 feet below land surface across most of the state including the Dawes County area. Nebraska is highly dependent on groundwater for drinking water and the state's agricultural industry utilizes vast amounts of groundwater to irrigate crops.

2.4.1 Fresh Water Aquifers

The White River Group contains the fresh water aquifers in the project area as shown on Figure 2.4-1. The Arikaree Group, Brule Formation, and the sandstone of the basal Chadron Formation are considered the water-bearing intervals. The alluvial deposits are not typically considered to be a reliable water source. Sandy siltstones, overbank sheet sandstones and occasional thick channelized sandstones that occur throughout the Orella Member of the Brule Formation may be locally water-bearing units. These sandstone and siltstone units are difficult to correlate over any large distance and are discontinuous lenses, rather than laterally continuous strata. The Brule Formation has historically been considered the shallowest aquifer above the Basal Chadron Sand aquifer and water supply wells have been completed in this unit.

Available groundwater data for both the Brule Formation and basal sandstone of the Chadron Formation at the MEA do not indicate any documented flow rate variations or recharge issues that would impact groundwater quality as a result of ISR mining operations in the basal sandstone of the Chadron Formation. There are no surface-water ponds within the MEA permit boundary and only limited, intermittent flow in ephemeral drainages. The Brule Formation, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data do not indicate any seasonality or pumping effects by domestic wells within this zone.

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 (ft bls), with the exception of locations where the overlying alluvium is not present. In general, the static water level for Brule Formation wells in the MEA ranges from 50 to 150 ft bls, depending on local topography.

Groundwater from the basal sandstone of the Chadron Formation Aquifer is not used as a domestic supply within or near the MEA because of the greater depth (580 to 940 ft bls) and inferior water quality. Gosselin et al. (1996) state that: (1) *"the sands near the bottom of the Chadron Formation yield sodium-sulphate water with high total dissolved solids,"* and (2) in proximity to *"uranium deposits in the Crawford area, groundwater from the Chadron Formation is not suitable for domestic or livestock purposes because of high radium concentrations."*

2.4.2 Base of Underground Source of Drinking Water

The base of the Chadron Sand of the White River Group is the base of the Underground Source of Drinking Water (USDW) in the MEA (refer to Figure 2.4-1). Fresh water wells are completed primarily in the Brule Formation because the Brule is shallower than the Chadron Sand and historically known to contain fewer minerals. Furthermore, the Chadron Sand is the source of uranium for ISR operations in this area.

The subsurface geologic characteristics beneath the MEA will prevent disposal fluids injected into the Injection Zone from impacting the overlying fresh water aquifers. Between the lowermost USDW and the Injection Zone are over 2,500 feet of sediments primarily consisting of low permeability shale. This separating aquitard protects against vertical migration of injected fluids to the USDWs. 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.

3.0 INJECTION ZONE

The subsurface interval composed of the Lower Dakota, Morrison and Sundance Formations has been identified as the Injection Zone at the MEA. The Morrison Formation has demonstrated the capability to accept large volumes of the injected waste stream over an extended period of time at the nearby CBO, located approximately six miles to the northwest. It is anticipated that the Morrison Formation will be the injection interval at MEA.

The Injection Zone is defined on the geologic cross-sections presented on Drawings 2.3-1 and 2.3-2. Structural contours on top of the Injection Zone are presented as Drawing 2.3-3.

3.1 Estimated Porosity and Permeability

The average porosity of the Injection Zone is estimated to be approximately 25 percent and the average permeability is estimated to be approximately 500 millidarcies based on information collected from the same geologic formations in DDW #1 and DDW #2 at the CBO site, located approximately six miles to the northwest. These estimated values were selected assuming the Morrison would be the predominant receiver of fluids. Site-specific data will be collected from all potential injection intervals (Morrison and Sundance Formations) during the installation of DDW #1 at MEA to provide porosity and permeability data for each formation within the Injection Zone (refer to Section 7.0).

3.2 Estimated Formation (Bottom-Hole) Temperature

The bottom-hole temperature at the midpoint (D) of the Injection Zone is estimated to be approximately 118°F ($T_{average}$) based on a mean surface temperature (T_{Mean}) of 50°F and an average geothermal gradient (m) of 0.020 °F/ft. This is comparable to the bottom-hole temperatures recorded at 138°F to 151°F in the DDW #1 and DDW #2 at CBO six miles to the northwest (refer to Table 3.0-1).

$$
\begin{aligned}
T_{average} &= T_{Mean} + m\,D \\
&= 50 + 0.020\left(\frac{3{,}150 + 3{,}650}{2}\right) \\
&= 118\,^{0}F
\end{aligned}
$$

3.3 Estimated Formation (Bottom-Hole) Pressure

The bottom-hole pressure (P_{BH}) at the top of the Injection Zone at an estimated depth of 3,150 ft bls is estimated to be approximately 729.2 psi based on a fluid level of 1,504 feet and an average pressure gradient of 8.52 pounds per gallon (lb/gal) (0.443 per square inch per foot [psi/ft]) for the fluid column above the Injection Zone. This estimate is comparable to original bottom-hole pressures recorded in DDW #1 and DDW #2 at CBO six miles to the northwest; which was measured at values ranging from 890 at 3,359 feet to 1,015 psi at 3,784 feet (refer to Table 3.0-1).

3.4 Estimated Formation Brine Characteristics

The estimated concentrations of total dissolved solids 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.

Total dissolved solids (TDS) of formation water recovered from the Morrison and Sundance Formations in DDW #1 and DDW #2 at the CBO approximately six miles to the northwest demonstrate both formations contain fluids in excess of 10,000 mg/L TDS. The Morrison Formation fluid TDS is in excess of 23,000 mg/L and the Sundance Formation fluid TDS is in excess of 35,000 mg/L (refer to Table 3.0-1). Formation water quality for the Lower Dakota is not currently available.

Formation water samples will be collected from the Morrison and Sundance Formations in the first well drilled at MEA to document water quality in both formations is greater than 10,000 mg/L TDS beneath this site.

3.5 Calculated Formation Fracture Pressure

The fracture gradient at the top of the Injection Zone, estimated to be approximately 3,150 feet deep, was estimated from a graph of formation pore pressures, depth and fracture gradient (Figure 3.5-1) adapted after Eaton, 1969. Using an assumed pore pressure of 9.0 lb/gal, the estimated fracture gradient at the top of the Injection Zone was determined to be 13.725 lb/gal which is equivalent to 0.714 psi/ft (13.725 lb/gal x 0.052 psi/ft/lb/gal). Therefore, the calculated fracture pressure at the top of the Injection Zone, estimated to be at a depth of approximately 3,150 feet deep, is 2,249 psi (3,150 feet x 0.714 psi/ft).

3.6 Calculated Critical Pressure Rise

Critical pressure rise (Δp_c) is defined as that level of pressurization in the Injection Zone sufficient to drive fluids from the Injection Zone to the base of the USDW through a hypothetical wellbore or other artificial penetration. Such an artificial penetration may be assumed to be filled with mud, as are all the known inactive wellbores in the MEA Area of Review (AOR).

Mud-filled wellbores may have been partially or never cased, and were left full of drilling mud to the ground surface. Over decades, drilling mud may settle partially, and it is assumed that the top 50 feet of such wellbores is filled with freshwater rather than mud. It is also assumed that the old drilling fluid has gel strength of at least 20 pounds per square foot (lb/ft^2). Drilling muds may be assumed to be heavier than 9 pounds per gallon (lb/gal), so this is the assumed worst-case mud density.

The critical pressure rise (Δp_c) for the Injection Zone is calculated as follows:

$$\Delta P_{Critical\ Rise} = \left(L_{Injection\ Interval} - d_{fallback}\right)\left(\rho_{Mud}\right)(0.052) + P_{Gel\ Strength} - P_{Initial}$$

$$= (3{,}150\ feet - 50\ feet)\,(9.0\ lb/gal)(0.052) + \frac{0.00333\left(L_{Injection\ Interval} - d_{Fallback}\right)\left(S_{Gel\ Strength}\right)}{\left(D_1 - D_2\right)} - (3{,}150 - 1{,}504)(8.52)\,0.052$$

$$= (3{,}150\ feet - 50\ feet)\,(9.0\ lb/gal)(0.052) + \frac{0.00333(3{,}150 feet - 50\ feet)\left(20\ lb/ft^2\right)}{(9.875\ inches - 7\ inches)} - 729.2$$

$$= 1{,}450.8\ psi + 71.8\ psi - 729.2\ psi$$

$$= 793.4\ psi$$

Where,

Δp_c	=	Calculated Critical Pressure Rise (793.4 psi)
$L_{Injection\ Interval}$	=	Estimated distance from top of the Injection Interval to ground level (3,150 feet)
$d_{Fallback}$	=	Amount of fallback of drilling mud (50 feet assumed)
ρ_{Mud}	=	Minimum expected drilling fluid density in abandoned oil and gas wells (assumed 9.0 lb/gal)
$P_{Gel\ Strength}$	=	Pressure needed to overcome gel strength force from drilling mud left in abandoned oil and gas wells (psi)
$S_{Gel\ Strength}$	=	Gel Strength (assumed 20 lb/ft^2)
D_1	=	Diameter of wellbore, inches (assumed 9⅞ inches)
D_2	=	Diameter of casing in wellbore, inches (assumed 7 inches)
0.052	=	Conversion Factor (psi/ft per lb/gal)

It will require a pressure rise of at least 793.4 psi in the Injection Zone to exert enough force to drive fluid from the top of the Injection Zone at 3,150 feet to the base of the USDW at 1,050 feet.

4.0 CONFINING ZONE

The subsurface interval between approximately 1,050 and 3,150 feet beneath the MEA has been identified as the Upper Confining Zone overlying the Injection Zone. This 2,100-foot thick interval consists predominantly of low permeability shale.

The Upper and Lower Confining Zones are defined on the geologic cross-section presented on Drawings 2.3-1 and 2.3-2. As depicted on the cross-section, the Confining Zones are laterally continuous on a regional basis. Structural contours on top of the Upper Confining Zone are presented on Drawing 2.3-4.

5.0 WASTE STREAM CHARACTERISTICS

The waste stream that will be injected underground via the nonhazardous waste injection wells at MEA consists of materials generated during ISR uranium mining operations as follows:

1. Production bleed wastes which constitute 0.5 – 1.5 percent of the total production flow from active ISR operations. (During excursions, may range to 5 percent.)
2. Groundwater sweep waste from restoration activities in the mining area.
3. Brine waste from the water treatment system (reverse osmosis) used to restore groundwater.
4. Treated wastewater from lined ponds.
5. Laboratory wastes from mining-related analysis.

A characterization of the typical (composite) waste stream is provided in Table 5.0-1. Appendix 5.0-1 includes a copy of the original analytical reports.

The Total Dissolved Solids (TDS) levels of the disposal fluid are generally lower than the measured TDS of formation waters in the Morrison and Sundance formations. With the exception of an increase in minor amounts of radionuclides, the injection stream will not impact existing water quality.

Compatibility tests will be performed with formation water and disposal fluids during completion of Well #1 at MEA.

The Nebraska Administrative Code, Title 128 - Chapter 4 "Determination, Notification, Reporting and Recordkeeping" Section 002 "Hazardous waste determination" requires generators of a waste to determine whether the waste is a solid waste under regulatory definition and if so, whether it is a hazardous waste.

CBR has made this determination per Chapter 2 "Definition of Solid Waste and Hazardous Waste". The water being discharged into the MEA injection well is not characterized as a hazardous waste based on the following:

- Section 008.04 exclusions, source or by-product material as defined by the Atomic Energy Act of 1954, as amended, 42 U.S.C. 2011 et. seq. unless the material is mixed with hazardous waste as defined in Chapter 3, 005 through 016 are not solid waste. Also, Per Section 009.05 05 solid waste from the extraction, beneficiation and processing of ores and minerals (including coal, phosphate rock and overburden from the mining of uranium ore), as described in 40 CFR 261.4(b)(7) are not hazardous wastes. Hazardous waste regulations exclude source, special nuclear, and byproduct materials from the definition of hazardous waste.
- Section 009.05 05 solid waste from the extraction, beneficiation and processing of ores and minerals (including coal, phosphate rock and overburden from the mining of uranium ore), as described in 40 CFR 261.4(b)(7) are not hazardous wastes. Therefore wastes resulting from in-situ uranium mining are not regulated as hazardous wastes.
- 40 CFR 261.4(b)(7)(i) clarifies activities considered within the realm of beneficiation as follows. "For purposes of 40 CFR 261.4(b)(7), beneficiation of ores and minerals is restricted to the following activities; crushing; grinding; washing; dissolution; crystallization; filtration; sorting; sizing; drying; sintering; pelletizing; briquetting; calcining to remove water and/or carbon dioxide; roasting, autoclaving, and/or chlorination in preparation for leaching (except where the roasting (and/or autoclaving and/or chlorination)/leaching sequence produces a final or intermediate product that does not undergo further beneficiation or processing); gravity concentration; magnetic separation; electrostatic separation; flotation; ion exchange; solvent extraction; electrowinning; precipitation; amalgamation; and heap, dump, vat, tank, and in situ leaching.

Based on process knowledge of ongoing ISR mining operations at CBO, no listed hazardous wastes are contained in the waste stream to be injected underground via the planned injection wells at the MEA.

6.0 ZONE OF ENDANGERING INFLUENCE AND AREA OF REVIEW

6.1 Anticipated Operational Life of Injection Wells

The expected operational life of the two injection wells currently being permitted at MEA is approximately 17 years (2015 through 2032) corresponding to current projections of the ISR uranium mining operations.

6.2 Anticipated Change in Reservoir Conditions

Anticipated changes in reservoir conditions include the emplacement of the injected waste fluid and associated pressurization of the Injection Zone. The interface between injected fluid and the formation brine (the waste front) will expand radially away from the point of injection over time. As fluid is injected, the Injection Zone will continue to pressurize due to the resistance of fluid movement and the compression of the formation fluid and matrix.

The maximum radial spread of the emplaced fluid and associated in-situ formation pressure increase during the initial 10-year permit time frame and the anticipated 17 year life of the MEA are projected in the following sections. An assumed constant injection rate of 200 gallons per minute per well (gpm/well) was utilized in the following calculations. (Note: this calculation will be updated in the future based on the actual capacity of existing DDW's if additional injection wells are permitted and installed under the Area Permit.)

6.3 Calculation of Radius of Emplaced Fluid

The following equation is used to calculate the future radius of emplaced fluids, e.g., waste front location or waste plume radius:

$$r_p = \sqrt{\frac{0.13368\, V_f}{\pi\, b\, \phi}}$$

SUBSURFACE

Where:

r_p = radial distance of wastewater front (feet)

V_f = Cumulative volume of fluid to be injected into the Injection Zone for the 10-year life of the permit, in gallons (2 wells x 200 gpm/well x 1440 min/day x 365.25 days/yr x 10 yrs = 2,103,840,000 gallons).

ø = assumed average effective porosity, in percent (25 percent)[1]

b = effective reservoir thickness, in feet (200 feet)

Since the two injection wells could potentially be injecting simultaneously at 200 gpm/well, it was assumed that all of the flow (2 wells x 200 gpm/well = 400 gpm) would enter the Injection Zone simultaneously at a single point of injection to determine the maximum potential radius of emplaced fluid in the Injection Zone.

Substituting the above values into the equation above:

$$r_p = \sqrt{\frac{0.13368(2{,}103{,}840{,}000)}{\pi(200)(0.25)}}$$

$$= 1{,}338 \text{ feet}$$

Assuming a constant injection rate of 400 gpm for the 10-year permit life, the predicted radius of emplaced fluids within the Injection Zone will extend a maximum radius of 1,338 feet from the point of injection as shown on Figure 6.3-1.

Assuming a constant injection rate of 400 gpm for the currently anticipated 17 year life of the project, the predicted radius of emplaced fluid within the Injection Zone will extend a maximum radius of 1,745 feet from the point of injection as shown on Figure 6.3-2.

$$r_p = \sqrt{\frac{0.13368(3{,}576{,}528{,}000)}{\pi(200)(0.25)}}$$

$$= 1{,}745 \textit{ feet}$$

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1 Assumed porosity of 25 percent is consistent with measured porosities in well DDW #1 and DDW #2 at CBO six miles away. The actual porosity value will be determined when MEA WDW #1 is drilled and logged.

6.4 Calculation of Zone of Endangered Influence

The Zone of Endangered Influence (ZOEI) is an area in which pressure in the Injection Zone could potentially cause vertical migration of the injected fluid into a USDW via a man-made wellbore or transmissive fault. Vertical migration is otherwise inhibited by the confining shales which serve as aquitards (see Section 2.3.5).

The equation used to calculate the reservoir pressure at the top of the injection interval is as follows:

ΔP_{Rise} = *Future Pressure Rise*

$$\Delta P_{Rise} = \frac{162.6\,\mu}{kh}\left(\left[q_1\left(\log\left(\frac{k t_1}{\varphi \mu c_t r_1^2}\right) - 3.2275\right)\right] + \left[q_2\left(\log\left(\frac{k t_1}{\varphi \mu c_t r_2^2}\right) - 3.2275\right)\right]\right)$$

The above expression is the same equation presented in Mathews and Russell, 1967, Pressure Buildup and Flow Test in Wells, American Institute of Mining, Met. Eng. Monograph, Vol. 1, 18p, where the variables are expressed in the following units:

Explanations of the equation variables are presented in Table 6.4-1 and below:

ΔP_{Rise} = Pressure Rise in WDW #1 at the wellbore radius, (psi);
Φ = Porosity (0.25, fraction);
µ = Viscosity (0.63 cp);
k = Permeability (500 md);
h = Injection interval net thickness (200 feet);
t_1 = Injection period (24 hrs/day x 365.25 days/yr x 10 yrs = 87,660 hrs);
q_1 = Injection rate per well (200 gpm x 1440 min/day x 1 bbl/42 gal = 6,857.14 bbl/day);
q_2 = q1 = 6,857.14 bbl/day;
c_t = Total compressibility (rock + fluid; 6.3×10^{-6} psi^{-1});

SUBSURFACE

r_1 = Wellbore radius (0.51 feet);
r_2 = Distance between WDW #1 and WDW #2 (1,320 feet);

Substituting the above values into the equation, the projected pressure rise at the point of injection following 10 years of injecting at the maximum rate of 400 gpm (200 gpm/well) into the two planned injection wells will be 106.6 psi, as calculated below:

$$\Delta P_{Rise} = \frac{162.6(0.63)}{(500)(200)}\left(\left[(6{,}857.14)\left(\log\left(\frac{(500)(87{,}660)}{(0.25)(0.63)(6.3 \times 10^{-6})(0.51)^2}\right)-3.2275\right)\right]+\left[(6{,}857.14)\left(\log\left(\frac{(500)(87{,}660)}{(0.25)(0.63)(6.3 \times 10^{-6})(1{,}320)^2}\right)-3.2275\right)\right]\right)$$

$$= 106.6\ psi$$

Since the pressure rise (106.6 psi) in the Injection Zone due to injection will never exceed the Critical Pressure Rise (793.4 psi) calculated in Section 3.6, there will never be a ZOEI at the site.

Substituting the above values into the equation, the projected pressure rise at the point of injection following 17 years of injecting at the maximum rate of 400 gpm (200 gpm/well) into the planned injection wells will be only 107.7 psi, as calculated below:

$$\Delta P_{Rise} = \frac{162.6(0.63)}{(500)(200)}\left(\left[(6{,}857.14)\left(\log\left(\frac{(500)(149{,}022)}{(0.25)(0.63)(6.3 \times 10^{-6})(0.51)^2}\right)-3.2275\right)\right]+\left[(6{,}857.14)\left(\log\left(\frac{(500)(149{,}022)}{(0.25)(0.63)(6.3 \times 10^{-6})(1{,}320)^2}\right)-3.2275\right)\right]\right)$$

$$= 109.9 psi$$

This pressure rise is still considerably less (685.7 psi) than the pressure rise needed to exceed the Critical Pressure Rise for the Injection Zone. It would require an average injection rate of 1,513 gpm per well over 17 years for the pressure rise at each well to equate to the Critical Pressure Rise. Therefore, the two wells are located a sufficient distance apart and injection operations at each well will not result in endangerment to the USDW.

6.5 Area of Review Determination

The AOR for the MEA Area Permit is determined to be two miles surrounding the calculated ZOEI using guidelines established in NDEQ Title 122, Chapter 14. Since there is no ZOEI (refer to Section 6.4), the AOR has arbitrarily been set at a conservative distance of 2 miles surrounding the Area Permit boundary as depicted on Figure 6.5-1.

The nearest well intersecting the Injection Zone within the AOR is the Josephson Joe et al Hollibaugh No. 1 which is located approximately 6,000 feet north of planned WDW #1. The maximum pressure rise at this well will be 39.5 psi which is 753.9 psi below the critical pressure. All of the other non-freshwater (oil and gas) penetrations intersecting the permitted Injection Zone within the 2-mile AOR are outside the cone of influence boundary and have either been properly constructed or have been properly plugged and abandoned (Table 6.7-1). Therefore, no corrective action is required for any of the AOR wells.

6.6 Freshwater Penetrations Within Area of Review

Under current Nebraska law, domestic or livestock wells completed prior to September 09, 1993 do not have to be registered (NRS 2008). Therefore, there is little public information available for the pre-1993 completed wells. However, efforts were made by CBR to gather available information on the wells completed in the MEA through interviews with land owners and local drillers. Available information is presented in Table 6.6-1. Based on the available information, there are no known private water supply wells completed in the basal Chadron Sand in the MEA and associated AOR.

There are a total of 140 private water supply wells (121 active, 14 inactive, 4 abandoned and 1 unknown status) within the AOR. Sorted by use, 89 are livestock, 23 are multi-use, 13 are agricultural, 6 are domestic, 5 are unknown, 2 are other, 1 is garden and 1 is a CBR exploration well. The available information shows that 45 wells are completed in the Brule Formation, 8 are completed in the Arikaree, 44 are completed in the Arikaree/Brule and 43 have unknown zones.

Of the 140 wells, 14 private water supply wells (11 active, 2 inactive and 1 abandoned) are located within the permit boundaries of the MEA. Livestock usage accounts for 11 of the wells, with 1 classified as domestic, 1 as other and 1 as unknown.

Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree or Brule Formation, with no domestic or agricultural use of groundwater from the Basal Chadron Sand (Figure 6.6-1 and Table 6.6-1).

6.7 Non Freshwater (Oil and Gas) Penetrations Within Area of Review

A total of six (6) abandoned oil and gas exploration test holes were identified in the designated AOR, with one (Hollibaugh 1) identified in the MEA (NOGC 2011). The six wells were drilled and plugged in 1952/1953 (1 well), 1956/1956 (1 well), 1969/1969 (2 wells), 1981/1981 (1 well) and 1981/1982 (1 well). The total depths of these wells ranged from 2,641 to 3,956 feet. There are currently no active oil and gas exploration activities within the MEA or the associated AOR.

The locations of the six abandoned oil and gas exploration test holes within the AOR are shown on Figure 6.7-1. One well (Hollibaugh 1) was drilled within the MEA and one well (Smith 1-A) was drilled adjacent to the MEA permit boundary. A tabulation of all oil and gas exploration test holes within the MEA and associated AOR, which have penetrated the injection zone are shown on Table 6.7-1.

Based on data provided by the Nebraska Oil and Gas Conservation Commission (NOGCC), Plugging Affidavits were available for all six of the abandoned exploration test holes. Well information and plugging affidavits for the test holes are presented in Appendix 6.7-1.

6.8 Artificial Penetration Corrective Action Program

NOGCC records were searched to identify oil and gas wells within the AOR. The records show there is one abandoned well within the MEA and there are five abandoned wells within the AOR. Table 6.7-1 provides a list of these wells and Figure 6.7-1 shows the approximate location of each well. Based on available

Plugging Record forms obtained from NOGCC records, all oil and gas penetrations identified within the MEA and AOR have been properly plugged and abandoned. No corrective action is required.

7.0 WELL CONSTRUCTION

The following sections describe how each injection well within the MEA Area Permit will be installed and constructed to satisfy NDEQ well construction requirements. In general, the wells will be constructed such that:

1. Injected fluids and formation fluids in the Injection Zone do not cause deterioration of the water quality of fresh and/or usable water zones;
2. The loss of fresh and/or usable water due to downward migration is prevented;
3. The release of injected fluids into an unauthorized zone is prevented; and
4. Corrosion will be prevented from compromising these measures.

7.1 Drilling Procedures

The injection wells will be drilled and installed utilizing typical oil field well installation procedures. Appendices 7.1-1 and 7.1-2 include detailed descriptions of the procedures for drilling and completing each well. Figures 7.1-1 and 7.1-2 present proposed below ground and wellhead construction details for the wells, respectively.

7.2 Open-Hole Logging

Open-hole electric logs will be run from the base of conductor pipe to the total depth of the drilled borehole advanced for construction of each well. Table 7.2-1 summarizes the open-hole logging program.

7.3 Casing and Cementing Program

Table 7.3-1 summarizes the casing and cementing program for the injection wells. Figure 7.1-1 provides a schematic of the proposed below ground construction details for the injection wells.

7.4 Injection Tubing, Packer and Annular Fluid

Figure 7.1-1 provides a schematic of the proposed below ground construction details for the wells. The injection tubing, packer and annular fluid proposed for use in the well are depicted on the schematic.

7.5 Mechanical Integrity Demonstration

The mechanical integrity of each well will be demonstrated during the construction of the well utilizing well logs and pressure tests. Table 7.5-1 provides a summary of the Mechanical Integrity Testing Program.

7.6 Injectivity Testing and Formation Fluid Testing

After each well has been constructed, demonstrated to maintain mechanical integrity, and perforated, an injectivity test will be performed to determine the well injection capacity and reservoir characteristics (refer to Appendix 7.1-2).

Prior to performing the injectivity tests, the bottom-hole pressure, bottom-hole temperature, and static fluid level will be determined. A representative sample of formation fluid will also be obtained from the Injection Interval to provide for compatibility testing between the waste stream and the formation fluid (refer to Appendix 7.1-2).

7.7 Well Completion Report

A report documenting the drilling, installation, construction and testing of each injection well will be submitted to NDEQ within 90 days of completion of all well installation and testing activities.

8.0 INJECTION WELL OPERATING PROCEDURES

The following sections demonstrate that each of the injection wells will be operated in such a manner that is protective of the USDW.

8.1 Maximum Allowable Surface Injection Pressure

To prevent fracturing in the Injection Zone and the overlying Confining Zone, the maximum surface injection pressure at each injection well is calculated to be 739 psi. This is based on an assumed fracture gradient of 0.714 psi/ft and no tubing friction pressure losses or pressure losses due to skin damage.

Maximum Allowable Surface Injection Pressure (MASIP) is calculated using the following formula:

$$\begin{aligned} MASIP &= 0.85\,(BHP - H) + TF + SE \\ &= 0.85\,(2{,}249.0 - 1{,}379.2) + 0 + 0 \\ &= 739.3 \text{ psi} \end{aligned}$$

Where:

MASIP	=	maximum allowable surface injection pressure (894.0 psi);
BHP	=	bottomhole fracture pressure (2,249 psi, from Section 3.5);
H	=	hydrostatic pressure in the wellbore corresponding to the maximum requested specific gravity (1.01 x 0.4335 psi/foot x 3,150 feet BGL= 1,379.2 psi);
TF	=	pressure drop due to tubing friction (assumed to be zero);
SE	=	pressure drop due to skin damage (assumed to be zero).

The completion procedures discussed in Section 7.0 include a step rate test to determine the actual fracture gradient for the wells resulting in a maximum fracture pressure.

8.2 Pre-Injection Facilities

Figure 8.2-1 includes a flow diagram of the planned pre-injection equipment associated with operation of the injection wells (i.e., surface facilities). The pre-injection equipment includes:

- a transfer pump to obtain water from the ISR mining operation;
- a solids control system to remove any remaining suspended solids in the waste stream to reduce potential of well fouling;
- a surge tank for temporary storage of the waste stream prior to injection;
- an injection pump to pump the waste stream down the well; and
- a Well Annulus Monitoring System (WAMS).

8.3 Injection Well Instrumentation and Monitoring Systems

Recording devices located on the discharge side of the injection pump will continuously record that well's injection rate/volume/temperature, surface injection pressure, and annulus pressure between the casing and injection tubing. The locations of these monitoring devices are depicted on Figure 8.2-1.

A corrosion resistant or noncorrosive fluid; e.g., nitrogen, will be maintained under pressure in the annular space between the injection tubing and the protection casing. A WAMS unit will continuously monitor the annular space above the packer between the injection tubing and protection casing. The unit will automatically compensate for temperature changes by increasing or decreasing nitrogen or pump pressure in the top of the pressure vessel. The annulus pressure will always be maintained at a pressure that exceeds the operating injection pressure.

8.4 Mechanical Integrity Monitoring Plan

Mechanical integrity of each injection well will be monitored in accordance with Chapter 20, Monitoring Requirements, of NDEQ Title 122 Rules and Regulations for Underground Injection and Mineral Production Wells (effective April 2, 2002).

Except during workovers or routine maintenance, any well which is not operational shall conform to the mechanical integrity requirements of this section and shall sustain a positive pressure on the annulus during the period of non-use. If a well cannot meet the mechanical integrity requirements of this section, the operator shall submit a plan to NEDQ within 30 days of the test, to properly bring the facility into compliance.

8.5 Well Stimulation Plan

Should it ever be necessary to artificially stimulate the well, CBR will devise a stimulation plan and provide the plan to NDEQ for approval prior to implementation.

8.6 Contingency Plans for Shut-In or Well Failures

Each injection well will be equipped with a high-level shutoff switch to prevent operation of the injection pump at pressures greater than the designated MASIP. The wells will be equipped with a low pressure shutoff switch that will deactivate the injection pump in the event of a surface leak. In addition, each well will be equipped with a high/low pressure shutdown switch with a pressure sensor on the tubing/casing annulus. This pressure switch is intended to stop the injection pump in the event of 1) a tubing leak, or 2) a casing, packer, or wellhead leak.

If an alarm or shutdown is triggered, the cause of the alarm or shutdown will be immediately investigated to identify the root cause of the situation.

- Immediately cease injection operations;
- Take all necessary steps to determine the presence or absence of a leak; and
- Provide verbal notification to NDEQ within 24 hours.

If the alarm or shutdown is not related to mechanical integrity and the cause of the alarm or shutdown is corrected, injection operations will be resumed.

If the mechanical integrity of the well is in question, the well will remain out of service until the mechanical integrity of the well is restored to the satisfaction of NDEQ and the agency approves resumption of injection operations.

8.7 Recordkeeping and Reporting

Operations and monitoring records will be maintained, and written monitoring reports will be submitted periodically to NDEQ in accordance with Chapter 22, Reporting Requirements of NDEQ Title 122 Rules and Regulations for Underground Injection and Mineral Production Wells (effective April 2, 2002).

9.0 INJECTION WELL CLOSURE AND SITE RESTORATION

The following sections describe the closure plans and associated costs for properly plugging and abandoning each injection well installed within the MEA Area Permit in accordance with NDEQ regulations.

A Notice of Intent to Close will be provided to NDEQ at least 180 days prior to the anticipated well closure start date.

9.1 Plugging and Abandonment Procedures

A schematic of the below ground details of the proposed closure is included as Figure 9.1-1. The proposed plugging and abandonment procedure is presented below:

1. Remove all flow lines and instrumentation connected to the wellhead and in the immediate area of the injection well.
2. Rig up a pump truck and cement truck and pump 10 bbls (56 cubic feet (ft^3) or 53 sacks) of Class H cement down the 4½ inch tubing followed by 56 bbls of fresh water to spot a cement plug across the perforated completion from approximately 3,200 feet to 4,000 feet up to the packer at approximately 3,150 feet. Allow the cement to cure overnight.
3. Pressure test the tubing to 500 psi for at least 30 minutes.
4. Rig up a wireline unit and tag the top of cement inside the 4½ inch tubing, and perforate the 4½ inch tubing with a tubing puncher above the cement plug at approximately 3,150 feet.
5. Rig up a pump truck and a cement truck and establish circulation between the tubing and tubing annulus through the holes punched in the tubing at approximately 3,150 feet. Circulate 338 bbls (1,896 ft^3) of Class H cement between the tubing and tubing annulus to fill the well to land surface with cement.
6. Remove the wellhead, and cut-off all casings and tubing at least three feet below surrounding land surface.
7. Add additional cement as necessary to ensure the top of the cement is at the top of the tubing and all casing strings.
8. Weld a steel plate over the 16 inch conductor casing.
9. Install a permanent marker on the surface above the well inscribed with the following information: operator's name, well class, well name and number, serial number, section, township, range, parish and date plugged and abandoned.

9.2 Plugging and Abandonment Costs

The estimated cost to plug and abandon each well is presented in the table below. This cost estimate has been prepared to reflect costs in effect in May 2011 that would be imposed upon the state should the well be abandoned.

Description of Service	**Estimated Cost**
Wireline Services	10,000
Rental Tools	10,000
Pumping Service	10,000
Cementing Service	20,000
Excavating and Welding	5,000
Mud/Brine	5,000
Frac Tanks	5,000
Vacuum Trucks	5,000
Miscellaneous	5,000
SUBTOTAL	**75,000**
Field Supervision, Project Management, Procurement	15,000
Total Estimated Cost (January 2012)	**$90,000**

9.3 Injection Operations Surface Restoration

Estimated land surface restoration will include removal of all surface facilities directly associated with the injection operations, power line removal, installing the well abandonment marker, re-grading the well site, replacement of topsoil, and reseeding the site to the landowner's specifications.

9.4 Well Closure Report

An Injection Well Closure Report will be submitted to NDEQ within 90 days after completion of all planned closure activities at each well. If multiple wells are closed at the same time, an Injection Well Closure Report will be prepared for each well.

9.5 Financial Responsibility

A demonstration of financial responsibility for closure (well abandonment) will be submitted under separate cover.

10.0 REFERENCES

Eaton, B.A., 1969 Eaton, B.A., "Fracture Gradient Prediction and Its Application in Oilfield Operations," Journal of Petroleum Technology, October, 1969, pp. 1353 – 1360.

Gosselin, D. C., Headrick, J., Chen, X-H., Summerside, S. E., 1996. Regional Analysis of Rural Domestic Well-water Quality -- Hat Creek-White River Drainage Basin; from Domestic Water-well Quality in Rural Nebraska, Nebraska Department of Health.

Mathews and Russell, 1967, Pressure Buildup and Flow Test in Wells, American Institute of Mining, Met. Eng. Monograph, Vol. 1, 18p.

Nixon, D.A., 1995, The Structure of the Pine Ridge of the Tri-State Region of Wyoming, Nebraska, and South Dakota and its Relationship to the Black Hills Dome, Geological Society of America Abstracts with Programs, 29th annual meeting, p.77.

USGS, 2009, Seismic hazard map for Nebraska.

TABLE 1.7-1

APPLICABLE REGULATORY PERMITS
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

ISSUING AGENCY	PERMIT DESCRIPTION
Nebraska Department of Environmental Quality P.O. Box 98922 Lincoln, Nebraska 68509-8922	Underground Injection Control Class III Auth. NE0122611 Approved: April 24, 1990 Amended to increase flow on August 16, 2007
	Aquifer Exemption Approval Effective: March 23, 1984 *Aquifer Exemption for North Trend Expansion Area Approval: Pending
	Underground Injection Control Class III Permit Application for North Trend Expansion Area Submitted: August 15, 2008 Approval: Pending
	Underground Injection Control Class I Authorization NE0206369 Approved: September 9, 1994 Replaced July 2, 2004
	Underground Injection Control Class I Authorization NE0210457 Approved: July 2, 2004
	National Pollutant Discharge Elimination System Permit NE0130613 Approved: September 30, 1994
	Mineral Exploration Permit NE0209317 Approved June 3, 2003 Replaced July 16, 2007
	Mineral Exploration Permit NE0210679 Approved July 16, 2007
	Mineral Exploration Permit NE0210678 Approved: July 16, 2007
	Mineral Exploration Permit NE0210680 Approved: July 18, 2007
	Mineral Exploration Permit NE0210824 Approved: August 19, 2009
	Underground Injection Control Class V Authorization NE0207888 Approved: November 6, 2000
	Evaporation Pond Design Approved: July 21, 1988
Nebraska Department of Environmental Quality P.O. Box 98922 Lincoln, Nebraska 68509-8922	Construction Stormwater NPDES General Permit NER 100000 Authorization No. NER105203 Approved: December 19, 2006

TABLE 1.7-1 (CONT'D)

APPLICABLE REGULATORY PERMITS
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

ISSUING AGENCY	PERMIT DESCRIPTION
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, Nebraska 68509-4676	Industrial Ground Water Permit Approved: August 7, 1991
NE Dept of Health & Human Services Regulation & Licensure P.O. Box 95007 Lincoln, Nebraska 68509-5007	Class IV Public Water Supply Permit NE3121024 Approved: April 12, 2002
US Nuclear Regulatory Commission Washington, DC 20555	*Source Material License SUA 1534 Amendment for New Satellite Facility: North Trend Expansion Area Submitted: May 30, 2007 NRC Approval: Pending Source Material License SUA – 1534 License Renewal request by CBR Submitted: November 27, 2007 NRC Approval: Pending Source Materials License SUA-1534 Amendment to Increase Flow Issued: November 30, 2007 Source Materials License SUA-1534 Issued December 29, 1989 Renewed: February 28 1998
US EPA 1200 Pennsylvania Ave, NW Washington, DC 20460	Aquifer Exemption Approval Effective: June 22, 1990 Aquifer Exception for North Trend Expansion Area Approved April 7, 2011

TABLE 1.7-1 (CONT'D)

APPLICABLE REGULATORY PERMITS
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

ISSUING AGENCY	PERMIT DESCRIPTION
Nebraska Department of Environmental Quality P.O. Box 98922 Lincoln, Nebraska 68509-8922	Underground Injection Control Class III Permit for North Trend Expansion Area NE0210740 Approved August 15, 2011 Underground Injection Control Class I Authorization, Well #2 at existing Crow Butte Operation NE0210825 Approved November 25, 2010 Underground Injection Control Class I Amendment, Revision to Vanadium Standard NE022210457 Approved July 1, 2010

TABLE 2.2-1

Generalized Geologic and Hydrostratigraphic Framework of Nebraska 2011, ver. 2

J.T. Korus and R.M. Joeckel, Conservation and Survey Division, SNR, UN-L

Era	Period	Epoch	Age, Ma	Lithostratigraphy (west – east)	Lithology	Hydrostratigraphy	Uses
Cenozoic	Quaternary	Holocene		DeForest Fm. and other units	dune sands, alluvium	alluvial valley aquifers	DMIC
			0.01				
		Pleistocene		Peoria Loess; Gilman Canyon Fm.; Loveland Loess; Kennard Fm.; multiple loesses and alluvial units; pre-Illinoian glacial tills	sand, gravel, silt & clay; loess; glacial sediments	paleovalley aquifers in SE Nebr.; High Plains Aquifer	d; DMIC; d
			2.6				
	Tertiary – Neogene	Pliocene		Broadwater Fm. & corr. units	sand & gravel	High Plains Aquifer	DMIC
			5.3				
		Miocene		Ogallala Group	sand, sandstone, siltstone, gravel	High Plains Aquifer	DMIC
			23				
	Tertiary – Paleogene	Oligocene		Arikaree Group	sandstone and siltstone	High Plains Aquifer	DMIC
				White River Gp.: Brule Fm.; LWRG[1]	siltstone, sandstone & claystone	Chadron Aquifer[1]	U
			33.9				
		Eocene		unnamed unit in northeastern Nebraska	sandstone & congl.		
			55.8				
		Paleocene					
			65.5				
Mesozoic	Cretaceous	Late Cretaceous		Laramie Fm.†; Fox Hills Fm.†	sandstone and siltstone; sandstone and shale	Laramie-Fox Hills Aquifer[2]	
				Pierre Shale	shale with minor shaly chalk, siltstone & sandstone		
				Niobrara Fm.	shaly chalk and limestone	Niobrara Aquifer	dmi
				Carlile Shale	shale with minor sandstone	Codell Aquifer	d
				Greenhorn Ls. & Graneros Shale	limestone and shale		dmic
			99.6				
		Early Cretaceous		Dakota Group[3]	sandstone & conglomerate, siltstone, mudstone, & shale	Great Plains Aquifer System: Maha (Dakota) Aquifer	
				Morrison Fm.†; Sundance Fm.†	mudstone, siltstone, shale & sandstone	Great Plains Aquifer System: Apishapa Aq.	
	Jurassic		145.5				
	Triassic		201.6	Goose Egg Fm.†; Nippewalla Gp.†; Sumner Gp.†	sandst., sh., mudst., ls., & evaporites		
			251				
Paleozoic	Permian			upr. Council Grove - Chase Gps.[4]	limest., shale, mudst. & evaporites	////	
			299				
	Pennsylvanian			Cherokee - lwr. Council Grove Gps.[4,5]	limest., shale, mudst. & sandst.	////	d
			318				
	Mississippian			Multiple units†	limestone, sandy limestone, argillaceous limestone, oolitic limestone, dolomite, silty dolomite argillaceous dolomite, shaly dolomite, sandy dolomite, shale, siltstone & chert	Western Interior Plains Aquifer System: Mississippian Aquifer	
			359				
	Devonian					Western Interior Plains Aquifer System: Silurian-Devonian Aquifers	
			416				
	Silurian						
			444				
	Ordovician					Western Interior Plains Aquifer System: Galena-Maquoketa Aq.	
			488				
	Cambrian					Cambro-Ordovician Aq.	
			542				
Precambrian				mostly igneous and metamorphic rocks†			

Diagram is not to scale relative to geologic time and stratigraphic thicknesses.

Hydrostratigraphic characteristics and water quality

- primary aquifers with good quality water
- secondary aquifers with good quality water
- secondary aquifers with generally poor quality water
- //// aquitards with local low-yield aquifers
- aquitards

[1] lower White River Group - includes Chamberlain Pass and Chadron Formations according to some authors; "Chadron Aquifer" historically refers to aquifer in lower White River Group

[2] important aquifer in Colorado, but present in Nebraska only in extreme southwestern Panhandle

[3] Dakota Formation in adjacent states

[4] includes correlative units with different names in northwest Nebraska

[5] Cherokee, Marmaton & Pleasanton Groups are not exposed in Nebraska

† present only in subsurface

Groundwater uses and related aspects

- D major domestic use
- d minor domestic use
- I major irrigation use
- i minor irrigation use
- M major municipal use
- m minor municipal use
- C major commercial/industrial use
- c minor commercial/industrial use
- units used for wastewater injection
- units with potential use for wastewater injection
- U unit mined for uranium by in-situ leaching (Dawes Co.)
- unit with potential use for carbon sequestration
- unit producing petroleum or natural gas
- unit with natural gas potential

Cite as: Korus, J.T., and Joeckel, R.M., 2011. Generalized geologic and hydrostratigraphic framework of Nebraska 2011, ver. 2. Conservation and Survey Division, School of Natural Resources, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. Geologic Maps and Charts (GMC) 38.

University of Nebraska Lincoln

TABLE 2.3-1

SHALLOW STRATIGRAPHY NOMENCLATURE
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

SYSTEM	FORMATION OR GROUP	SUBFORMATION OR GROUP
Quaternary	Alluvium	
Oligocene / Miocene	Arikaree Group	Upper Harrison Beds Harrison-Monroe Creek Formation Gering Formation
Eocene/Oligocene	White River Group	Brule Formation Chadron Formation • Upper Chadron • Upper/Middle Chadron • Middle Chadron • Basal Chadron Sandstone
Cretaceous	Pierre Shale	

TABLE 3.0-1

PHYSICAL AND CHEMICAL DATA FOR MORRISON/SUNDANCE FORMATIONS
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

PARAMETER	VALUE	SOURCE/MEASUREMENT METHOD
Formation Temperature	138°F to 151°F	Downhole gauges (falloff testing)
Formation Pressure	890 psi @ 3,359 feet to 1,015 psi @3,784 feet	Pumping Testing Analyses
Static Water Level	1,300 to 1,500 feet BGS	Slick line measurements
Formation Fracture Pressure	2,148 psi @ 3,580 feet to 2,270 psi @3,784 feet	Estimated from (1) pressures induced during drilling & cementing operations, and (2) regional information
Formation Porosity	20 to 26% (25%)	Calculated from open hole logs
Gross Formation Thickness	370 to 415 feet	Calculated from open hole logs
Net Formation Thickness	67 to 130 feet	Calculated from open hole logs
Average Permeability / Hydraulic Conductivity (to Formation Water)	14 to1,000 md (500 md) 0.079 to 4.84 ft/d	Falloff Testing Analyses
Average Permeability / Hydraulic Conductivity (to Injection Water)	8.85 to 625 md (500 md) 0.049 to 3.03 ft/d	Falloff Testing Analyses
Formation Transmissivity (to Injection Water)	2.94 to 215 ft^2/d	Falloff Testing Analyses
Formation Storativity	4×10^{-5}	Estimated based on rock compressibility & porosity
Formation Water TDS	23,181 mg/l (Morrison) 35,529 mg/l (Sundance)	Laboratory analyses of formation water samples
Formation Water Specific Gravity / Density	1.01 (8.40#/gal) to 1.03 (8.58#/gal)	Laboratory analyses of formation water samples

Sources: Harlan & Associates, Inc. and Crow Butte Resources, Inc., Request for Modification of Class I UIC Permit, March 27, 2000 (Well No. 1) and Petrotek, CBR DDW No. 2 Frilling-Completion Report (Well No. 2)

TABLE 5.0-1

WASTE STREAM CHARACTERIZATION DATA (1)
MARSLAND EXPANSION AREA
CROW BUTTE RESOURCES, INC.
DAWES COUNTY, NEBRASKA

Waste Stream Constituent	Typical Concentration Range	Requested Permit Limit	Units
Uranium (U3O8)	3 - 5	25	mg/L
Radium-226	650 - 1,300	5,000	pCi/L
Arsenic	0 - 0.30	5	mg/L
Barium	0 - 0.10	100	mg/L
Cadmium	0 - 0.010	1	mg/L
Chromium	0 - 0.050	5	mg/L
Lead	0 - 0.050	5	mg/L
Mercury	0 - 0.0007	0.20	mg/L
Selenium	0 - 0.25	1	mg/L
Silver	0	5	mg/L
Vanadium	1 - 2	100	mg/L
Alkalinity	700 - 2,000	4,100	mg/L
Calcium	50 - 200	report only	mg/L
Chloride	450 - 7,000	40,000	mg/L
Sodium	900 - 6,000	40,000	mg/L
Sulfate	600- 2,000	10,000	mg/L
pH	7.0 - 9.0	5.0 - 9.5	S.U.
Specific Gravity			NA

mg/L Milligrams per liter
pCi/L Picocurriers per liter
S.U. Standard Units
NA Not applicable
(1) Waste stream characterization data obtained from identical underground injection operations ongoing at CBO approximately 6 miles to the northwest of MEA

TABLE 6.4-1

ASSUMPTIONS USED IN ZOEI CALCULATIONS
MARSLAND EXPANSION AREA
CROW BUTTE RESOURCES, INC.
DAWES COUNTY, NEBRASKA

Number of Injection Wells:	2
Maximum Injection Rate:	200 gallons per minute/well
Injection Period:	10 years (life of permit)
Injection Interval Thickness:	200 feet
Injection Zone Porosity:	25 percent
Injection Zone Permeability:	500 millidarcies
Injection Zone Fluid TDS:	25,000 mg/L
Injection Zone Fluid Density:	1.01 (viscosity 0.63)
Waste Stream Fluid Density:	1.01 (viscosity 0.63)

Note: Assumptions were derived from data collected from identical underground injection operations ongoing at CBP approximately six miles to the northwest of MEA.

TABLE 6.6-1

REGISTERED WATER WELLS WITHIN MEA AREA OF REVIEW
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

Well #	Estimated Depth (ft)	Formation	Well Use	Well Status	Within MEA
700	180-200	Brule	Livestock	Active	Yes
701	180-200	Brule	Livestock	Active [c]	Yes
702	180-200	Brule	Livestock	Active	No
703	280	Brule	Domestic/Livestock	Active	No
704	Unknown	Unknown [a]	Livestock	Active	No
705	Unknown	Arikaree	Livestock	Active	Yes
706	Unknown	Unknown [a]	Livestock	Active	No
707	Unknown	Unknown [a]	Livestock	Active	No
708	Unknown	Unknown [a]	Livestock	Active	No
709	Unknown	Unknown [a]	Livestock	Active	No
710	Unknown	Unknown [a]	Livestock	Active	No
711	Unknown	Unknown [a]	Livestock	Active	No
712	Unknown	Unknown [a]	Livestock	Active	No
713	Unknown	Unknown [a]	Livestock	Active	No
714	135	Brule [b]	Domestic/Livestock	Active	No
715	135	Arikaree	Agricultural	Active	No
716	135	Brule	Agricultural	Active	No
717	160	Arikaree/Brule	Livestock	Active	No
719	160	Brule	Livestock	Active	No
720	Unknown	Unknown [a]	Other	Active	No
721	Unknown	Unknown [a]	Other	Active	Yes
722	160	Brule	Livestock	Active	Yes
723	220	Brule	Domestic/Livestock	Active	No
724	Unknown	Unknown [a]	Domestic/Livestock	Inactive	No
725	240	Brule	Livestock	Active	No
727	180	Arikaree/Brule	Livestock	Active	Yes
728	260	Brule	Livestock	Active	Yes
729	Unknown	Unknown [a]	Livestock	Active	No
730	Unknown	Unknown [a]	Domestic	Active	Yes
731	180	Brule	Livestock	Active	Yes
732	280	Brule	Agricultural	Active	No
733	Unknown	Unknown [a]	Livestock	Active	Yes
734	300	Brule [b]	Livestock	Active	No
735	375	Brule [b]	Livestock	Active	No
736	200	Brule [b]	Agricultural	Active	No
737	340	Brule [b]	Agricultural	Inactive	No
738	260	Arikaree/ Brule [b]	Livestock	Active	No
739	60	Arikaree	Livestock/Garden	Active	No
740	110	Brule	Agricultural	Active	No
741	190	Brule	Agricultural	Active	No
742	60	Arikaree [b]	Livestock	Active	No
743	140	Brule [b]	Livestock	Active	No
744	80	Arikaree	Livestock	Active	No
745	140 [c]	Brule	Livestock	Active	No
746	Unknown	Unknown [a]	Livestock	Active	No
747	225	Arikaree/Brule	Livestock	Active	Yes
748	Unknown	Unknown [a]	Livestock	Active	No
749	Unknown	Unknown [a]	Livestock	Active	No
750	Unknown	Unknown [a]	Livestock	Active	No
751	Unknown	Unknown [a]	Livestock	Active	No
752	200-300	Brule	Domestic/Livestock	Active	No
753	200-300	Brule	Domestic/Livestock	Active	No
754	200-300	Brule	Livestock	Active	No
755	200-300	Brule	Livestock	Active	No

Review

Well #	Estimated Depth (ft)	Formation	Well Use	Well Status	Within MEA
756	200-300	Brule	Livestock	Active	No
759	200-300	Brule	Livestock	Active	No
760	Unknown	Unknown[a]	Agricultural	Active	No
761	Unknown	Unknown[a]	Livestock	Active	No
762	200-300	Arikaree/ Brule[b]	Livestock	Active	No
763	200-300	Arikaree/ Brule[b]	Livestock	Active	No
764	200-300	Arikaree/ Brule[b]	Livestock	Active	No
765	200-300	Arikaree/ Brule[b]	Livestock	Active	No
767	200-300	Arikaree/ Brule[b]	Livestock	Active	No
768	200-300	Arikaree/ Brule[b]	Domestic	Active	No
769	200-300	Arikaree/ Brule[b]	Livestock	Active	No
771	200-300	Arikaree/ Brule[b]	Livestock	Active	No
772	200-300	Arikaree/ Brule[b]	Livestock	Active	No
773	200-300	Arikaree/ Brule[b]	Livestock	Active	No
774	200-300	Arikaree/ Brule[b]	Domestic/Livestock	Active	No
775	220	Arikaree/ Brule[b]	Livestock	Active	No
776	200-300	Arikaree/ Brule[b]	Livestock	Active	No
777	60	Arikaree	Domestic/Garden	Active	No
778	60	Arikaree	Garden	Active	No
781	60	Arikaree/Brule	Livestock	Active	No
782	100	Brule[b]	Agricultural	Active	No
783	70	Arikaree/ Brule[b]	Domestic	Active	No
784	40-60	Arikaree/ Brule[b]	Livestock	Inactive	No
785	140	Arikaree/ Brule[b]	Livestock	Inactive	No
786	140	Arikaree/ Brule[b]	Livestock	Inactive	No
787	130	Brule	Livestock	Inactive	Yes
788	130-140	Arikaree	Livestock	Inactive	Yes
790	Unknown	Unknown[a]	Livestock	Active	No
791	Unknown	Unknown[a]	Livestock	Active	No
792	Unknown	Unknown[a]	Livestock	Active	No
793	300	Arikaree/ Brule[b]	Livestock	Active	No
794	300	Arikaree/ Brule[b]	Domestic/Livestock	Active	No
795	350	Arikaree/ Brule[b]	Domestic/Livestock	Active	No
796	350	Arikaree/ Brule[b]	Domestic/Livestock	Active	No
798	200	Brule	Livestock	Active	No
799	250	Brule	Livestock	Active	No
800	Unknown	Unknown[a]	Livestock	Active	No
801	220	Arikaree/ Brule[b]	Domestic/Garden	Active	No
802	180-200	Brule	Livestock	Active	No
803	Unknown	Unknown[a]	Livestock	Active	No
804	Deep	Unknown[a]	Domestic/Livestock	Active	No
805	Shallow	Unknown[a]	Livestock	Inactive	No
806	Unknown	Unknown[a]	Livestock	Inactive	No
808	160	Arikaree/ Brule[b]	Domestic/Livestock	Active	No
809	300	Brule	Livestock	Active	No
810	>300	Unknown[a]	Domestic/Livestock	Active	No
811	>300	Unknown[a]	Domestic/Livestock	Active	No
812	260	Unknown[a]	Domestic/Livestock	Active	No
813	280	Unknown[a]	Livestock	Active	No
814	Unknown	Unknown	CBR Exploration	Inactive	No
815	140	Brule	Domestic	Active	No
816	140	Brule	Livestock	Active	No
817	160	Brule	Livestock	Active	No
818	140	Arikaree/Brule[b]	Livestock	Active	No
819	140	Arikaree/Brule[b]	Livestock	Active	No

Well #	Estimated Depth (ft)	Formation	Well Use	Well Status	Within MEA
821	160	Brule[b]	Livestock	Active	No
822	140	Brule[b]	Livestock	Active	No
823	100	Arikaree/Brule[b]	Livestock	Active	No
827	Unknown	Unknown[a]	Livestock	Active	No
828	160	Arikaree/Brule[b]	Domestic	Active	No
834	300	Brule	Domestic/Livestock	Inactive	No
835	300	Brule	Livestock	Inactive	No
836	220	Brule	Livestock	Active	No
837	300	Brule[b]	Livestock	Active	No
838	300	Arikaree/Brule[b]	Livestock	Active	No
839	300	Arikaree/Brule[b]	Livestock	Active	No
840	300	Arikaree/Brule[b]	Livestock	Active	No
841	220	Brule[b]	Livestock	Active	No
842	300	Arikaree/Brule[b]	Livestock	Active	No
843	300	Brule[b]	Livestock	Active	No
845	Unknown	Unknown[a]	Domestic/Livestock	Active	No
846	Unknown	Unknown[a]	Livestock	Active	No
849	Unknown	Unknown[a]	Livestock	Active	No
850	200	Arikaree/Brule[b]	Agricultural	Active	No
851	140	Arikaree/Brule[b]	Agricultural	Active	No
853	150	Arikaree/Brule[b]	Agricultural	Active	No
856	Unknown	Unknown[a]	Unknown	Unknown	No
857	40-50	Arikaree/Brule[b]	Domestic/Agricultural	Inactive	No
858	200	Arikaree/Brule[b]	Agricultural	Active	No
859	120	Arikaree/Brule[b]	Domestic	Inactive	No
861	40	Arikaree/Brule[b]	Domestic/Livestock/ Agricultural	Active	No
862	155	Arikaree/Brule[b]	Domestic/Agricultural	Active	No
ABANDONED WELLS					
726A	300	Brule	Unknown	Abandoned	Yes
867A	Unknown	Unknown[a]	Unknown	Abandoned	No
868A	Unknown	Unknown[a]	Unknown	Abandoned	No
869A	Unknown	Unknown[a]	Unknown	Abandoned	No

[a] Information provided by well owner and information from nearby wells is insufficient to make a definite determination of aquifer utilized. However, based on discussions with land owners and known completion depths of private water wells in the area suggest these wells are completed within the Arikaree or Brule Formations.

[b] Information provided by well owner and information from nearby wells indicate that one or more aquifer is utilized, but cannot be specifically determined. Assigned formation based on available information.

[c] Well is designated as active but is unused.

TABLE 6.7-1

NON-FRESHWATER (OIL AND GAS) PENETRATIONS WITHIN AREA OF REVIEW
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

		LOCATION					
OPERATOR	WELL NAME	TWP/RGE SECTION	LONGITUDE	LATITUDE	SPUD DATE	DATE PLUGGED	TD (FT)
Currently Unassigned	Hollibaugh No. 1	T29N R51W Sec 12	-103.246563	42.508268	1/31/1969	1/18/1969	3,295
Leclair - Westwood Inc.	Chicoine 1	T30N R50W Sec 30	-103.241768	42.551971	10/28/1981	11/1/1981	2,641
Leclair - Westwood Inc.	Chicoine 1A	T30N R50W Sec 30	-103.241702	42.54835	11/3/1981	8/9/1982	3,069
Toltek Drilling Co.	Smith 1-A	T29N R50W Sec 29	-103.207949	42.464678	2/11/1969	2/14/1969	2,091
Potter, Tom	Porter 1	T30N R51W Sec 20	-103.325346	42.554958	2/23/1956	3/28/1956	3,779
Gulf Oil Corp.	Royal 1	T30N R51W Sec 23	-103.280293	42.555982	12/15/1952	1/23/1953	3,956

TABLE 7.2-1

OPEN-HOLE LOGGING PROGRAM
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

Interval	Open Hole Log Description
Surface Casing Borehole	Dual Induction/Spontaneous Potential/Formation Density/ Compensated Neutron/Caliper/Gamma Ray
	Four Arm Caliper
Protection Casing Borehole	Dual Induction/Spontaneous Potential/Formation Density/ Compensated Neutron/Caliper/Gamma Ray/Fracture Finder
	Four Arm Caliper

TABLE 7.3-1

CASING AND CEMENTING PROGRAM
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

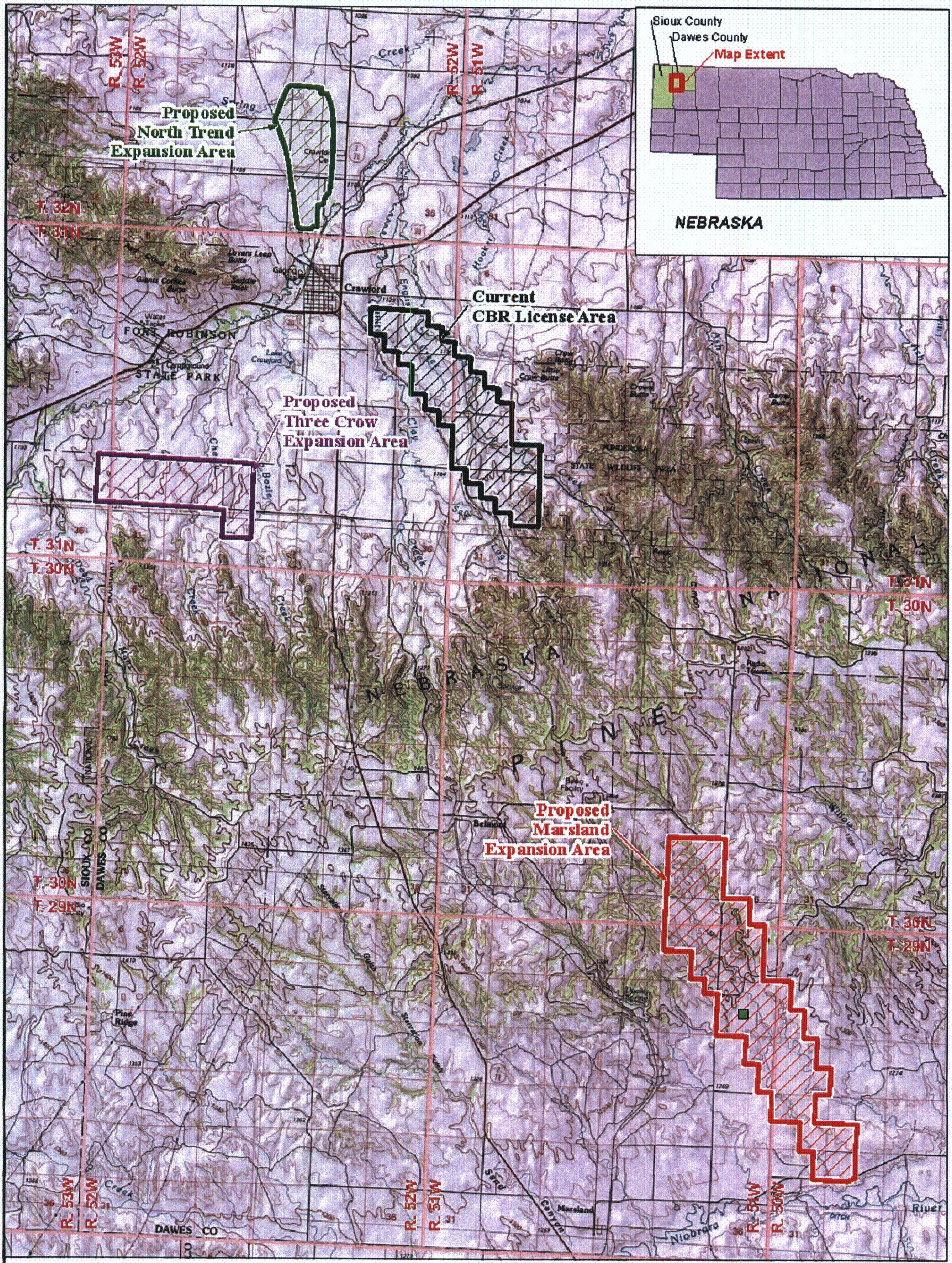
Type	Interval (ft)	Description	Cement
Conductor	0 – 80 (+/-)	16 inch, 62.58 lb/ft, Grade B, welded	Augured and grouted or driven
Surface Casing	0–1,050 (+/-)	10¾ inch, 40.50 lb/ft, J-55, ST&C	Lead Cement 850 ft to surface: Light Type I - II ≈ 312 sx, 692.6 ft^3, mixed at 12 ppg with 2.22 ft^3/sack yield. Tail Cement 850 ft to Total Depth (≈1,050 ft): ≈161 sx, 188.4 ft^3, premium, mixed at 15.8 ppg with 1.17 ft^3/sack yield. Final volumes to be calculated from caliper log plus 50% excess.
Protection Casing	0–4,000(+/-)	7 inch, 26 lb/ft, K-55, LT&C	Lead Cement 3,400 ft to surface: Light Type I - II ≈ 502 sx, 1,044.2 ft^3, mixed at 12.2 ppg with 2.08 ft^3/sack yield. Tail Cement 3,400 ft to Total Depth (≈4,000 ft): ≈173 sx, 199.0 ft^3, premium, mixed at 15.8 ppg with 1.17 ft^3/sack yield. Final volumes to be calculated from caliper log plus 20% excess.
Injection Tubing	0–3,600 (+/-)	4 1/2 inch, 11.60 lb/ft, K-55, LT&C	N/A

(1)Injection tubing will be coated for corrosion prevention purposes.

TABLE 7.5-1

MECHANICAL INEGRITY TESTING PROGRAM
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

Well Component(s) Tested	Test Description
10-3/4" Surface Casing	Pressure Test Surface Casing above Float Shoe to 1000 psi for 30 minutes
	Cement Bond/Variable Density/Gamma Ray Log from Surface to base of casing
7" Protection Casing	Pressure Test Protection Casing above Float Shoe to 1500 psi for 30 minutes
	Cement Bond/Variable Density/Gamma Ray Log from Surface to base of casing
	Base Casing Inspection Survey from the Surface to total depth
	Base Temperature Survey from the Surface to total depth
7" Protection Casing and 4 1/2" Injection Tubing System	Radioactive Tracer Survey (Pump-Log and Time-Drive)
	7" x 4 1/2" Annulus Pressure Tested to 1500 psi for 30 minutes



LEGEND

- Proposed Marsland Satellite Facility Site
- Proposed Marsland Expansion Area
- Proposed Three Crow Expansion Area
- Proposed North Trend Expansion Area
- Current CBR License Area

N

0 1 2

Miles

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

SUBSURFACE

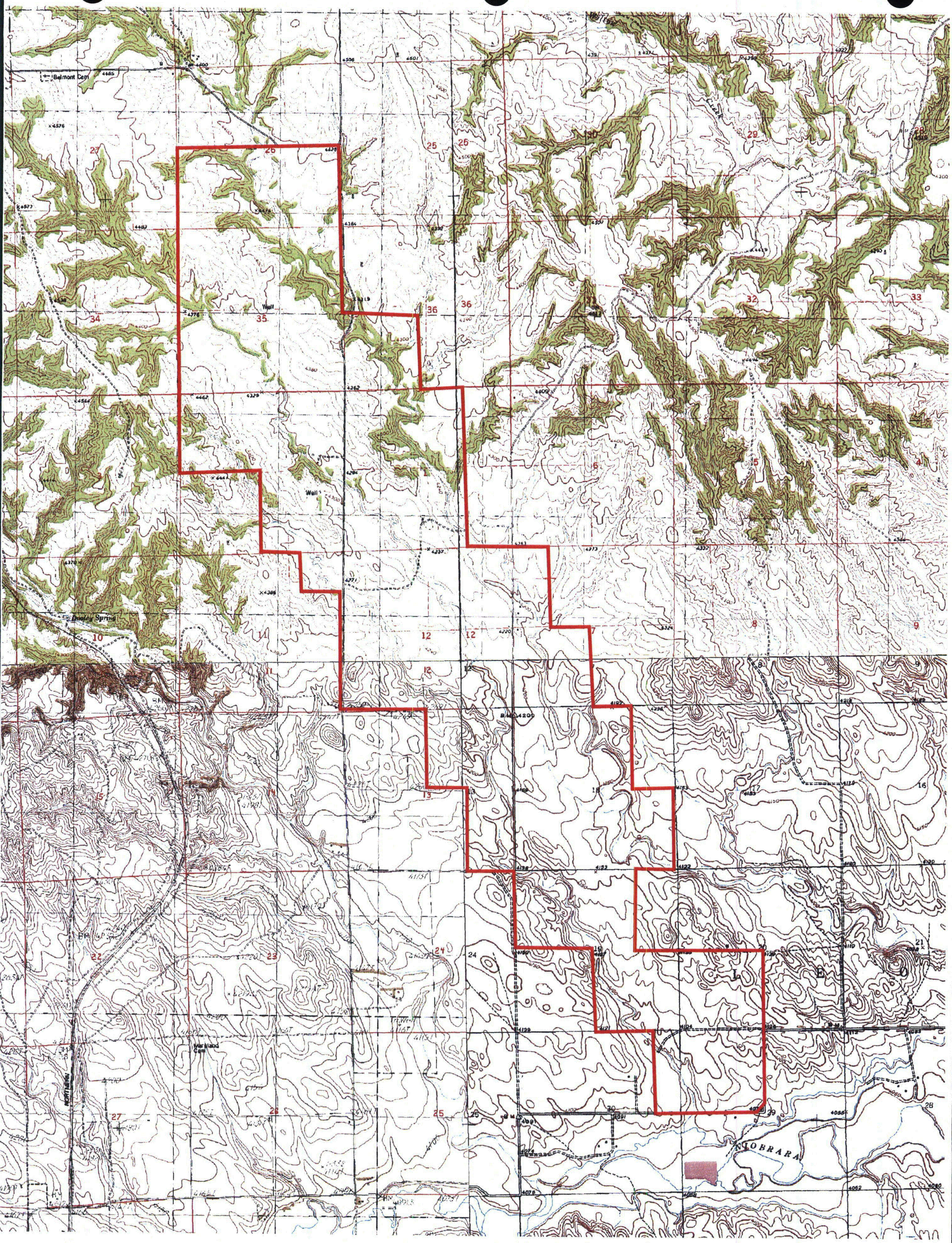
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 1.1-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

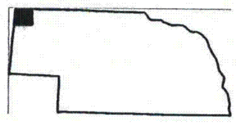
SITE LOCATION MAP

DATE: 03/26/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



Proposed Marsland Expansion Area Boundary

Maps compiled from USGS Quads: Belmont, NE
Coffee Mill Butte SW, NE
Box Butte Reservoir West, NE
Marsland, NE



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SUBSURFACE

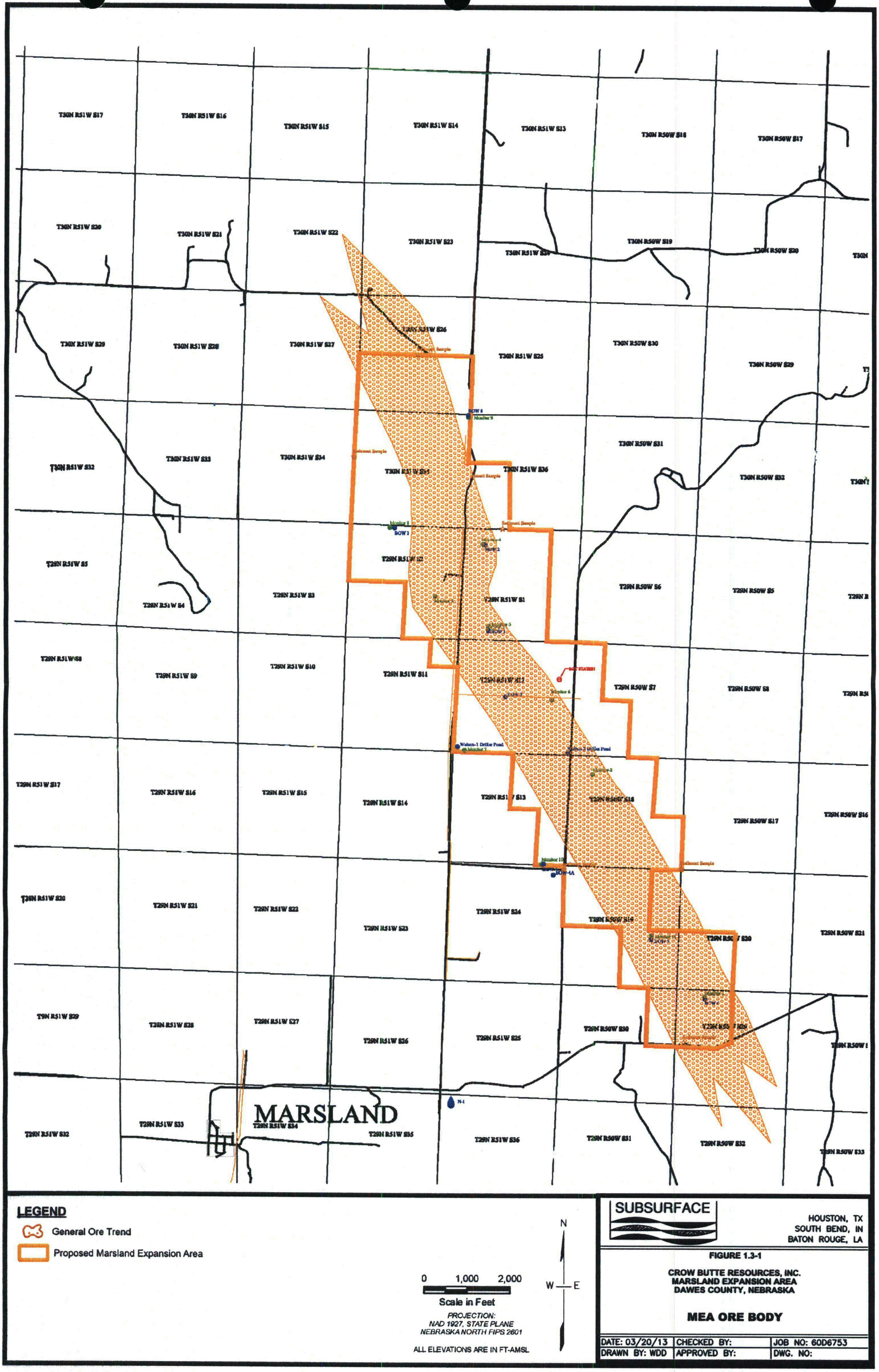
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 1.1-2

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

SITE MAP

DATE: 03/20/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

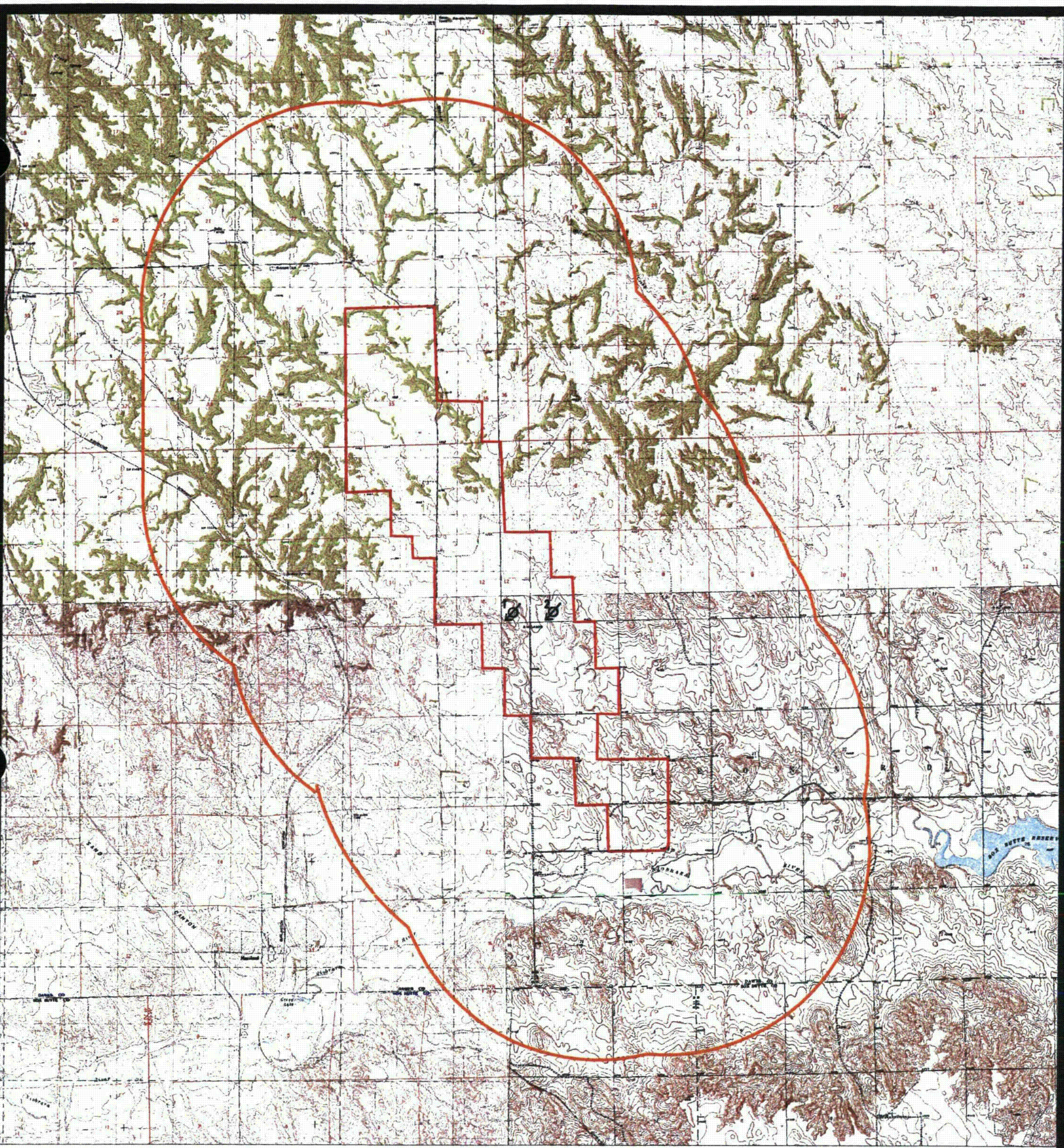
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 1.3-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

MEA ORE BODY

DATE: 03/20/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



LEGEND

Approximate Injection Well Locations

Proposed Marsland Expansion Area

AOR Boundary (2-mile fixed radius)

Sources for Oil/Gas Test Holes

Nebraska Oil and Gas Conservation Commission, (http://www.nogcc.ne.gov/NOGCCPublications.aspx), Accessed on 08/01/2011

Sources for Sand/Gravel Pits

1. Dawes County, (http://dawes.assessor.gisworkshop.com/Assessor/index.jsp), Accessed on 08/03/2011, and
2. Burchett, R.R. 1971. Directory of Nebraska Quarries, Pits and Mines. Resource Report Number 5. University of Nebraska Conservation and Survey Division, Lincoln. March.

SUBSURFACE

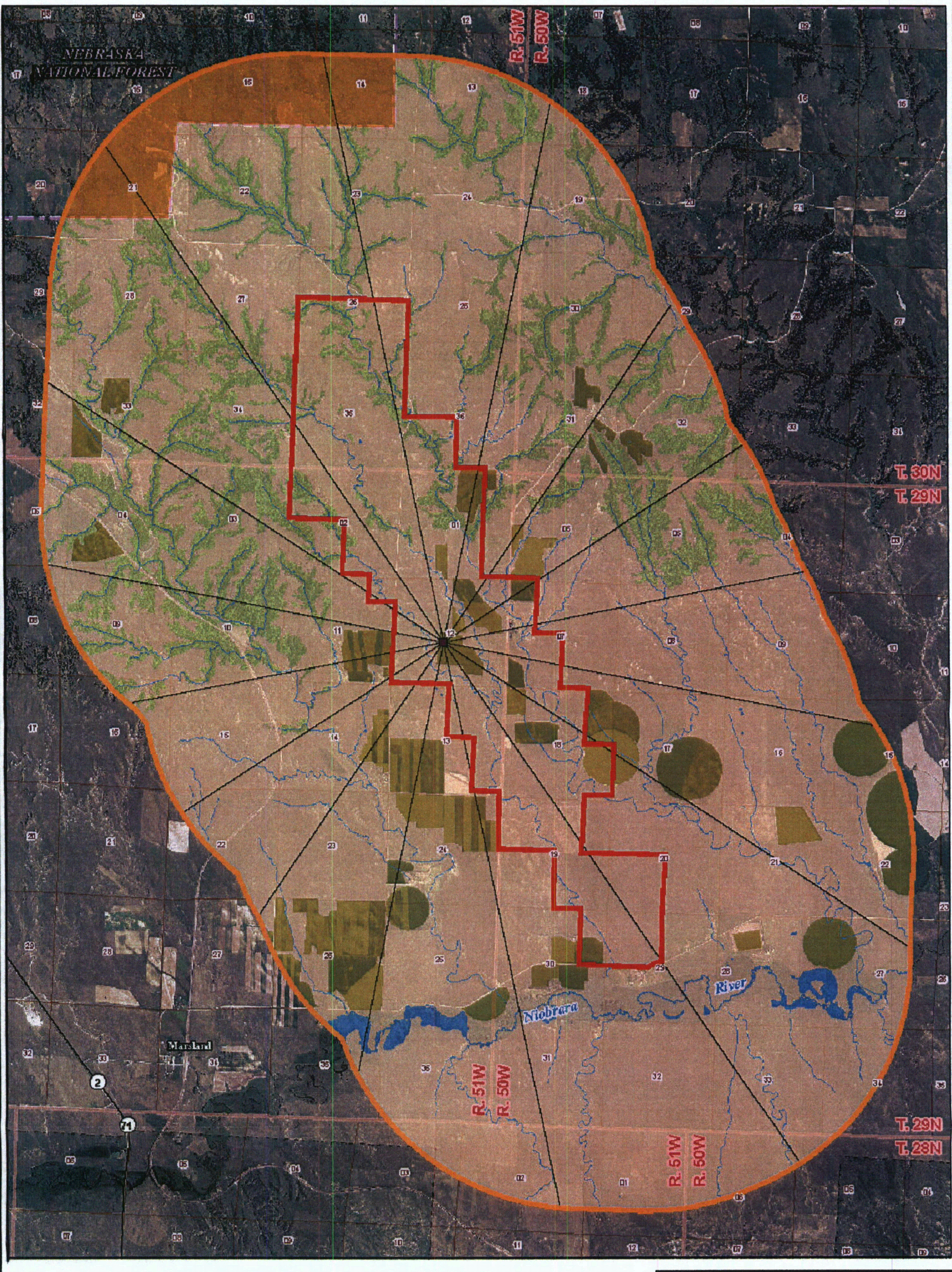
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 1.4-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

AREA PERMIT BOUNDARY AND INJECTION WELL LOCATIONS

DATE: 03/20/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



LEGEND

- Proposed Marsland Satellite Plant Centroid
- Compass Sector Boundary
- Proposed Marsland Expansion Area
- Area of Review
- Nebraska National Forest Boundary

Land Use*

- Cropland
- Drainage/Potential Wetland
- Forest Land
- Rangeland
- Recreational Land

* Land use data were interpreted from aerial image. The delineation of "Drainage/Potential Wetland" type also referenced NHD Flowlines and NWI Wetland Dataset.

N

0 2,250 4,500
Feet

PROJECTION: NAD1927,
STATEPLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USDA NAIP IMAGERY 2010

SUBSURFACE

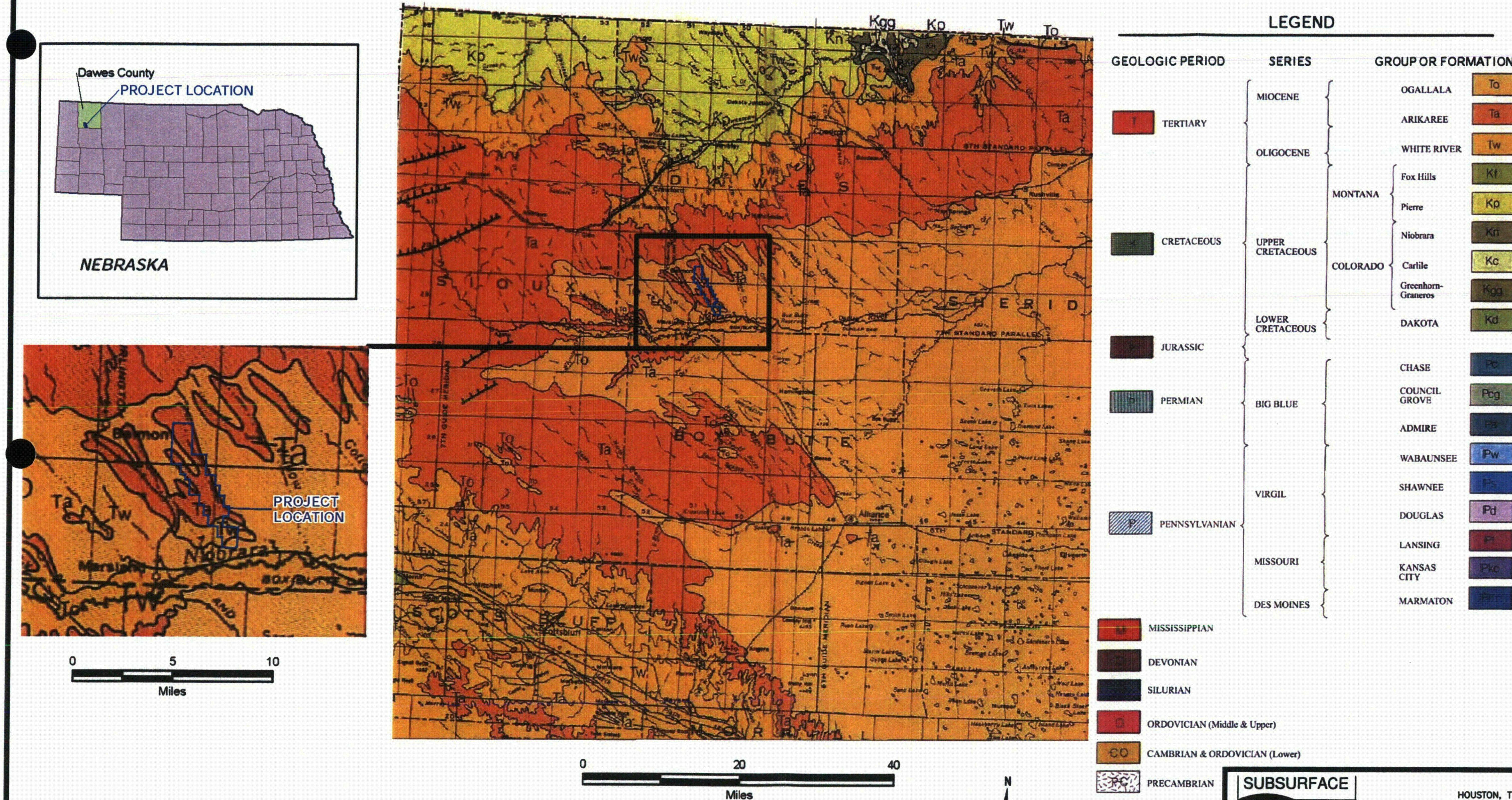
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 1.5-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

AREA LAND USE PATTERN

DATE: 03/26/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



Source:
Burchett, R.R., 1986, Geologic bedrock map of Nebraska; University of Nebraska Conservation and Survey Division, Geologic Maps and Charts1, scale 1:1000000.

PROJECTION: NAP 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

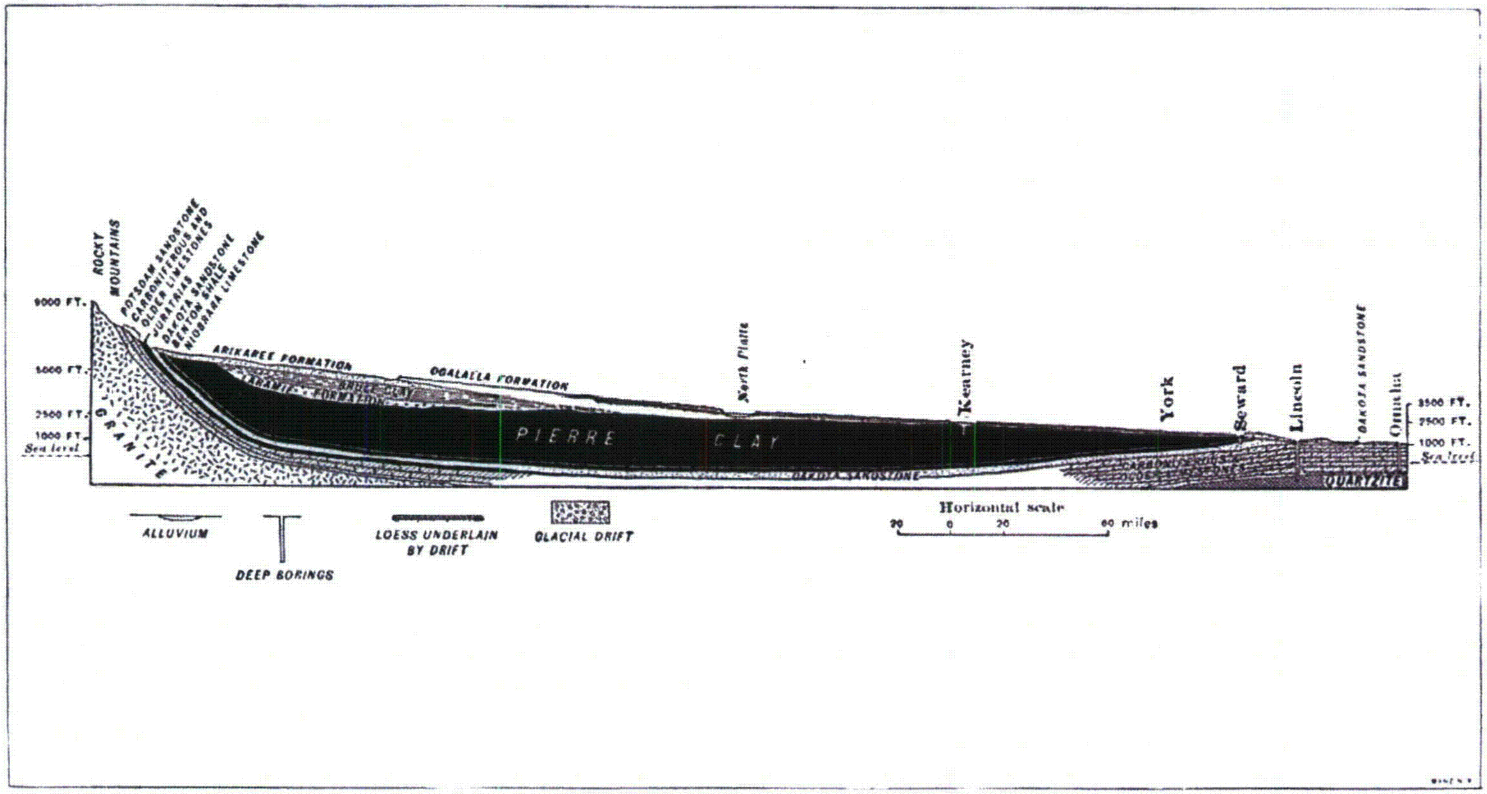
SUBSURFACE
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 2.2-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

BEDROCK GEOLOGY OF WESTERN NEBRASKA

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

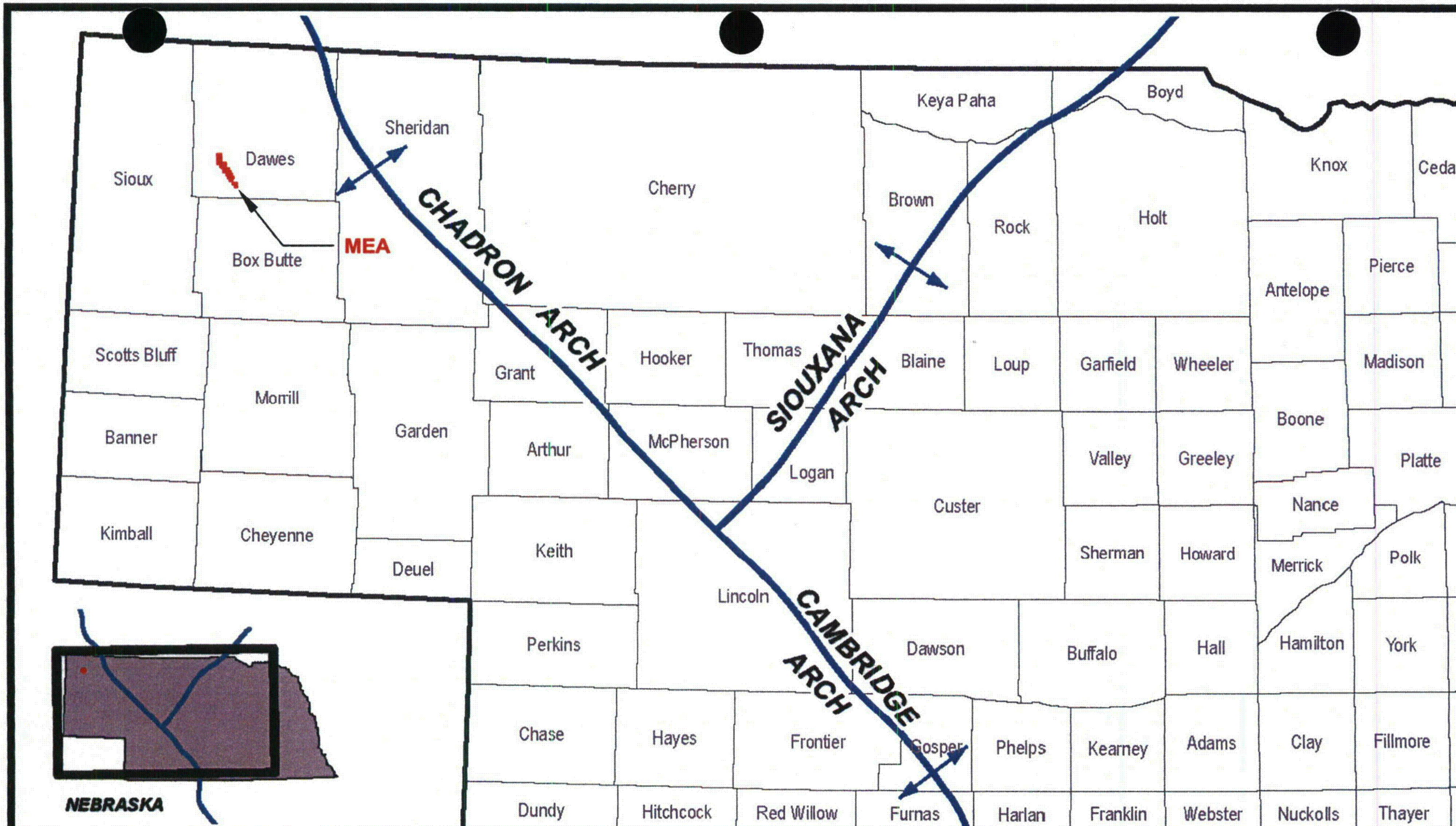
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 2.2-2

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

REGIONAL GEOLOGIC CROSS-SECTION

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



LEGEND

- Proposed Marsland Expansion Area (MEA)
- Nebraska County Boundary
- Nebraska State Boundary

0 15 30
Miles

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

SOURCE: STIX, J. 1982

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SUBSURFACE

HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 2.3-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

LOCATION OF CHADRON ARCH

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:

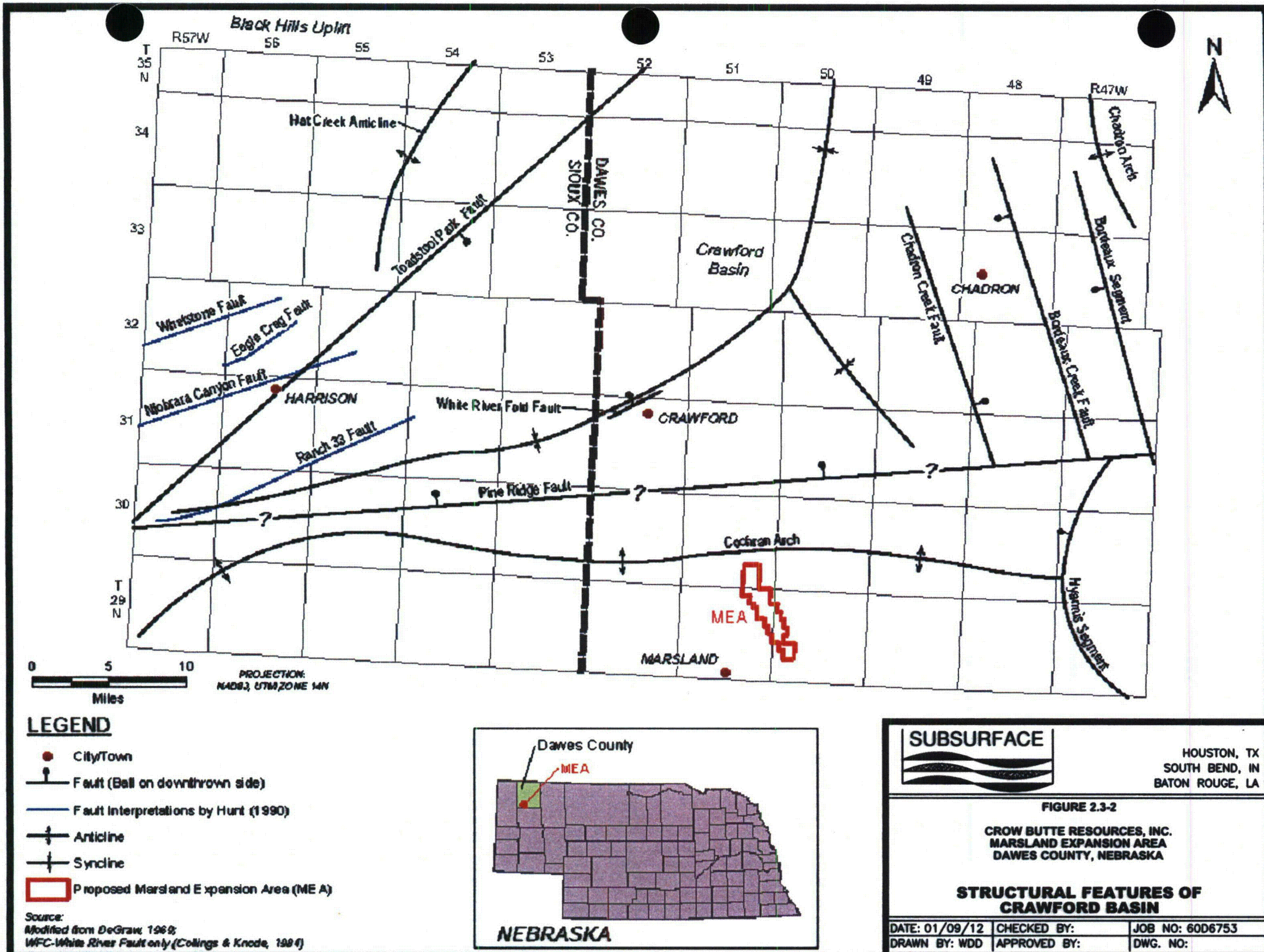
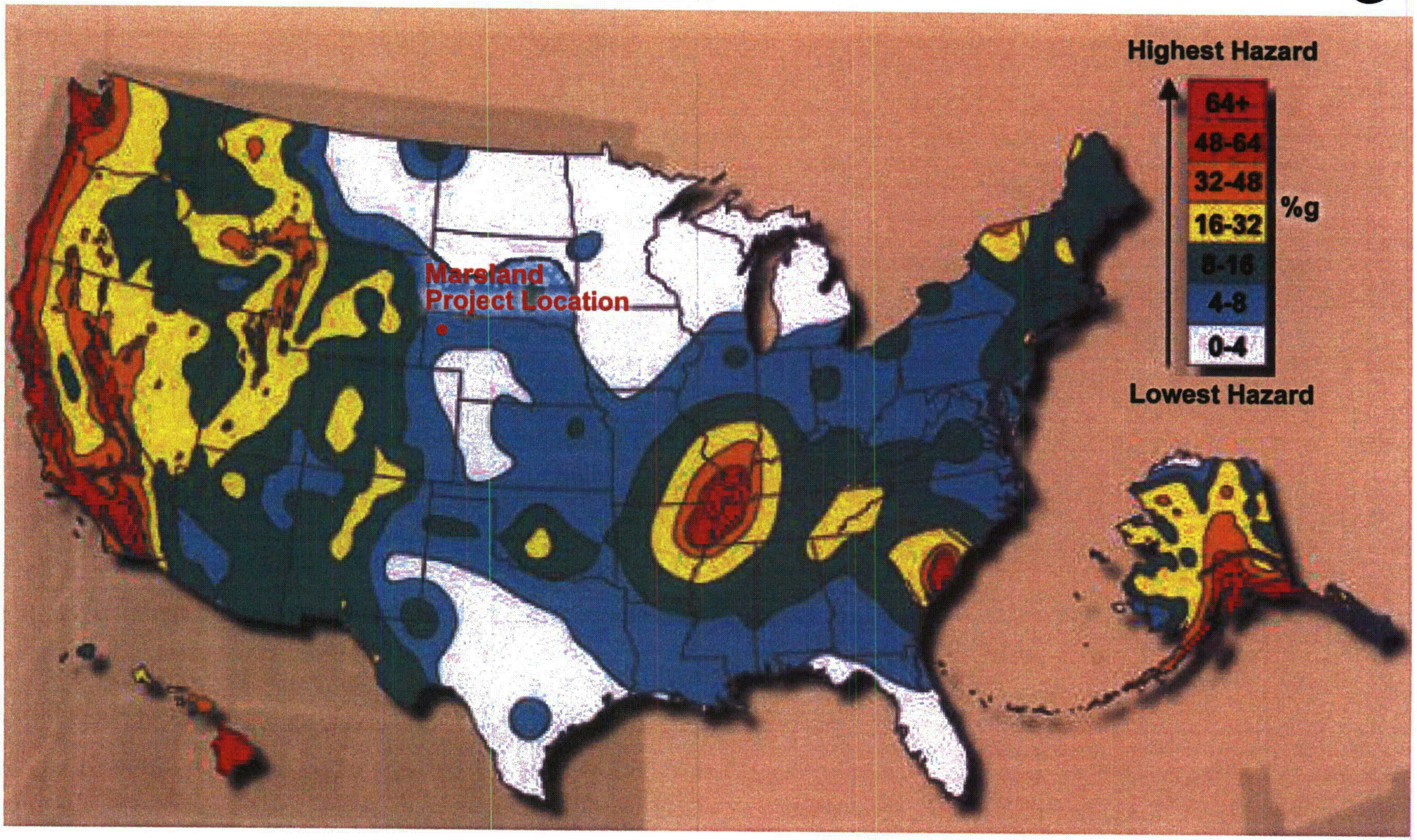


FIGURE 2.3-2

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

STRUCTURAL FEATURES OF CRAWFORD BASIN



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SUBSURFACE

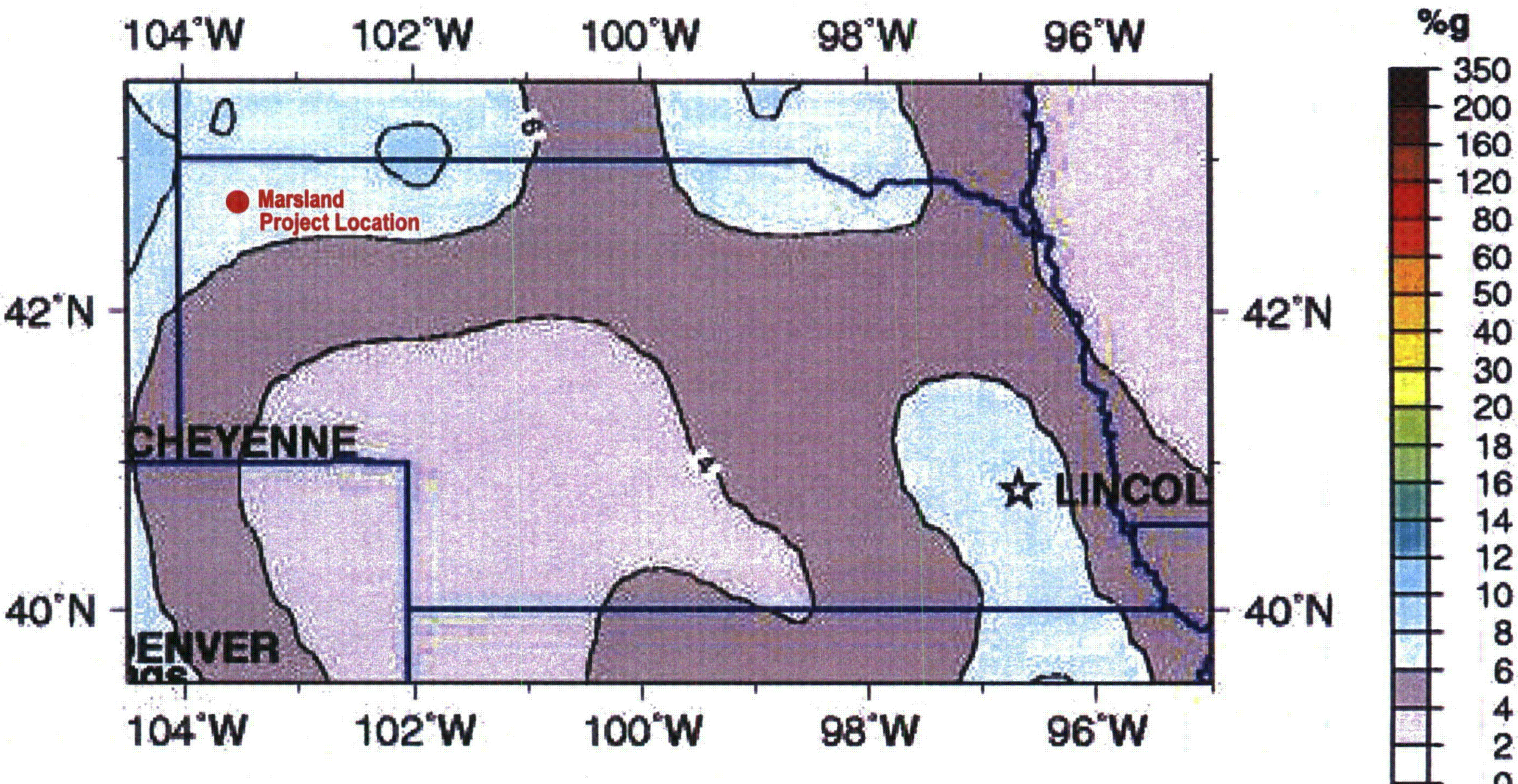
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 2.3-3

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

NATIONAL HAZARD MAP

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
Site: NEHRP B-C boundary
National Seismic Hazard Mapping Project (Peterson, M.D. 2008)

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SUBSURFACE

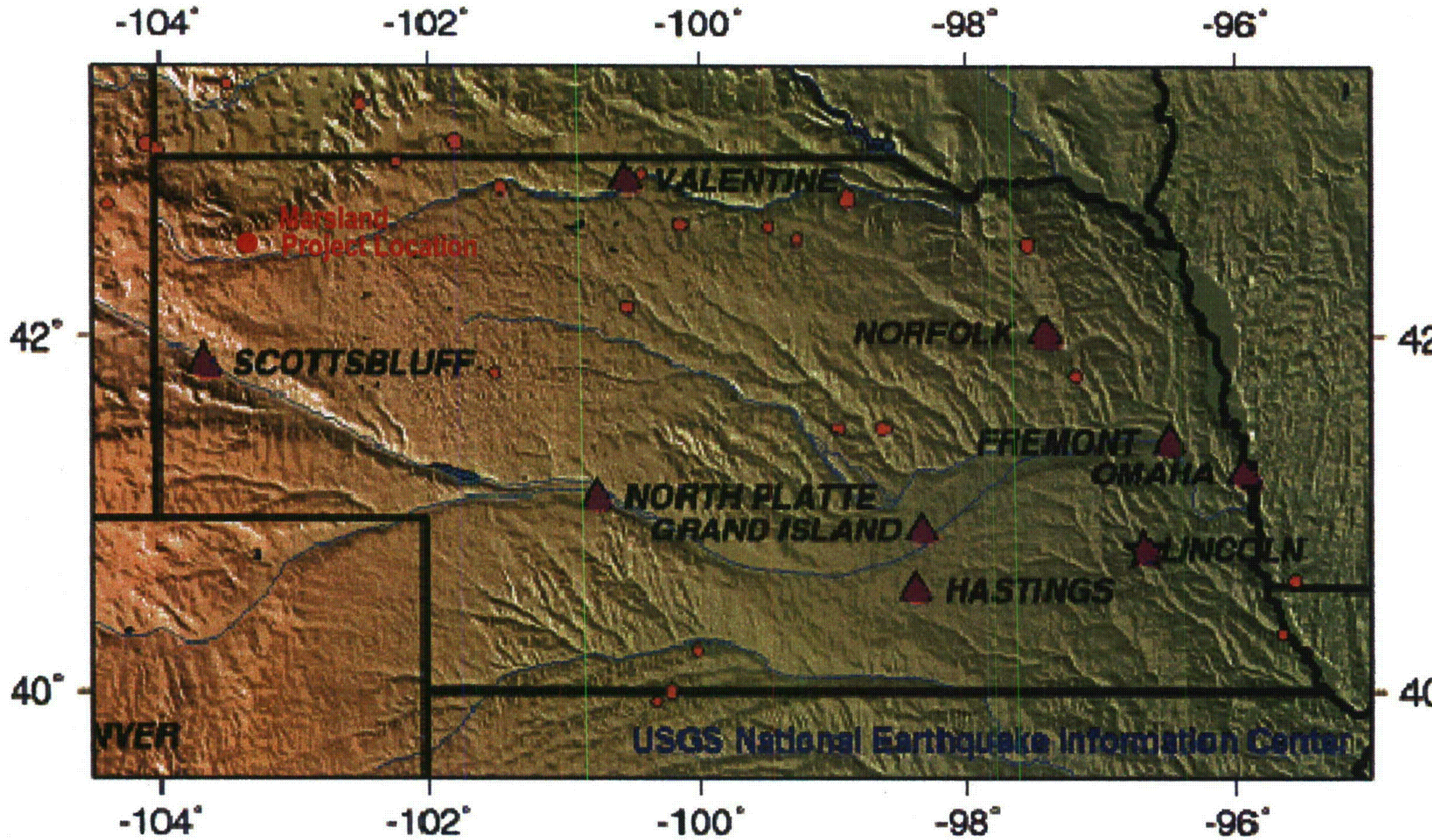
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

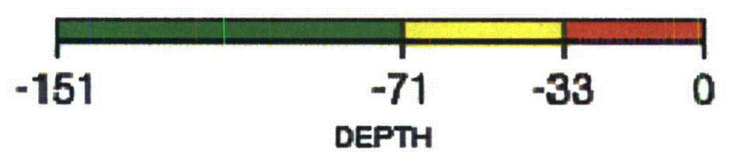
FIGURE 2.3-4

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

SEISMIC HAZARD MAP FOR NEBRASKA (2008)

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:





Depth is in kilometers.
Purple Triangles: Cities
Purple Star: Capital City
Circles: Earthquakes (color represents depth range)
Earthquake locations are from the USGS/NEIC PDE catalog

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SUBSURFACE

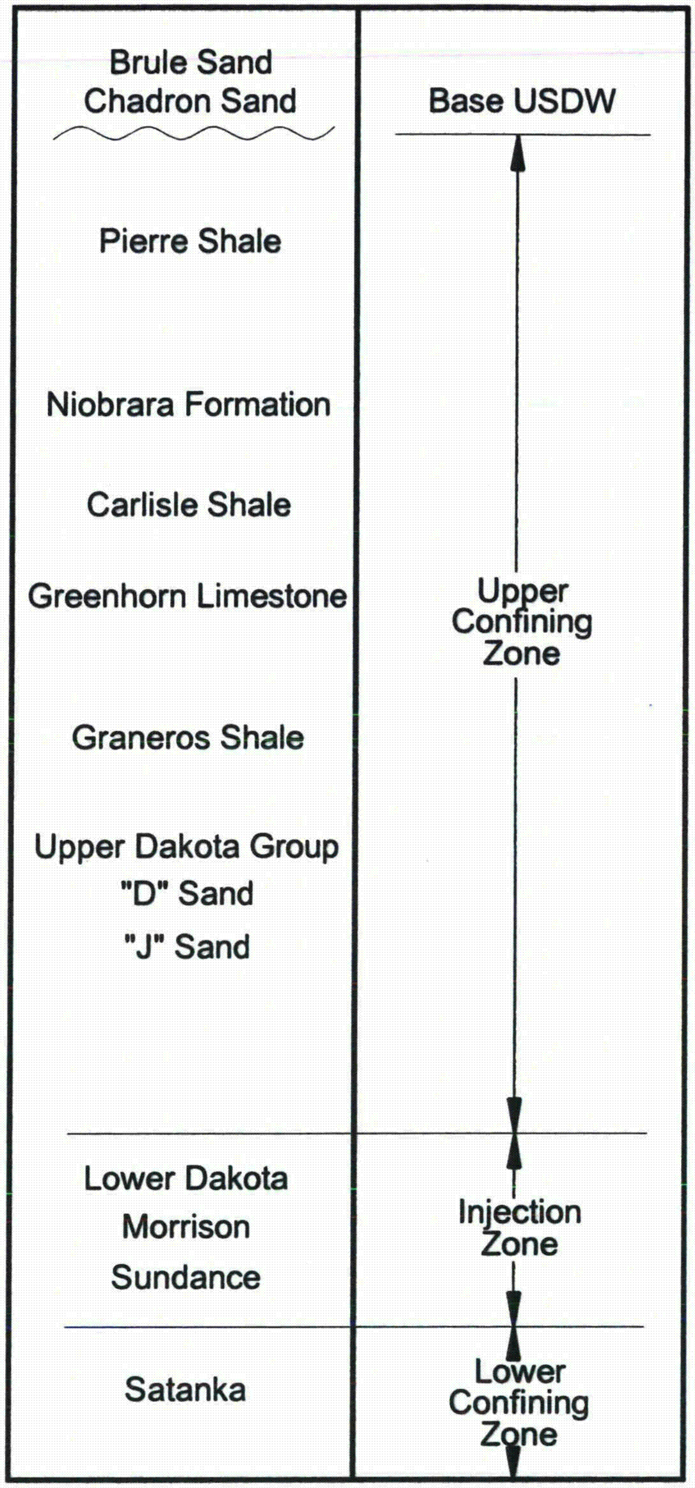
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 2.3-5

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

SEISMICITY OF NEBRASKA
1990 - 2006

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 2.3-6

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

INJECTION ZONE AND CONFINING ZONES

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:

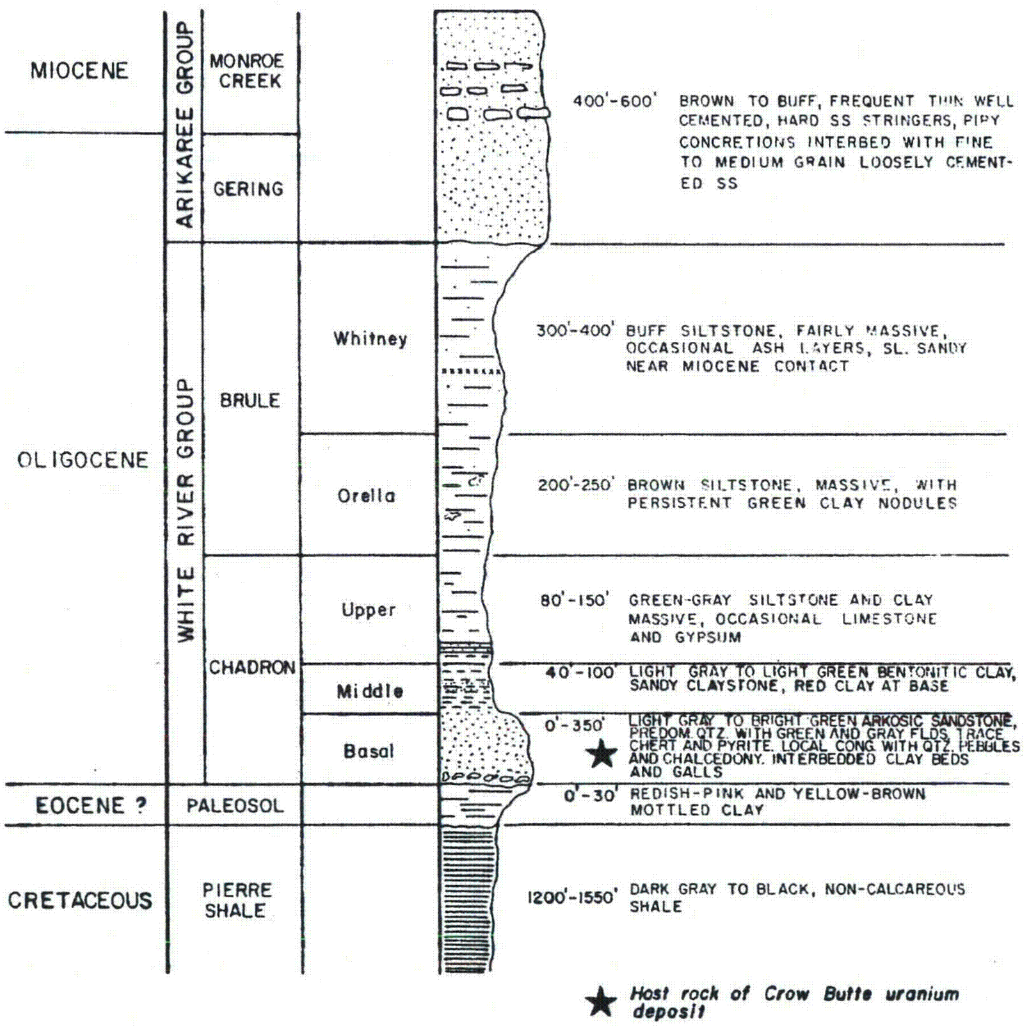
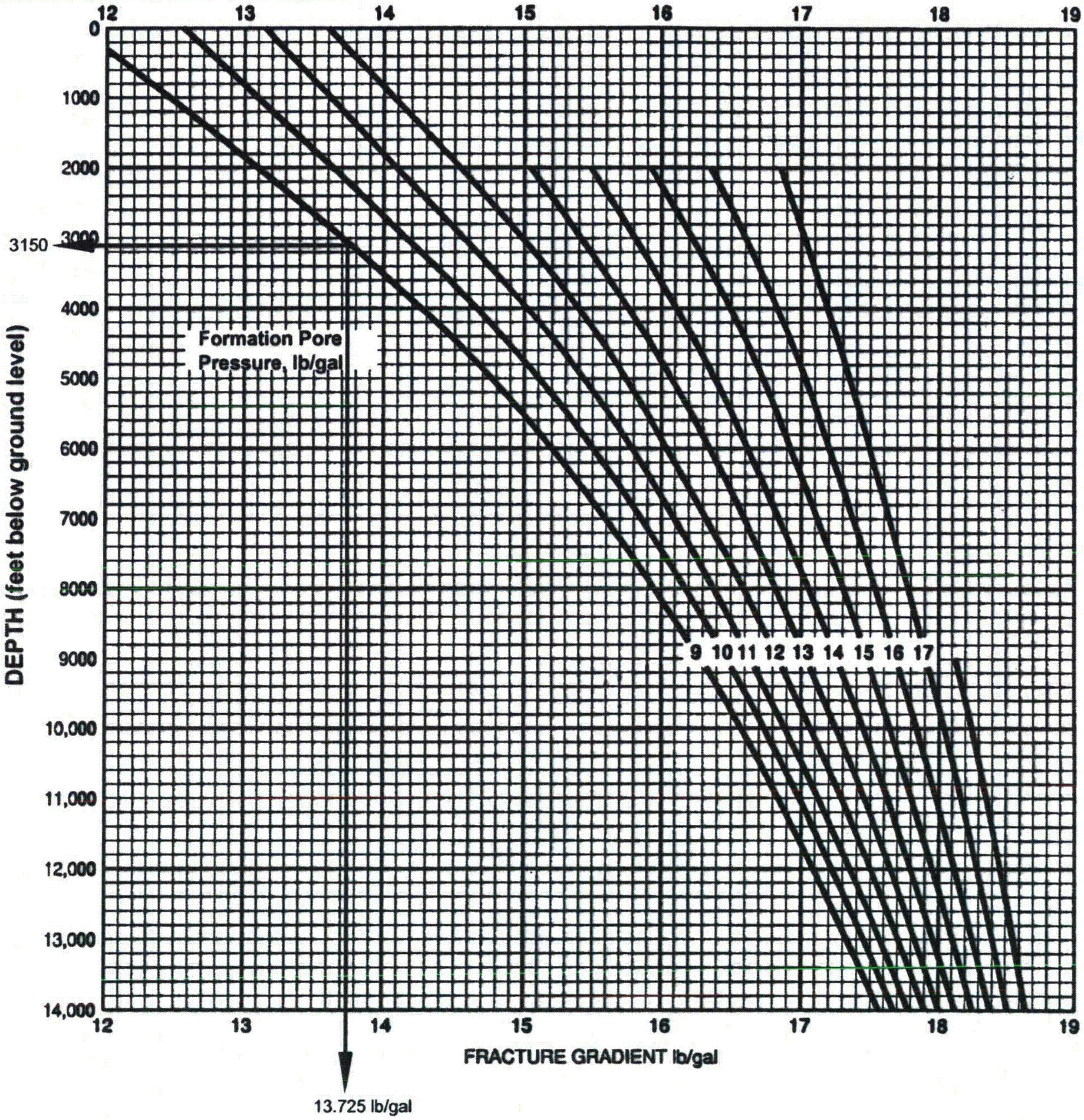


FIGURE 4. Stratigraphic Column: Crow Butte Project Area

FIGURE 2.4-1

FRESHWATER AQUIFERS



Fracture Gradient at Estimated Top of Injection Zone (3150 ft/bls) = 13.725 lb/gal

SOURCE: ADAPTED FROM EATON, 1969

SUBSURFACE

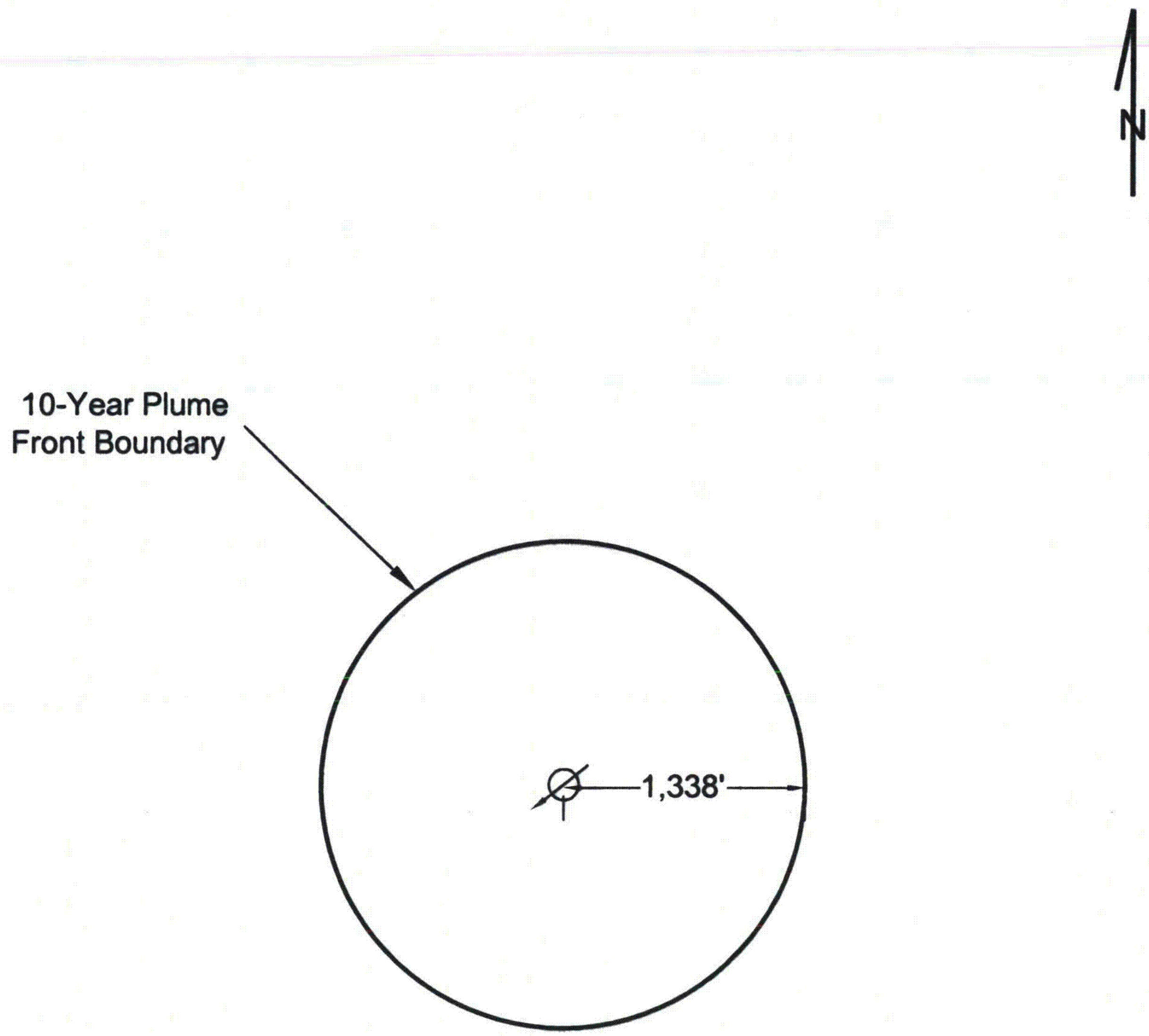
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 3.5-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

GRAPH USED TO DETERMINE FRACTURE GRADIENT

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

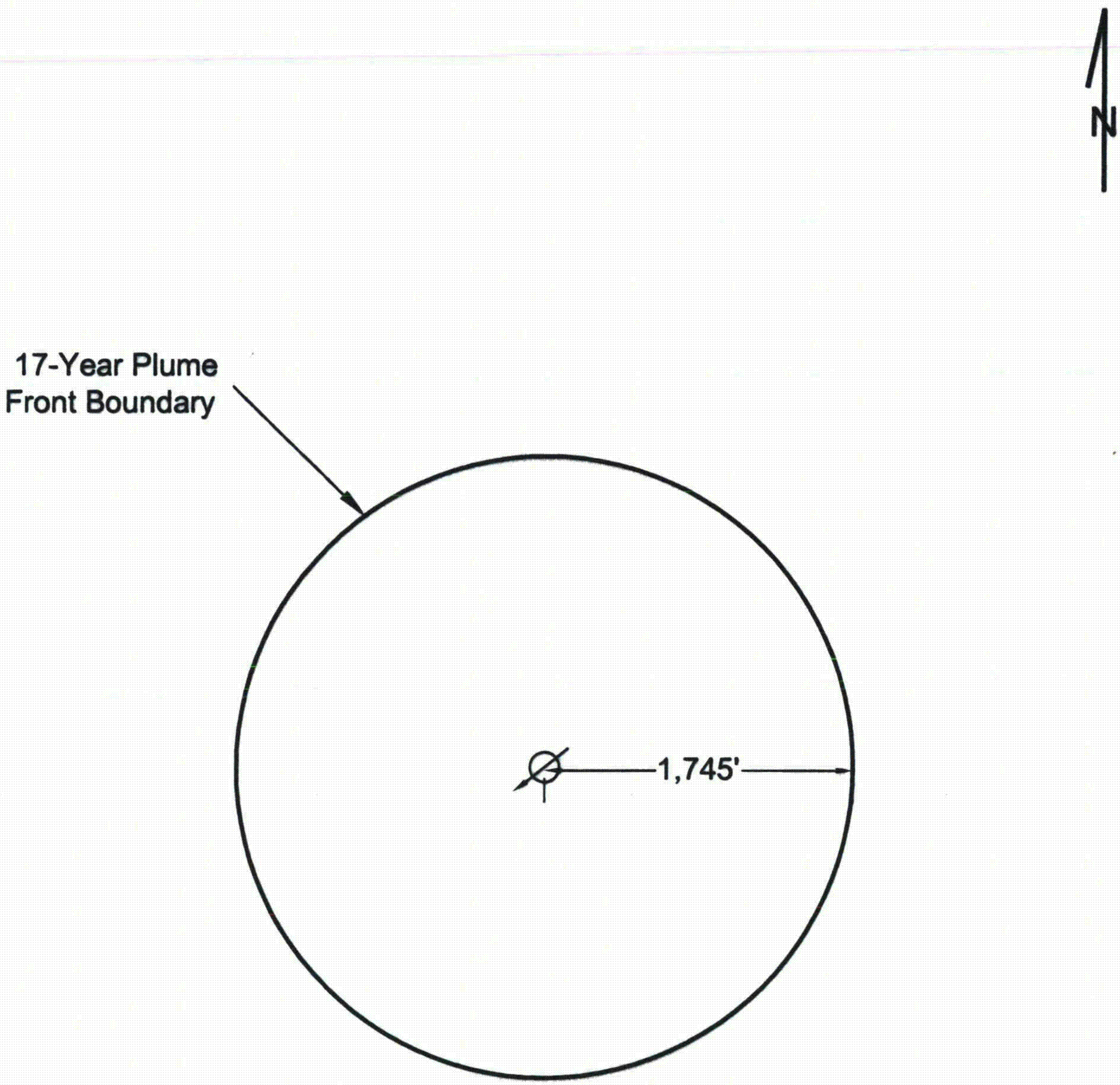
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 6.3-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

10-YEAR WASTE FRONT BOUNDARY

DATE: 01/09/12	CHECKED BY:	JOB NO: 6006753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

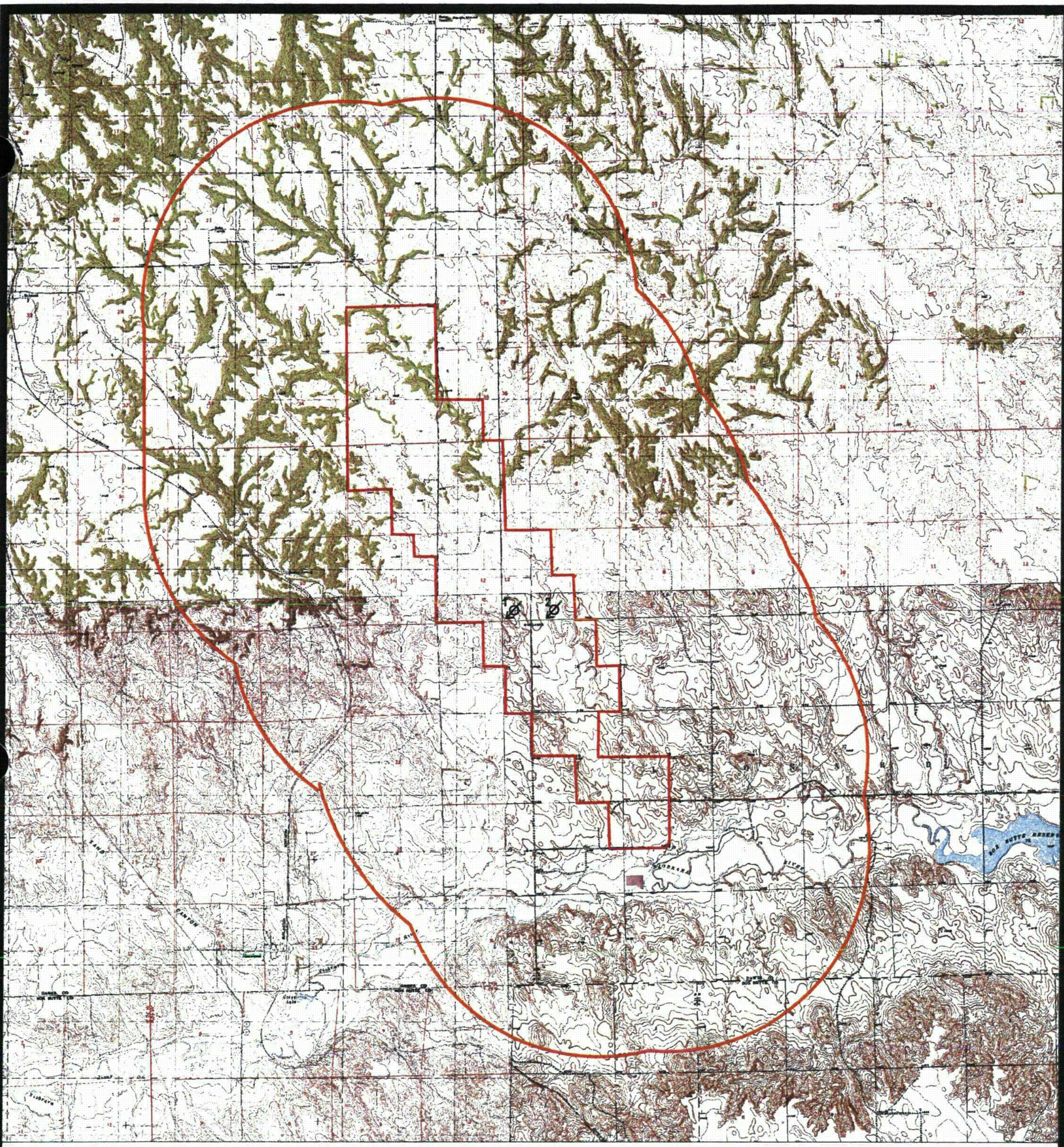
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 6.3-2

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

17-YEAR WASTE FRONT BOUNDARY

DATE: 03/26/13	CHECKED BY:	JOB NO: 6006753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



LEGEND

- Approximate Injection Well Locations
- Proposed Marsland Expansion Area
- AOR Boundary (2-mile fixed radius)

Sources for Oil/Gas Test Holes

Nebraska Oil and Gas Conservation Commission, (http://www.nogcc.ne.gov/NOGCCPublications.aspx), Accessed on 08/01/2011

Sources for Sand/Gravel Pits

1. Dawes County, (http://dawes.assessor.gisworkshop.com/Assessor/index.jsp), Accessed on 08/03/2011, and

2. Burchett, R.R. 1971. Directory of Nebraska Quarries, Pits and Mines. Resource Report Number 5. University of Nebraska Conservation and Survey Division, Lincoln. March.

SUBSURFACE

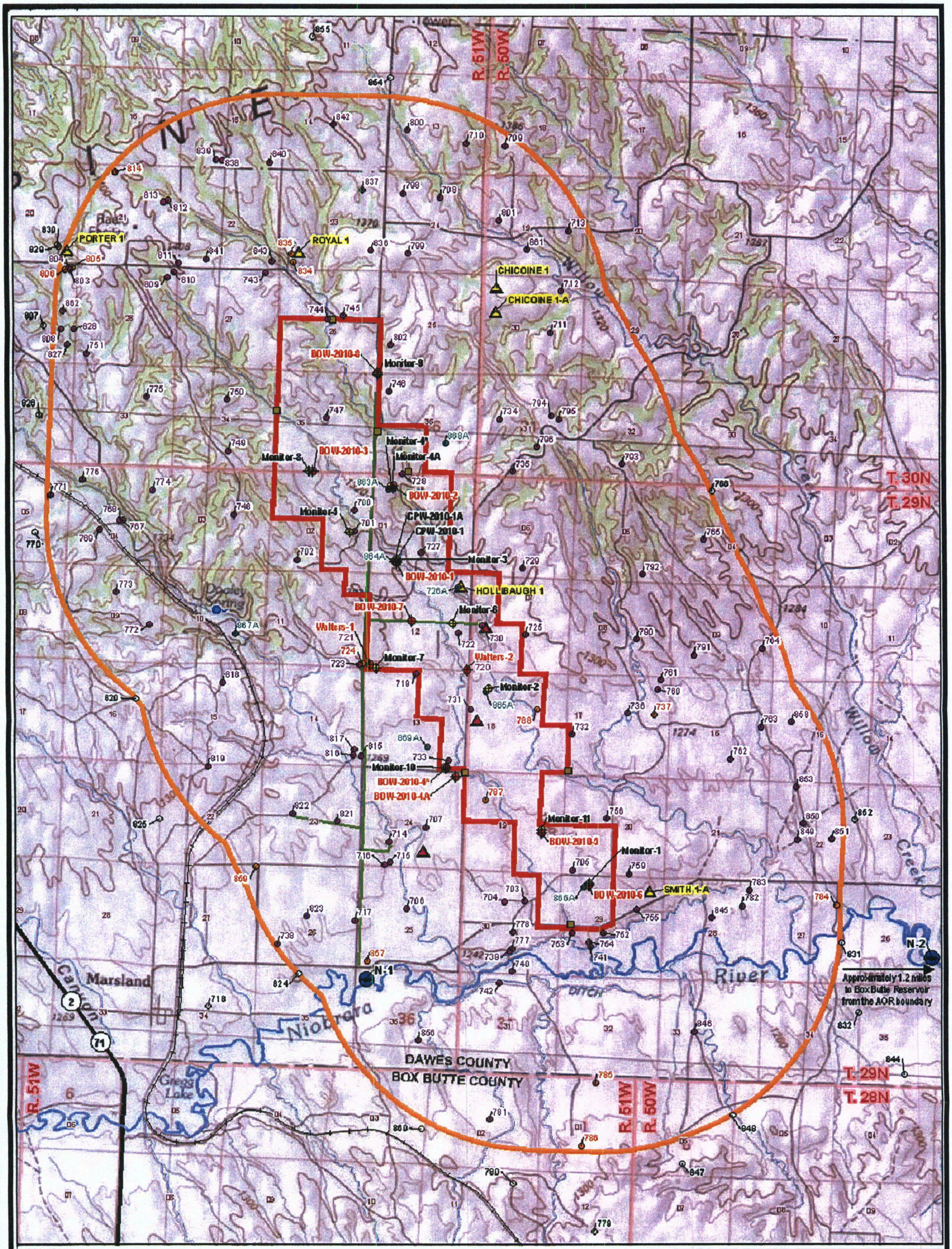
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 6.5-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

AREA OF REVIEW MAP

DATE: 03/20/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



LEGEND

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

Pumping Test Monitoring Wells

- Monitor-3 — Basal Chadron Sandstone Well
- BOW-2010-6 — Brule Formation Well

* BOW-2010-4 is inactive and scheduled to be abandoned; Monitor-4 is abandoned

- Sand/Gravel Pit, Inactive
- Dry Hole, Dry and Abandoned

Private Water Supply Wells

- 781 Active Well
- 786 Inactive Well
- 726A Abandoned Well
- 780 Well Located outside of AOR
- Powerline
- Railroad

N

0 0.5 1
Miles

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

SUBSURFACE

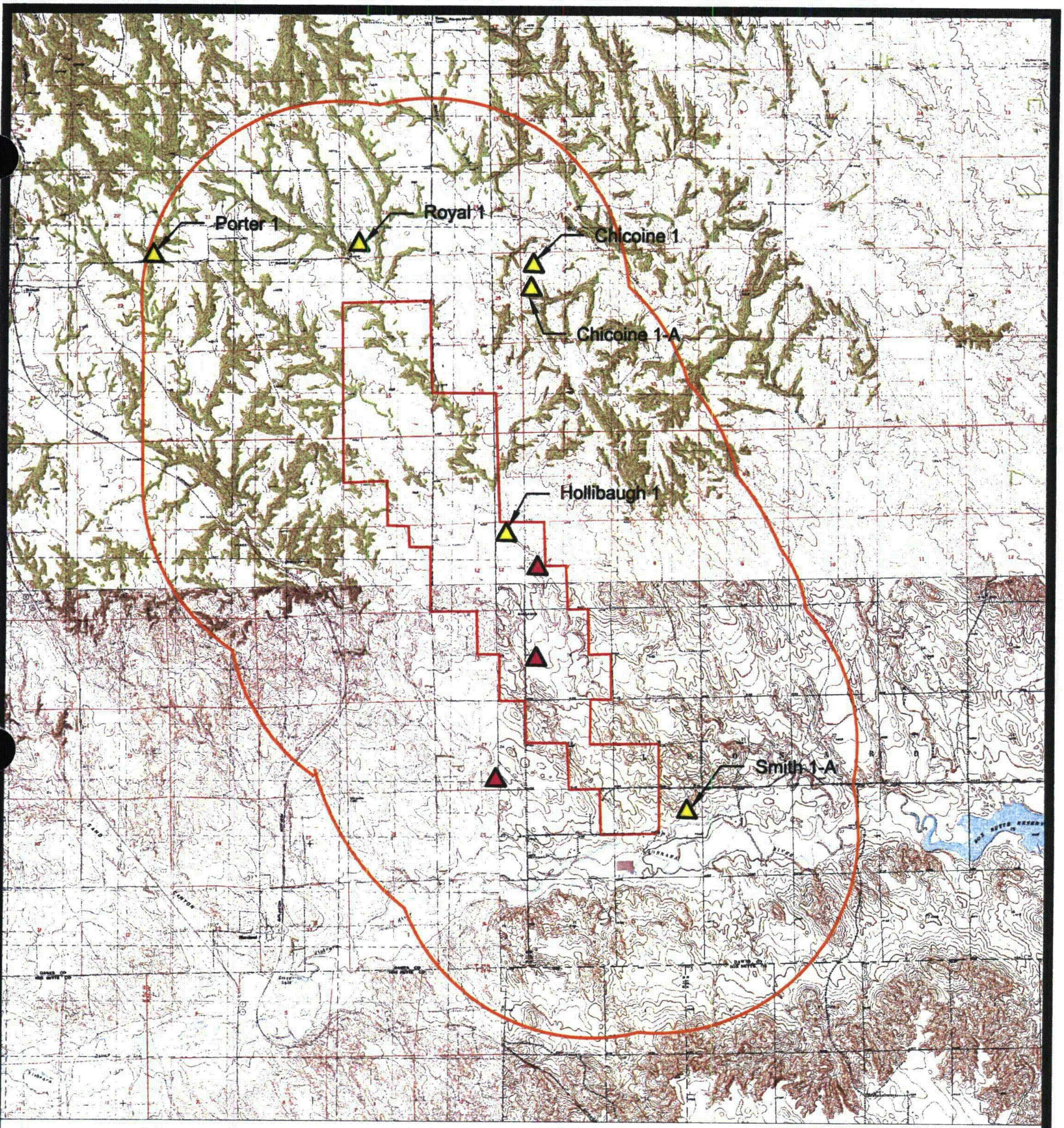
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 6.6-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

WATER WELL LOCATIONS WITHIN AREA OF REVIEW

DATE: 03/27/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



LEGEND

- ▲ Sand/Gravel Pit, Inactive
- △ Dry Hole, Dry and Abandoned
- Proposed Marsland Expansion Area
- AOR Boundary (2-mile fixed radius)

Sources for Oil/Gas Test Holes

Nebraska Oil and Gas Conservation Commission, (http://www.nogcc.ne.gov/NOGCCPublications.aspx), Accessed on 08/01/2011

Sources for Sand/Gravel Pits

1. Dawes County, (http://dawes.assessor.gisworkshop.com/Assessor/index.jsp), Accessed on 08/03/2011, and

2. Burchett, R.R. 1971. Directory of Nebraska Quarries, Pits and Mines. Resource Report Number 5. University of Nebraska Conservation and Survey Division, Lincoln. March.

SUBSURFACE

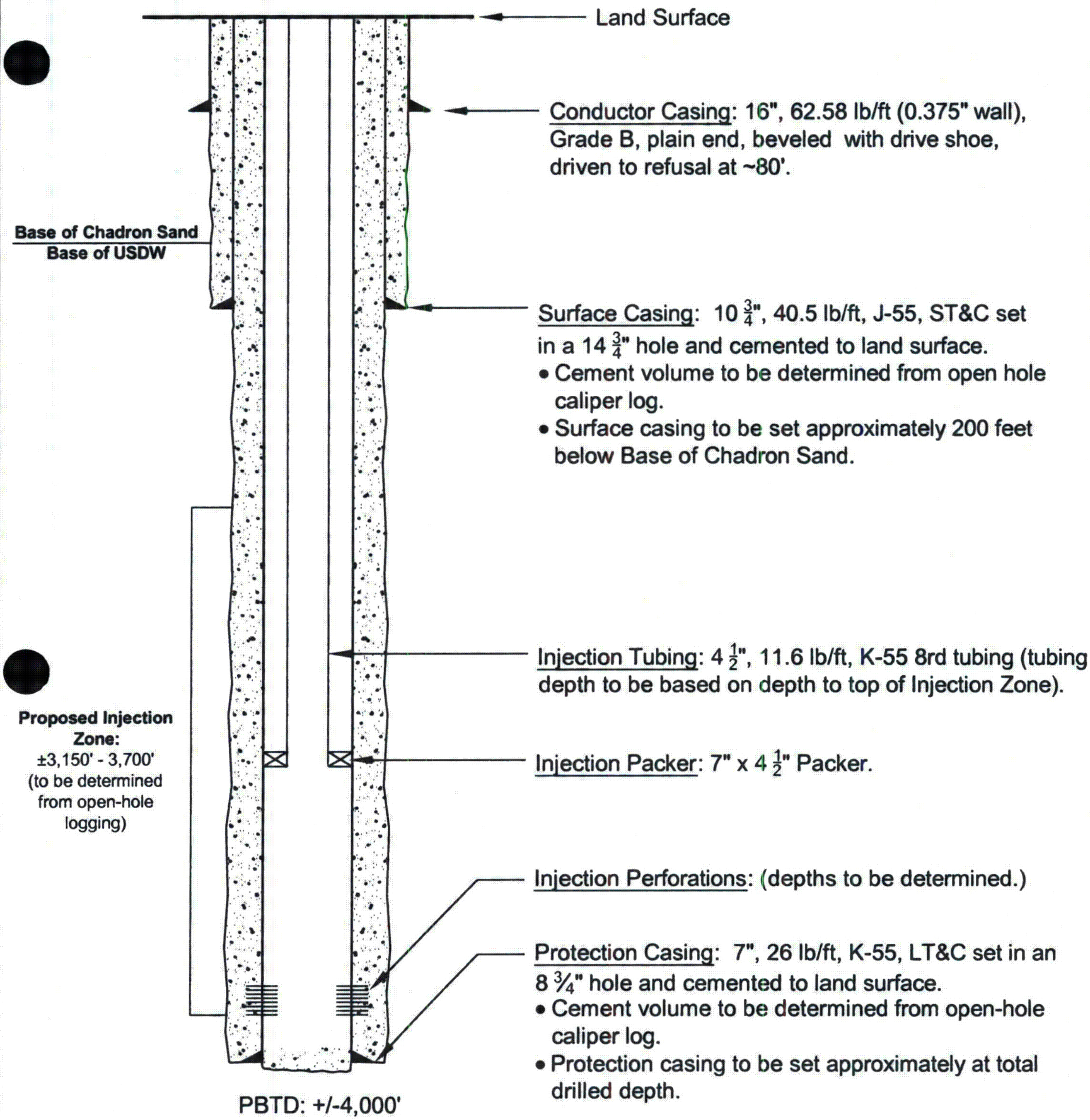
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 6.7-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

NON-FRESHWATER OIL AND GAS PENETRATIONS WITHIN AOR

DATE: 03/26/13	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



NOTE: Depths depicted on figure are estimated. Actual depths will be presented on updated figure included in well completion report.

SUBSURFACE

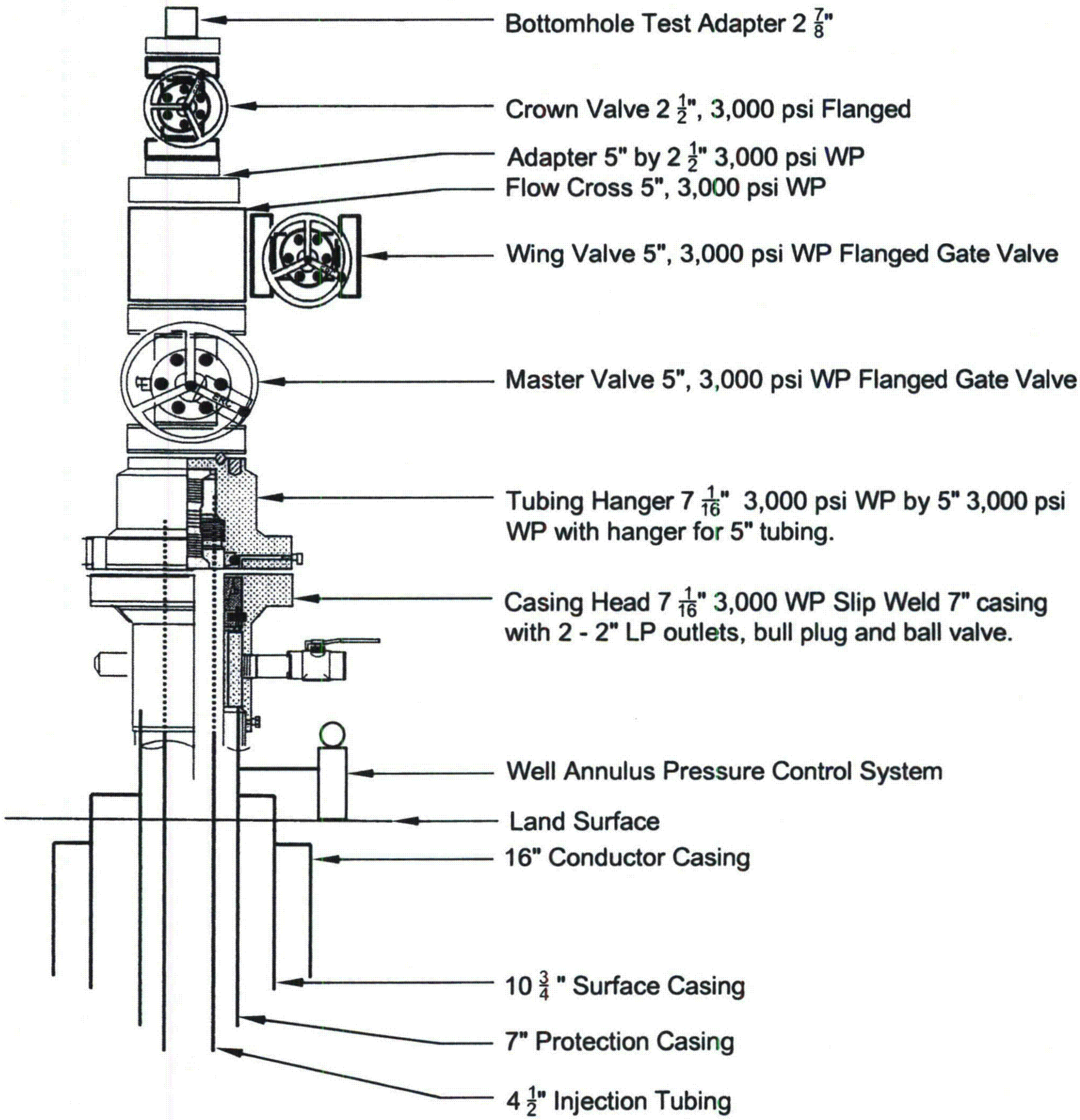
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 7.1-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

PROPOSED WELL SCHEMATIC

DATE: 01/09/12	CHECKED BY:	JOB NO: 6006753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

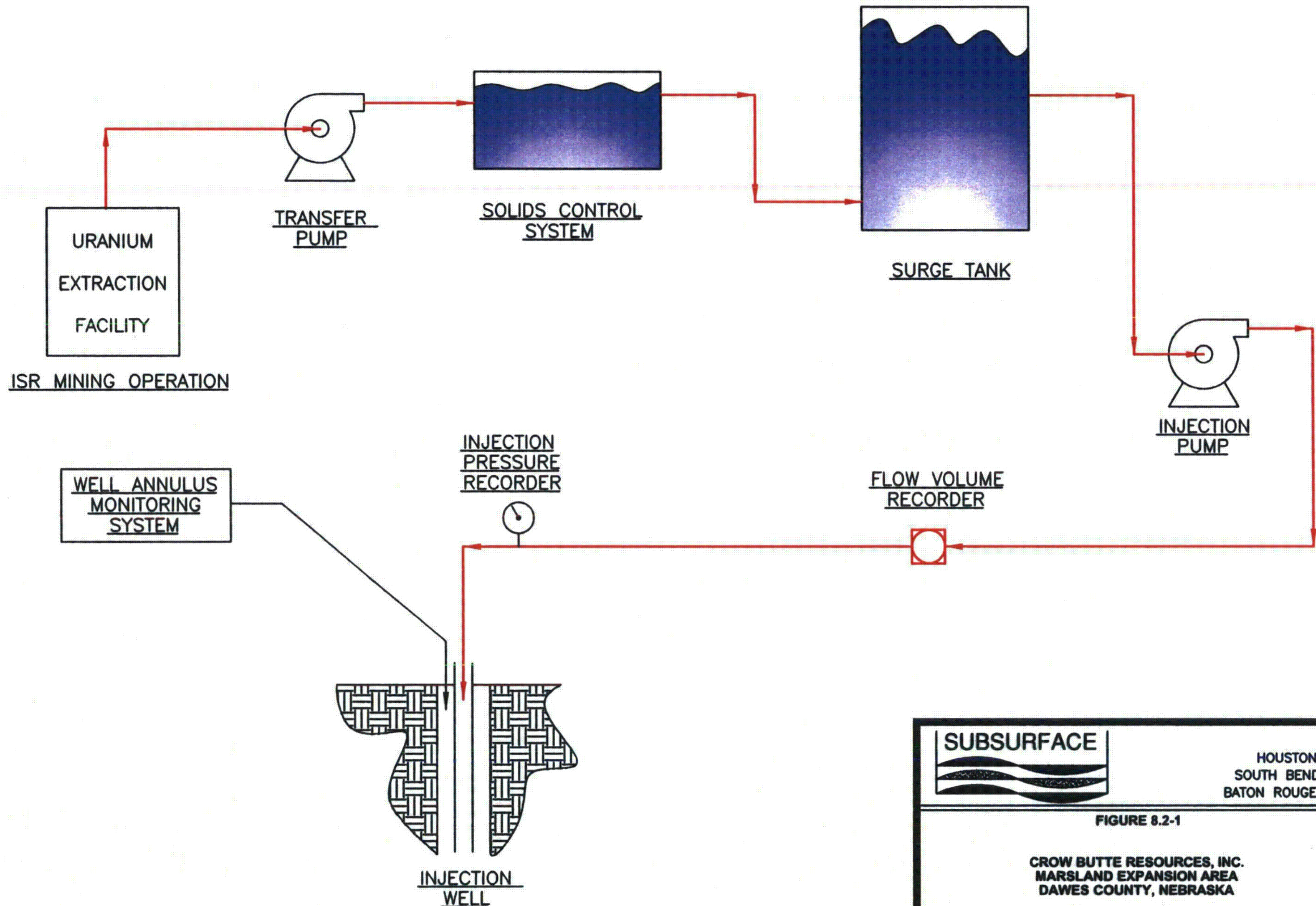
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 7.1-2

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

PROPOSED WELLHEAD SCHEMATIC

DATE: 01/09/12	CHECKED BY:	JOB NO: 6006753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



SUBSURFACE

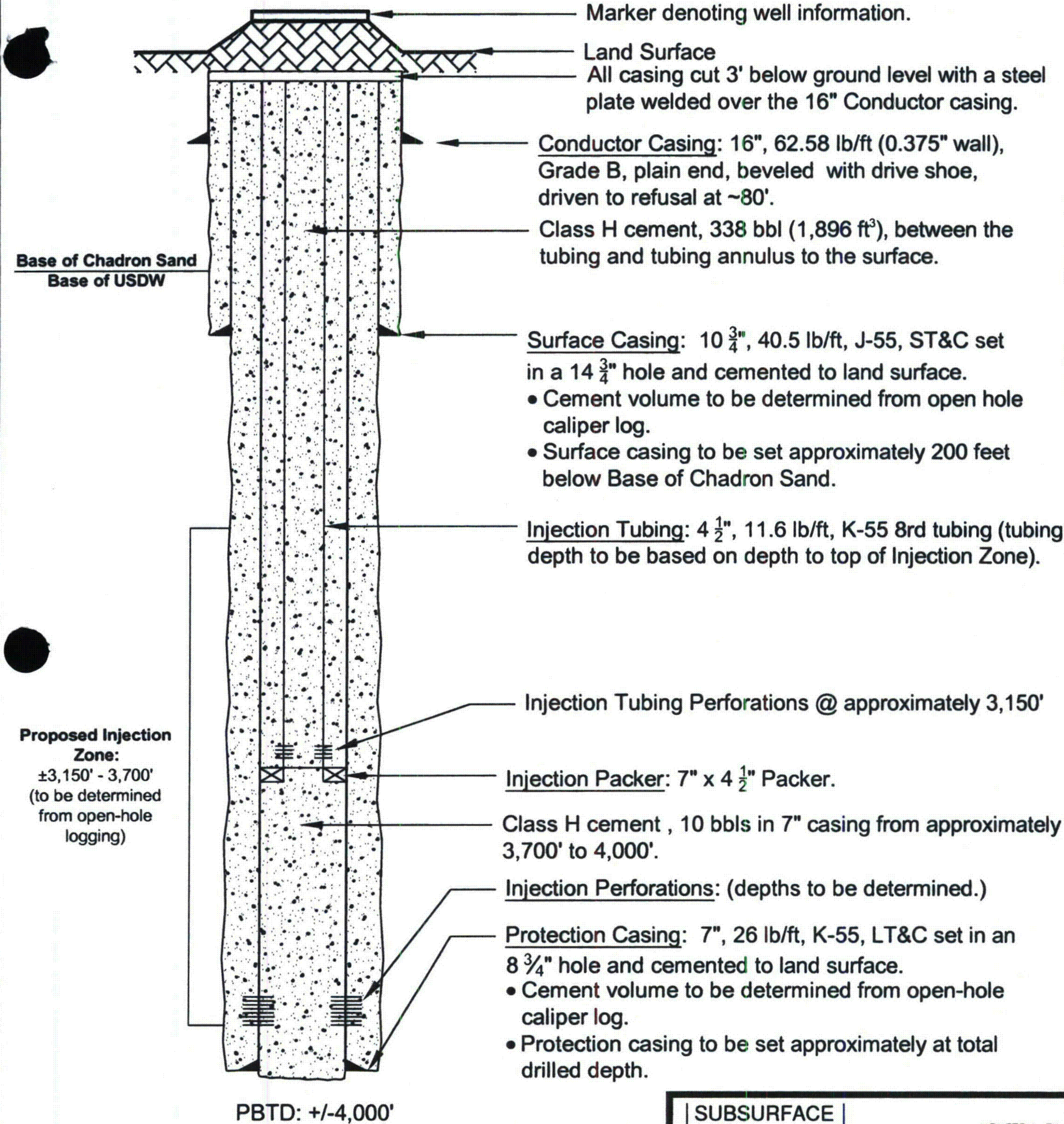
HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 8.2-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

INJECTION WELL SURFACE FACILITIES

DATE: 01/09/12	CHECKED BY:	JOB NO: 60D6753
DRAWN BY: WDD	APPROVED BY:	DWG. NO:



NOTE: Depths depicted on figure are estimated. Actual depths will be presented on updated figure included in well completion report.

SUBSURFACE

HOUSTON, TX
SOUTH BEND, IN
BATON ROUGE, LA

FIGURE 9.1-1

CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

PROPOSED PLUGGED AND ABANDONED WELL SCHEMATIC

DATE: 01/09/12	CHECKED BY:	JOB NO: 6006753
DRAWN BY: WDO	APPROVED BY:	DWG. NO:

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
SUBSURFACE
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY NEBRASKA
DRAWING NO. 2.3-1
SOUTHWEST-NORTHEAST
GEOLOGIC CROSS-SECTION

WITHIN THIS PACKAGE...

01-D01

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
SUBSURFACE
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY NEBRASKA
DRAWING NO. 2.3-2
NORTWEST-SOUTHEAST
GEOLOGIC CROSS-SECTION

WITHIN THIS PACKAGE...

01-D02

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
SUBSURFACE
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY NEBRASKA
DRAWING NO. 2.3-3
STRUCTURE CONTOUR MAP
TOP OF INJECTION ZONE
WITHIN THIS PACKAGE...

01-D03

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
SUBSURFACE
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY NEBRASKA
DRAWING NO. 2.3-4
STRUCTURE CONTOUR MAP
TOP OF CONFINING ZONE
(TOP OF PIERRE SHALE)

WITHIN THIS PACKAGE...

01-D04X

APPENDIX 2.3-1

NEIC LISTING OF SEISMIC EVENTS WITHIN 200-MILE RADIUS

SUBSURFACE

APPENDIX 2.3-1

NEIC: Earthquake Search Results

U. S. GEOLOGICAL SURVEY

EARTHQUAKE DATA BASE

FILE CREATED: Thu Jan 19 20:19:33 2012
Circle Search Earthquakes= 21
Circle Center Point Latitude: 42.502N Longitude: 103.255W
Radius: 124.280 km
Catalog Used: PDE
Data Selection: Historical & Preliminary Data
1974 -Present

CAT	YEAR	MO	DA	ORIG TIME	LAT	LONG	DEP	MAGNITUDE	IEM NFO TF	DTSVNWG	DIST km
PDE	1975	05	16	055701.50	43.24	-103.68	5		4F.	....	88
PDE	1978	05	07	160619.60	42.30	-101.93	15	4.3 MLGS	5F.	....	111
PDE	1983	05	06	061446.95	42.96	-102.20	5	3.3 MLGS	...	....	100
PDE	1987	01	01	080224.07	42.79	-103.48	5	3.5 LgGS	3F.	....	36
PDE	1989	02	09	051545.80	42.69	-101.90	5	3.8 LgGS	5F.	....	113
PDE	1990	01	28	045959.19	43.31	-102.50	5	4.0 LgTUL	5F.	....	108
PDE	1990	03	02	041527	43.30	-102.50	5	3.2 MLGS	4F.	....	107
PDE	1992	11	02	065410.34	42.74	-104.39	5	3.0 MLGS	5F.	....	96
PDE	1994	03	18	225143.15	43.40	-103.50	5	2.8 LgGS	.F.	....	101
PDE	1994	03	20	071506	43.40	-103.50	5	2.3 LgGS	.F.	....	101
PDE	1996	04	09	024808.19	43.07	-104.10	5	3.7 LgGS	3F.	....	93
PDE	1996	05	03	074751.53	43.04	-104.02	5	3.1 LgGS	...	....	87
PDE	1998	06	18	162638.32	42.62	-103.00	5	3.4 LgGS	.F.	....	24
PDE	2006	09	07	062320.02	42.98	-102.24	5	2.6 LgGS	...	....	98
PDE	2007	04	24	093501.26	42.58	-102.94	5	2.7 LgGS	...	....	27
PDE	2008	08	22	230131.81	43.08	-104.29	5	3.1 MLGS	...	....	105
PDE-W	2011	03	10	013813.68	42.86	-104.09	5	2.9 LgGS	2F.	....	78
PDE-Q	2011	11	14	065138.40	43.04	-103.42	5	4.0 mbGS	3F.	....	61
PDE-Q	2011	11	15	093146.13	43.05	-103.50	5	3.3 LgGS	4F.	....	64
PDE-Q	2011	11	19	082808.38	43.07	-103.46	5	2.8 LgGS	...	....	65
PDE-Q	2012	01	16	134110.73	43.45	-103.05	5	3.0 LgGS	3F.	....	106

USGS National Earthquake Information Center
USGS Privacy Statement | Disclaimer

APPENDIX 5.0-1

WASTE STREAM ANALYTICAL DATA

SUBSURFACE

LABORATORY ANALYTICAL REPORT
TO BE PROVIDED BY CAMECO

APPENDIX 6.7-1

WELL RECORDS FOR NON-FRESHWATER (OIL AND GAS) PENETRATIONS WITHIN AREA OF REVIEW

NEBRASKA SCOUT TICKET

County:	DAWES		**API:**	26045210040000	
Fld:			**Loc:**	NE NE 12-29N-51W 660 FNL 660 FEL	
Oper:	CURRENTLY UNASSIGNED		**NAD83**	**Latitude:**	42.5082676941368
Name:	HOLLIBAUGH 1			**Longitude:**	-103.246562991091

Spud Dt:	01/13/1969	**GR Elev:**	4236	**Lse No:**	99999		
Comp. Dt:		**KB Elev:**	4244	**Status:**	DA	**Stat Dt:**	01/18/1969
1st PR Dt:		**BHT:**	102	**Type:**	DH		
P&A Dt:	01/18/1969	**TVD:**					
		DTD:	3295				

	Natural IP		Treated IP
Oil:	0	**Oil:**	0
Gas:	0	**Gas:**	0
Water:	0	**Water:**	0

Formation Tops | **Production Tests** | **Cores**

Formation Tops	
NIOBRARA	1915
CARLILE	2231
GREENHORN	2462
BELLE FOURCHE	2500
MOWRY "X" BENTONITE	2600
GURLEY "D" SAND	2730
HUNTSMAN SHALE	2970
CRUISE "J" SAND	3130

Well Construction | **Cement** | **Perforations**

Type	Dia	Top	Bot	Sacks	Top	Bot	Top	Bot	Sht	Comment
[illegible]	12.25	0	216							
[illegible]	8.625	0	216			216				
HOL2	7.875	0	3295	10		310				
HOL2	7.875	0	3295	35		2930				

Well - Specific Stimulations

Formation:		**Top Perf:**		**Bot Perf:**			
Type:		**Vol:**		**Prop:**	LBS	**Acid Conc:**	%
Comment:							

Nebraska Oil and Gas Conservation Commission
Form 2

NOTIFICATION OF INTENT TO DRILL OR RE-ENTER

APPLICATION TO DRILL [X] RE-ENTER [ ]

Instructions: Notice must be given to the Director, and approval obtained before proceeding with the work described herein. Submit this form in triplicate for wells on patented or Federal lands, and in quadruplicate for wells on State lands. One approved copy will be returned to the operator.

Operator

GABLE DRILLING COMPANY, INC.---Joe Josephson & V. E. Autry

DEC 2 1968

Address

508 Patterson Bldg., Denver, Colorado 80202

DESCRIPTION OF WELL AND LEASE

Well Number	Name of Lease	Elevation (ground)
5	~~None~~ Known Holibaugh	4236'

Well Location	Sec.	Twp.	Range	County
NE NE	12	29	51	Dawes

Footage Location

660 ft. from (N) (S) line, 660 ft. from (E) (W) line of NE ¼

Field & Reservoir (If wildcat, so state)	Will hole be directionally drilled?	Contractor
Wildcat	Yes	GABLE DRILLING CO., INC.

Nearest distance from proposed location to property or lease line:	Distance from proposed location to nearest drilling, completed or applied-for well on the same lease:
Not Known feet	None Known feet

Proposed depth and deepest formation to be tested	Rotary or cable tools	Approximate date work will start
Morrison Approx. 3600'	Rotary	1/7/69

Number of acres in lease:	Number of wells on lease, including this well, completed in or drilling to this reservoir:
320	None

Surface casing program:

Amt.: 150 ft. | Size: 8 5/8 in. O. D. | Wt. 24 lbs/ft. | Cement 100 sacks

Status of bond (check one)

$2500.00 "one well" bond attached [ ] $10,000.00 blanket bond on file [XX]

Permit Number: 26 045 21004

Approval Date: 12 3 68

Approved By: Jack T Fish

Signature of operator or agent

Operator and Contractor
Title

November 29, 1968
Date

Sample cut required by Nebraska Geological Survey

Yes [X] No [ ]

Notice: Complete the location plat on reverse side. Be sure that you have given all information requested. Much unnecessary correspondence will thus be avoided.

Nebraska Oil and Gas Conservation Commission
Form 6

PLUGGING RECORD

Instructions: Within thirty days following the plugging of a dry hole, or the abandonment of a producing well, the owner or operator shall submit this form in duplicate for wells on patented or Federal lands, and in triplicate for wells on State lands. Geological information will be held confidential for a period of twelve months if requested in writing. Fill out form as completely as possible.

Operator
GABLE DRILLING CO., INC. --- Joe Josephson & V. E. Autry

Address
508 Patterson Bldg., Denver, Colo. 80202

Well Number	Lease Name	Field and reservoir (If wildcat, so state)
1	Hollibaugh	Wildcat

Location	County
NE NE Sec. 12 Twp. 29 N Range 51 W	Dawes

Footage Location
660 ft. from (N) (S) line, 660 ft. from (E) (W) line of Northeast ¼ section

Spud Date	Date reached T.D.	Date Plugged	Total Depth	P.B.T.D.
1-13-69	1-17-69	1-18-69	3295 dlr. 3283log	NA

Elevation	Reference (indicate)	Producing rate on initial completion: Oil (bbls/day)	Gas (MCF/day)	Water (bbls/day)
4244 KB 4236 GL	(KB) (GL) (DF)	NA		

Application to drill this well was filed in name of:	Producing rate at time of abandonment: Oil (bbls/day)	Gas (MCF/day)	Water (bbls/day)
	NA		

CONDITION OF HOLE

Name each formation containing oil or gas. Indicate which formations open to well bore at time of plugging.	Fluid Content	Depth Interval	Size, kind and depth of plugs used. Indicate zones squeeze cemented giving amount of cement.
Muddy - J, Zone3	Water	2810-2930	#1 35 sacks cement
Tertiary sands & gravels	Water	280-310	#2 10 sacks cement
Top plug omitted at landowner's	request for	his conversion	into a domestic water well.

Size, kind and depth of any additional plugs

Heavy drilling mud between cement plugs.

CASING RECORD

Size casing in O.D.	Weight lbs/ft.	Setting Depth	Amount Recovered	Amount left in well	Method of parting (shot, ripped, etc.)
8 5/8	24#	216' KB	none	208'	NA

Was hole filled with mud-laden fluid?

Niobrara Shale	1913
Codell sandstone	2224
Greenhorn limestone	2465
Bentonite Marker	2595
Muddy J Zone 1	2731
Zone 2	2771
Zone 3	2848
Zone 4	2927
Cheyenne sandstone	3132

No cores or tests.

...h water well, give pertinent details of plugging operations to base of fresh water sand. Attach letter from surface ... a fresh water well and agreeing to assume full liability for subsequent plugging which may be required.

...statements herein made are complete and correct.

RECEIVED
MAR 31 1969
Nebraska Oil & Gas
Cons. Commission

Robert L. Kramer
Signature

Geologist
Title

March 28, 1969
Date

NEBRASKA SCOUT TICKET

County:	DAWES			**API:**	26045210670000		
Fld:				**Loc:**	NW NW 30-30N-50W 660 FNL 660 FWL		
Oper:	PETRONOMICS INC			**NAD83**		**Latitude:**	42.5519706998262
Name:	CHICOINE 1					**Longitude:**	-103.2417684602
Spud Dt:	10/28/1981	**GR Elev:**	4455	**Lse No:**	99999		
Comp. Dt:	11/01/1981	**KB Elev:**		**Status:**	DA	**Stat Dt:**	11/01/1981
1st PR Dt:		**BHT:**	0	**Type:**	DH		
P&A Dt:	11/01/1981	**TVD:**					
		DTD:	2641				

	Natural IP		Treated IP
Oil:	0	**Oil:**	0
Gas:	0	**Gas:**	0
Water:	0	**Water:**	0

Formation Tops **Production Tests** **Cores**

Well Construction				Cement			Perforations			
Type	Dia	Top	Bot	Sacks	Top	Bot	Top	Bot	Sht	Comment
HOL1	12.25	0	484							
SURF	8.625	0	484	500		484				
HOL2	7.875	0	2641			50				
HOL2	7.875	0	2641			500				
HOL2	7.875	0	2641			2100				

Well - Specific Stimulations

Formation: **Top Perf:** **Bot Perf:**

Type: **Vol:** **Prop:** LBS **Acid Conc:** %

Comment:

Nebraska Oil and Gas Conservation Commission
Form 2

4

RECEIVED OCT 23 1981 NEBRASKA OIL & GAS CONS. COMMISSION

NOTIFICATION OF INTENT TO DRILL OR RE-ENTER

APPLICATION TO DRILL [X] RE-ENTER [ ]

Instructions: Notice must be given to the Director, and approval obtained before proceeding with the work described. Submit in triplicate for wells on patented or Federal lands, and in quadruplicate for wells on State lands. One approved copy will be returned to the operator.

Operator: Petronomics / LeClair-Westood, Inc. - Agent		
Address: 388 Denver Club Bldg, Denver CO 80202 (303) 825-4258		

DESCRIPTION OF WELL AND LEASE

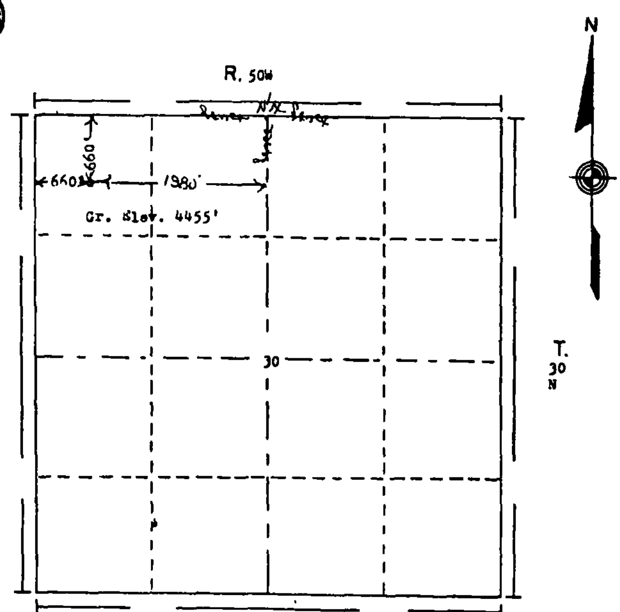
Well Number: #1	Name of Lease: Chicoine	Elevation (ground): Plats to be sent when received
Well Location: C NW/4 NW/4 Sec 30 Twp. 30N Range 50W		County: Dawes
Footage Location: 660' ft. from (N) (S) line, 660' ft. from (E) (W) line of ¼		
Field & Reservoir (If wildcat, so state): Wildcat	Will hole be directionally drilled? No	Contractor: Circle M Drilling, Inc.
Nearest distance from proposed location to property or lease line: 660' feet	Distance from proposed location to nearest drilling, completed or applied-for well on the same lease: None feet	
Proposed depth and deepest formation to be tested: 3150' or Skull Creek	Rotary or cable tools: Rotary	Approximate date work will start: Nov 1, 1981
Number of acres in lease: 80	Number of wells on lease, including this well, completed in or drilling to this reservoir: None	
Surface casing program: Amt.: 350 ft. Size: 8-5/8 in. O.D. Wt. 24 lbs/ft.	Cement: 300 sx or sufficient to circulate sacks	
Status of bond (check one): $2500.00 "one well" bond attached [ ]	$10,000.00 blanket bond on file [X]	

Permit Number: 26 045 21067	[signature] Signature of operator or agent
Approval Date: 23 Oct 81	Dist. Supt. Title
Approved By: [signature]	10-21-81 Date

Sample cut required by Nebraska Geological Survey Yes [X] No [ ]

Notice: Complete the location plat on reverse side. Be sure that you have given all information requested. Much unnecessary correspondence will thus be avoided.

PEC FORM F-106



Scale··· 1" = 1000'

Powers Elevation of Denver, Colorado has in accordance with a request from Debbie Short for LeClair Westwood, Inc. determined the location of No.1 Chicoine to be CNW NW Section 30 Township 30N Range 50W of the 6th Principal Meridian Dawes County, Nebraska

I hereby certify that this plat is an accurate representation of a correct survey showing the location of

Date: 10-23-81

[signature]
Licensed Land Surveyor No. 200
State of Nebraska

Nebraska Oil and Gas Conservation Commission
Form 6

PLUGGING RECORD

Instructions: Within thirty days following the plugging of a dry hole, or the abandonment of a producing well, the owner or operator shall submit this form in duplicate for wells on patented or Federal lands, and in triplicate for wells on State lands. Geological information will be held confidential for a period of twelve months if requested in writing. Fill out form as completely as possible.

Operator: Petronomics, Inc.

Address: 3603 Westcenter Drive, Houston. Texas 77042

Well Number	Lease Name	Field and reservoir (If wildcat, so state)
1	Vernon P. Chicoine	Niobrara

Location: NW/4 NW/4 Sec. 30 Twp. 30N Range 50W — County: Dawes

Footage Location: ft. from (N) (S) line, ft. from (E) (W) line of ¼

Spud Date	Date reached T.D.	Date Plugged	Total Depth	P. B. T. D.
10-28-81	10-31-81	11-1-81	2641	

Elevation: 4455 — Reference (indicate): (KB) (GL) (DF)

Producing rate on initial completion: Oil (bbls/day) — Gas (MCF/day) — Water (bbls/day)

Application to drill this well was filed in name of: Petronomics, Inc.

Producing rate at time of abandonment: Oil (bbls/day) — Gas (MCF/day) — Water (bbls/day)

CONDITION OF HOLE

Name each formation containing oil or gas. Indicate which formations open to well bore at time of plugging.	Fluid Content	Depth Interval	Size, kind and depth of plugs used. Indicate zones squeeze cemented giving amount of cement.
Niobrara	water	2130'	Cement Plug 1900 - 2100'
		484	Cement Plug 450 - 500'
			Cement Plug 5 - 50'

Size, kind and depth of any additional plugs

CASING RECORD

Size casing in O. D.	Weight lbs/ft.	Setting Depth	Sacks Cement	Amount Recovered	Amount left in well	Method of parting (shot, ripped, etc.)
8 5/8	24	484	500		484	

Was hole filled with mud-laden fluid? yes

If this well was plugged back for use as a fresh water well give pertinent details of plugging operations to base of fresh water sand. Attach letter from surface owner authorizing completion of this well as a fresh water well and agreeing to assume full liability for subsequent plugging which may be required.

I/We hereby swear or affirm that the statements herein made are complete and correct.

(If new log on well)
NO CORES
NO TESTS
NO LOGS
LOST HOLE

Signature: [signature]

Title: Vice Pres.

Date: March 18, 1982

NEBRASKA SCOUT TICKET

County:	DAWES		**API:**	26045210680000	
Fld:			**Loc:**	SW NW 30-30N-50W 1980 FNL 660 FWL	
Oper:	LECLAIR-WESTWOOD INC		**NAD83**	**Latitude:**	42.5483496148749
Name:	CHICOINE 1-A			**Longitude:**	-103.241701560481

Spud Dt:	11/03/1981	**GR Elev:**	4484	**Lse No:**	99999		
Comp. Dt:	11/09/1981	**KB Elev:**	4490	**Status:**	PA	**Stat Dt:**	08/09/1982
1st PR Dt:		**BHT:**	118	**Type:**	OIL		
P&A Dt:	08/09/1982	**TVD:**		**Natural IP**		**Treated IP**	
		DTD:	3050	**Oil:**	0	**Oil:**	
				Gas:	0	**Gas:**	
				Water:		**Water:**	

Formation Tops		Production Tests	Cores
PIERRE SHALE	1258		
NIOBRARA	2144		
GREENHORN	2683		
BELLE FOURCHE	2704		
MOWRY "X" BENTONITE	2818		
GURLEY "D" SAND	2960		

Well Construction				Cement			Perforations			
Type	Dia	Top	Bot	Sacks	Top	Bot	Top	Bot	Sht	Comment
HOL1	11	0	484							
SURF	8.625	0	484	500	0	484				
HOL2	7.875	484	3050							
[illegible]	7.875	0	30	20	0	30				
PLG1	4.5	470	500	20	470	500				
PROD	4.5	1175	2633	175	1175	2633				

Well - Specific Stimulations

Formation:		**Top Perf:**		**Bot Perf:**			
Type:		**Vol:**		**Prop:**	LBS	**Acid Conc:**	%
Comment:							

Nebraska Oil and Gas Conservation Commission
Form 2

NOTIFICATION OF INTENT TO DRILL OR RE-ENTER

RECEIVED NOV - 9 1981 NEBRASKA OIL & GAS CONS. COMMISSION

APPLICATION TO DRILL [XX]   RE-ENTER [ ]

Instructions: Notice must be given to the Director, and approval obtained before proceeding with the work described herein. Submit this notice in triplicate for wells on patented or Federal lands, and in quadruplicate for wells on State lands. One approved copy will be returned to the operator.

Operator: PETRONOMICS/LeCLAIR-WESTWOOD, INC. - Agent

Address: 388 Denver Club Bldg, Denver CO 80202   (303) 825-4258

DESCRIPTION OF WELL AND LEASE

Well Number	Name of Lease	Elevation (ground)
#1-A	Chicoine	Plats to be sent when when received.

Well Location	County
C SW/4 NW/4 Sec. 30 Twp. T30N Range R50W	Dawes

Footage Location: 1980' ft. from (N) line, 660' ft. from (W) line of SW/4, NW/4 ¼

Field & Reservoir (If wildcat, so state)	Will hole be directionally drilled?	Contractor
Wildcat	No	Circle M Drilling, Inc.

Nearest distance from proposed location to property or lease line:	Distance from proposed location to nearest drilling, completed or applied-for well on the same lease:
660' feet	1320 feet

Proposed depth and deepest formation to be tested	Rotary or cable tools	Approximate date work will start
3150' or Skull Creek	Rotary	November 3, 1981

Number of acres in lease:	Number of wells on lease, including this well, completed in or drilling to this reservoir:
80	None

Surface casing program: Amt.: 350 ft. Size: 8-5/8 in. O.D. Wt. 24 lbs/ft. Cement 300 sx or sufficient to circulate sacks

Status of bond (check one)

$2500.00 "one well" bond attached [ ] $10,000.00 blanket bond on file [XX]

Permit Number: 26 045 21028

Approval Date: 11-3-81

Approved By: [signature]

[signature]
Signature of operator or agent

Operations Superintendent
Title

November 3, 1981
Date

Sample cut required by Nebraska Geological Survey
Yes [X]   No [ ]

Notice: Complete the location plat on reverse side. Be sure that you have given all information requested. Much unnecessary correspondence will thus be avoided.

cc: Petronomics

Verbal Approval given by Mr. Paul Roberts on 11/3/81. DSH

Nebraska Oil and Gas Conservation Commission
Form 5

4

WELL COMPLETION OR RE-COMPLETION REPORT

Instructions: Within thirty days following the completion or re-completion of any well, the owner or operator shall submit this form in duplicate for wells on patented or Federal lands, and in triplicate for wells on State lands. Geological information will be held confidential for a period of twelve months if requested in writing. If multiple completion, submit separate report for each completion.

DESIGNATE TYPE OF COMPLETION

New Well [X] Work-Over [ ] Deepen [ ] Plug Back [ ] Same Reservoir [ ]

Different Reservoir [ ] Oil [ ] Gas [X] Unsuccessful [ ]

DESCRIPTION OF WELL AND LEASE

Operator: Petronomics, LeClair-Westwood, Inc. - Agent

Address: 388 Denver Club Building

Well No.	Lease Name	Field and Reservoir (If wildcat, so state)
1A	Chicoine	W/C

Location: C SW NW Sec. 30 Twp. 30N Range 50W County Dawes

Footage Location: 1980 feet from (N) (S) line, 660 feet from (E) (W) line, of SW/4-NW/4 ¼

Spud Date	Date reached T.D.	Date Completed	Elevation	Reference (Indicate)
11-3-81	11-9-81	11-9-81	4484	(DF), (GL), (KB)

Total Depth	P.B.T.D.	Single or multiple completion	Was well directionally drilled?
3050	2590	Single	NO

Producing interval(s) for this completion	Type of logs run in well
Niobrara	CSLC - GR DLL-GR CNL

Rotary tools used (interval)	Cable tools used (interval)	Principal Contractor
0 to TD	-------------	Circle "M" Drilling

CASING RECORD

Report all strings set—surface, intermediate, production, etc.

Purpose of String	Size hole drilled	Size casing set (in. O.D.)	Weight lbs/ft.	Setting Depth	Sacks Cement
Surface	11"	8 5/8	24#	484'	500 sx w/2% gel
Production	7 7/8	4½	10.5#	2633'	175 sx 50/50 Poz

LINER RECORD

Top, ft.	Bottom, ft.	Sacks Cement

TUBING RECORD

Size	Setting Depth	Packer set at

PERFORATION RECORD

Shots per Ft.	Size & Type	Depth Interval

ACID, FRACTURE, SHOT, CEMENT SQUEEZE RECORD

Amount and Kind of Material Used	Depth Interval Treated

INITIAL PRODUCTION

Date of first production	Producing method (flowing, pumping, gas lift, etc.)

RATE OF PRODUCTION PER 24 HOURS	Oil bbls.	Gas MCF	Water bbls.	Gas-oil ratio CFPB

Niobrara 2260 to 2457 (... sold) Oil Purchaser

D-Sd 2965 - 77

J-Sd 3003 - 3007

...ents herein made are complete and correct.

Signature

Operations Superintendent
Title

Well S/I waiting on completion rig.

December 15, 1981
Date

ED '81 12

DAILY DRILLING REPORT

Petronomics Chicoine 1-A

SW/4 - NW/4 Sec. 30, T30N R50W, Dawes County, Nebraska

11/3/81: Spudded 7:15 PM, midnight depth 523', KB 4490'

11/4/81: Set 8 5/8 surface pipe at 485', plug down 12:05 PM

11/5/81: 7:00 PM depth 1870, start to mud up for Niobrara

11/6/81: 8:00 AM, Depth 2603, repairing KB. 8 units gas through Niobrara.

11/7/81: Drilled to 3069 at 2:20 AM, kelly bushing slipping. Decided to log. Ran Dual Laterolog and Densilog - Neutron - Gamma Ray Logs. Finished logging noon 11/7.

11/8/81: Ran 4 1/2" casing to 2633'. Casing on bottom 10:00 AM. Cemented with 30 bbls. cement with 2% KCl, and 175 sacks 50-50 Poznix with 2% gel and 10% salt. Landed plug, tested casing to 2000 P.S.I. - OK. Released rig 12:00 noon.

RECEIVED APR 12 1982 NEBRASKA OIL & GAS CONS. COMMISSION

Final Tops:

KB	4490
Niobrara	2120
1st Chalk	2186
2nd Chalk	2246
3rd Chalk	2360
Codell Ss.	2436
Greenhorn Ls.	2684
"D" Sand	2963
T.D.	3069

Deepening and Testing

12/11/81 Moved rig to location, Rigged up. KB4490'

12/12/81 Picked up bit, collars, tubing (2")

12/14/81 Ran tubing, tagged bottom. Cleaned out 240 ft. of ho. . Circulated hole clean. TD 2900

12/15/81 Drilled 220 ft. Circulated clean. TD 3120

12/16/81 Pulled tubing and collars.

12/17/81 Started Drilling. Swivel packing went bad. Circulated hole clean. Rigged up O.W.P. to log Niobrara. Rigged O.W.P. down. TD 3120

12/18/81 Drilled in J sand. Circulated clean. Rigged up O.W.P. and logged sand. TD 3143

12/19/81 Swab tested J sand. Rigged O. W. P. and perforated

12/19/81 (Cont.) Niobrara. Swab tested Rigged down and prepared to move.

12/21/81 Moved rig out.

Test Results

J sand swab test: Fluid entry 25'/hr. after swab down. No shows of gas, very little fluid entry in J sand.

Niobrara swab test: Perforated - got some fill-up, no shows of gas. More fill-up in Niobrara - 60' fill-up after perfs. After 30 minutes - no show of gas.

Additional tops after deepening:

"J" Sand - 3071'
TD - 3143'

Nebraska Oil and Gas Conservation Commission
Form 6

PLUGGING RECORD

Instructions: Within thirty days following the plugging of a dry hole, or the abandonment of a producing well, the owner or operator shall submit this form in duplicate for wells on patented or Federal lands, and in triplicate for wells on State lands. Geological information will be held confidential for a period of twelve months if requested in writing. Fill out form as completely as possible.

Operator: PETRONOMICS, Inc.

Address: 630 N. Federal Highway, Suite 402, North Palm Beach FL 33408

Well Number	Lease Name	Field and reservoir (If wildcat, so state)
1-A	Chicoine	Wildcat

Location: SW/NW Sec. 30 Twp. 30N Range 50W — County: Dawes

Footage Location: 1820 ft. from (N) (S) line, 660 ft. from (E) (W) line of Sec. 30 T30N ¼ R50W

Spud Date	Date reached T.D.	Date Plugged	Total Depth	P. B. T. D.
11-3-81	11-7-81	8-9-82	3069	

Elevation: 4490 Reference (Indicate): (KB) XXXXX

Producing rate on initial completion		
Oil (bbls/day)	Gas (MCF/day)	Water (bbls/day)

Application to drill this well was filed in name of: Petronomics, Inc.

Producing rate at time of abandonment		
Oil (bbls/day)	Gas (MCF/day)	Water (bbls/day)

CONDITION OF HOLE

Name each formation containing oil or gas. Indicate which formations open to well bore at time of plugging.	Fluid Content	Depth Interval	Size, kind and depth of plugs used. Indicate zones squeeze cemented giving amount of cement.
			20 sack cement plug
			0-30 feet and
			470-500 feet

Size, kind and depth of any additional plugs

CASING RECORD

Size casing in O. D.	Weight lbs/ft.	Setting Depth	Sacks Cement	Amount Recovered	Amount left in well	Method of parting (shot, ripped, etc.)
4½"	10.5	2633	175	1175	1458	shot

Was hole filled with mud-laden fluid? Yes

If this well was plugged back for use as a fresh water well, give pertinent details of plugging operations to base of fresh water sand. Attach letter from surface owner authorizing completion of this well as a fresh water well and agreeing to assume full liability for subsequent plugging which may be required.

I/We hereby swear or affirm that the statements herein made are complete and correct.

RECEIVED
AUG 26 1982
NEBRASKA OIL & GAS CONS. COMMISSION

(If new dry hole, complete well log on reverse side of form)

A.B. McClelland — Signature

President — Title

8-23-82 — Date

NEBRASKA SCOUT TICKET

County:	DAWES			**API:**	26045210080000		
Fld:				**Loc:**	NE NE 29-29N-50W 640 FNL 710 FEL		
Oper:	TOLTEK DRLG CO			**NAD83**		**Latitude:**	42.4646778165178
Name:	SMITH 1-A					**Longitude:**	-103.207948704242
Spud Dt:	02/11/1969	**GR Elev:**	4106	**Lse No:**	99999		
Comp. Dt:		**KB Elev:**	4116	**Status:**	DA	**Stat Dt:**	02/14/1969
1st PR Dt:		**BHT:**	109	**Type:**	DH		
P&A Dt:	02/14/1969	**TVD:**					
		DTD:	2901				

	Natural IP		Treated IP
Oil:	0	**Oil:**	0
Gas:	0	**Gas:**	0
Water:	0	**Water:**	0

Formation Tops | **Production Tests** | **Cores**

Formation Tops	
PIERRE SHALE	947
NIOBRARA	1716
CODELL	2038
CARLILE	2050
GREENHORN	2294
BELLE FOURCHE	2310
MOWRY "X" BENTONITE	2418
GURLEY "D" SAND	2554
HUNTSMAN SHALE	2703
CRUISE "J" SAND	2760
SKULL CREEK SHALE	2800

Well Construction				Cement			Perforations			
Type	Dia	Top	Bot	Sacks	Top	Bot	Top	Bot	Sht	Comment
HOL1	12.25	0	400							
SURF	8.625	0	400			400				
HOL2	7.875	0	2901	10		32				
HOL2	7.875	0	2901	15		400				

Well - Specific Stimulations

Formation:		**Top Perf:**		**Bot Perf:**			
Type:		**Vol:**		**Prop:**	LBS	**Acid Conc:**	%
Comment:							

Nebraska Oil and Gas Conservation Commission
Form 2

(5)

NOTIFICATION OF INTENT TO DRILL OR RE-ENTER

APPLICATION TO DRILL [X] RE-ENTER [ ]

Instructions: Notice must be given to the Director, and approval obtained before proceeding with the work described herein. Submit this form in triplicate for wells on patented or Federal lands, and in quadruplicate for wells on State lands. One approved copy will be returned to the operator.

Operator: Toltek Drilling Company & O.N. Beer

Address: 340 Denver Club Bldg., Denver, Colorado 80202

DESCRIPTION OF WELL AND LEASE

Well Number: 1-A | Name of Lease: Smith | Elevation (ground): -

Well Location: NE NE Sec. 29 Twp. 29 N Range 50 W | County: Dawes

Footage Location: 660 ft. from (N) (S) line, 660 ft. from (E) (W) line of NE ¼

Field & Reservoir (if wildcat, so state): wildcat | Will hole be directionally drilled? no | Contractor: Toltek Drilling Company

Nearest distance from proposed location to property or lease line: 660 feet | Distance from proposed location to nearest drilling, completed or applied-for well on the same lease: feet

Proposed depth and deepest formation to be tested: 3100' Skull Creek | Rotary or cable tools: Rotary | Approximate date work will start: February, 1969

Number of acres in lease: 160 | Number of wells on lease, including this well, completed in or drilling to this reservoir:

Surface casing program: Amt.: 400 ft. | Size: 8 5/8 in. O.D. | Wt. 24 lbs/ft. | Cement 300 sacks

Status of bond (check one): $2500.00 "one well" bond attached [ ] $10,000.00 blanket bond on file [X]

Permit Number: 26 045 21008

Approval Date: 1. 17. 69

Approved By: [signature]

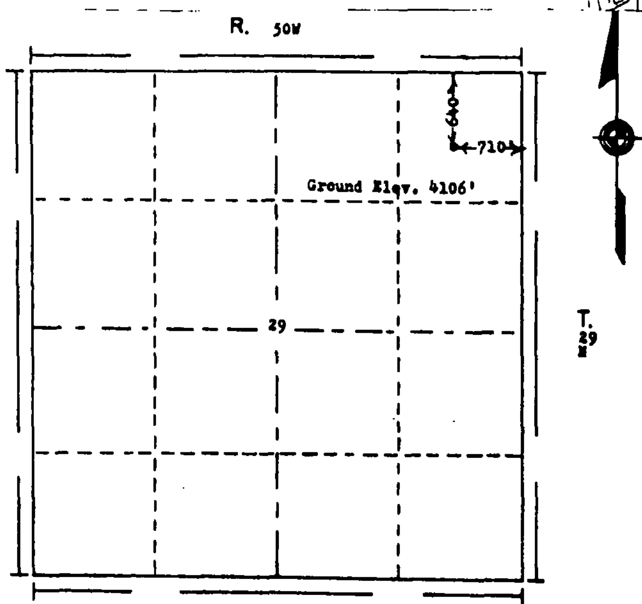
[signature]
Signature of operator or agent

Richard D. Gasch, Executive Vice President
Title

January 16, 1969 JAN 17 1969
Date

Sample cut required by Nebraska Geological Survey: Yes [X] No [ ]

Notice: Complete the location plat on reverse side. Be sure that you have given all information requested. Much unnecessary correspondence will thus be avoided.



Scale ··· 1" = 1000'

Powers Elevation Company, Inc. of Denver, Colorado has in accordance with a request from Mr. Gasch for O.N. Beer, Inc. determined the location of No. 1 ? to be 640' FN & 710' FE Section 29 Township 29N Range 50W of the 6th Principal Meridian Dawes County, Nebraska

I hereby certify that this plat is an accurate representation of a correct survey showing the location of

Date 1-15-69

[signature]
Licensed Land Surveyor No. 200
State of Nebraska

Nebraska Oil and Gas Conservation Commission
Form 6

PLUGGING RECORD

Instructions: Within thirty days following the plugging of a dry hole, or the abandonment of a producing well, the owner or operator shall submit this form in duplicate for wells on patented or Federal lands, and in triplicate for wells on State lands. Geological information will be held confidential for a period of twelve months if requested in writing. Fill out form as completely as possible.

Operator: Toltek Drilling Company & O.N. Beer

Address: 340 Denver Club Bldg., Denver, Colorado 80202

Well Number	Lease Name	Field and reservoir (If wildcat, so state)
1-A	Smith	wildcat

Location	County
NE NE Sec. 29 Twp. 29 N Range 50 W	Dawes

Footage Location: 640 ft. from (N) ~~(S)~~ line, 710 ft. from (E) ~~(W)~~ line of NE ¼

Spud Date	Date reached T.D.	Date Plugged	Total Depth	P. B. T. D.
2-11-69	2-14-69	2-14-69	2901'	

Elevation: 4106' Reference (indicate) ~~(KB)~~ (GL) ~~(DF)~~

Producing rate on initial completion		
Oil (bbls/day)	Gas (MCF/day)	Water (bbls/day)

Application to drill this well was filed in name of: Toltek Drilling Company

Producing rate at time of abandonment		
Oil (bbls/day)	Gas (MCF/day)	Water (bbls/day)

CONDITION OF HOLE

Name each formation containing oil or gas. Indicate which formations open to well bore at time of plugging.	Fluid Content	Depth Interval	Size, kind and depth of plugs used. Indicate zones squeeze cemented giving amount of cement.

Size, kind and depth of any additional plugs

10 sacks top of surface casing
15 sacks bottom of casing

CASING RECORD

Size casing in O. D.	Weight lbs/ft.	Setting Depth	Amount Recovered	Amount left in well	Method of parting (shot, ripped, etc.)

Was hole filled with mud-laden fluid? Yes

If this well was plugged back for use as a fresh water well, give pertinent details of plugging operations to base of fresh water sand. Attach letter from surface owner authorizing completion of this well as a fresh water well and agreeing to assume full liability for subsequent plugging which may be required.

I/We hereby swear or affirm that the statements herein made are complete and correct.

Signature: [signature]

(If new dry hole, complete well log on reverse side of form)

Title: Executive Vice President

Date: February 17, 1969

NEBRASKA SCOUT TICKET

County:	DAWES			**API:**	26045050110000		
Fld:				**Loc:**	SE SE 20-30N-51W 660 FSL 660 FEL		
Oper:	CURRENTLY UNASSIGNED			**NAD83**		**Latitude:**	42.5549578231732
Name:	PORTER 1					**Longitude:**	-103.32534600137
Spud Dt:	02/23/1956	**GR Elev:**		**Lse No:**	99999		
Comp. Dt:		**KB Elev:**		**Status:**	DA	**Stat Dt:**	03/28/1956
1st PR Dt:		**BHT:**	0	**Type:**	DH		
P&A Dt:	03/28/1956	**TVD:**					
		DTD:	3779				

	Natural IP	Treated IP
Oil:	0	0
Gas:	0	0
Water:	0	0

Formation Tops | **Production Tests** | **Cores**

Formation Tops	
GREENHORN	2898
BELLE FOURCHE	2932
GURLEY "D" SAND	3208
CRUISE "J" SAND	3396

Well Construction				Cement			Perforations			
Type	Dia	Top	Bot	Sacks	Top	Bot	Top	Bot	Sht	Comment
HOL1	15	0	250							
SURF	10.75	0	250	130		250				
HOL2	9.5	0	3779	5		16				
HOL2	9.5	0	3779	15		262				
HOL2	9.5	0	3779	20		2550				
HOL2	9.5	0	3779	50		3394				

Well - Specific Stimulations

Formation: **Top Perf:** **Bot Perf:**

Type: **Vol:** **Prop:** LBS **Acid Conc:** %

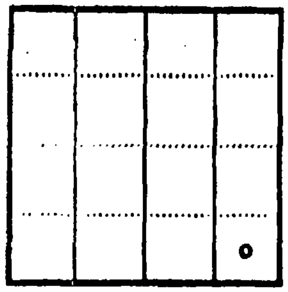
Comment:

STATE OF NEBRASKA NOTIFICATION OF INTENTION TO DRILL NOV 2? 1955

2081

INSTRUCTIONS: Fill in single copy as completely as possible, attach check made payable to Nebraska Geological Survey (Plugging Record Account) for sum of Twenty-five dollars ($25.00) and mail to Nebraska Geological Survey, Nebraska Hall, University of Nebraska, Lincoln, Nebraska. Notifications must be approved prior to spudding.

* In the case of Irregular Tracts or Unitized Areas Furnish Detailed Map with Footage Measurements.



Locate Well on Section Plat

Name of Operator: Tom Potter

* Location of Lease (Exact Part of Section): SE¼ of Section 20-30N-51W

Office Address: 1517 Denver Club Building, Denver, Colorado

Name of Lease: Porter Well No. 1

Legal Description Location (Example: C NW/4 SW/4):

C SE¼ SE¼ Sec. 20 ; Twp. 30N N.; Rge. 51W (E) (W); County Dawes

660 Ft. (E) (W) of (W) (E) line; 660 Ft. (N) (S) of (S) (N) line of SE¼ ¼

Closest distance to property line 660 feet.

If location less than 330 feet from nearest property line state fully here or on attached sheet reasons for drilling on irregular location:

Nature of Well (wildcat) ([illegible]) Name of Field Chadron Area

Kind of tools to be used: (cable) (rotary) Approximate spudding date November 30, 1955

Contemplated casing program: Surface pipe: (new) (used) Size 10 3/4 in., Weight 32.75 Lbs.;

cement to be used 150 sacks; amount 250 ft.

Additional casing program if known:

Not known

Signature of Operator or Operator's Agent: Tom Potter

AUG 2 1956

NO LOGS RUN

PLUGGING AFFIDAVIT—STATE OF NEBRASKA

INSTRUCTIONS: Fill in completely as possible one copy and mail to Nebraska Geological Survey, Nebraska Hall, University of Nebraska, Lincoln, Nebraska within 15 days after plugging (Revised Statutes of Nebraska, 1943, sections 57-213 to 57-217, amended by Legislative Bill 433, 62nd Session, Legislature of Nebraska.) Underline applicable words or letters, cross out those not applicable.

Lease Name PORTER .... Well No. 1

Legal Description Location (Example: C N/2-NE/4-NE/4):

C SE/4SE/4 Sec. 20, Twp. 30N No., Rge. 51W [redacted] (W); County Dawes

660 Ft. [redacted] (W) of [redacted] (E) line; 660 Ft. (N) [redacted] of [redacted] (S) line of SE/4 ¼

Operating Company Tom Petter

Complete Mailing Address 1032 Life of America Bldg., Dallas, Texas

Contractor Petter Drilling Co.

Complete Mailing Address 1032 Life of America Bldg., Dallas, Texas

Drilled with (cable) (rotary) tools. Spudding date 2/23/56 ; completion date 3/29/56 ; plugging date 3/28/56

Surface Pipe Data: Casing (new) [redacted] Size 10-3/4" in. Weight 32.75 lbs.

Amount Set 250 ft.; Cement used 130 sax; kind Regular

Surface Hole Data: Size of hole 13-3/4 in.; Depth of hole 262½ ft.

Total Depth of hole 3779 ft. (Attach electric log ~~or driller's log~~ - None Made) Elevation .... ground

Nature of Well: (wildcat) [redacted] .... derrick floor

.... Kelley bushing

Reason for Abandonment Fishing Job and Dry

Casing record other than surface pipe (indicate amount, size and weight of each string run, how set or cemented, whether pulled or left in hole and where cut if partially pulled) ....

Plugging Record (state in detail each step in plugging procedure)

Left 385' of pipe in hole
Put 50 sacks of cement at 3394'
Put 20 sacks of cement at 2550'
Put 15 sacks of cement at 262'
Put 5 sacks of cement at surface pipe

Plugging Procedure Approved by .... Date March 29, 1956
(Insert "blanket approval" in case of fields or areas where standard plugging procedure has been approved by the Nebraska Geological Survey)

Name of Witness to Plugging Bill Painter Address Chadron, Nebraska

AFFIDAVIT

I, Tom Petter of the Petter Drilling Company Company, being first duly sworn on oath, state: That I have knowledge of the facts, statements and matters herein contained and that the same are true and correct.

Tom Petter

In Witness whereof I hereinbefore set my hand and affix my official seal this 31st day of July, 19 56.

My commission Expires: 6/1/57

Geneviève S. Miller
Notary Public
Dallas County, Texas

No Log Available

NEBRASKA SCOUT TICKET

County:	DAWES			**API:**	26045050120000		
Fld:				**Loc:**	SW SW 23-30N-51W 960 FSL 860 FWL		
Oper:	GULF OIL CORP			**NAD83**		**Latitude:**	42.5559818232852
Name:	ROYAL 1					**Longitude:**	-103.280292679135
Spud Dt:	12/15/1952	**GR Elev:**	4465	**Lse No:**	99999		
Comp. Dt:		**KB Elev:**	4469	**Status:**	DA	**Stat Dt:**	01/23/1953
1st PR Dt:		**BHT:**	128	**Type:**	DH		
P&A Dt:	01/23/1953	**TVD:**					
		DTD:	3956				

	Natural IP		Treated IP
Oil:	0	**Oil:**	0
Gas:	0	**Gas:**	0
Water:	0	**Water:**	0

Formation Tops | **Production Tests** | **Cores**

Formation	Top
NIOBRARA	2287
CARLILE	2512
GREENHORN	2768
BELLE FOURCHE	2800
GURLEY "D" SAND	3098
CRUISE "J" SAND	3226
MORRISON	3624
SUNDANCE	3747

Well Construction | **Cement** | **Perforations**

Type	Dia	Top	Bot	Sacks	Top	Bot	Top	Bot	Sht	Comment
[illegible]	15	0	377							
[illegible]	10.75	0	377	250	0	377				
HOL2	9.5	377	3956	10	0	22				
HOL2	9.5	377	3956	40	320	400				

Well - Specific Stimulations

Formation:		**Top Perf:**		**Bot Perf:**			
Type:		**Vol:**		**Prop:**	LBS	**Acid Conc:**	%
Comment:							

319

11/25/52

STATE OF NEBRASKA

NOTIFICATION OF INTENTION TO DRILL

INSTRUCTIONS: Fill in single copy as completely as possible, attach check made payable to Nebraska Geological Survey (Plugging Record Account) for sum of Twenty-five dollars ($25.00) and mail to Nebraska Geological Survey, Nebraska Hall, University of Nebraska, Lincoln, Nebraska.

Name of Operator: Gulf Oil Corporation

Office Address: 134 E. Midwest Ave., Casper, Wyoming

Name of Lease: Roscoe Royal ..... Well No. 1

Legal Description Location (Example: C NW/4 SW/4): 300' N and 200' E of C SW SW

130'W + 30'S of C

NE-SW-SW Sec. 23; Twp. 30 N.; Rge. 51 ~~(E)~~ (W); County Dawes

860 Ft. (E) ~~(W)~~ of (W) ~~(E)~~ line; 960 Ft. (N) ~~(S)~~ of (S) ~~(N)~~ line of SW ¼

Closest distance to property line ..... feet.

If location less than 330 feet from nearest property line state fully here or on attached sheet reasons for drilling on irregular location: Location fell too close to farmer's barn yard and buildings was moved 300' north and 200' east.

Kind of tools to be used: ~~(cable)~~ (rotary) Approximate spudding date 11-28-52

Contemplated casing program: Surface pipe: (new) (used), Size 10-3/4" in., Weight 32.75 lbs.;

cement to be used will cement to surface sacks; amount 275' more or less

Additional casing program if known: .....

Signature of Operator or Operator's Agent: [signature]

District Superintendent

PLUGGING AFFIDAVIT—STATE OF NEBRASKA

INSTRUCTIONS: Fill in as completely as possible one copy and mail to Nebraska Geological Survey, Nebraska Hall, University of Nebraska, Lincoln, Nebraska within 15 days after plugging (Revised Statutes of Nebraska, 1943, sections 57-213 to 57-217, amended by Legislative Bill 433, 62nd Session, Legislature of Nebraska.) Underline applicable words or letters, cross out those not applicable.

Lease Name Roscoe Royal Well No. 1

Legal Description Location (Example: C N/2-NE/4-NE/4):

C SW SW Sec. 23, Twp. 30 No., Rge. 51 (E) (W); County Dawes

860 Ft. (E) (W) of (W) (E) line; 960 Ft. (N) (S) of (S) (N) line of SW ¼

Operating Company Gulf Oil Corporation

Office Address 134 E. Midwest Ave., Casper, Wyoming

Contractor Dunbar Drilling Company

Office Address Denver, Colorado

Drilled with (cable) (rotary) tools. Spudding date 12-15-52 ; completion date 1-23-53

Surface Pipe Data: Casing (new) (used) Size 10-3/4 in. Weight 32.75 lbs.

Amount Set 377 ft.; Cement used 250 sax; kind Ash Grove Reg. Portland

Surface Hole Data: Size of hole 13-3/4 in.; Depth of hole 109 ft.

Total Depth of Hole 3956 ft. (Attach electric log or driller's log) Elevation: 4465' ground

4468' derrick floor

Nature of Well: (wildcat) (field well offset) (abandoned producer) 4469' Kelly bushing

Reason for Abandonment Dry Hole

Casing record other than surface pipe (indicate amount, size and weight of each string run, how set or cemented, whether pulled or left in hole and where cut if partially pulled) none

Plugging Record (state in detail each step in plugging procedure) Filled hole with heavy mud from total depth to 400', placed 40 sacks cement plug from 400' to 320', heavy mud from 320' to 22', 10 sacks cement plug from 22' to bottom of cellar.

Plugging Procedure Approved by E. C. Reed Date 1-22-53
(Insert "blanket approval" in case of fields or areas where standard plugging procedure has been approved by the Nebraska Geological Survey)

Name of Witness to Plugging F. H. Frederick Address 740 South 15th St.
Worland, Wyoming

AFFIDAVIT

I, Lester LeFavour of the Gulf Oil Corporation Company, being first duly sworn on oath, state: That I have knowledge of the facts, statements and matters herein contained and that the same are true and correct.

Lester LeFavour

In Witness whereof I hereinbefore set my hand and affix my official seal this 26th day of January, 1953.

My commission Expires: Jan. 5 - 1957 Bill J. Parker
Notary Public

APPENDIX 7.1-1

WELL INSTALLATION PROCEDURES

APPENDIX 7.1-1

WELL INSTALLATION PROCEDURE
CLASS I NON-HAZARDOUS WASTE INJECTION WELLS
CROW BUTTE RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

Location Preparation

1. Stockpile dirt in location specified by CBO personnel.
2. Construct access roadway and drilling location.
3. Construct reserve pit. Line pit with minimum 12 mil liner. (Reserve pit to be dewatered and buried at end of project.)
4. Install a containment cellar, approximately 8-foot diameter by 6 feet deep around the well location.
5. Provide freshwater source to drilling location.
6. Provide storage for required freshwater; i.e., frac tanks.

Conductor Pipe Installation

1. Move in and rig up (MIRU) crew and equipment and auger a 22 inch diameter hole to 80 feet. Centralize 16 inch, 62.58 lb/ft, 0.375 inch wall, Grade B, plain end, beveled conductor pipe in the augered hole and fill the annulus to land surface with approximately 4 yd^3 of redi-mix cement.
2. Cut the 16 inch conductor pipe approximately 4 feet above grade.
3. Install a 4 inch outlet for draining the conductor pipe after cementing the surface casing.

Drilling Rig Mobilization and Rig Up

1. MIRU drilling rig and ancillary support equipment. Rig up a 24 hour manned mud logging unit to evaluate drill cutting samples.
2. Install a spill containment earthen berm around the rig diesel tank and other critical rig components.

3. Weld a temporary flange to the 16 inch conductor pipe and nipple up an annular BOP to the flange and function test. Install a bell nipple and flow line to the BOP.

4. Mix spud mud.

5. Drill a 9⅞ inch pilot hole to a depth of approximately 200 feet below the base of the Chadron Sand at approximately 850 feet. Have the mud logger catch drill cutting samples at 30-foot intervals from the base of the conductor casing to a depth of 500 feet, then catch drill cutting samples at 10-foot intervals to the casing setting depth. Evaluate the drill cuttings and drill time to locate the base of the Chadron Sand. Continue drilling the 9⅞ inch pilot hole 200 feet below the base of the Chadron Sand.

6. Conduct deviation surveys 60 feet below the conductor casing, then at 500-foot intervals to total depth and at the final drilled depth. The hole shall be maintained at a maximum deviation of 1° from vertical between surveys and no more than 2° at casing point.

7. Upon reaching a depth of 200 feet below base of Chadron Sand at approximately 1,050 feet, stop drilling and condition borehole.

8. MIRU an open-hole wireline unit to run geophysical logs as presented on Table 7.2-1.

9. Open the 9⅞ inch hole to 14¾ inches with a hole opener to the casing point at approximately 1,050 feet. Run deviation surveys at 500-foot intervals to assure the hole is following the pilot hole. Maintain drilling fluid parameters and hydraulics necessary to prevent or minimize hole washout.

10. MIRU casing crew and run 10¾ inch, 40.50 lb/ft, J-55, ST&C surface casing to total depth of approximately 1,050 feet.

11. MIRU cementing equipment. Circulate a minimum of 1½ annular volumes ("bottoms up") prior to cementing.

12. Cement the surface casing annulus from bottom to top as defined in the casing and cement program presented on Table 7.3-1. Cement volume will be calculated from the open hole caliper log with a minimum of 50% excess. Catch and archive dry samples of the cement at the beginning, middle, and end of each cement type. Catch and archive wet samples of cement at intervals of 100 sacks mixed. Observe cement returns and obtain a weight of the returned cement.

Catch and archive a minimum of three wet samples of the return cement, with the final sample caught at "plug down".

13. At plug down, open the bradenhead valve or remove the bull plug and drain the cement from the drilling nipple and annular BOP and wash out with water. Do not allow the casing to move for a minimum of 24 hours after cement is in place.

14. If cement does not circulate to surface, run a temperature log and determine the top of the cement in the annulus. If necessary, run one-inch trim pipe and fill the annulus to the surface.

15. Wait on cement for a minimum of 24 hours before slacking off of the casing.

16. MIRU a cased-hole wireline unit to run logs as presented on Table 7.5-1.

17. Cut-off the 10¾ inch surface casing and nipple down the annular BOP and drilling nipple. Cut off the 16 inch casing flange and install a 3,000 psi WP flange to the 10¾ inch surface casing at ground level.

18. Install a 13⅝ inch, 3M annular BOP. Install a test plug and pressure test the annular BOP to 1,500 psi. Remove the test plug.

19. Trip in the hole with a 9⅞ inch bit and pressure test the surface casing to 1,500 psi.

20. Drill out the float collar, cement joint and cement shoe, and drill to total depth. Maintain drilling fluids and hydraulics as necessary to minimize hole washout and to facilitate logging and cementing the protection casing. Continue catching samples at 30-foot intervals or as required by the mud logging personnel. Continue deviation surveys at 500-foot intervals to total depth.

21. Circulate the wellbore clean and condition the hole for open hole geophysical logging.

22. MIRU an open-hole wireline unit to run geophysical logs as presented on Table 7.2-1. Obtain sidewall cores as deemed necessary.

23. Condition the hole for running protection casing.

24. MIRU casing equipment. Run 7 inch, 26 lb/ft, K-55, LT&C casing to total depth. Run a float shoe and float collar above the first joint. Run centralizers at the shoe joint and on 90-foot spacing (across the coupling of every other joint) from

total depth to the top of the Injection Zone and then on every third joint to the surface.

25. MIRU cementing equipment. Circulate a minimum of 1½ "bottoms up" prior to cementing. Reduce the viscosity of the drilling fluid.

26. Cement the annulus from total depth to land surface as defined in the cement recommendation. Cement volume will be calculated from the open hole caliper log with a minimum of 20% excess (regulatory requirement is 20%). Catch and archive dry samples of the cement at the beginning, middle, and end of each cement type in both stages. Catch and archive wet samples of cement at intervals of 100 sacks mixed.

27. Displace the cement with drilling mud and bump the plug with 500 psi over circulating pressure. Release the pressure to assure that the floats are holding. Observe the returns and catch a sample of the returned cement. Catch and archive a minimum of three wet samples of the return cement, the last sample to be caught at "plug down". Open the outlets on the 10¾ inch casing and drain the BOP stack and wash out with fresh water.

28. If cement does not circulate to surface, run a temperature log and determine the top of the cement in the annulus. If necessary, run one-inch tremie pipe and fill the annulus to the surface.

29. Leave the protection casing in full tension for a minimum of 24 hours and observe the consistency of the returned cement samples.

30. MIRU a cased-hole wireline unit to run logs as presented on Table 7.5-1.

31. Nipple down the BOP stack and cut-off the 7 inch protection casing. Install an 11 inch by 7 inch 3M Slip-on-Weld (SOW) casing head with a hanger bowl for 5 inch injection tubing.

32. Install to the casing head a temporary 11 inch 3M blind flange tapped with threads for a 2 inch LP nipple and ball valve.

33. Rig down and move out the drilling equipment.

34. Remove reserve pit contents and transport to CBO ponds and/or DDW for fluid disposal.

APPENDIX 7.1-2

WELL COMPLETION AND TESTING PROCEDURES

SUBSURFACE

APPENDIX 7.1-2

WELL TESTING PROCEDURES
CAMECO RESOURCES, INC.
MARSLAND EXPANSION AREA
DAWES COUNTY, NEBRASKA

1. Prepare the location for a completion rig. Cut the 10¾ inch casing approximately two feet below ground level and weld a plate from the 10¾ inch casing to the 7-inch casing. Cut the 7-inch casing at ground level and install a 7-inch by 7-1/16-inch, 3000 psi WP casing head equipped for 4½ inch slips and packoff. Set rig anchors.

2. Move in a completion rig with circulating and drilling equipment. Install a 7-1/16 inch double gate blowout preventer (BOP) and test BOP.

3. Run a 6½ inch bit, casing scraper, and 4¾ inch drill collars on a 2⅞ inch work string. Pressure test the casing and pipe rams to 1500 psi above the cement plug. Wash the drilling mud out of the casing to the float collar. Drill any excess cement to the wiper plug and circulate the well with clean fresh water containing 2% KCl.

4. Pressure test the casing according to NDEQ regulations (at minimum test the casing to 1500 psi for 30 minutes using a calibrated digital pressure recorder). The annulus pressure test must hold a surface pressure of 0.25 psi/foot x total vertical depth for a period of 30 minutes with the change in pressure of less than ten percent.

5. Pull the bit and casing scraper, lay down the drill collars.

6. Run a cement bond log on the 7-inch casing.

7. Install a lubricator and perforate deeper formation to be sampled in selected intervals as determined by the open hole log evaluation.

8. Run bottomhole pressure gauges (surface readout and down-hole recorder) to the top of the perforations and record the initial bottomhole pressure of the reservoir.

9. Run a test packer on the workstring and set the packer approximately 100 feet above the top perforation.

10. Swab test (or nitrogen jet) the perforations to recover a representative sample of the formation water. Monitor the water returns for pH, specific conductance,

temperature and turbidity until at least three samples are consistent. Collect samples of the water for standard water analysis.

11. Run bottomhole pressure gauges (surface readout and down-hole recorder) to the top of the perforations. Conduct a step rate test to determine the fracture pressure in the formation.

12. Run an injection test followed by a pressure falloff test to determine the reservoir properties. Evaluate the data for prediction of reservoir performance and determination of the need for further stimulation, acidization, and/or fracture stimulation.

13. Recover the test packer and run and set a retrievable bridge plug above the deeper formation sampled, as determined from the open hole logs. Test the bridge plug to 1,000 psi.

14. Pull the work string and perforate the shallower formation to be sampled in selected intervals as determined by the open hole log evaluation.

15. Test as described in Steps 8 through 12 above.

16. Pull the test packer out of the well and recover the bridge plug.

17. Lay down the work string and packer. Install an injection packer on 4½ inch, 11.6 lb/ft, K-55, LT&C injection tubing.

18. Perform the mechanical integrity test as required by NDEQ regulations including a radioactive tracer survey, annulus pressure test, and baseline temperature survey.

    The radioactive tracer survey results will be evaluated to determine the injection profile (percent of total injected fluid accepted by the perforated intervals) in order to estimate aquifer thickness for the radius of influence calculations required for a Class I application.

    The baseline temperature survey will be started no deeper than the base of the conductor casing (approximately 120 feet).

19. Remove BOP and install a properly sized wellhead.