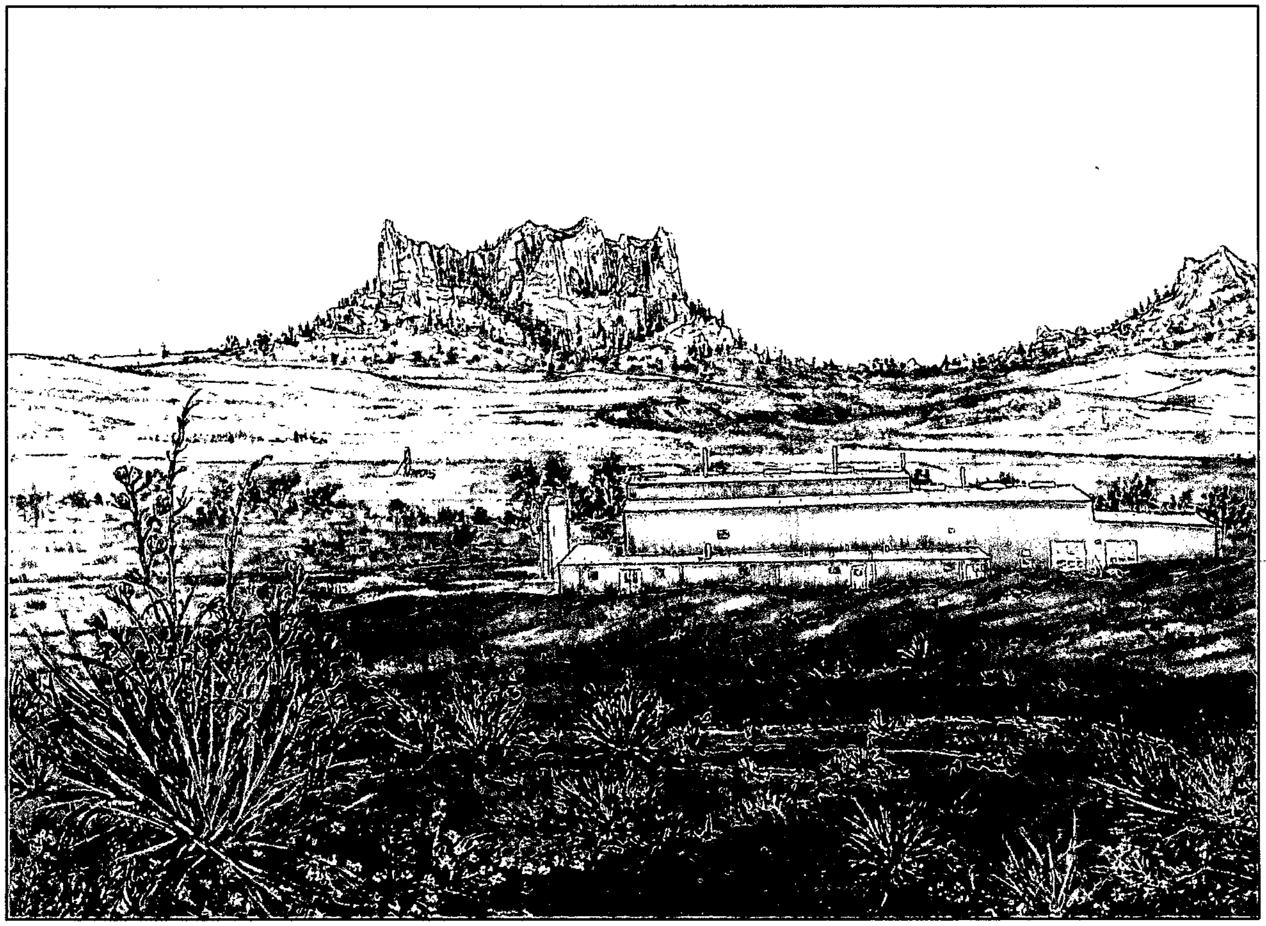
Application for Amendment of

USNRC Source Materials License SUA-1534

North Trend Expansion Area

Environmental Report – Volume I

Sections 1 through 10



Prepared By: **Crow Butte Resources, Inc.**
86 Crow Butte Road
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1 INTRODUCTION OF THE ENVIRONMENTAL REPORT

1.1 INTRODUCTION

Crow Butte Resources Inc. (CBR) submits this Environmental Report (ER) in support of a license amendment application to the United States Nuclear Regulatory Commission (NRC) for amendment of Radioactive Source Materials License SUA-1534. The amendment request concerns the proposed development of additional uranium in-situ leach (ISL) mining resources located in Dawes County, Nebraska. The proposed development area for use as a satellite facility to the main CBR plant is referred to as the North Trend Expansion Area. The current NRC License Number SUA-1534 (Amendment 21) for the Crow Butte Project was issued on January 29, 2007. The expiration date of this license is February 28, 2008.

This ER is prepared to supplement the information presented to the NRC in support of issuance of Source Materials License SUA-1534 in 1989 and the subsequent renewal in 1998. This ER provides the supplemental information necessary to determine the environmental impacts of amending SUA-1534 to allow uranium recovery activities in the North Trend Expansion Area. The amendment application is submitted in accordance with the licensing requirements contained in 10 CFR Part 40 and provides the NRC staff with the necessary information to support the preparation of an Environmental Assessment (EA) as required in 10 CFR Part 51.

This ER has been prepared using suggested guidelines and standard format from NRC. The ER is presented primarily in the format found in NUREG-1748, *Environmental Review Guidance for Licensing Actions Associated with NMSS Programs* (August 2003). CBR understands that this amendment will be considered a complex licensing action requiring that NRC prepare an EA to fulfill the agency's responsibilities under the National Environmental Protection Act (NEPA). The pertinent guidance in NUREG-1748 was used to ensure that all information is provided to allow NRC Staff to complete their review of this amendment application and prepare the required EA.

1.1.1 Crow Butte Uranium Project Background

The original development of what is now the Crow Butte Uranium Project was performed by Wyoming Fuel Corporation, which constructed a research and development (R&D) facility in 1986. The project was subsequently acquired and operated by Ferret Exploration Company of Nebraska until May 1994, when the name was changed to Crow Butte Resources, Inc. (CBR). This change was only a name change and not an ownership change. CBR is the owner and operator of the Crow Butte Project.

The research and development (R&D) facility was located in the N1/2SE1/4 of Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska. Operations at this facility were initiated in July 1986, and mining took place in two wellfields (WF-1 and WF-2). Mining in WF-2 was completed in 1987 and restoration of that wellfield has been completed. WF-1 was incorporated into Mine Unit 1 of commercial operations.

The current production wellfield is located within the licensed area as shown in Figure 1-3. The process plant is located in Section 19, Township 31 North, Range 51 West, Dawes County, Nebraska. This original licensed area is approximately 3,300 acres and the surface area affected over the estimated life of the project is approximately 1,100 acres.

CBR has successfully operated the current production area since commercial operations began in 1991. Production of uranium has been maintained at design quantities throughout that period with no adverse environmental impacts.

1.1.2 Site Location and Description

The location of the original Crow Butte Project Area is in portions of Sections 11, 12, 13, and 24 of Township 31 North, Range 52 West and Sections 18, 19, 20, 29, and 30 of Township 31 North, Range 51 West, Dawes County, Nebraska. The plant site is situated approximately 4.0 miles southeast of the city of Crawford.

The proposed North Trend Expansion Area is located in Sections 21, 22, 27, 28, 33, and 34 of Township 32 North, Range 52 West. Figure 1-1 shows the general location of the current license area and the proposed North Trend Expansion Area.

Approximately 100% of the minerals leased in the North Trend Expansion Area are on private lands. Figure 1-2 shows the land ownership in the proposed North Trend Expansion Area.

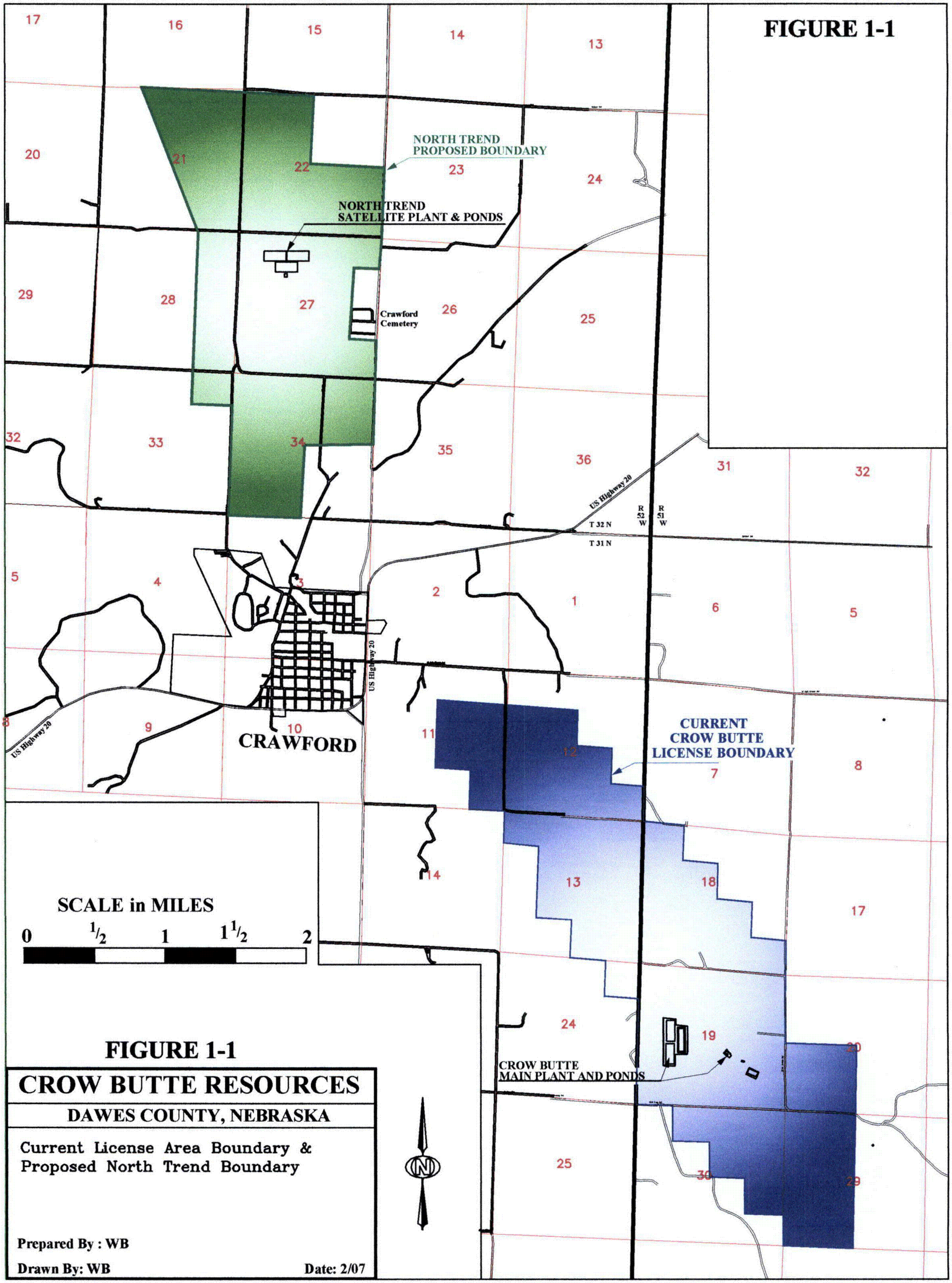
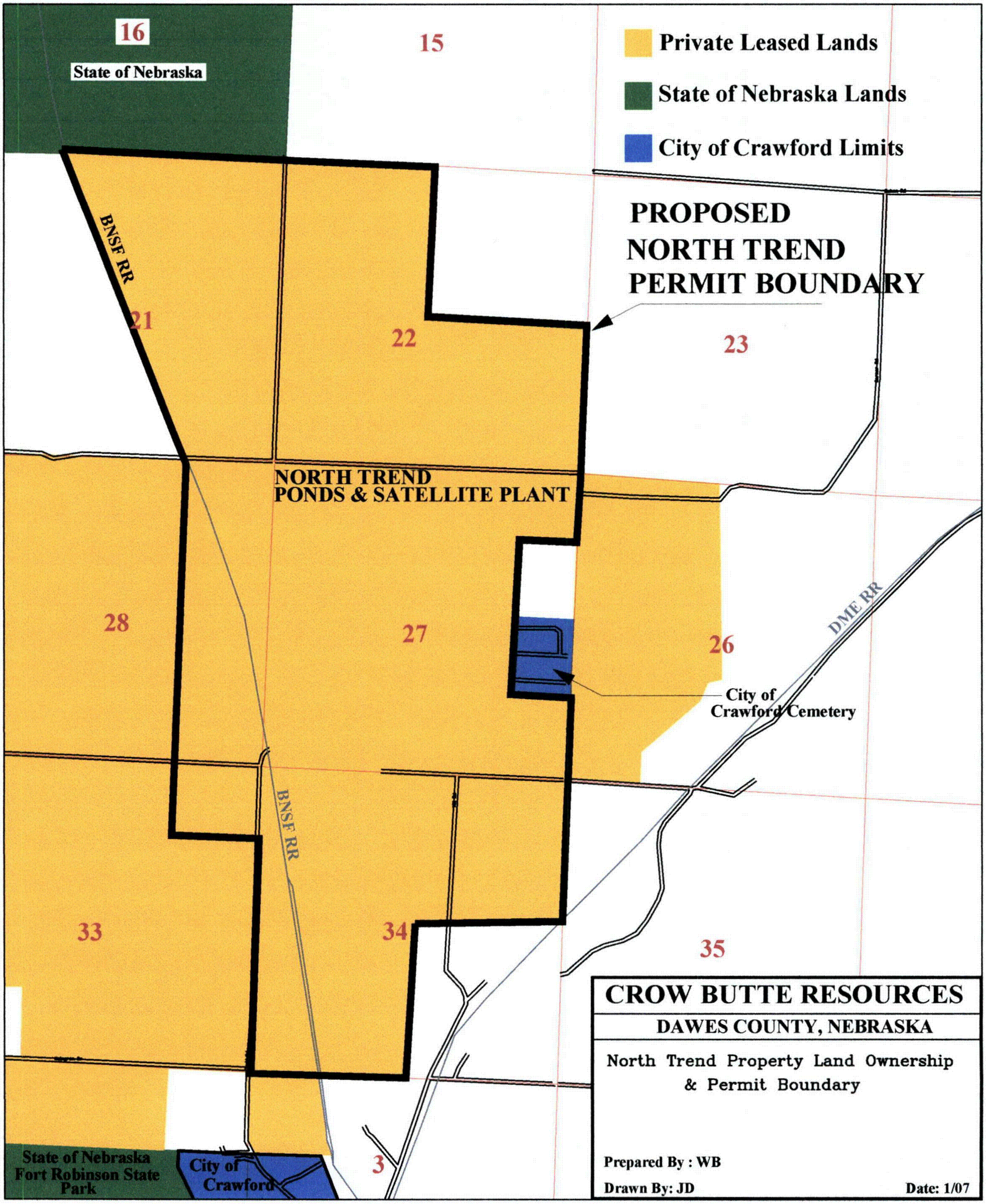


FIGURE 1-1
NORTH TREND
PROPOSED BOUNDARY
NORTH TREND
SATELLITE PLANT & PONDS
Crawford
Cemetery
US Highway 20
R 52 W
R 51 W
T 32 N
T 31 N
CRAWFORD
CURRENT
CROW BUTTE
LICENSE BOUNDARY
CROW BUTTE
MAIN PLANT AND PONDS
SCALE in MILES
0 1/2 1 1 1/2 2
FIGURE 1-1
CROW BUTTE RESOURCES
DAWES COUNTY, NEBRASKA
Current License Area Boundary &
Proposed North Trend Boundary
Prepared By : WB
Drawn By: WB
Date: 2/07

FIGURE 1-2

North Trend Property Land Ownership



1.1.3 Operating Plans, Design Throughput, and Production

The current Crow Butte Plant is licensed for a flow rate of 5,000 gallons per minute, excluding restoration flow, under SUA-1534. Total annual production is limited to 2 million pounds of yellowcake.

Uranium extracted from the North Trend wellfield will be processed in a satellite facility located within the North Trend Expansion Area. The North Trend satellite plant will operate at a flow rate of 4,500 gpm with an expected annual production rate of 500,000 to 600,000 pounds U_3O_8. Total reserves for the North Trend Expansion Area are not developed at this time; however, CBR has estimated recoverable resources at approximately 5,000,000 pounds U_3O_8. The proposed North Trend license area encompasses approximately 2,110 acres. The planned mine units area will impact approximately 1,310 acres based on CBR's current knowledge of available reserves.

The uranium extracted from the North Trend Expansion Area will be loaded onto ion exchange resin in the satellite plant. The ion exchange resin will then be transported by tanker truck to the Crow Butte central plant for elution, drying, and packaging. Barren resin will be returned to the North Trend satellite plant by tanker truck.

1.1.4 Proposed Operating Schedules

1.1.4.1 Current Production Area

Sufficient reserves in the current license area have been estimated to allow mining operations to continue until the end of 2014. Completion of groundwater restoration in the current license area is scheduled for 2023. Status of the current mine unit operations is shown in Table 1-1. Projected production and restoration schedules for the current production area are shown in Figure 1-3.

Table 1-1: Current Production Area Mine Unit Status

Mine Unit	Production Initiated	Current Status
Mine Unit 1	April 1991	Groundwater Restored; Reclamation Underway
Mine Unit 2	March 1992	Groundwater restoration
Mine Unit 3	January 1993	Groundwater restoration
Mine Unit 4	March 1994	Groundwater restoration
Mine Unit 5	January 1996	Production
Mine Unit 6	March 1998	Production
Mine Unit 7	July 1999	Production
Mine Unit 8	July 2002	Production
Mine Unit 9	October 2003	Production

Additional mine unit plans are developed approximately one year prior to the planned commencement of new mining operations. For the current production area, planning and construction are underway for Mine Units 10 and 11. The layout of the current and planned mine units in the current license area is shown in Figure 1-4.

Figure 1-3 Current Production Area Mine Unit Schedule

ID	Task Name	Start	Finish
1	**Current Production Area**	**Mon 1/1/07**	**Fri 10/3/25**
2	**Current Production Area**	**Mon 1/1/07**	**Thu 1/1/15**
3	Year 2007 at 800,000 lbs	Mon 1/1/07	Tue 1/1/08
4	Year 2008 at 800,000 lbs	Tue 1/1/08	Tue 12/30/08
5	Year 2009 at 800,000 lbs	Thu 1/1/09	Thu 12/31/09
6	Year 2010 at 800,000 lbs	Fri 1/1/10	Fri 12/31/10
7	Year 2011 at 800,000 lbs	Sat 1/1/11	Sat 12/31/11
8	Year 2012 at 700,000 lbs	Mon 1/2/12	Mon 12/31/12
9	Year 2013 at 600,000 lbs	Tue 1/1/13	Tue 12/31/13
10	Year 2014 at 500,000 lbs	Wed 1/1/14	Thu 1/1/15
11	**Groundwater Restoration**	**Mon 1/1/07**	**Mon 10/2/23**
12	MU2	Mon 1/1/07	Fri 11/16/07
13	MU3	Mon 1/1/07	Mon 10/27/08
14	MU4	Mon 1/1/07	Wed 4/15/09
15	MU5	Tue 6/26/07	Fri 8/20/10
16	MU6	Tue 1/1/08	Tue 11/8/11
17	MU7	Fri 6/19/09	Thu 4/25/13
18	MU8	Fri 12/30/11	Mon 1/12/15
19	MU9	Wed 8/27/14	Fri 9/8/17
20	MU10	Thu 2/2/17	Thu 10/29/20
21	MU11	Fri 8/2/19	Mon 10/2/23
22	Final Site Reclamation	Tue 10/3/23	Fri 10/3/25

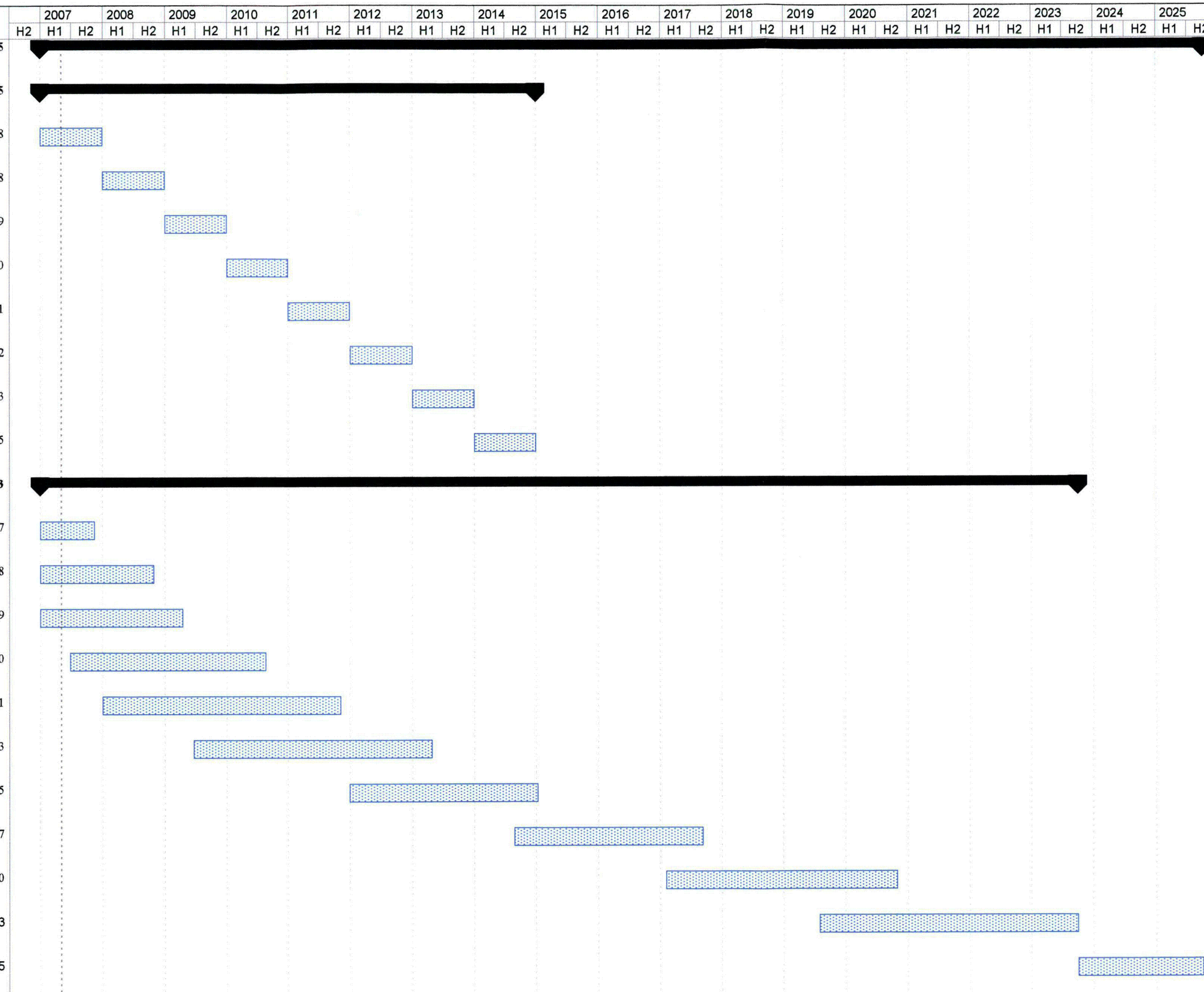
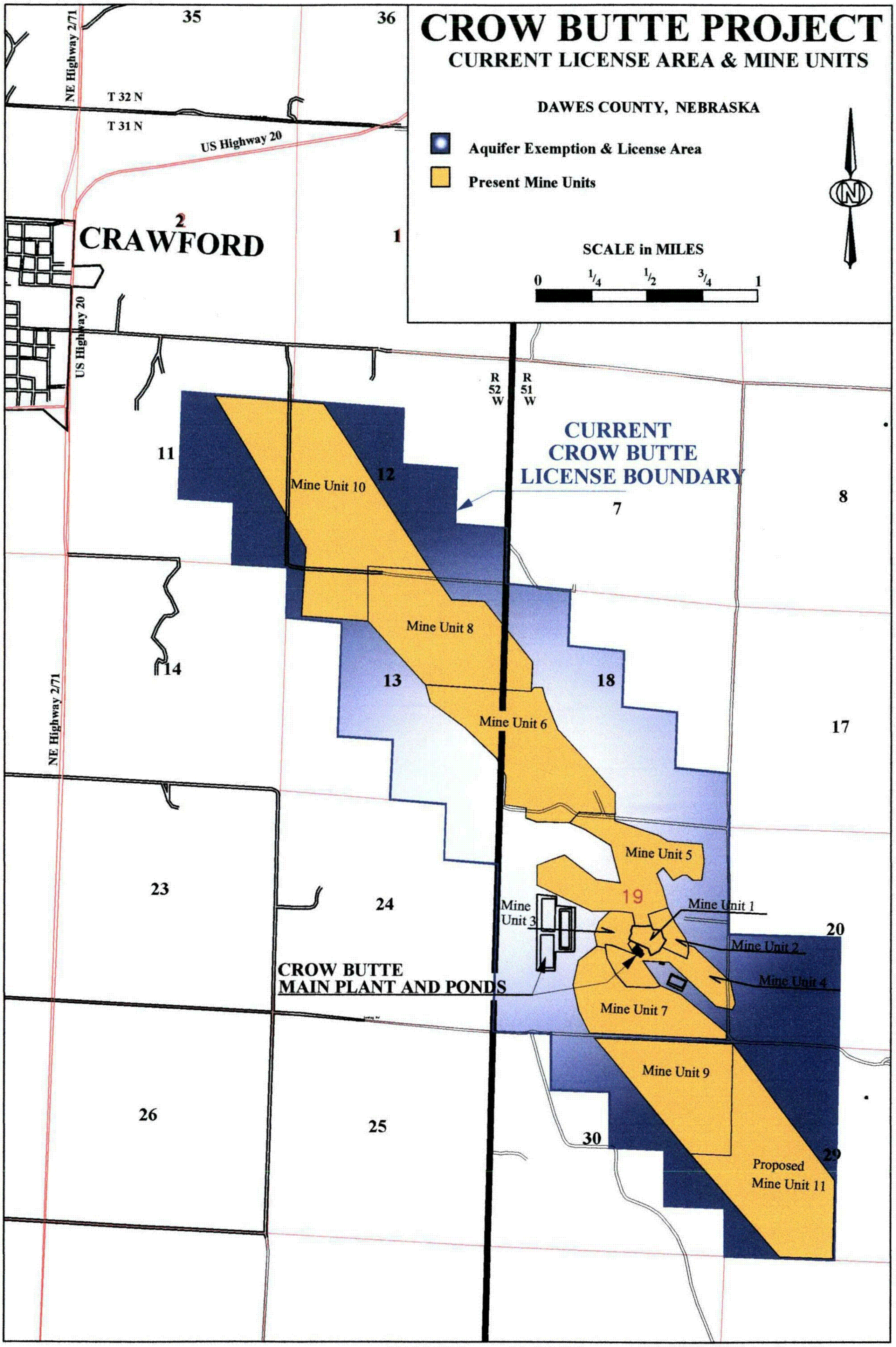


FIGURE 1-4


CROW BUTTE PROJECT
CURRENT LICENSE AREA & MINE UNITS
DAWES COUNTY, NEBRASKA
Aquifer Exemption & License Area
Present Mine Units
SCALE in MILES
0 1/4 1/2 3/4 1
N
CURRENT
CROW BUTTE
LICENSE BOUNDARY
CRAWFORD
NE Highway 2/71
US Highway 20
T 32 N
T 31 N
R 52 W
R 51 W
Mine Unit 10
Mine Unit 8
Mine Unit 6
Mine Unit 5
Mine Unit 1
Mine Unit 2
Mine Unit 3
Mine Unit 4
Mine Unit 7
Mine Unit 9
Proposed
Mine Unit 11
CROW BUTTE
MAIN PLANT AND PONDS
35
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1.1.4.2 North Trend Expansion Area Schedule

Assuming favorable regulatory action by the NRC and State of Nebraska regulatory agencies, CBR projects initial construction of the North Trend satellite plant and associated facilities in 2009. Production is scheduled to begin in late 2009 and last for approximately 11 years. Groundwater restoration activities at North Trend are expected to begin in late 2012 with Mine Unit NT-1. Groundwater restoration will extend for eight years with final site decommissioning completed by mid-2023.

Projected production and restoration schedules for the North Trend Expansion Area are shown in Figure 1-5. The layout of the proposed North Trend license area and mine units is shown in Figure 1-6.

Figure 1-5 North Trend Expansion Area Schedule

ID	Task Name	Start	Finish
1	**North Trend Production and Restoration**	**Mon 1/5/09**	**Wed 5/8/24**
2	**North Trend Facility Construction**	Mon 1/5/09	Fri 12/4/09
3	**North Trend Production**	**Fri 12/4/09**	**Mon 8/3/20**
4	Mine Unit NT-1	Fri 12/4/09	Sat 11/3/12
5	Mine Unit NT-2	Mon 3/29/10	Tue 3/26/13
6	Mine Unit NT-3	Mon 8/1/11	Tue 7/29/14
7	Mine Unit NT-4	Wed 8/1/12	Mon 8/3/15
8	Mine Unit NT-5	Mon 8/5/13	Fri 8/5/16
9	Mine Unit NT-6	Tue 8/5/14	Tue 8/8/17
10	Mine Unit NT-7	Mon 8/3/15	Fri 8/3/18
11	Mine Unit NT-8	Wed 8/3/16	Fri 8/2/19
12	Mine Unit NT-9	Tue 8/1/17	Mon 8/3/20
13	**Groundwater Restoration**	**Mon 11/5/12**	**Tue 5/9/23**
14	Mine Unit NT-1	Mon 11/5/12	Fri 8/21/15
15	Mine Unit NT-2	Tue 5/28/13	Mon 5/30/16
16	Mine Unit NT-3	Wed 7/30/14	Tue 5/2/17
17	Mine Unit NT-4	Tue 8/4/15	Mon 5/7/18
18	Mine Unit NT-5	Mon 8/8/16	Fri 5/10/19
19	Mine Unit NT-6	Wed 8/9/17	Tue 5/12/20
20	Mine Unit NT-7	Mon 8/6/18	Fri 5/7/21
21	Mine Unit NT-8	Mon 8/5/19	Fri 5/6/22
22	Mine Unit NT-9	Wed 8/5/20	Tue 5/9/23
23	**Final Site Reclamation**	Wed 5/10/23	Wed 5/8/24

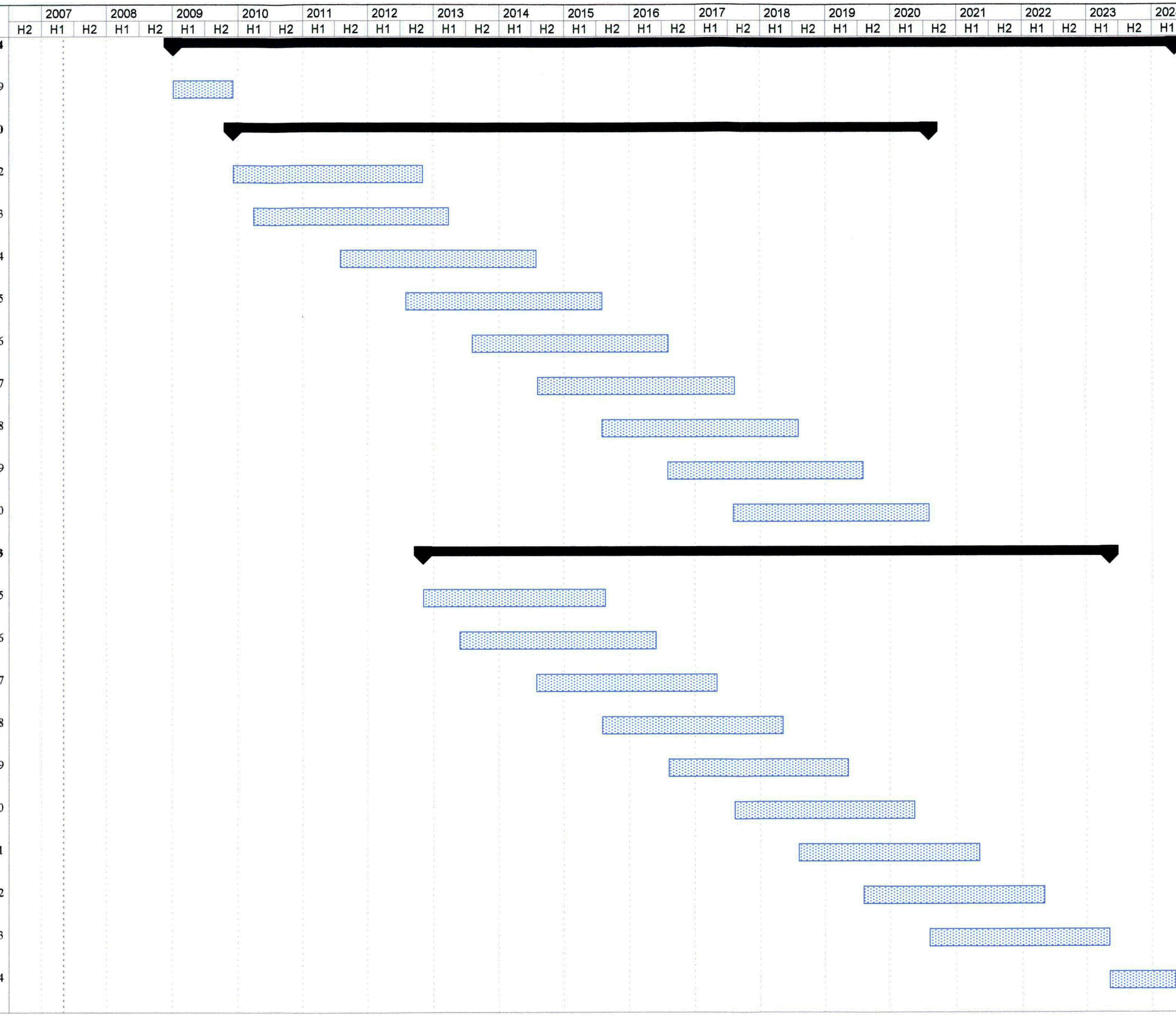
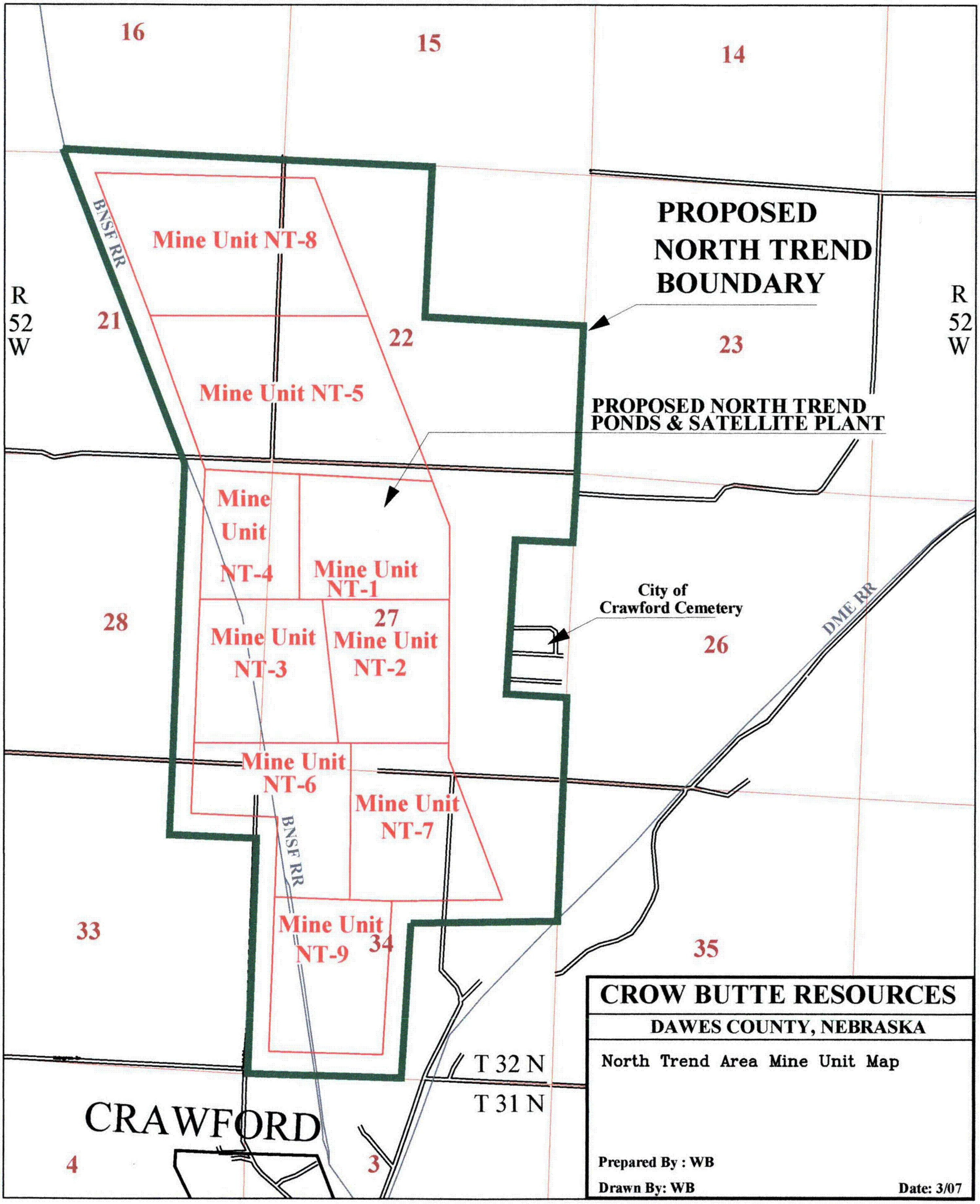


FIGURE 1-6

North Trend Area Mine Unit Map



1.2 PURPOSE AND NEED FOR THE PROPOSED ACTION

NRC Source Materials License SUA-1534 authorizes CBR to conduct mining operations in the current license area. Based on current plans, mining schedules, and reserve estimates, CBR could continue production at the present annual levels of approximately 800,000 pounds U_3O_8 until 2012 when reserves would begin to deplete. CBR estimates that by 2014, production in the current license area would decrease to the point where commercial operations would no longer be economical and would be discontinued. Groundwater restoration, surface reclamation, and decommissioning would become the primary activities.

CBR has developed commercially-viable uranium resources in the area near the current license area. Development and recovery of these resources using satellite plants will allow CBR to extend the operation of the existing Crow Butte central plant in the current license area. The use of satellite facilities in these areas will minimize the cost and environmental impact from construction activities.

The timely approval of uranium recovery activities in the North Trend Expansion Area will allow CBR to maintain uranium production at currently-licensed quantities and provide a smooth transition of mining activities from the current license area to the North Trend satellite. CBR has developed a talented, qualified workforce based largely on local residents. If the North Trend Expansion Area is not developed, CBR estimates that some of these personnel (e.g., well drilling, well and wellfield construction) will no longer be required as early as 2010.

Failure to develop these additional resources would leave a large resource unavailable for energy production supplies. Although CBR is continuing to develop estimates of the reserves at North Trend, the current estimated recoverable resource is 2,000,000 pounds U_3O_8.

In 2005, total domestic U.S. uranium production was approximately 3 million pounds U_3O_8, of which over 800,000 pounds (or approximately 27 percent) was produced at the Crow Butte Project. During the same year, domestic U.S. uranium consumption was approximately 66 million pounds U_3O_8 with approximately 17% supplied by domestic producers. The Crow Butte Project (including the North Trend Area) represents an important source of new domestic uranium supplies that are essential to provide a continuing source of fuel to power generation facilities.

In addition to leaving a large deposit of valuable mineral resources untapped, failure to develop the North Trend Expansion Area would result in the loss of a large investment in time and money made by CBR for the rights to and the development of these valuable

deposits. Denial of the amendment request would also have an adverse economic effect on the individuals that own the mineral rights in the North Trend Expansion Area.

1.3 THE PROPOSED ACTION

1.3.1 Site Location and Layout

The location of the current license area of the Crow Butte Project is in Sections 11, 12, and 13 of Township 31 North, Range 52 West and Sections 18, 19, 20, 29, and 30 of Township 31 North, Range 51 West, Dawes County, Nebraska. The proposed North Trend Expansion Area is located in Sections 21, 22, 27, 28, 33, and 34 of Township 32 North, Range 52 West.

The maps used in this section and other sections of this amendment application are Vector 7.5 minute quad maps. These are CAD/GIS drawings where each road, stream, and contour line are individual entities. The layers in these maps were derived from the U.S. Census Bureau's TIGER/Line data, USGS Digital Line Graph (DLG) Data, USGS Digital Elevation Model (DEM) data, Bureau of Land Management (BLM) Section Line data, National Geodetic Survey (NGS) benchmark data, and USGS Geographical Names Information System (GNIS) data This base map was then used for each of the figures prepared for this document with the addition of the pertinent information for that figure.

Figure 1-7 shows the general area surrounding the project area including the current license area and the proposed North Trend Expansion Area. Figure 1-7 also shows the original commercial study area (CSA) and the 2.0-mile review area associated with the North Trend Expansion Area.

Figure 1-8 shows the general project site layout and restricted areas for the current license area including the central plant building area, the R&D facility, the current mine unit boundaries, the deep disposal well, and the R&D and commercial evaporation ponds.

Figure 1-9 shows the proposed location of the North Trend satellite plant, wellfields, evaporation pond, deep disposal well, and controlled area boundaries within the North Trend Expansion Area.

Figure 1-10 shows the project location with topographical features, drainage and surface water features, nearby population centers and political boundaries as well as principal highways, railroads, transmission lines, and waterways.

Figure 1-7

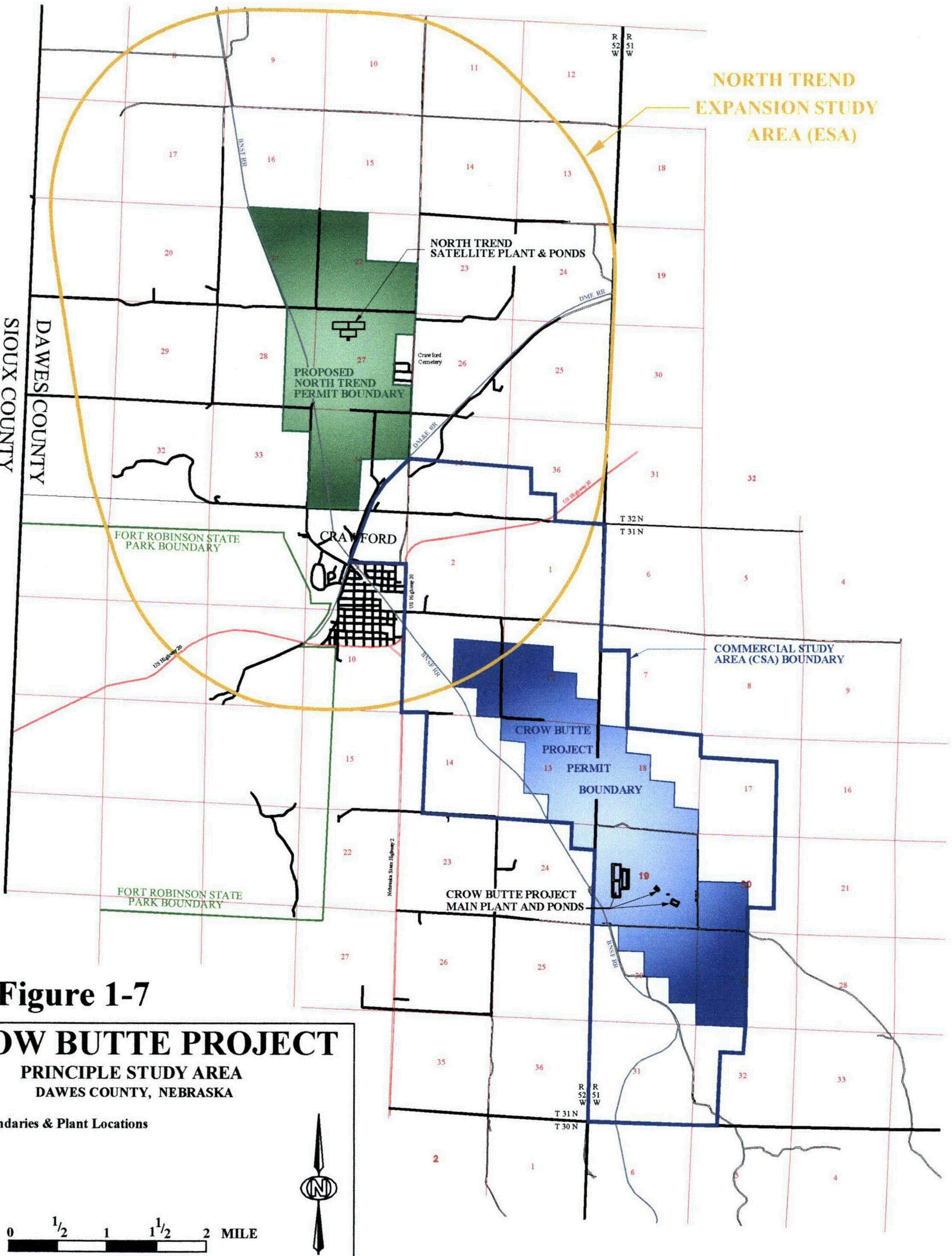


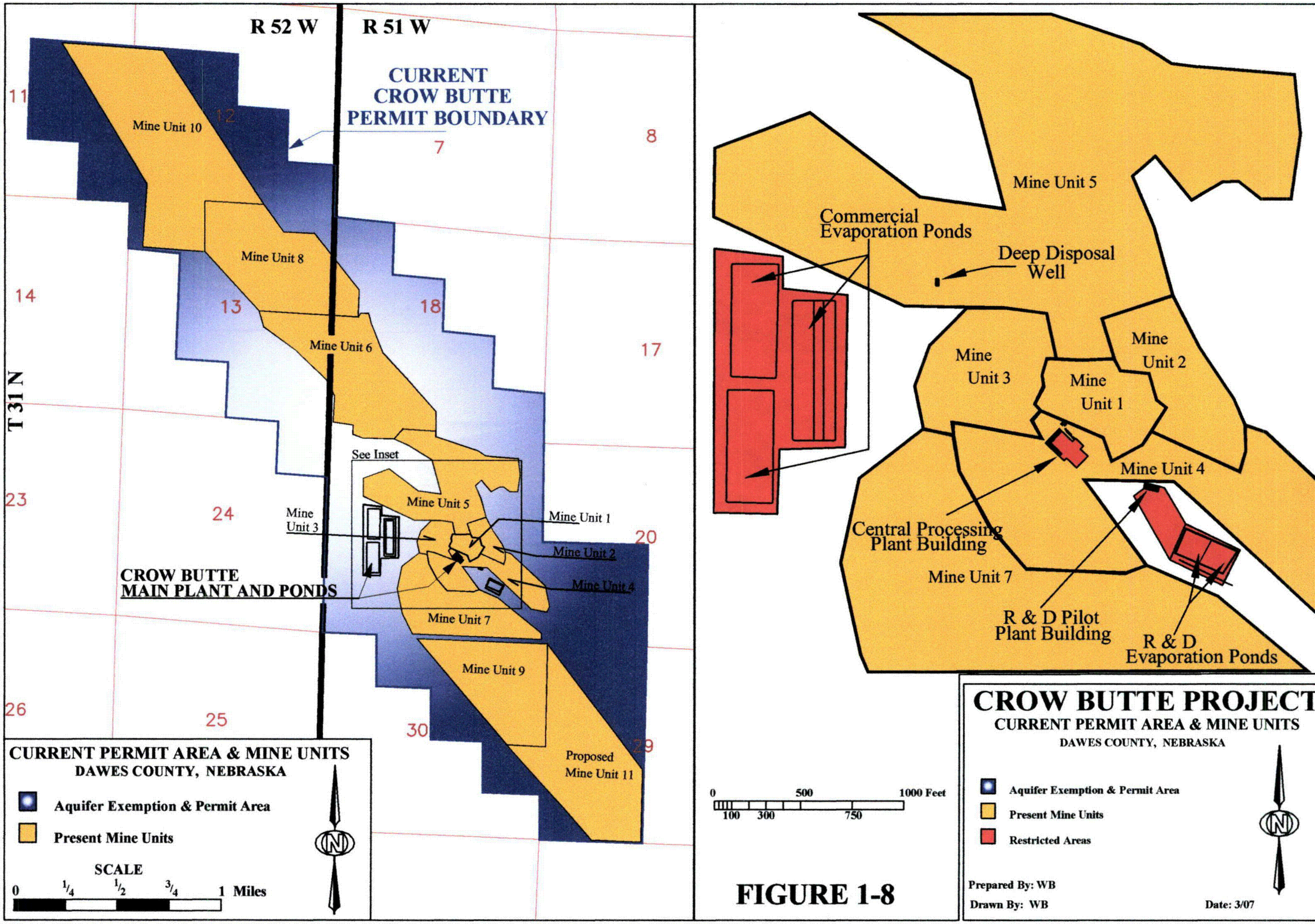
Figure 1-7

CROW BUTTE PROJECT
PRINCIPLE STUDY AREA
DAWES COUNTY, NEBRASKA

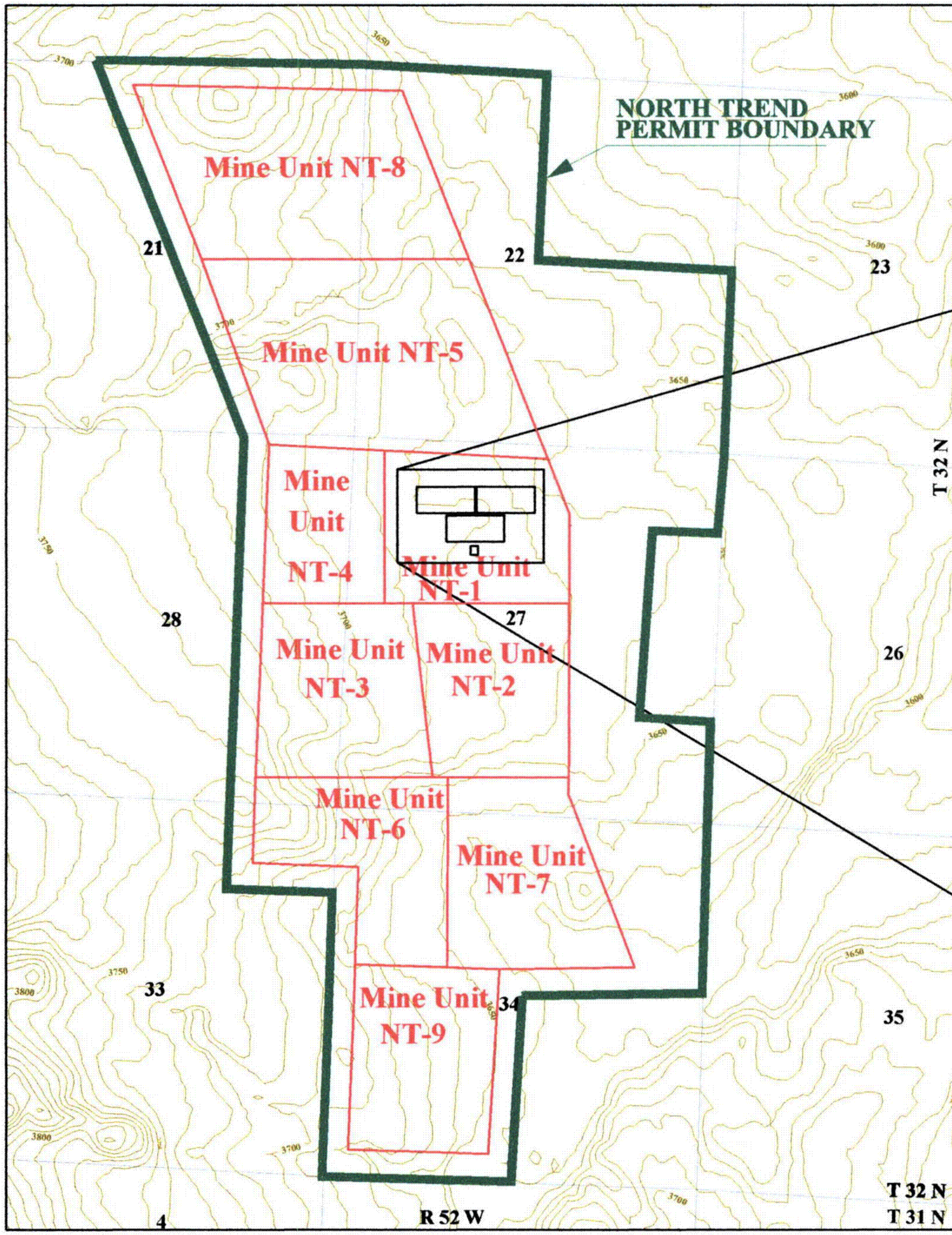
Permit Boundaries & Plant Locations

SCALE 0 1/2 1 1 1/2 2 MILE

FIGURE 1-8


R 52 W
R 51 W
CURRENT CROW BUTTE PERMIT BOUNDARY
T 31 N
11
12
7
8
14
13
18
17
23
24
20
26
25
30
29
Mine Unit 10
Mine Unit 8
Mine Unit 6
See Inset
Mine Unit 5
Mine Unit 3
Mine Unit 1
Mine Unit 2
Mine Unit 4
Mine Unit 7
Mine Unit 9
Proposed Mine Unit 11
CROW BUTTE MAIN PLANT AND PONDS
CURRENT PERMIT AREA & MINE UNITS
DAWES COUNTY, NEBRASKA
Aquifer Exemption & Permit Area
Present Mine Units
SCALE
0 1/4 1/2 3/4 1 Miles
N
Commercial Evaporation Ponds
Deep Disposal Well
Mine Unit 5
Mine Unit 3
Mine Unit 1
Mine Unit 2
Mine Unit 4
Mine Unit 7
Central Processing Plant Building
R & D Pilot Plant Building
R & D Evaporation Ponds
0 500 1000 Feet
100 300 750
FIGURE 1-8
CROW BUTTE PROJECT
CURRENT PERMIT AREA & MINE UNITS
DAWES COUNTY, NEBRASKA
Aquifer Exemption & Permit Area
Present Mine Units
Restricted Areas
Prepared By: WB
Drawn By: WB
Date: 3/07

CROW BUTTE RESOURCES, INC.
License Amendment Application
North Trend Expansion Area



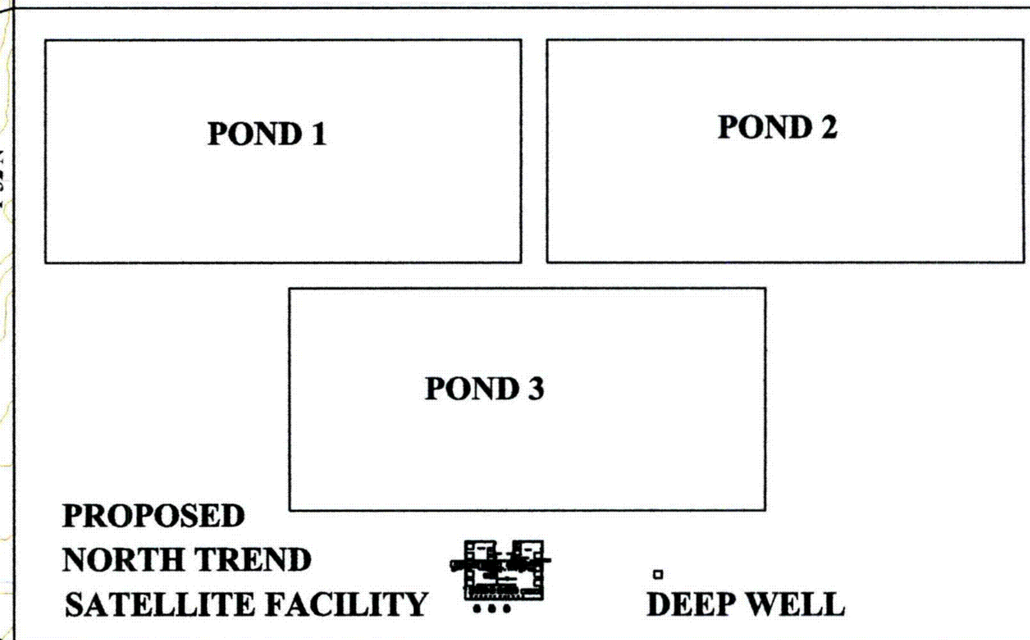


FIGURE 1-9

CROW BUTTE RESOURCES, INC.

General Arrangement
Satellite Plant
Plan View

Figure 1-10

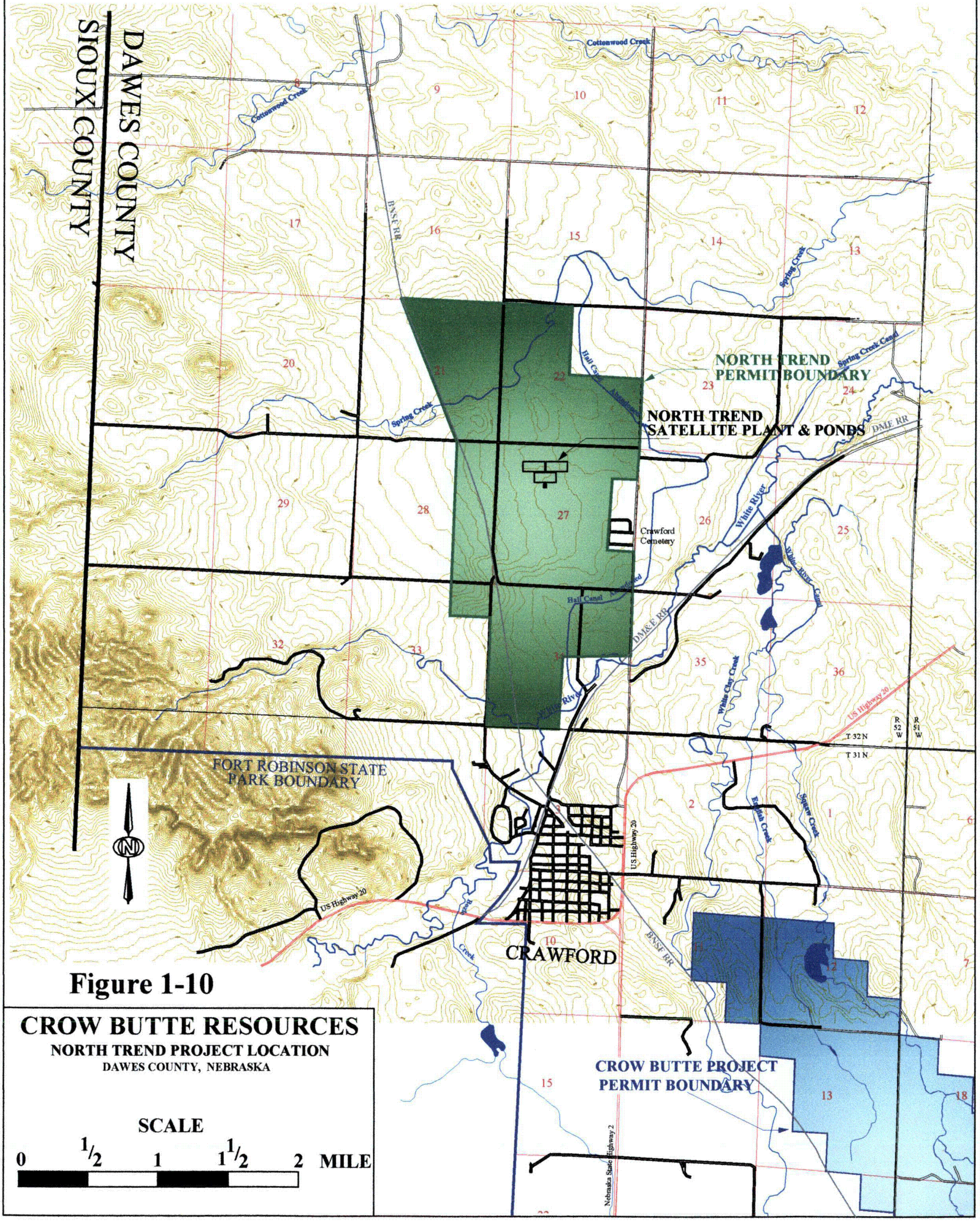


Figure 1-10

CROW BUTTE RESOURCES

NORTH TREND PROJECT LOCATION

DAWES COUNTY, NEBRASKA

SCALE

0 — 1/2 — 1 — 1 1/2 — 2 MILE

1.3.2 Description of Proposed Facility

Production of uranium by in-situ leach (ISL) mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by ion exchange, and then from the ion exchange resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluent) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium.

The North Trend Expansion Area is being developed by Crow Butte Resources in conjunction with their Crow Butte Uranium Project and the central plant currently licensed under USNRC Source Material License SUA-1534. The North Trend Expansion Area will be developed by constructing independent wellfields and mining support facilities while utilizing existing processing equipment to the greatest extent possible for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance that a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the North Trend Expansion Area to provide chemical makeup of leach solutions, recovery of uranium by ion exchange, and restoration capabilities. The ion exchange processes at the satellite facility serve to recover the uranium from the leach solution in a form (loaded ion exchange resin) that is relatively safe and simple to transport by tanker truck to the central plant for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the ion exchange circuit.

1.3.2.1 Solution Mining Process and Equipment

In the current licensed area, uranium is recovered by in-situ leaching from the Chadron Sandstone at a depth that varies from 400 feet to 800 feet. The overall width of the mineralized area varies from 1000 feet to 5000 feet. The ore body ranges in grade from less than 0.05% to greater than 0.5% U3O8, with an average grade estimated at 0.27% U3O8.

In the North Trend Expansion Area, uranium will also be recovered from the Chadron Sandstone. The depth in the North Trend Expansion Area ranges from 400 to 800 feet. The width varies from 100 feet to 1,000 feet.

1.3.2.1.1 Well Construction and Integrity Testing

Three well construction methods and appropriate casing materials are used for the construction and installation of production and injection wells.

The well casing material will be polyvinyl chloride (PVC). PVC well casing is 4.5 inch SDR-17 (or equivalent). The PVC casing joints normally have a length of approximately 20 feet each. With SDR-17 PVC casing, each joint is connected by a watertight o-ring seal, which is located with a high strength nylon spline.

Pilot holes for monitor, production, and injection wells are drilled to the top of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole is logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described and are not necessarily described in the order of their preferred use. Any of the methods are appropriate for monitor wells and have been approved by the NDEQ under the UIC Permit.

- Method No. 1, shown in Figure 1-11, involves the setting of an integral casing/screen string. The method consists of drilling a hole, geophysically logging the hole to define the desired screen interval, and reaming the hole if necessary to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed into the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weepholes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by airlifting or pumping.

- Method No. 2, shown in Figure 1-12, uses a screen telescoped down inside the cemented casing. As in the first method, a hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next a string of casing with a plug at the lower end and weep holes just above the plug is set into the hole. Cement is then pumped down the casing and out the weep holes. It returns to the surface through the annulus. After the cement has cured, the residual cement in the casing and plug are drilled out, with the drilling continuing through the desired zone. The screen with a packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again

accomplished by airlifting or pumping. Minor variations from these procedures may be used as conditions require.

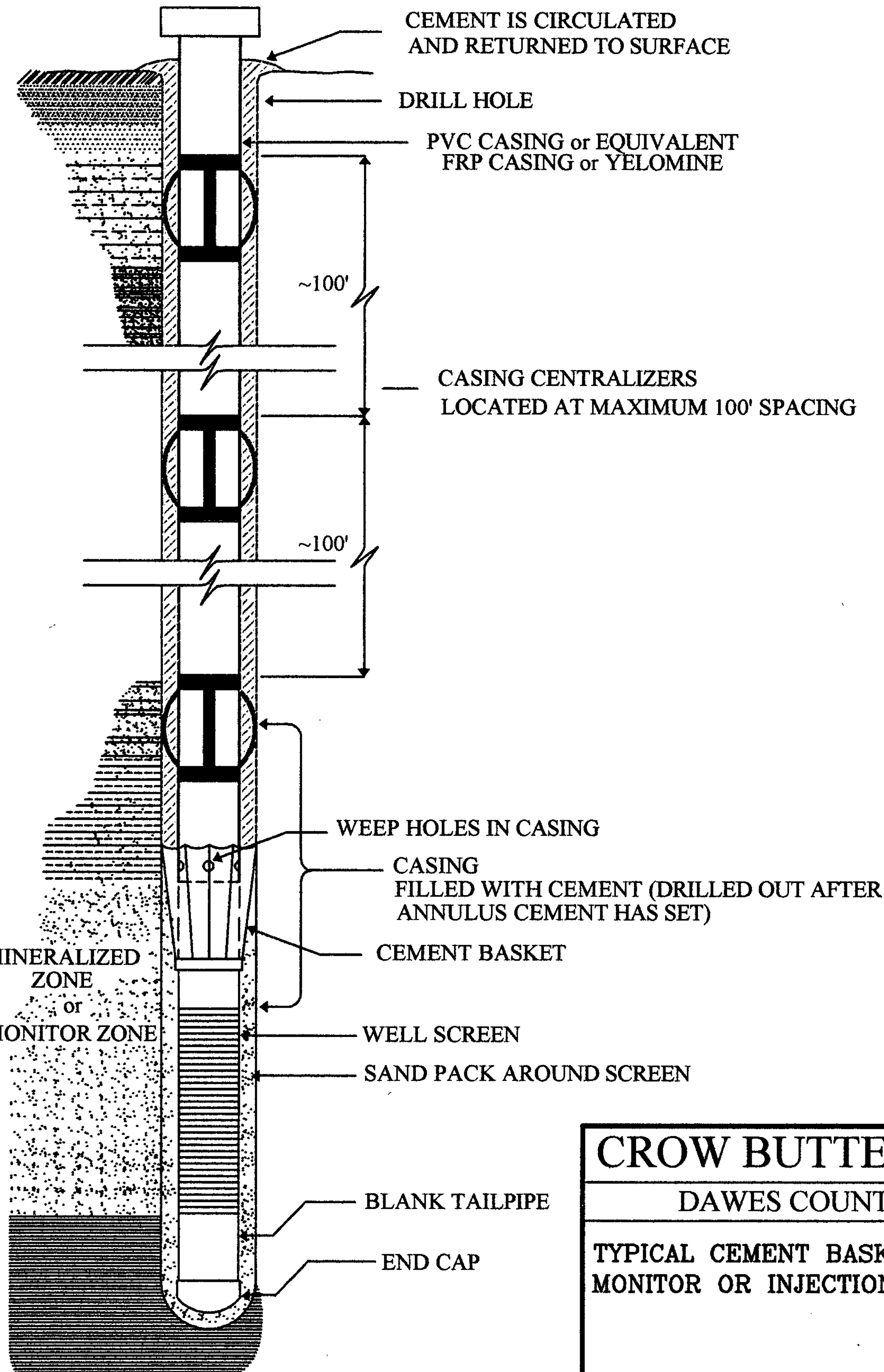
- Method Number 3, as shown in Figure 1-13, is similar to methods 1 and 2. The casing is cemented in place the entire length, and, after the cement grout has cured, the casing and grout are cut away to expose the interval to be mined or monitored. A screen is then telescoped into the open interval.

Casing centralizers, located at a maximum 100-foot spacing, are run on the casing to ensure it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare instances, however, the drilling may result in a larger annulus volume than anticipated and cement may not return all the way to the surface. In these cases the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is performed by placement of a tremie hose from the surface as far down into the annulus as possible. Cement is pumped into the annulus until return to the surface is observed.

A well completion report is completed on each well. This data is kept available on-site for review.

Figure 1-11

Well Completion Method No. 1



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

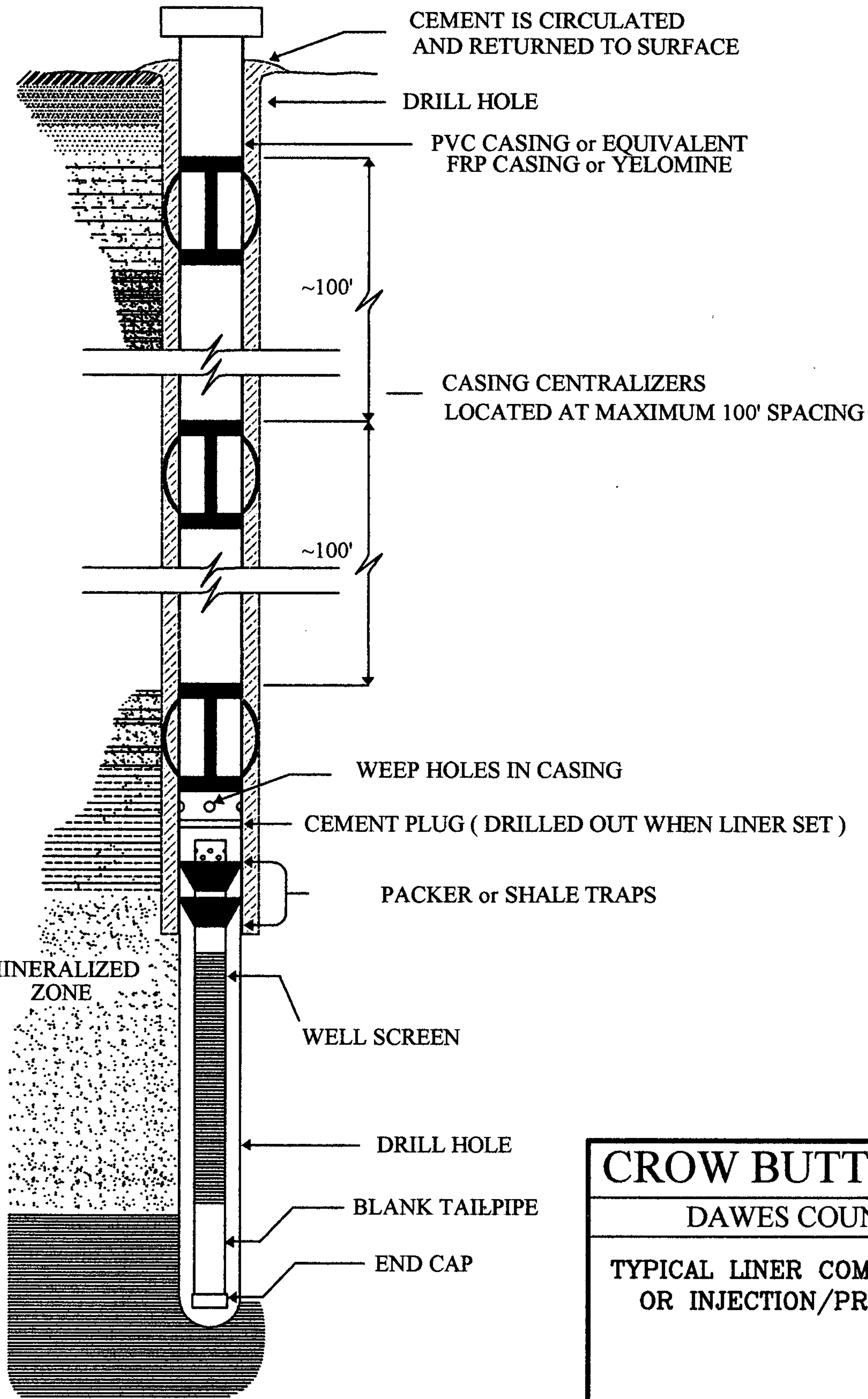
Prepared By : WB

Drawn By: WB

Date: 1/07

Figure 1-12

Well Completion Method No. 2



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

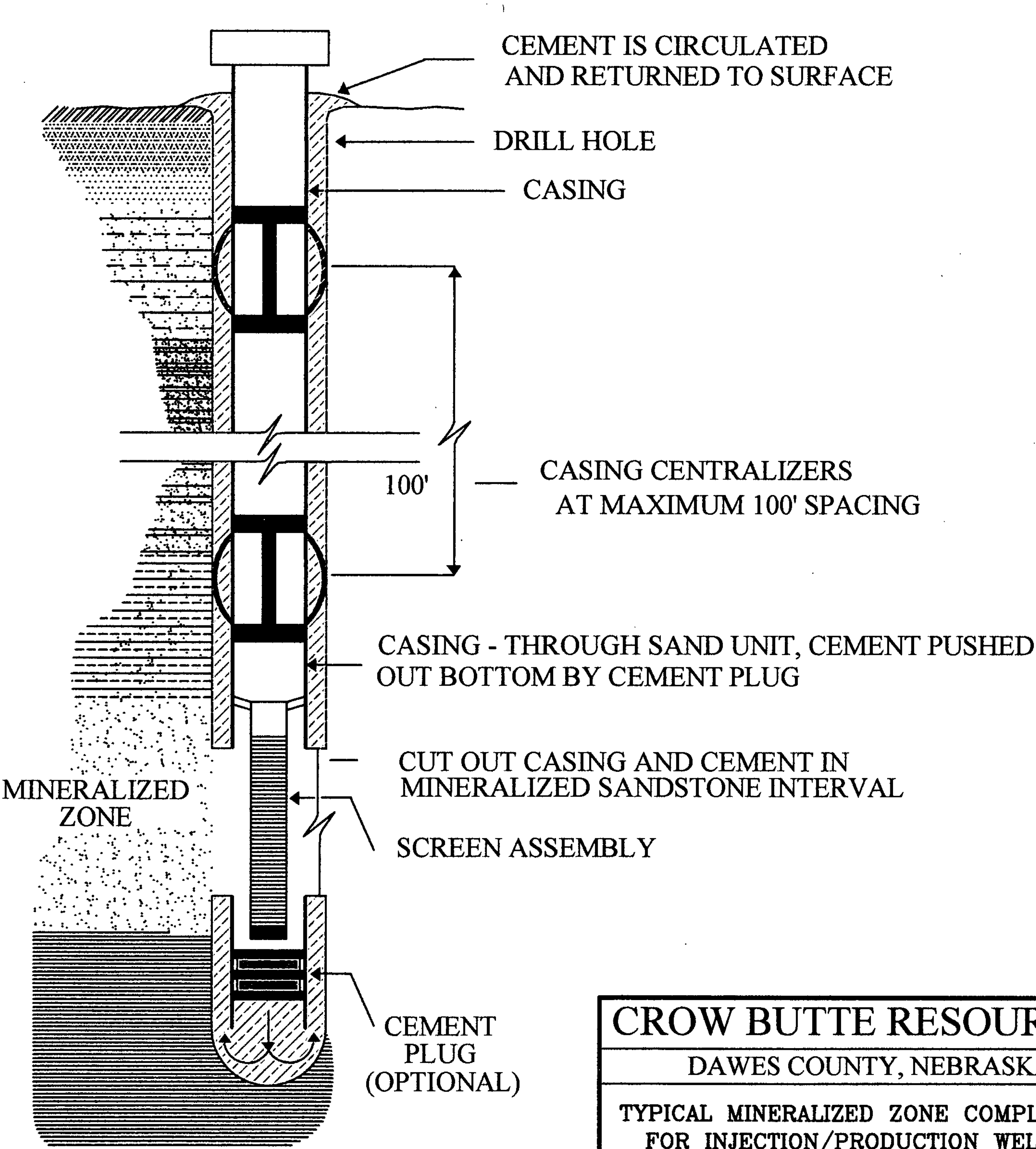
Prepared By : WB

Drawn By: WB

Date: 1/07

Figure 1-13

Well Completion Method No. 3



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL MINERALIZED ZONE COMPLETION
FOR INJECTION/PRODUCTION WELLS

Prepared By : WB

Drawn By: WB

Date: 1/07

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

The well is developed until the water produced is clear. This can be determined visually or with a turbidimeter. During the final stages of initial development, water samples will be collected in a transparent or translucent container and visually examined for turbidity (i.e., cloudiness and visual suspended solids). Development is continued until clear, sediment-free formation water is produced.

When the water begins to become clear, the development will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will be continued. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. Monitoring for pH and conductivity is performed during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

Field-testing of all (i.e., injection, production, and monitor) wells is performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MIT) is performed using pressure-packer tests. Every well will be tested after well construction is completed before it can be placed in service, after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing, at least once every five years, and whenever there is any question of casing integrity. To assure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The MIT procedures have been approved by the NDEQ and are currently contained in EMS Program Volume III, *Operating Manual*. These same procedures will be used at the North Trend Expansion Area.

The following general MIT procedure is used:

- The test consists of placement of one or two packers within the casing. The bottom packer is set just above the well screen and the upper packer is set at the wellhead. The packers are inflated with nitrogen and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 psi).
- The well is then "closed in" and the pressure is monitored for a minimum of twenty minutes.
- If more than ten percent of the pressure is lost during this time period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Section 6.0.

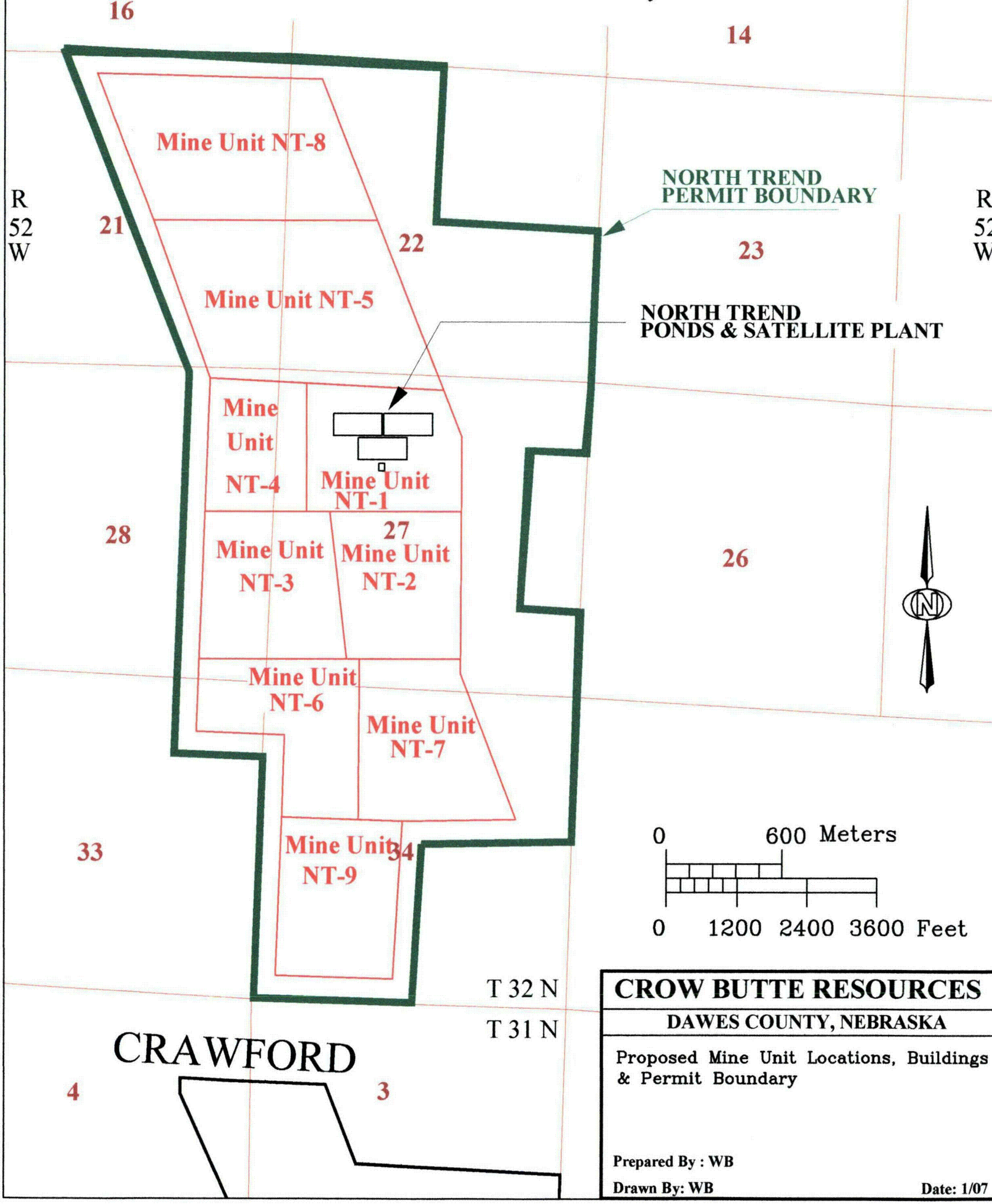
CBR submits all integrity testing records to the NDEQ for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

1.3.2.1.2 Wellfield Design and Operation

The proposed North Trend Mine Unit map and mine schedule are shown in Figure 1-14 and Figure 1-15. The preliminary map and mine schedule are based on CBR's current knowledge of the area. As the North Trend Expansion Area is developed, the mine schedule and a mine unit map will be developed further. The North Trend Expansion Area will be subdivided into an appropriate number of mine units. Each mine unit will contain a number of wellhouses where injection and recovery solutions from the satellite plant building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellfield houses will be either polyvinyl chloride (PVC) or high-density polyethylene (HDPE) with butt welded joints or an equivalent. In the wellfield house, injection pressure will be monitored on the injection trunk lines. Oxidizer will be added to the injection stream and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite control room. The North Trend Expansion Area wellfields will be designed in a manner consistent with the existing CBR wellfields.

FIGURE 1-14

North Trend Mine Unit Layout



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

Proposed Mine Unit Locations, Buildings & Permit Boundary

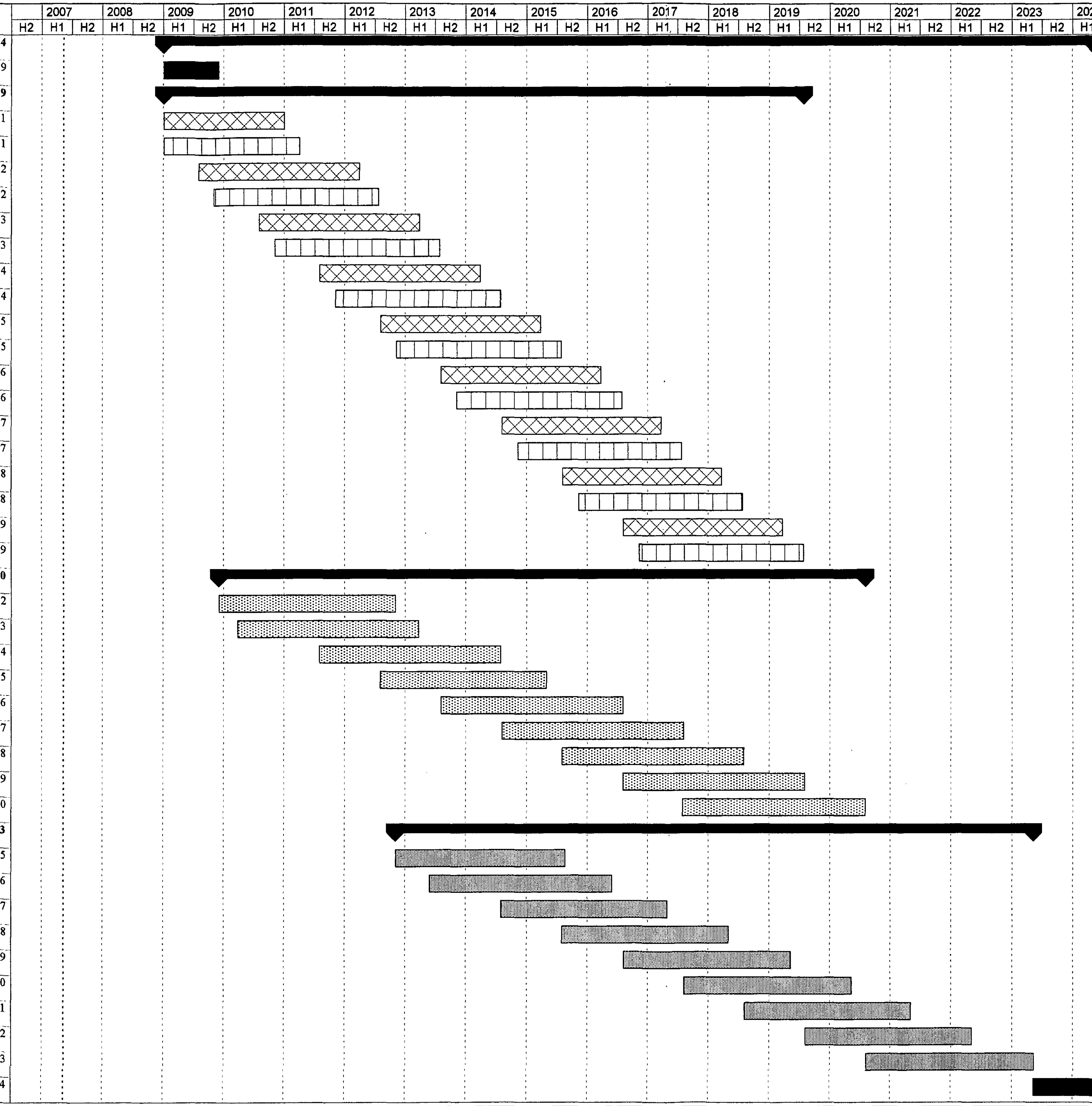
Prepared By : WB

Drawn By: WB

Date: 1/07

Figure 1-15 North Trend Mine Unit Schedule

ID	Task Name	Start	Finish
1	**North Trend Mine Unit Schedule**	**Mon 1/5/09**	**Wed 5/8/24**
2	**North Trend Facility Construction**	Mon 1/5/09	Fri 12/4/09
3	**North Trend Wellfield Construction**	**Mon 1/5/09**	**Fri 7/26/19**
4	Mine Unit NT-1 Well Development Drilling and Casing	Mon 1/5/09	Wed 1/5/11
5	Mine Unit NT-1 Surface Construction	Mon 1/5/09	Tue 4/5/11
6	Mine Unit NT-2 Well Development Drilling and Casing	Mon 8/3/09	Fri 3/30/12
7	Mine Unit NT-2 Surface Construction	Mon 11/2/09	Mon 7/23/12
8	Mine Unit NT-3 Well Development Drilling and Casing	Tue 8/3/10	Fri 3/29/13
9	Mine Unit NT-3 Surface Construction	Mon 11/8/10	Mon 7/29/13
10	Mine Unit NT-4 Well Development Drilling and Casing	Wed 8/3/11	Fri 3/28/14
11	Mine Unit NT-4 Surface Construction	Tue 11/8/11	Tue 7/29/14
12	Mine Unit NT-5 Well Development Drilling and Casing	Fri 8/3/12	Fri 3/27/15
13	Mine Unit NT-5 Surface Construction	Thu 11/8/12	Wed 7/29/15
14	Mine Unit NT-6 Well Development Drilling and Casing	Mon 8/5/13	Fri 3/25/16
15	Mine Unit NT-6 Surface Construction	Fri 11/8/13	Fri 7/29/16
16	Mine Unit NT-7 Well Development Drilling and Casing	Tue 8/5/14	Fri 3/24/17
17	Mine Unit NT-7 Surface Construction	Mon 11/10/14	Fri 7/28/17
18	Mine Unit NT-8 Well Development Drilling and Casing	Wed 8/5/15	Fri 3/23/18
19	Mine Unit NT-8 Surface Construction	Tue 11/10/15	Fri 7/27/18
20	Mine Unit NT-9 Well Development Drilling and Casing	Fri 8/5/16	Fri 3/22/19
21	Mine Unit NT-9 Surface Construction	Thu 11/10/16	Fri 7/26/19
22	**North Trend Production**	**Fri 12/4/09**	**Mon 8/3/20**
23	Mine Unit NT-1	Fri 12/4/09	Sat 11/3/12
24	Mine Unit NT-2	Mon 3/29/10	Tue 3/26/13
25	Mine Unit NT-3	Mon 8/1/11	Tue 7/29/14
26	Mine Unit NT-4	Wed 8/1/12	Thu 4/30/15
27	Mine Unit NT-5	Mon 8/5/13	Fri 8/5/16
28	Mine Unit NT-6	Tue 8/5/14	Tue 8/8/17
29	Mine Unit NT-7	Mon 8/3/15	Fri 8/3/18
30	Mine Unit NT-8	Wed 8/3/16	Fri 8/2/19
31	Mine Unit NT-9	Tue 8/1/17	Mon 8/3/20
32	**Groundwater Restoration**	**Mon 11/5/12**	**Tue 5/9/23**
33	Mine Unit NT-1	Mon 11/5/12	Fri 8/21/15
34	Mine Unit NT-2	Tue 5/28/13	Mon 5/30/16
35	Mine Unit NT-3	Wed 7/30/14	Tue 5/2/17
36	Mine Unit NT-4	Fri 7/31/15	Thu 5/3/18
37	Mine Unit NT-5	Mon 8/8/16	Fri 5/10/19
38	Mine Unit NT-6	Wed 8/9/17	Tue 5/12/20
39	Mine Unit NT-7	Mon 8/6/18	Fri 5/7/21
40	Mine Unit NT-8	Mon 8/5/19	Fri 5/6/22
41	Mine Unit NT-9	Wed 8/5/20	Tue 5/9/23
42	**Final Site Reclamation**	Wed 5/10/23	Wed 5/8/24



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7	Mine Unit NT-2 Surface Construction	Mon 11/2/09	Mon 7/23/12
8	Mine Unit NT-3 Well Development Drilling and Casing	Tue 8/3/10	Fri 3/29/13
9	Mine Unit NT-3 Surface Construction	Mon 11/8/10	Mon 7/29/13
10	Mine Unit NT-4 Well Development Drilling and Casing	Wed 8/3/11	Fri 3/28/14
11	Mine Unit NT-4 Surface Construction	Tue 11/8/11	Tue 7/29/14
12	Mine Unit NT-5 Well Development Drilling and Casing	Fri 8/3/12	Fri 3/27/15
13	Mine Unit NT-5 Surface Construction	Thu 11/8/12	Wed 7/29/15
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15	Mine Unit NT-6 Surface Construction	Fri 11/8/13	Fri 7/29/16
16	Mine Unit NT-7 Well Development Drilling and Casing	Tue 8/5/14	Fri 3/24/17
17	Mine Unit NT-7 Surface Construction	Mon 11/10/14	Fri 7/28/17
18	Mine Unit NT-8 Well Development Drilling and Casing	Wed 8/5/15	Fri 3/23/18
19	Mine Unit NT-8 Surface Construction	Tue 11/10/15	Fri 7/27/18
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25	Mine Unit NT-3	Mon 8/1/11	Tue 7/29/14
26	Mine Unit NT-4	Wed 8/1/12	Thu 4/30/15
27	Mine Unit NT-5	Mon 8/5/13	Fri 8/5/16
28	Mine Unit NT-6	Tue 8/5/14	Tue 8/8/17
29	Mine Unit NT-7	Mon 8/3/15	Fri 8/3/18
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37	Mine Unit NT-5	Mon 8/8/16	Fri 5/10/19
38	Mine Unit NT-6	Wed 8/9/17	Tue 5/12/20
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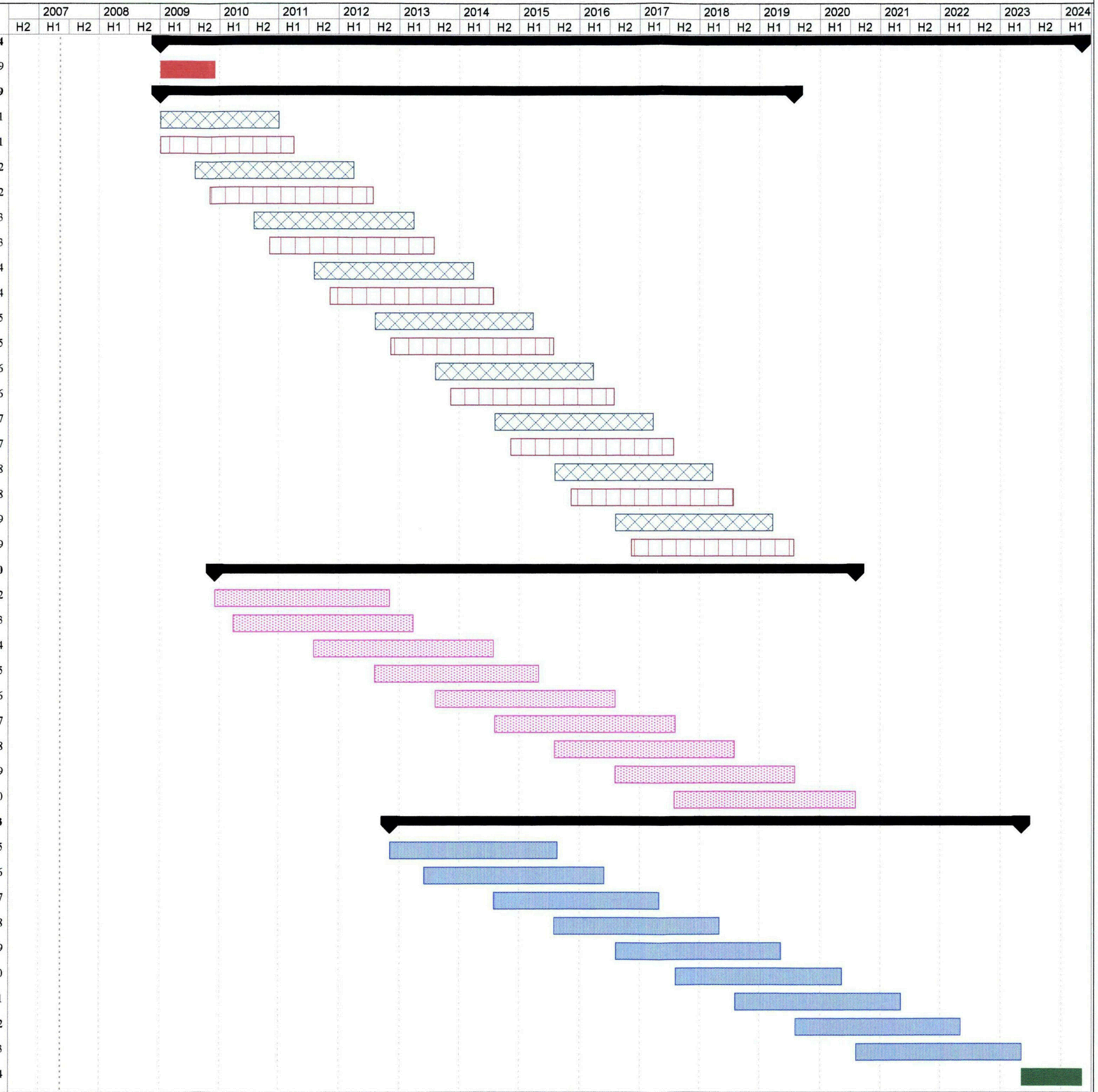
42	**Final Site Reclamation**	Wed 5/10/23	Wed 5/8/24



The wellfield injection/production pattern employed is based on a hexagonal seven spot pattern, which is modified as needed to fit the characteristics of the ore body. The standard production cell for the seven spot pattern contains six injection wells surrounding a centrally located recovery well.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown in Figure 1-16. The wellfield is a repeated seven spot design, with the spacing between production wells ranging from 65 to 150 feet.

Other wellfield designs include alternating single line drives.

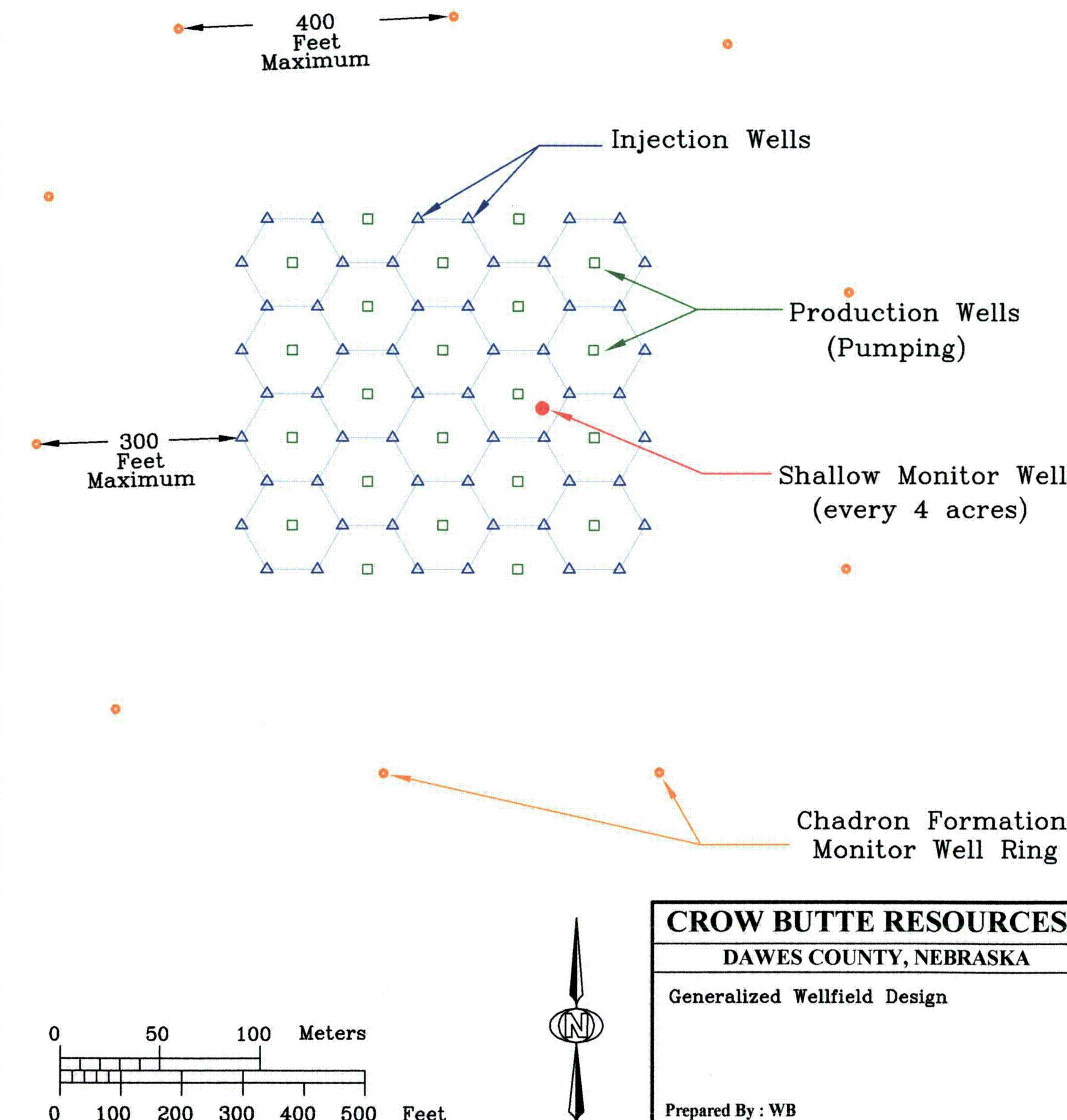
All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within each mine unit, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient the natural groundwater movement from the surrounding area is toward the wellfield providing additional control of the leaching solution movement. The difference between the amount of water produced and injected is the wellfield "bleed." The minimum over-production or bleed rates will be a nominal 0.5% of the total wellfield production rate and the maximum bleed rate typically approaches 1.5%. Over-production is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed.

Monitor wells will be placed in the Chadron Formation and in the first significant water-bearing Brule sand above the Chadron Formation. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations. The typical locations of monitor wells for the proposed North Trend mine map are shown in Figure 1-17. As previously noted, the map is preliminary based on CBR's current knowledge of the area. As the North Trend Expansion Area is developed, the mine unit map will be developed further.

Injection of solutions for mining will be at a rate of 4,500 gpm with a one half to one and one half percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be leak tested and buried prior to production operations.

FIGURE 1-16

Typical Wellfield Layout



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

Generalized Wellfield Design

Prepared By : WB

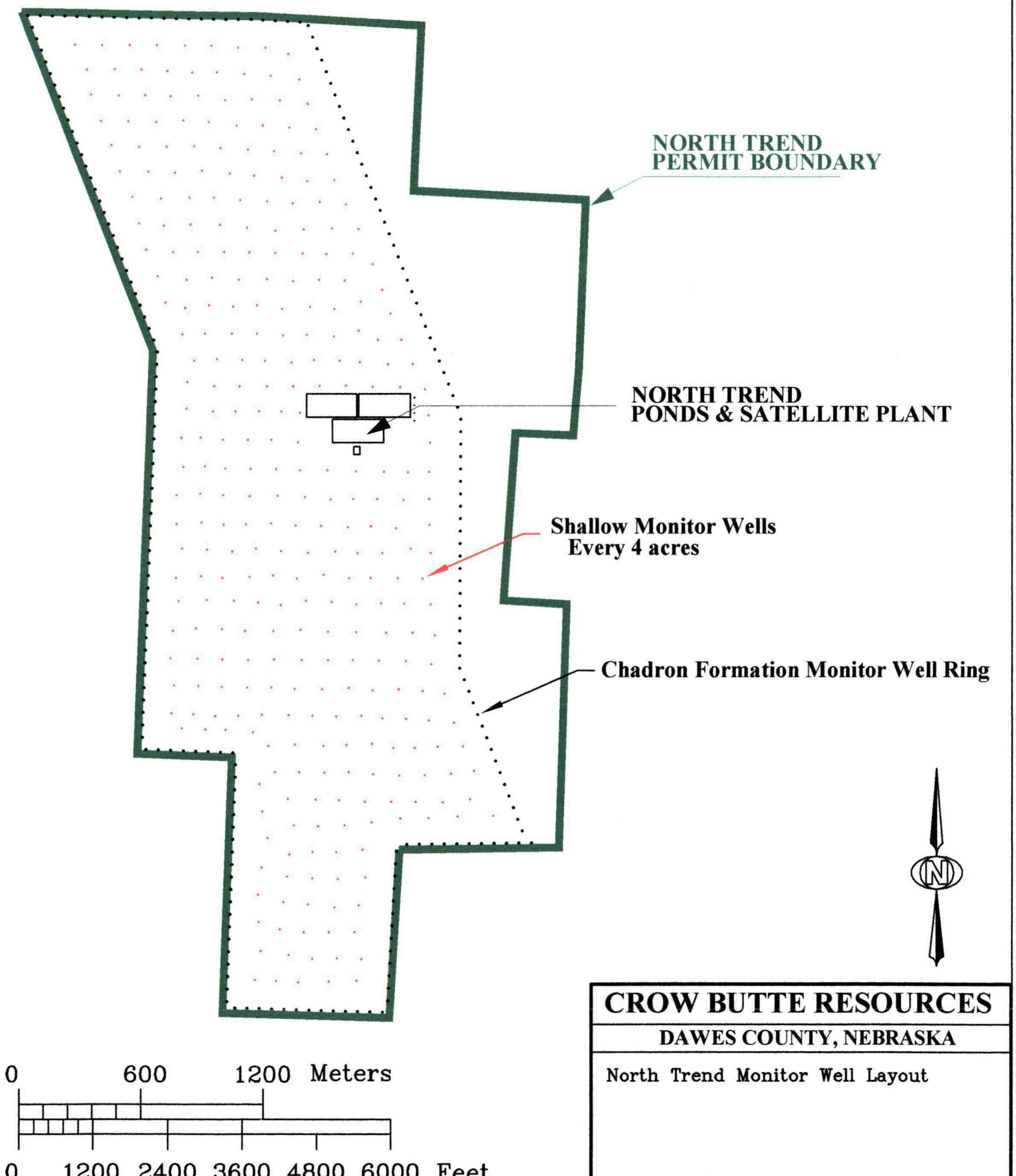
Drawn By: WB

Date: 1/07

A water balance for the proposed North Trend Expansion Facility is shown on Figure 1-18. The liquid waste generated at the satellite plant will be primarily the production bleed which, at a maximum scenario, is estimated at 1.5% of the production flow. At 4,500 gpm the volume of liquid waste would be 35,478,000 gallons per year. Crow Butte Resources proposes to adequately handle the liquid waste through the combination of deep disposal well injection and evaporation ponds.

FIGURE 1-17

North Trend Monitor Well Layout

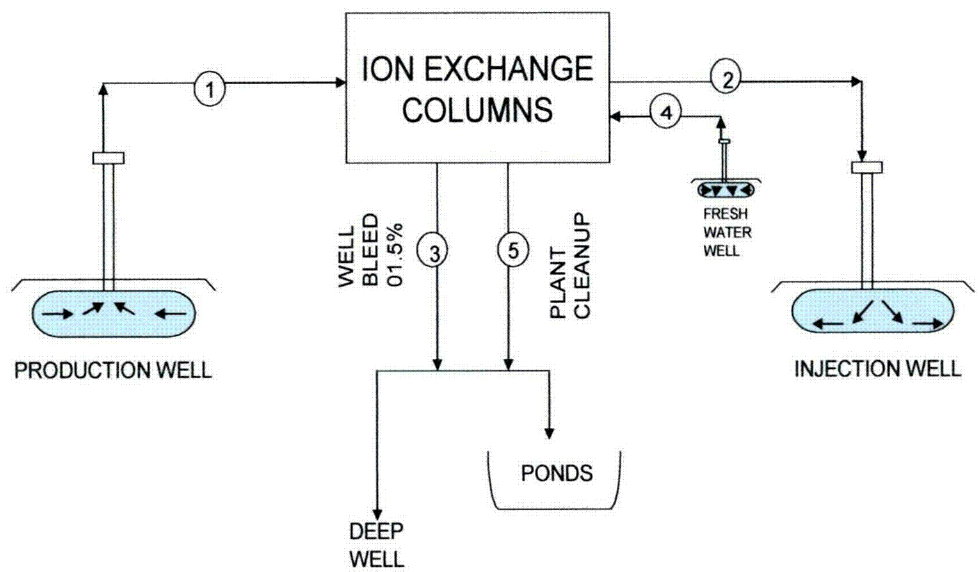


CROW BUTTE RESOURCES
DAWES COUNTY, NEBRASKA
North Trend Monitor Well Layout
Prepared By : WB
Drawn By: WB Date: 1/07

Figure 1-18: North Trend Water Balance

NORTH TREND WATER BALANCE

FOR 1.5% BLEED AND FULL PRODUCTION



STREAM #	1	2	3	4	5
SOLUTION GPM*	4500	4432.5	67.5	2	2

*BALANCE IS NOMINAL FOR A 1.5% BLEED. ACTUAL BALANCE MAY VARY ACCORDINGLY.

Regional information, previous CBR permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is 0.63 psi per foot of well depth. This value has historically and successfully been applied to CBR operations. As such, the injection pressure is limited to less than 0.63 psi per foot of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested.

1.3.2.1.3 Process Description

Uranium solution mining is a process that takes place underground, or in-situ, by injecting lixiviant (leach) solutions into the ore body and then recovering these solutions when they are rich in uranium. The chemistry of solution mining involves an oxidation step to convert the uranium in the solid state to a form that is easily dissolved by the leach solution. Hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2) are typically used as the oxidant because both revert to naturally occurring substances. Carbonate species are also added to the lixiviant solution in the injection stream to promote the dissolution of uranium as a uranyl carbonate complex.

The reactions representing these steps at a neutral or slightly alkaline pH are:

Oxidation: $UO_{2\,(solid)} + H_2O_{2\,(in\ solution)} \rightarrow UO_{3\,(at\ solid\ surface)} + H_2O$

$UO_{2\,(solid)} + \frac{1}{2} O_{2\,(in\ solution)} \rightarrow UO_{3\,(at\ solid\ surface)}$

Dissolution: $UO_3 + 2\ HCO_3^{-1} \rightarrow UO_2(CO_3)_2^{-2} + H_2O$

$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \rightarrow UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{-2}$, (UDC), and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength.

Solutions resulting from the leaching of uranium underground will be recovered through the production wells and piped to the satellite plant for extraction. The uranium recovery process utilizes the following steps:

1. Loading of uranium complexes onto an ion exchange resin;

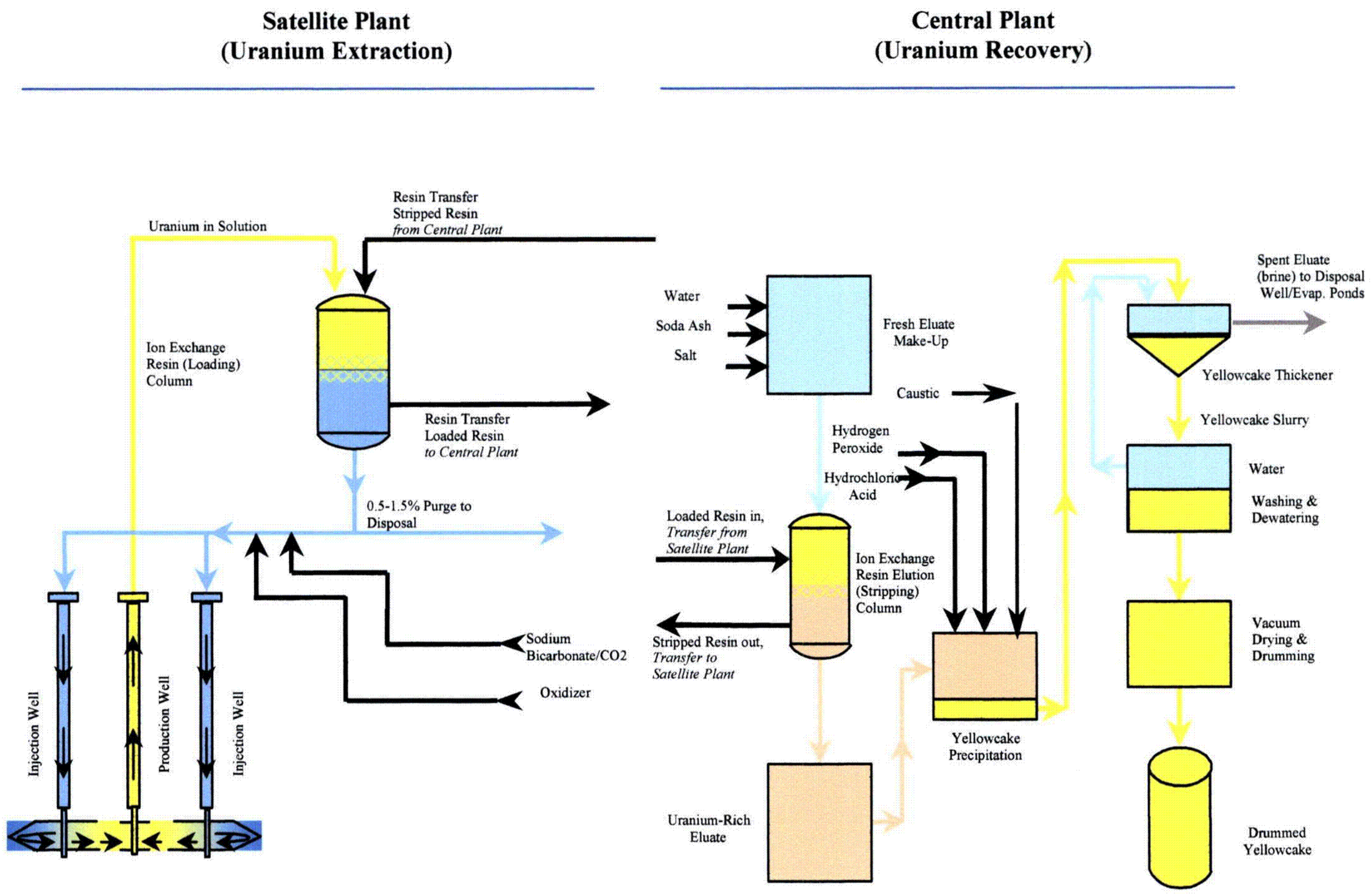
2. Reconstitution of the leach solution by addition of carbon dioxide and/or sodium bicarbonate and an oxidizer;

3. Elution of uranium complexes from the resin; and,

4. Precipitation of uranium.

The first two steps will be performed at the North Trend satellite plant. Steps 3 and 4 will be performed at the current central plant. The process flow sheet for the above steps is shown in Figure 1-19. The left side of Figure 1-19 depicts the uranium extraction process that is completed at the satellite plant. The right side of the figure shows the uranium recovery steps that will be performed at the central plant. Once the ion exchange resin at the satellite plant is loaded to capacity with uranium complexes, the resin will be transferred to the central plant for the completion of uranium recovery.

Figure 1-19: Process Flow Diagram



The recovery of uranium from the leach solution in the North Trend Expansion Facility will take place in the ion exchange columns. The uranium bearing leach solution enters the pressurized downflow ion exchange column and passes through resin bed. The uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

$$2\,R\,HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

$$2\,RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^{-}$$

$$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate or sulfate ions.

The now barren leach solution passes from the IX columns to be reinjected into the formation. The solution is refortified with sodium and carbonate chemicals as required and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition is shown in Table 1-2.

Once the majority of the ion exchange sites on the resin in an IX column are filled with uranium, the column will be taken out of service. The resin loaded with uranium will be transferred to a tanker truck for transport to the central plant for elution and final processing. Once the resin has been stripped of the uranium by the process of elution, the resin will be returned to the North Trend Satellite Plant for reuse in the ion exchange circuit.

At the central plant, the loaded resin that has been transported from the satellite facility will be stripped of uranium by an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^{-} + CO_3^{-2} \longrightarrow 2\,RCl + UO_2(CO_3)_2^{-2}$$

After the uranium has been stripped from the resin, the resin is rinsed with a solution containing sodium bicarbonate. This rinse removes the high chloride eluent physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

Table 1-2: Typical Lixiviant Concentrations

SPECIES	RANGE	
	Low	High
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12000
pH	≤ 6.5	10.5

* All values in mg/l except pH (units).

NOTE: The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in "injection fluid".

When a sufficient volume of pregnant eluent is held in storage, it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

Sodium hydroxide (NaOH) is then added to raise the pH to a level conducive for precipitating pure crystals.

Hydrogen peroxide is then added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide is further dewatered and washed. The solids discharge is either sent to the vacuum dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

1.3.2.2 Central Plant, Satellite Plant, Wellfields, and Chemical Storage Facilities – Equipment Used and Material Processed

The uranium recovery process described in the preceding section will be accomplished in two steps. The uranium recovery from the leach solution by ion exchange will be performed at the North Trend Satellite Plant. The subsequent processing of the loaded ion exchange resin to remove the uranium (elution), the precipitation of uranium, and the dewatering and packaging of solid uranium (yellowcake) will be performed at the existing central plant. The capacity for resin handling and cleaning, elution, precipitation, dewatering and washing, and drying in the central plant will be increased appropriately to handle the processing of material from the North Trend Expansion Area in addition to the material that will continue to be produced in the current license area. Depending upon the mining schedules for the existing wellfield and the North Trend Expansion area, it is possible that the belt filter and dryer capacity may be increased.

1.3.2.2.1 North Trend Satellite Plant Equipment

Only the equipment proposed for the North Trend Satellite Plant is described in this section. The equipment and processes in the central plant are covered under the existing USNRC Source Materials License Number SUA-1534. A general arrangement for the Satellite Plant is shown on Figure 1-20. The North Trend Satellite Plant facilities will be housed in a building approximately 130 feet long by 100 feet wide. The satellite plant equipment includes the following systems:

- Ion exchange;
- Filtration;
- Resin transfer; and
- Chemical addition.

The North Trend Satellite Plant will be located within a 30 acre fenced area in the E½ of the NW¼, Section 27, T32N, R52W. This area will also contain the evaporation ponds, deep disposal well, and chemical storage areas. Figure 1-21 shows the plan view of these facilities.

The satellite plant will house the ion exchange (IX) columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, a small laboratory and an employee break room. Bulk soda ash and carbon dioxide and oxygen in compressed form and/or hydrogen peroxide will be stored adjacent to the satellite plant or in the wellfield. Sodium bicarbonate and/or gaseous carbon dioxide are added to the lixiviant as the fluid leaves the satellite plant for the wellfields. Gaseous oxygen is added to the injection line for each injection well at the wellhouses.

The ion exchange system consists of eight fixed bed ion exchange columns. The ion exchange columns will be operated as three sets of two columns in series with two columns available for restoration. The ion exchange system is designed to process recovered leach solution at a rate of 4,500 gpm with each column sized at 11.5 foot diameter by 21 foot overall height with 500 cubic feet of resin operated downflow. Once a set of columns is loaded with uranium, the resin is transferred to a truck for transport to the central plant at the Crow Butte facility.

After the ion exchange process, the barren leach solution recovered from the wellfield is replenished with an oxidant and leaching chemicals. The injection filtration system consists of optional backwashable filters, with an option of installing polishing filters downstream. The lixiviant injection pumps are centrifugal type.

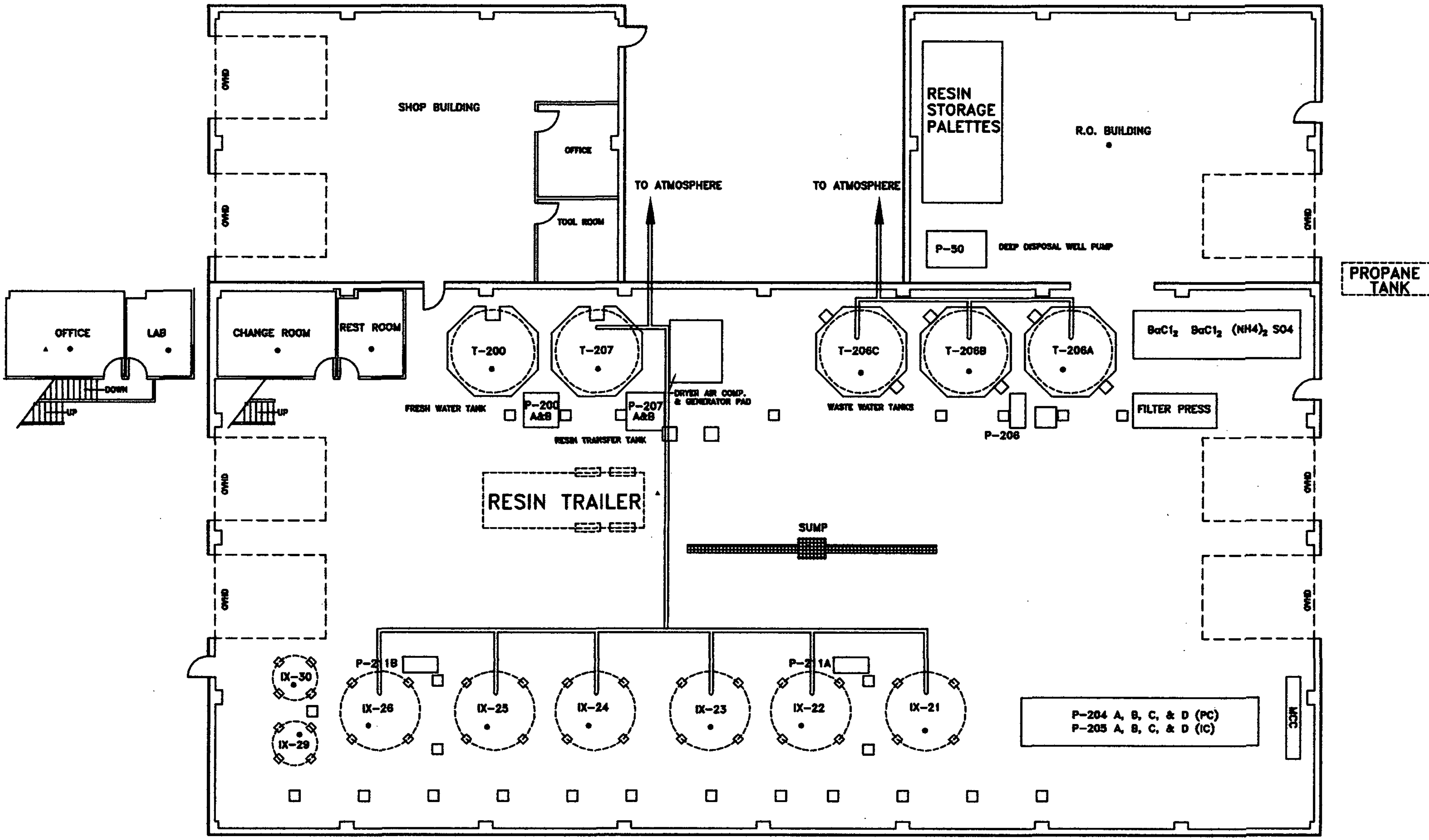


Figure 1-20

LEGEND

▲ RADON TESTING LOCATIONS

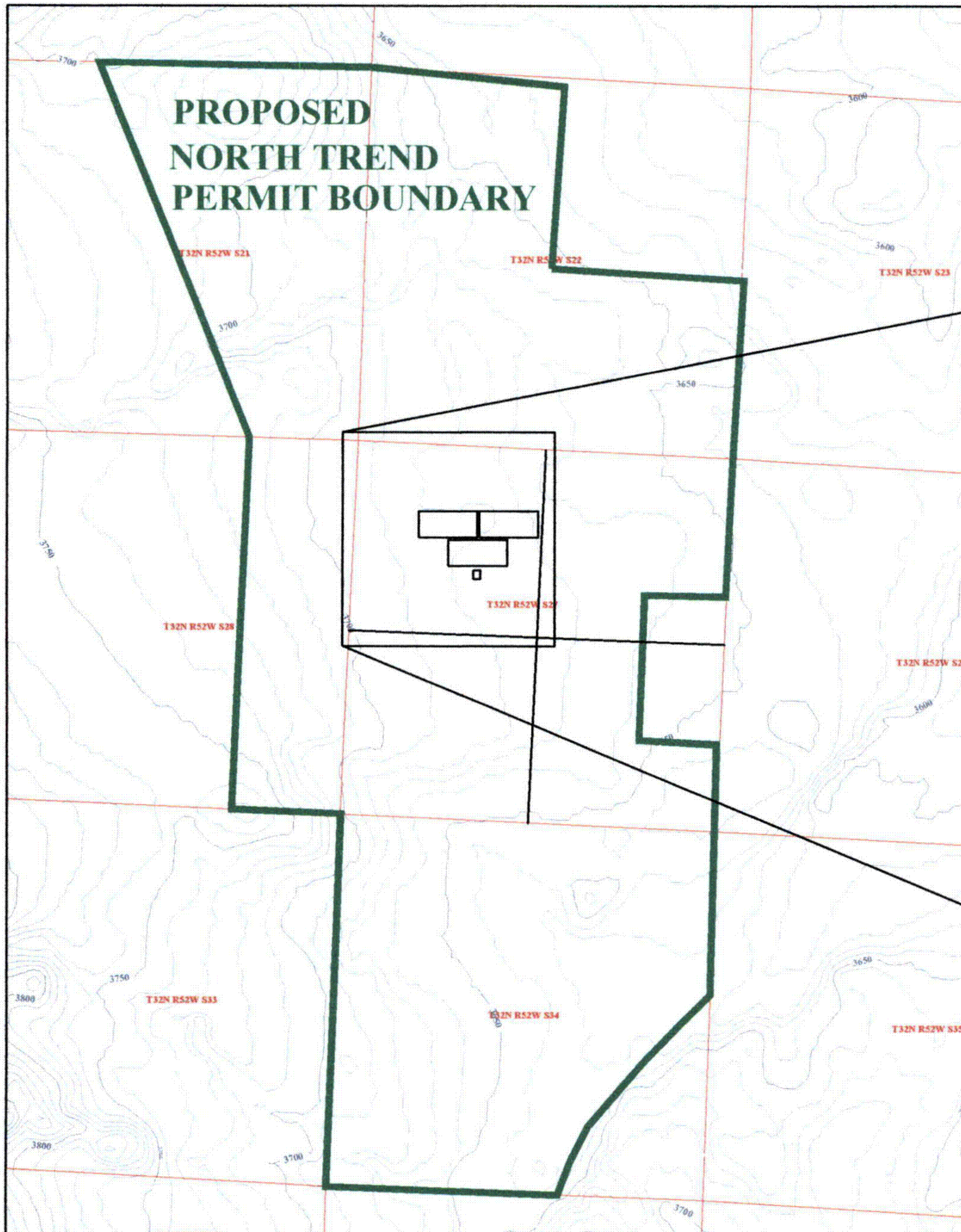
● GAMMA SURVEY LOCATIONS

0 20 40

CROW BUTTE RESOURCES

NORTH TREND OPERATION
GENERAL SATELLITE
LAYOUT

CROW BUTTE RESOURCES, INC.
License Amendment Application
North Trend Expansion Area



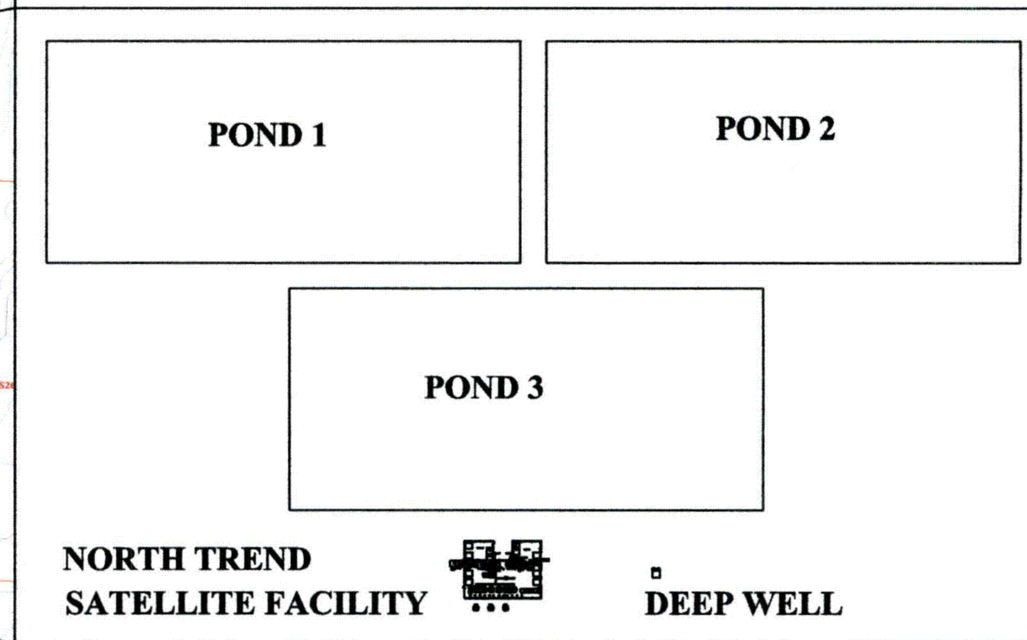


FIGURE 1-21

CROW BUTTE RESOURCES, INC.

General Arrangement
Satellite Plant
Plan View

1.3.2.2.2 Chemical Storage Facilities

Chemical storage facilities at the North Trend Satellite Plant will include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored. Other non-hazardous bulk process chemicals (e.g., sodium carbonate) that do not have the potential to impact radiological safety may be stored within the satellite facilities.

Process-related chemicals stored in bulk at the North Trend Satellite Plant will include carbon dioxide, oxygen, and or hydrogen peroxide. Sodium sulfide may also be stored for use as a reductant during groundwater restoration.

- Carbon Dioxide

Carbon dioxide is stored adjacent to the satellite plant where it will be added to the lixiviant prior to leaving the satellite plant.

- Oxygen

Oxygen is also typically stored at the satellite plant, or within wellfield areas, where it is centrally located for addition to the injection stream in each wellhouse. Since oxygen readily supports combustion, fire and explosion are the principal hazards that must be controlled. The oxygen storage facility will be located a safe distance from the satellite plant and other chemical storage areas for isolation. The storage facility will be designed to meet industry standards in NFPA-50.

Oxygen service pipelines and components must be clean of oil and grease since gaseous oxygen will cause these substances to burn with explosive violence if ignited. All components intended for use with the oxygen distribution system will be properly cleaned using recommended methods in CGA G-4.1. The design and installation of oxygen distribution systems is based on CGA-4.4.

The design location of the carbon dioxide and oxygen storage tanks are shown on Figure 1-20.

- Sodium Sulfide

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., sodium sulfide or hydrogen sulfide gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Sodium sulfide is currently used as the chemical reductant during ground-

water restoration at the current license area. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. Hydrogen sulfide gas has never been used at the Crow Butte Uranium Project. In the event that CBR determines that use of hydrogen sulfide as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the EHSMS Program, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system at the central plant (see Figure 1-22) has a maximum capacity of approximately 6,000 gals. Strict unloading procedures are utilized to ensure that safety controls are in place during the transfer of hydrochloric acid. Process safety controls are also in place at the central plant where hydrochloric acid is added to the precipitation circuit. Since precipitation will not be performed at the satellite facility, the use and storage of concentrated hydrochloric acid will not be necessary in this area.

None of the hazardous chemicals used at the Crow Butte Uranium Project are covered under the EPA's Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

Non-process related chemicals that will be stored at the North Trend Satellite Plant include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the satellite plant. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet EPA requirements.

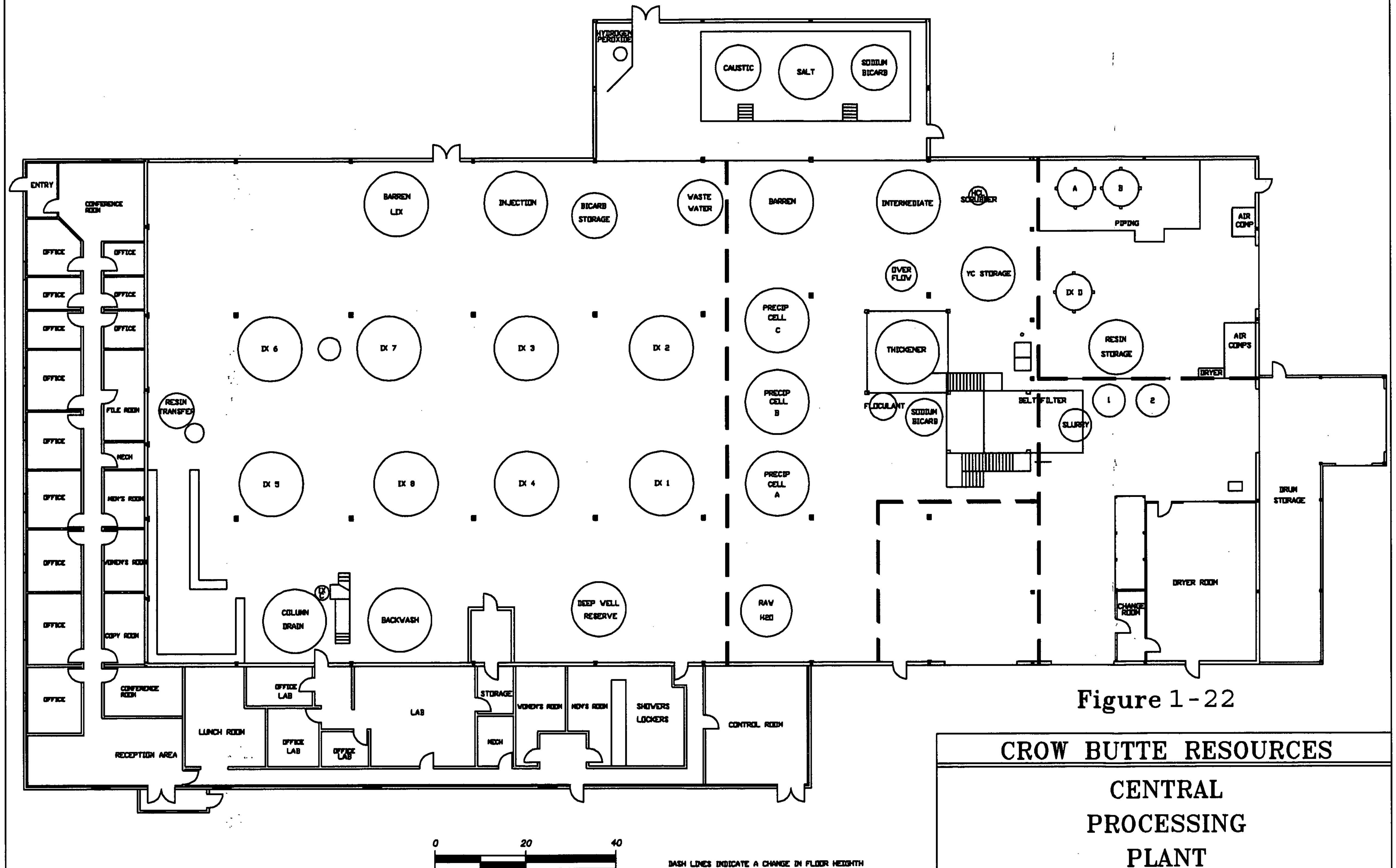


Figure 1-22

CROW BUTTE RESOURCES

CENTRAL PROCESSING PLANT

1.3.2.3 Instrumentation and Control

Wellfield instrumentation will be provided to measure total production and injection flow. In addition, instrumentation will be provided to indicate the pressure which is being applied to the injection wells. Wellfield houses will be equipped with wet building alarms to detect the presence of liquids in the wellfield house sumps.

Instrumentation will be provided to monitor the total flow into the satellite facility, the total injection flow leaving the plant, and the total waste flow leaving the plant. Instrumentation will be provided on each injection and production well to record an alarm in the event of a change in flow that might indicate a leak or rupture in the system. The injection pumps will be sized or equipped so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines or the maximum pressure to be applied to the injection wells.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks.

1.3.2.4 Gaseous and Airborne Particulate Control

This section describes the gaseous effluent control systems that will be installed in the North Trend Satellite Facility.

1.3.2.4.1 Tank and Process Vessel Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks. Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. The design of the fans will be such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Regulatory Guide 8.31. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the satellite plant.

A tank ventilation system of this type is utilized in the central plant. Operational radiological in-plant monitoring for radon concentrations has proven this system to be an effective method for minimizing employee exposure.

1.3.2.4.2 Work Area Ventilation System

The work area ventilation system will be designed to force air to circulate within the satellite plant process areas. The ventilation system will exhaust outside the building, drawing fresh air in. During favorable weather conditions, open doorways and convection vents in the roof will assist in providing satisfactory work area ventilation. The design of the ventilation system will be adequate to ensure that radon daughter concentrations in the facility are maintained below 25 percent of the derived air concentration (DAC) from 10 CFR Part 20.

1.3.2.5 Liquid Waste

1.3.2.5.1 Sources of Liquid Waste

As a result of in-situ leach mining, there are several sources of liquid waste. The potential wastewater sources that exist at the North Trend Satellite Facility will be similar to those currently generated and managed at the central process plant. These sources of wastewater include the following:

- Water Generated During Well Development

This water is recovered groundwater and has not been exposed to any mining process or chemicals; however, the water may contain elevated concentrations of naturally-occurring radioactive material if the development water is collected from the mineralized zone. The water will be discharged directly to the solar evaporation pond and silt, fines and other natural suspended matter collected during well development will settle out in the pond. Well development water may also be treated with filtration and/or reverse osmosis and used as plant make-up water or disposed of in the deep well.

- Liquid Process Waste

The operation of the satellite facility results in one primary source of liquid waste, a production bleed as previously discussed. This bleed will be routed to either the deep disposal well or an evaporation pond.

- Aquifer Restoration Waste

Following mining operations at North Trend, restoration of the affected aquifer commences, which results in the production of wastewater. The current groundwater restoration plan consists of four activities:

1. Groundwater Transfer;
2. Groundwater Sweep;
3. Groundwater Treatment; and,
4. Wellfield Circulation.

Only the groundwater sweep and groundwater treatment activities will generate wastewater. During groundwater sweep, water is extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A reverse osmosis (RO) unit will be used to reduce the total dissolved solids (TDS) of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the waste disposal system. The brine is sent to the wastewater disposal system.

- Stormwater Runoff

Stormwater may be contaminated by contact with industrial materials. Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater National Pollutant Discharge Elimination System (NPDES) permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 requires that procedural and engineering controls be implemented such that runoff will not pose a potential source of pollution.

- Domestic Liquid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal when the systems are designed, maintained, and operated properly. CBR currently maintains a Class V UIC Permit issued by the NDEQ

for operation of the septic system at the current license area. A similar permit will be required for the North Trend Satellite Facility.

1.3.2.5.2 Liquid Waste Disposal

Two methods of disposal are proposed for the North Trend Satellite Facility:

- Deep Disposal Well

CBR has operated the deep disposal well at the current license area for over ten years with excellent results and no serious compliance issues. CBR expects that the liquid waste stream at the North Trend Satellite Facility will be chemically and radiologically similar to the waste disposed of in the current deep disposal well.

CBR plans to install a deep disposal well at the North Trend Satellite Facility as the primary liquid waste disposal method. CBR has found that permanent deep disposal is preferable to evaporation in evaporation ponds. All compatible liquid wastes at the North Trend Satellite Facility will be disposed of in the planned deep well. At the time of preparation of this amendment request and ER, a permit application is under preparation for submittal to the NDEQ for a Class I UIC Permit for the North Trend Satellite Facility.

- Evaporation Pond

Evaporation pond design, installation and operation criteria are those found in USNRC Regulatory Guide 3.11. The evaporation pond configuration at the North Trend Facility will be similar to the existing ponds at the current CBR license area. The exact number and capacity of the ponds will depend upon the performance of the deep disposal well as far as waste water disposal rate.

Each pond will have the capability of being pumped to a water treatment plant before disposal. A variety of treatment options exist depending upon the specific chemical contaminants identified in the wastewater. In general, a combination of chemical precipitation and reverse osmosis is adequate to treat the water to a quality that falls well within NPDES criteria.

As noted in Section 3.12, CBR currently maintains three commercial and two R & D evaporation ponds in the current license area. The current pond inspection program is based on NRC recommendations in Regulatory Guide 3.11.1 and will be implemented for the North Trend evaporation ponds.

1.3.2.6 Solid Waste

Solid waste generated at the North Trend Satellite site is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste will be segregated based on whether it is clean or has the potential for contamination with 11(e).2 byproduct materials.

1.3.2.6.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include trash, piping, valves, instrumentation, equipment and any other items which are not contaminated or which may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Section 5 of the Technical Report. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

1.3.2.6.2 11(e).2 Byproduct Material

Solid 11(e).2 byproduct waste consists of solid waste contaminated with 11e.(2) byproduct material that cannot be decontaminated.

11(e).2 byproduct material generated at ISL facilities consists of filters, personal protective equipment (PPE), spent resin, piping, etc. These materials will be stored on site until such time that a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility. CBR currently maintains an agreement for waste disposal at a properly licensed facility as a license condition for SUA-1534. CBR is required to notify NRC in writing within 7 days if the disposal agreement expires or is terminated and to submit a new agreement for NRC approval within 90 days of the expiration or termination.

If decontamination is possible, records of the surveys for residual surface contamination will be made prior to releasing the material. Decontaminated materials have activity levels lower than those specified in NRC guidance. An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

1.3.2.6.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. Disposal of

solid materials collected in septic systems must be performed by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124.

1.3.2.6.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128. Based on waste determinations conducted by CBR, as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator (CESQG). To date CBR only generates universal hazardous wastes such as spent waste oil and batteries. CBR estimates that the proposed North Trend Satellite Facility would produce approximately 800 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in EHSMS Program Volume VI, *Environmental Manual,* to control and manage these types of wastes.

1.3.2.7 Security

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in Volume VIII, *Emergency Manual.* Crow Butte Resources, Inc. (CBR) is committed to:

- Providing employees with a safe, healthful, and secure working environment;
- Maintaining control and security of NRC licensed material;
- Ensuring the safe and secure handling and transporting of hazardous materials; and,
- Managing records and documents that may contain sensitive and confidential information.

The NRC requires licensees to maintain control over licensed material (i.e., natural uranium ("source material") and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, *Storage and Control of Licensed Material*, requires the following:

§20.1801 Security of Stored Material

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material not in Storage

> The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored material at the Crow Butte Uranium Project would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded ion exchange resin removed from the restricted area for transfer to other areas. At the North Trend Expansion Area, stored material would typically include ion exchange resin and byproduct waste awaiting disposal.

1.3.2.7.1 License Area and Plant Facility Security

- Central Plant Facility Area

The active mining areas are controlled with fences and appropriate signs. All central plant facility areas where source or byproduct material is handled are fenced. The main access road is equipped with a locking gate. Strategically placed surveillance cameras monitor the access road and areas around the central plant facility. A 24-hour per day 7-day per week staff is on duty in the central plant facility.

Central plant operators perform an inspection to ensure the proper storage and security of licensed material at the beginning of each shift. The inspection determines whether all licensed material is properly stored in a restricted area or, if in controlled or unrestricted areas, is properly secured. In particular, operators ensure that loaded ion exchange resin, slurry, drummed yellowcake, and byproduct material is properly secured. If licensed material is found outside a restricted area, the operator will ensure that it is secured, locked, moved to a restricted area, or kept under constant surveillance by direct observation by site personnel or surveillance cameras. The results of this inspection will be properly documented.

- Office Building

There is a reception area located at the main entrance into the office building. All other entrances are locked during off-shift hours. There are a limited number of traceable keys to the office and they are given out to select employees. The main door and the door to the central plant facility entrance are also equipped with an access keypad.

Visitors entering the office are greeted by the receptionist and announced to the receiving person. All visitors are required to sign the access log and indicate the purpose of their visit and the employee to be visited. The person being visited is responsible to supervise the visitors at all times when they are on site. Visitors are only allowed at the facility during regular working hours unless prior approval is obtained from the Mine Manager or the Manager of Health, Safety, and Environmental Affairs.

1.3.3 North Trend Security

The entrance to the North Trend Expansion Area site will be from a gravel road to the south of the facility. The entrance to the site will be posted indicating that permission is required prior to entry. A gate on the access route will be capable of being locked. The satellite plant site within the license area will be properly posted in accordance with 10 CFR § 20.1902 (e). Evaporation ponds will be fenced and posted. All visitors entering the restricted areas on the North Trend Expansion Area site will be required to register at the plant office and will not be permitted inside the plant or wellfield areas without proper authorization. Inexperienced visitors will be escorted unless they are frequent visitors who have been instructed regarding the potential hazards in various site areas.

The plant will routinely operate 24 hours per day and 7 days per week, so CBR employees will normally be on-site except for occasional shutdowns. The Satellite Plant structure will be equipped with locks to prevent unauthorized access. All plant personnel are instructed to immediately report any unauthorized persons to their supervisors. The supervisor will contact the reported unauthorized person and make sure that they have been authorized for entry. If the person is unauthorized, and has no business on the property, they will be escorted to the main entrance for departure.

1.3.3.1.1 Transportation Security

CBR routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. Department of Transportation (DOT). In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, *Security Plans*, requires that persons that offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

§172.800(b)(4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;

§172.800(b)(5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required for that class under the provisions of subpart F of this part;

§172.800(b)(7) A quantity of hazardous material that requires placarding under the provisions of subpart F of this part.

DOT requires that security plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must take measures to provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by CBR employees will generally be restricted to moving ion exchange resin from a satellite facility to the central plant facility or transferring contaminated equipment between company facilities. This transport generally occurs over short distances through remote areas. Therefore, the potential for a security threat during transport by CBR vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel;
- Providing the means and methods of protecting the drivers, vehicles, and customer's cargo while on the road; and
- Establishing consistent security guidelines and procedures that shall be observed by all personnel.

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators;
- Off site tractors will always be secured when left unattended with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle;
- The unit is to be kept visible by an employee at all times when left unattended outside a restricted area.

The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel are expected to be knowledgeable of, and adhere to, these guidelines and procedures when performing any load-related activity.

1.3.3.2 Contamination Control Program

CBR will perform surveys for surface contamination in operating and clean areas of the North Trend Satellite Plant in accordance with the guidelines contained in USNRC Regulatory Guide 8.30. Surveys for total alpha contamination in clean areas will be conducted weekly. In designated clean areas, such as lunchrooms, offices, change rooms, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination that exceeds 250 dpm/100 cm^2 (25% of the removable limit) a smear survey must be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 dpm/100 cm^2, the area will be promptly cleaned and resurveyed.

All personnel leaving the restricted area will be required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area, such as in the wellfields, will be required to monitor themselves prior to leaving the area. All personnel will receive training in the performance of surveys for skin and personal contamination. All contamination on skin and clothing is considered removable, so the limit of 1,000 dpm/100 cm^2 is applied to personnel monitoring. Personnel will also be allowed to conduct contamination monitoring of small, hand-carried items for use in wellfield and controlled areas as long as all surfaces can be reached with the instrument probe and the item does not originate in yellowcake areas. All other items are surveyed as described below.

The RSO, the radiation safety staff, or properly trained employees perform surveys of all items from the restricted areas with the exception of small, hand-carried items described above. The release limits are set by *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses For Byproduct or Source Materials"*, USNRC, May 1987.

Surveys are performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.

2. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.

3. Swipes for removable contamination surveys as required.

Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use with other checks performed weekly.

As recommended in USNRC Regulatory Guide 8.30, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. A spot check of the employees assigned to the North Trend Satellite Plant site will be conducted, concentrating on plant operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

The contamination control program for the North Trend Satellite Plant will be implemented in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.*

1.4 APPLICABLE REGULATORY REQUIREMENTS, PERMITS, AND REQUIRED CONSULTATIONS

1.4.1 Environmental Approvals for the Current Licensed Area

As discussed previously, this is an amendment application for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1998. All other required permits for the existing Crow Butte Uranium Project have been obtained and maintained since that time. A summary of the relevant permits and authorizations for the current license area is given in Table 1-3.

Table 1-3: Environmental Approvals for the Current License Area

Issuing Agency	Permit Description
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, Nebraska 68509-8922	Underground Injection Control Class III Authorization NE0122611 Approved: April 24, 1990
	Aquifer Exemption Approval Effective: March 23, 1984
	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 Renewed: October 1, 2006
	Mineral Exploration Permit NE0209317 Approved: June 3, 2003
	Underground Injection Control Class V Authorization NE0207388 Approved: November 6, 2000
	Evaporation Pond Design Approved: July 21, 1988
	Construction Stormwater NPDES General Permit NER100000 Authorization # NER105203 Approved: December 19, 2006
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, Nebraska 68509-4676	Industrial Ground Water Permit I-2 Approved: August 7, 1991
Nebraska Department of Health and Human Services Regulation and Licensure PO Box 95007 Lincoln, Nebraska 68509-5007	Class IV Public Water Supply Permit NE3121024 Approved: April 12, 2002
U.S. Nuclear Regulatory Commission Washington, DC 20555	Source Materials License SUA-1534 Issued: December 29, 1989 Renewed: February 28, 1998
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW, Washington, DC 20460	Aquifer Exemption Approval Effective: June 22, 1990

1.4.2 Environmental Approvals and Consulatations for the Proposed North Trend Expansion Area

1.4.2.1 Environmental Approvals and Permits

The North Trend Expansion Area will be subject to similar permitting requirements as the current Crow Butte Uranium Project. Table 1-4 contains a summary list of the type of permit or authorization, the granting authority, and the status.

1.4.2.2 Environmental Consultations

During the course of the preparation of this license amendment application, consultations were conducted with several agencies:

1.4.2.2.1 Ecological Resources

Preparation of the ecological resources discussion (Sections 3.5 and 4.5) required consultations with the following individuals and agencies:

- S. Anschutz, Nebraska Field Supervisor, U.S. Dept. of Interior, Fish and Wildlife Service, Grand Island, NE;
- M. Fritz, Raptor Biologist, Nebraska Game and Parks Commission. Lincoln, NE;
- K. Hams, Big Game Biologist, Nebraska Game and Parks Commission, Lincoln, NE;
- D. Ferraro, Herpetologist, University of Nebraska, Lincoln, NE;
- J. Godberson, Environmental Analyst Supervisor, Nebraska Game and Parks Commission, Lincoln, NE; and
- T. Nordeen, Biologist, Nebraska Game and Parks Commission, Alliance, NE.

1.4.2.2.2 Archeological Resources

Preparation of the historical and cultural resources discussion (Sections 3.8 and 4.8) required consultations with the following individuals and agencies:

- Steinacher, Terry, and L. Robert Puschendorf, Nebraska State Historic Preservation Officer.

1.4.2.2.3 Socioeconomic References

Preparation of the socioeconomic resources discussion (Sections 3.10 and 4.10) required consultations with the following individuals and agencies:

- T. Vogl, School Clerk, Crawford Public Schools.

Table 1-4: Environmental Approvals for the Proposed North Trend Expansion Area

Issuing Agency	Description	Status
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, Nebraska 68509-8922	Underground Injection Control Class III Permit (NDEQ Title 122)	Class III UIC Permit application under preparation; expected submittal to NDEQ in second quarter 2007
	Aquifer Exemption (NDEQ Title 122)	Aquifer exemption application under preparation; expected submittal to NDEQ in second quarter 2007
	Underground Injection Control Class I (NDEQ Title 122)	Class I UIC Permit application under preparation; expected submittal to NDEQ in third quarter 2007
	Industrial Stormwater NPDES Permit (NDEQ Title 119)	An Industrial Stormwater NPDES may not be required for a satellite facility depending on processes included and the final facility design.
	Construction Stormwater NPDES Permit (NDEQ Title 119)	Construction Stormwater NPDES authorizations are applied for and issued annually under a general permit based on projected construction activities. The Notice of Intent will be filed at least 30 days before construction activities begin in accordance with NDEQ requirements.
	Mineral Exploration Permit (NDEQ Title 135)	Mineral Exploration Permit NE0209317 Approved: June 3, 2003
	Underground Injection Control Class V (NDEQ Title 122)	The Class V UIC permit will be applied for following installation of an approved site septic system during facility construction.
	Evaporation Pond Design	The evaporation pond design will be submitted follow final facility design

Table 1-4: Environmental Approvals for the Proposed North Trend Expansion Area

Issuing Agency	Description	Status
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, Nebraska 68509-4676	Industrial Ground Water Permit (NDNR Title 456)	The Industrial Groundwater Permit application will be prepared for submittal to the NDNR; expected in the fourth quarter 2007
U.S. Nuclear Regulatory Commission Washington, DC 20555	Amendment to Source Materials License SUA-1534 (10 CFR 40)	The License Amendment for the North Trend Expansion Area will be submitted during the second quarter, 2007
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW, Washington, DC 20460	Aquifer Exemption (40 CFR 144, 146)	Aquifer exemption application forwarded to EPA following NDEQ action

2 ALTERNATIVES

2.1 NO-ACTION ALTERNATIVE

2.1.1 Summary of Current Activity

Crow Butte Resources, Inc. (CBR) currently operates the Crow Butte Uranium Project, a commercial in-situ leach (ISL) uranium mining operation located approximately 4 miles southeast of Crawford in Dawes County, Nebraska. Operation is allowed under USNRC Source Materials License SUA-1534.

A research and development (R&D) facility was operated in 1986 and 1987. Construction of the commercial process facility began in 1988, with production beginning in April of 1991. The total original license area is 3,300 acres and the surface area to be affected by the current commercial project will be approximately 1,100 acres. Facilities include the R&D facility, the commercial process facility and office building, solar evaporation ponds, parking, access roads and wellfields.

In the current license area, uranium is recovered by in-situ leaching from the Chadron Sandstone at a depth that varies from 400 feet to 800 feet. The overall width of the mineralized area varies from 1000 feet to 5000 feet. The ore body ranges in grade from less than 0.05% to greater than 0.5% U_3O_8, with an average grade estimated at 0.27% U_3O_8. Production is currently in progress in Mine Units 5 through 9. Groundwater restoration has been completed and received regulatory approval in Mine Unit 1. Groundwater restoration is currently underway in Mine Units 2 through 4.

The current extraction plant is operating with a licensed flow rate of 5,000 gpm. Maximum allowable throughput from the plant under SUA-1534 is currently 2,000,000 pounds of U_3O_8 per year.

2.1.2 Impacts of the No-Action Alternative

The no-action alternative would still allow CBR to continue mining operations in the current license area. Based on current plans and mining schedules discussed in Section 1, CBR could continue production at the present levels until 2012 when reserves would begin to deplete. CBR estimates that by 2014, production in the current license area would decrease to the point where commercial production would no longer be economical and would be discontinued. Restoration and reclamation activities would become the primary activities.

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

In addition to the loss of significant employment opportunities in Crawford and Dawes County, the premature closing of the Crow Butte Uranium Project before commercially-viable resources had been recovered would adversely affect the economic base of Dawes County. As discussed in further detail in Section 3, the Crow Butte Project currently provides a significant economic impact to the local Dawes County economy as shown in Table 2-1.

Table 2-1
Current Economic Impact of Crow Butte Uranium Project and Projected Impact from North Trend Expansion Area

	Current Crow Butte Operation Annual Economic Impact	Estimated Annual Economic Impact Due to North Trend Expansion Area
Employment		
Full Time Employees	52	+ 10 to 12
Full Time Contractor Employees	20	+ 4 to 7
Part Time Employees and Short Term Contractors	7	+ 10 to 15 (Satellite Construction)
CBR Payroll, 2006	$2,543,000	+ $400,000 to $480,000
Taxes		
Property Taxes	$627,000	-
Sales and Use Taxes	$238,000	-
Severance Taxes	$545,000	-
Total Taxes	$1,410,000	+ $1,000,000 to $1,200,000
Local Purchases		
Local Purchases, 2006 (est.)	$5,000,000	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts		
	$8,953,000	**+ $5,050,000 to $6,030,000**

If this amendment request is denied, the negative impact on the Dawes County economy would be felt as early as 2010 when employment levels for drilling and construction activities would be cut and purchases of services and materials would diminish. The potential positive economic impact to the local economy as discussed in Section 4.10 (and shown in Table 2-1) from construction and operation of the North Trend Expansion Area would be avoided.

A decision to not amend SUA-1534 to allow mining in the North Trend Expansion Area would leave a large resource unavailable for energy production supplies. Although CBR is continuing to develop estimates of the reserves at North Trend, the current estimated recoverable resource is 2,000,000 pounds U_3O_8.

In 2005, total domestic U.S. uranium production was approximately 3 million pounds U_3O_8, of which over 800,000 pounds (or approximately 27 percent) was produced at the Crow Butte Project. During the same year, domestic U.S. uranium consumption was approximately 66 million pounds U_3O_8 with approximately 17% supplied by domestic producers. The Crow Butte Project (including the North Trend Expansion Area) represents an important source of new domestic uranium supplies that are essential to provide a continuing source of fuel to power generation facilities.

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

Denial of the amendment request would have an adverse economic effect on the individuals that have surface leases with CBR and own the mineral rights in the North Trend Expansion Area.

2.2 PROPOSED ACTION

The proposed North Trend Expansion Area contains a licensed area of approximately 2,110 acres. Of this potential licensed area, the surface area to be affected by mining operations will be approximately 1,310 acres for the satellite plant and facilities including the wellfields. The North Trend Satellite Plant will be located within a 30-acre fenced area in the E½ of the NW¼ , Section 27, T32N, R52W. This area will also contain the evaporation ponds, deep disposal well and chemical storage areas.

The North Trend Expansion Area will be developed and operated by CBR. All land within the proposed license boundary of the North Trend Expansion Area is privately owned. CBR has obtained surface and mineral leases from the appropriate landowners.

Commercial production at the Crow Butte Project, including the proposed North Trend Expansion Area, is expected to extend over the next ten years with depletion of the uranium reserves at both areas by 2017. Aquifer restoration and reclamation will be done concurrent with operations, plus an additional five years at the end of the project for final decommissioning activities and surface reclamation. More detailed schedules were provided in Section 1.

The current CBR operation recovers uranium from the Chadron Sandstone. In the North Trend Expansion Area, uranium will also be recovered from the Chadron Sandstone. The depth in the North Trend Expansion Area ranges from 400 to 800 feet. The width varies from 100 feet to 1,000 feet.

The North Trend satellite plant process facilities will be housed in a building approximately 130 feet long by 100 feet wide. The proposed satellite plant equipment will include the following systems:

- Ion exchange;
- Filtration;
- Resin transfer; and,
- Chemical addition.

The in-situ process consists of an oxidation step and a dissolution step. The oxidants utilized in the facility are hydrogen peroxide and/or gaseous oxygen. A sodium bicarbonate lixiviant is used for the dissolution step.

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

- Loading of uranium complexes onto an ion exchange resin;
- Reconstitution of the solution by the addition of sodium bicarbonate and oxygen;
- Shipment of loaded ion exchange resin to the current central processing plant; and
- *Restoration of groundwater following mining activities.*

The North Trend satellite plant will be designed for a maximum flow rate, excluding restoration flow, of 4,500 gpm. Uranium-bearing resin will be transferred to the CBR central processing plant for elution and packaging of yellowcake.

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

Groundwater restoration activities consist of four steps:

- Groundwater transfer;
- Groundwater sweep;
- Groundwater treatment; and,
- Aquifer recirculation.

Groundwater restoration will take place concurrently with development and production activities. The goal of the groundwater restoration is to return the water quality of the affected zone to a chemical quality consistent with baseline conditions or, as a secondary goal, to the quality level specified by the Nebraska Department of Environmental Quality (NDEQ).

Following groundwater restoration activities, all injection and recovery wells will be reclaimed using appropriate plugging and abandonment procedures. In addition, a sequential land reclamation and revegetation program will be implemented on the site. This reclamation will be performed on all disturbed areas, including the plant, wellfields, ponds, and roads.

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

The environmental impacts of the requested action will be minimal as discussed in Section 4. The only radiological air impacts will be from the release of radon gas during production. The release of radon will be minimized by the use of pressurized downflow ion exchange columns. In addition, radon gas quickly dissipates in the atmosphere and results in a minimal additional exposure to the public as discussed in Section 4. All drying and packaging will be performed at the central processing plant using a vacuum drying system, so there are no additional radioactive air particulate releases.

In situ leach (ISL) mining of uranium alters the geochemistry and the water quality in the mining zone. CBR has proven in the current licensed area that impacts to groundwater can be controlled through stringent well construction techniques, wellfield operating methodologies that minimize excursions, and the use of best practicable technologies to restore the groundwater to premining baseline or class of use after mining activities are complete.

Mitigation measures are discussed in detail in Section 5.

The impacts discussed in Section 4 include short-term and long-term impacts; however, it should be noted that ISL mining techniques allow the entire mine site to be decommissioned and returned to unrestricted use within a relatively short time.

2.3 REASONABLE ALTERNATIVES

2.3.1 Process Alternatives

2.3.1.1 Lixiviant Chemistry

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

2.3.1.2 Groundwater Restoration

The restoration of the R&D project, the successful completion of restoration in Mine Unit 1, and the current restoration activities in Mine Units 2 through 4 at the current licensed Crow Butte site exhibit the effectiveness of the restoration methods, in which groundwater sweep, permeate/reductant injection, and aquifer recirculation restored the groundwater to pre-mining quality. No feasible alternative groundwater restoration method is currently available for the Crow Butte project. The NRC and NDEQ consider the method currently employed as the Best Practicable Technology (BPT) available.

2.3.1.3 Waste Management

Liquid wastes generated from production and restoration activities are handled by one of three methods: solar evaporation ponds, deep disposal well injection, or land application. All three methods are permitted at the current operation; however, only solar evaporation ponds and deep disposal have been used to date. The use of deep waste disposal wells in conjunction with storage/evaporation ponds to dispose of the high total dissolved solids (TDS) liquid wastes that primarily result from the yellowcake processing and drying facilities is considered the best alternative to dispose of these types of wastes. The North Trend deep disposal well would be completed at an approximate depth of 3,500 to 4,000 feet, isolated from any underground source of drinking water by approximately 2,500 feet of shale (Pierre and Graneros Shales). These discharges must be authorized by the State of Nebraska under a Class I UIC Permit to receive such wastes. CBR considered and rejected using land application as a disposal method at North Trend due to required treatment and monitoring costs and potential environmental impacts from a surface discharge.

Alternative pond design and locations for the North Trend satellite plant have also been considered. The current design is such that any seepage of toxic materials into the subsurface soils or hydrologic system would be prevented.

All solid wastes are transported from the site for disposal. Non-contaminated waste is shipped to an approved sanitary landfill. Contaminated wastes are shipped to a NRC-approved facility for disposal. Should a NRC- (or Agreement State) licensed disposal facility not be available to CBR at the time of decommissioning, the alternative of on-site burial may be necessary. This alternative could incur long-term monitoring requirements and more expensive reclamation costs. At this time, CBR believes that off-site disposal of 11(e)2 byproduct material from North Trend at a licensed disposal facility is the best alternative.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED

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

2.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to solution mining for the uranium deposits in the project area. Neither of these methods is

economically viable for producing the North Trend reserves at this time. These alternative methods are not economically feasible for several reasons including the spatial characteristics of the mineral deposit and environmental factors. The depth of the deposit and subsequent overburden ratio makes surface mining impractical. Surface mining is commonly undertaken on large, shallow (less than 300 feet) ore deposits. At the North Trend Expansion Area, uranium is recovered from depths ranging from 400 to 800 feet.

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

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

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

In a comparison of the overall impacts of in situ leaching of uranium compared with conventional mining, an NRC evaluation concluded that environmental and socioeconomic advantages of in-situ leaching include the following:

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

2. No mill tailings are produced and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by in-situ leaching is generally less than 1% of that produced by conventional milling methods (more than 948 kg (2090 lb) of tailings usually result from processing each metric ton (2200 lb) of ore.

3. Because no ore and overburden stockpiles or tailings pile(s) are created and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.

4. The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5% of the radium in an ore body is brought to the surface when in-situ leaching methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings and the potential for radiation exposure is significantly less than that associated with conventional mining and milling.

5. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.

6. Solution mining results in significantly less water consumption than conventional mining and milling.

7. The socioeconomic advantages of in situ leaching include:

   - The ability to mine a lower grade ore;
   - A lower capital investment;
   - Less risk to the miner;
   - Shorter lead time before production begins; and,
   - Lower manpower requirements.

Finally, and perhaps most importantly, since Crow Butte is now an established commercial solution mining site, there are no viable alternative mining methods at this time. The current market price of uranium makes an established solution mining operation the most economically viable method of mining uranium at North Trend at this time.

2.5 CUMULATIVE EFFECTS

2.5.1 Cumulative Radiological Impacts

On October 17, 2006, CBR submitted a license amendment request to the NRC requesting an increase in the licensed flow at the current Crow Butte operation. License Condition 10.5 of SUA-1534 limits current operation to an annual plant throughput of 5,000 gpm exclusive of restoration flow. CBR requested an amendment to this license condition to increase the licensed flow in order to increase production and assist in restoration efforts. The production increase would be accomplished by expanding the existing plant and mining existing wellfields to lower levels of soluble uranium. CBR requested approval to increase the annual plant throughput to 9,000 gpm exclusive of

restoration flow. The amendment request would not change the annual licensed production rate of 2,000,000 pounds of U_3O_8 per year.

Crow Butte Resources believes that the only environmental impact from approval of the increased flow rate at the current operation would be a corresponding increase in the emission of radon-222 from the current operation. The amendment request estimated a 22 percent increase in the maximum public dose were the increased flow approved. CBR estimated that the maximum public dose would remain well below the public dose limit found in 10 CFR § 20.1301.

NRC staff are currently (March 2007) reviewing the flow increase license amendment request. This is a separate licensing action that could have a cumulative effect with the North Trend Amendment Request, if approved by NRC.

2.5.2 Future Development

Crow Butte Resources has identified several additional resource areas in the region near the Crow Butte Central Plant that could conceivably be developed as satellite facilities. Development of these facilities is dependent upon further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR may submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area and at North Trend deplete.

2.6 COMPARISON OF THE PREDICTED ENVIRONMENTAL IMPACTS

Table 2-2 provides a summary of the environmental impacts for the no-action alternative (Section 2.1), the preferred alternative (Section 2.2), and the process alternatives (Section 2.3.1). The predicted impacts for the mining alternatives discussed in Section 2.4 are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts are discussed in greater detail in Section 4.

Table 2-2: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Land Surface Impacts	None	Minimal temporary impacts in wellfield areas; Significant surface and subsurface disturbance confined to a portion of the 30 acre satellite plant site.	Same as Preferred Alternative.	Same as Preferred Alternative. Potential additional impacts from land application of treated waste water.
Land Use Impacts	None	Loss of crop and cattle production in 1,310 acre impacted area for duration of project.	Same as Preferred Alternative.	Same as Preferred Alternative plus a potential long term land use impact from on-site disposal of 11(e)2 byproduct material.
Transportation Impacts	None	Minimal impact on current traffic levels. Estimated additional heavy truck traffic of 500 trips per year; additional 6 – 8 VTPD light duty trucks.	Same as Preferred Alternative.	Same as Preferred Alternative.
Geology and Soil Impacts	None	None	None	None
Surface Water Impacts	None	None	None	None
Groundwater Impacts	None	Consumption of Chadron groundwater for control of mining solutions and restoration (estimated at 50 gpm average)	Same as Preferred Alternative. Increased difficulty with groundwater restoration and stabilization.	Same as Preferred Alternative.
Ecological Impacts	None	No substantive impairment of ecological stability or diminishing of biological diversity.	Same as Preferred Alternative.	Same as Preferred Alternative.

Table 2-2: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Air Quality Impacts	None	Additional 14.5 tons per year total dust emissions due to vehicle traffic on gravel roads.	Same as Preferred Alternative.	Same as Preferred Alternative.
Noise Impacts	None	Barely perceptible increase over background noise levels in the area.	Same as Preferred Alternative.	Same as Preferred Alternative.
Historic and Cultural Impacts	None	None	None	None
Visual/Scenic Impacts	None	Moderate impact; noticeable minor industrial component in sensitive viewing areas.	Same as Preferred Alternative.	Same as Preferred Alternative plus possible long term visual and scenic impacts from on-site disposal cell for 11(e)2 byproduct material
Socioeconomic Impacts	Eventual loss over the next 5 to 10 years of positive economic impact of $8.95M to the local area as reserves deplete in the current licensed operation	Extension of the current annual direct economic impact of $8.95M plus the addition of between $5.05M and $6.03M annual direct economic impact to local area	Same as Preferred Alternative.	Same as Preferred Alternative.
Nonradiological Health Impacts	None	None	None	None
Radiological Health Impacts	None	12 % increase in estimated maximum dose from additional radon gas released at North Trend.	Same as Preferred Alternative.	Same as Preferred Alternative.

Table 2-2: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Waste Management Impacts	None	Generation of additional liquid and solid waste for proper disposal.	Same as Preferred Alternative. Mobilization of additional hazardous elements in lixiviant requiring disposal.	Same as Preferred Alternative. Potential additional long term impact from on-site disposal of 11(e)2 byproduct material.
Mineral Resource Recovery Impacts	Loss of a valuable domestic energy resource. CBR estimated reserves are under development but the current estimated recoverable resource is $2.0 million pounds with a current spot market value of $160 million.	Recovery and use of a domestic energy resource.	Same as Preferred Alternative.	Same as Preferred Alternative.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

This section provides a discussion of the current baseline conditions in the region of the North Trend Expansion Area. The description includes a discussion of the effects on the local environment from the current Crow Butte licensed operation.

3.1 LAND USE

The information in this section provides relevant data concerning the physical, ecological, and social characteristics of the current license area, the proposed North Trend Expansion Area, and the surrounding environs for uranium in situ mining.

This section indicates the nature and extent of present and projected land and water use and trends in population or industrial patterns. The information in this section was initially developed over a 9-month period in 1982 as part of the Research and Development (R&D) license application and updated in 1987 for the commercial license application and in 1997 for the License Renewal Application. Preliminary data were obtained from several sources followed by field studies to collect on-site data to check land uses. Interviews with various state and local officials provided additional information.

NUREG 1569 requires discussion of land and water use in the proposed license area, and within a 2.0-mile radius surrounding the license area. Because previous historical studies were performed assuming a 2.25-mile review area, some data in this section are based on a 2.25-mile radius. A 2.25-mile radius was used rather than the required 2.0-mile radius to remain consistent with other resource descriptions. For water resources, oil and gas resources and well locations the standard 2.0-mile review area is used.

Specifically for the North Trend area application, population, land use, and water use data have been re-evaluated by CBR during the spring of 2004. These original data were updated through additional data collection and review, personal communications, and site reconnaissance. Population distribution characteristics were updated in 2004 as well.

Land use within the North Trend area and a 2.25-mile review area is illustrated on Figure 3.1-1. Little change has been noted in area land use in the past 23 years, reflecting the stagnant nature of economic activity in the area and slight decline in the populations of the city of Crawford and Dawes County.

3.1.1 General Setting

The Crow Butte project site is located in west-central Dawes County, Nebraska, just north and west of the Pine Ridge area.

Figure 3.1-1 shows land use in the general location of the current license area and the proposed North Trend area. Table 3.1-1 provides a description of the land use types depicted on Figure 3.1-1.

The current license area is located about 4.0 miles southeast of the city of Crawford on Squaw Creek Road. State Highway 2/71 provides access to the project area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the project area from points east and west.

The North Trend Expansion Area is located north of the city of Crawford (Figure 3.1-1).

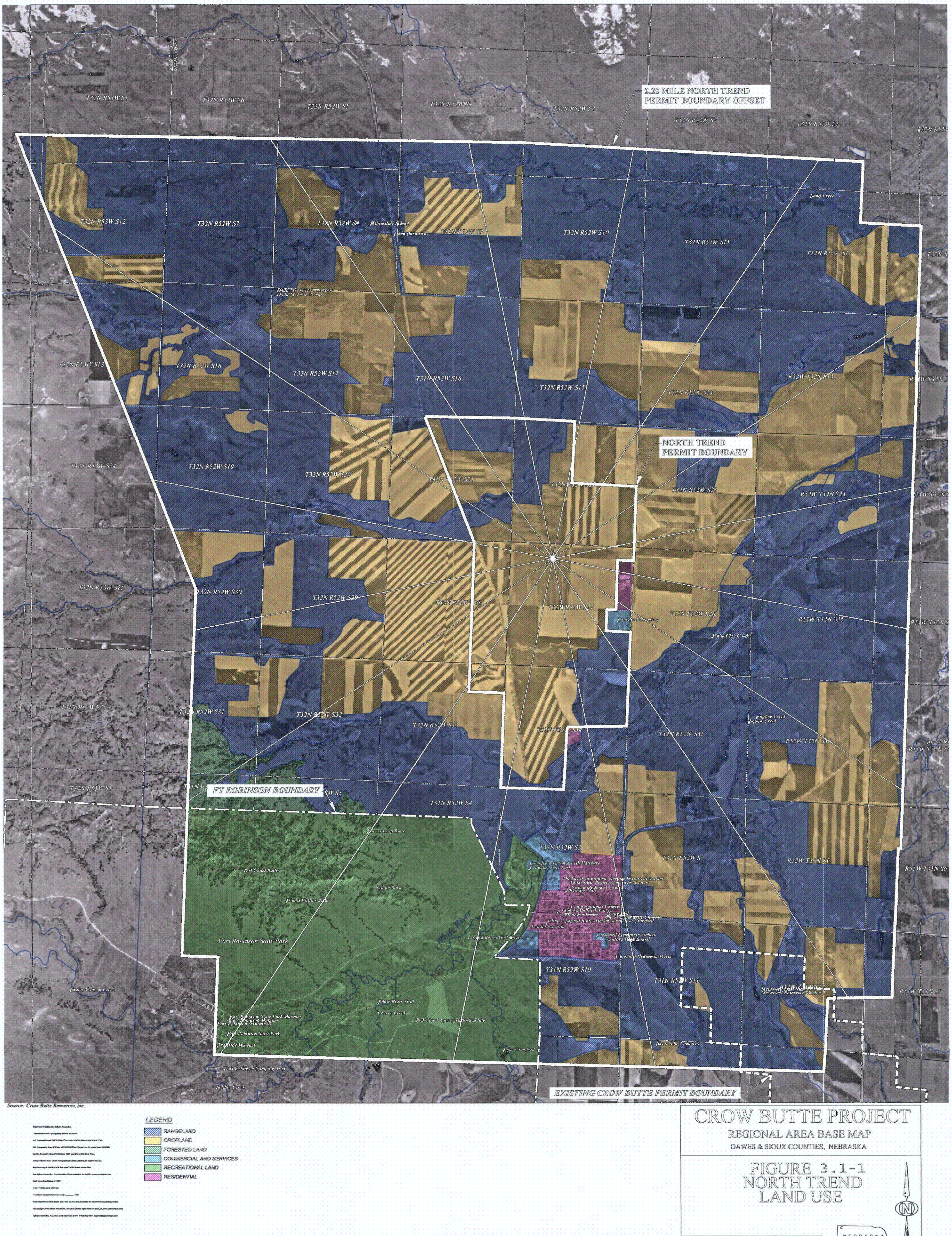
3.1.2 Land Use

The current license area and the proposed North Trend Expansion Area are located in west-central Dawes County, Nebraska, just north and west of the Pine Ridge Area. Land use within the North Trend Expansion Area and 2.25-mile review area around the North Trend Expansion Area is illustrated on Figure 3.1-1. (A 2.25-mile review area radius was used for land use rather than the 2-mile radius required in Regulatory Guide 3.46 to remain consistent with other resource descriptions.)

Figure 3.1-1 shows land use in the general location of the proposed North Trend Expansion Area. Table 3.1-1 describes the land use types depicted on Figure 3.1-1.

The current license area is located about 4 miles southeast of the City of Crawford via West Ash Creek Road and Squaw Creek Roads. State Highway 2/71 provides access to the project area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the project area from points east and west.

The North Trend Expansion Area is located approximately 0.5 mile north of Crawford and approximately 4.5 miles northwest of the current process plant. State Highway 2/71 runs along the east boundary of the North Trend Expansion Area.



Source: Crow Butte Resources, Inc.

CROW BUTTE PROJECT
REGIONAL AREA BASE MAP
DAWES & SIOUX COUNTIES, NEBRASKA

FIGURE 3.1-1
NORTH TREND
LAND USE

Date:3/7/07	Drawn:PBE	Fig. 3.1-1

I:\CO001223 ACAD\1223 Figure 2.2-1.dwg

TABLE 3.1-1 LAND USE DEFINITIONS

Croplands (C)	Harvested cropland, including grasslands cut for hay, cultivated summer-fallow, and idle cropland.
Commercial and Services (C/S)	Those areas are used predominantly for the sale of products and services. Institutional land uses, such as various educational, religious, health, and military facilities are also components of this category.
Forested Land (F)	Areas with a tree-crown density of 10 percent or more are stocked with trees capable of producing timber or other wood products and exert an influence on the climate or water regime. This category does not indicate economic use.
Habitat (H)	Land dedicated wholly or partially to the production, protection or management of species of fish or wildlife.
Industrial (I)	Areas such as rail yards, warehouses, and other facilities used for industrial manufacturing or other industrial purposes.
Mines, Quarries, or Gravel Pits (M)	Those extractive mining activities that have significant surface expression.
Pastureland (P)	Land used primarily for the long-term production of adapted, domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed.
Rangeland (R)	Land, roughly west of the 100th meridian, where the natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs; which is used wholly or partially for the grazing of livestock. This category includes wooded areas where grasses are established in clearings and beneath the overstory.
Urban Residential (UR)	Residential land uses range from high-density, represented by multi-family units, to low-density, where houses are on lots of more than 1 acre. These areas are found in and around Crawford and Ft. Robinson. Areas of sparse residential land use, such as farmsteads, will be included in categories to which they are related.
Water (W)	Areas of land mass that are persistently water-covered.
Recreational (RC)	Land used for public or private leisure, including developed recreational facilities such as parks, camps, and amusement areas, as well as areas for less intensive use such as hiking, canoeing, and other undeveloped recreational uses.

3.1.2.1 Current License Area

Table 3.1-2 presents land uses in 22 1/2° sectors centered on each of the 16 compass points. These sectors radiate out from the geographic center of the current License Area. Table 3.1-1 explains each of the land use types. The total areas of the sectors vary because of the irregular site boundary. Pastureland comprises the greatest portion of land use within the current license area and surrounding 2.25-mile area (29 percent). Cropland (28 percent), forest land (13 percent), and wildlife habitat (10 percent) are the other significant land uses.

3.1.2.2 North Trend Expansion Area

Table 3.1-3 presents land uses in 22 1/2° sectors centered on each of 16 compass points radiating out from the geographic center of the North Trend Expansion Area. Table 3.1-1 explains each of the land use types. Rangeland comprises the greatest portion of land use within the North Trend Expansion Area and surrounding 2.25-mile review area (52.2 percent). Cropland (33.3 percent), recreation (11.8 percent), forest land, urban land, and residential land are the other significant land uses.

Raising livestock is the primary land use within the North Trend Expansion Area and the surrounding 2.25-mile review area. In the North Trend Expansion Area, most of the land is cropland; however, most of the review area is rangeland, resulting in a higher proportion of land used for grazing. In 2003, an average of 48,000 head of livestock was reported in Dawes County (NASS 2004). Native grasslands are used for grazing or for cut hay. Livestock values have remained consistent between the years 1990 and 2001, the last year for which livestock values are available. In 2001, cash receipts for livestock and products totaled $21.0 million in Dawes County.

The primary land use specifically in the North Trend Expansion Area is cropland, primarily the production of wheat. A small amount of cropland in the North Trend Expansion Area is used for producing alfalfa. In 2003, the total wheat production in Dawes County was 1,836,500 bushels, an increase of 169 percent over the 2002 wheat production of 682,200 bushels.

Recreational lands also are present in Dawes County (see Table 3.1-4). Recreational opportunities provided by federal and state lands in the county have become an increasingly important component of the local economy. Fort Robinson State Park, the largest state park in Nebraska, is located within the 2.25-mile review area for the North Trend Expansion Area. Approximately 9 percent of the area within an 8-km (5-mile) radius of the current license area site is located within the Fort Robinson State Park. This part of the state park is west of Crawford, and includes portions of the Red Cloud Agency

Historical Site, the White River Trail, and several scenic landforms in a rugged area of buttes and Ponderosa Pine forest.

Other facilities at the park include lodging, showers, electrical hookups, pit toilets, ski and snowmobile trails, a rodeo arena, and a museum. Visitors to the park may go hunting, fishing, hiking, swimming, or horseback riding. Other recreational facilities in Dawes County include the Ponderosa Wildlife Management Area, Chadron State Park, Soldier Creek Management Unit, and the Red Cloud Picnic Area and associated trails in the Nebraska National Forest (Nebraska Game and Parks Commission, 1982).

TABLE 3.1-2 LAND USE OF THE CURRENT LICENSE AREA AND WITHIN A 2.25-MILE (3.6-KM) RADIUS OF THE LICENSE BOUNDARY (IN ACRES)

COMPASS SECTOR[1]	LAND USE[2]											TOTAL
	C	F	M	P	R	W	H	C/S	RC	UR	I	
N	890.9		101.9	894.1		13.7						1900.6
NNE	618.4		64.7	657.9								1341.0
NE	483.5	118.1	53.6	465.5	29.5							1150.2
ENE	126.5	470.9	59.7	476.6	69.9		58.2					1261.8
E	164.9	302.3	83.6	152.3			874.0					1577.1
ESE	116.0	101.0	185.2	39.5	6.0		1487.7					1935.4
SE	131.7	1109.6	481.0	239.4	779.9		543.0					3284.6
SSE	93.3	1318.5	446.8	440.6	232.8							2532.0
S	599.2	246.3	158.2	960.8	43.7							2008.2
SSW	607.0	27.7	47.8	742.0		8.0						1432.6
SW	628.0		12.7	467.3								1108.0
WSW	671.6	6.2	7.5	404.0					24.1			1113.4
W	622.1		27.1	405.4		3.0			607.9			1665.5
WNW	493.4		125.7	667.4		10.3		22.3	1038.9	61.0		2419.0
NW	1089.8	103.9	610.5	425.1		8.2	6.7	103.4	233.5	196.5	15.1	2792.7
NNW	888.0	57.5	345.6	1050.6		28.5		125.7				2495.9
TOTAL	8224.3	3862.0	2811.6	8488.5	1161.8	71.7	2969.6	251.4	1904.4	257.5	15.1	30017.9

1 22 $^1/_2$° sectors centered on each of the 16 compass points

2 See Table 3.1-1 for an explanation of land use types; C = cropland; F = forested land; M = mines, quarries or gravel pits; P = pastureland; R = rangeland; W = water; H = habitat; C/S = commercial and services; RC = recreational; UR = urban residential; I = industrial.

TABLE 3.1-3 PRESENT LAND USE OF THE NORTH TREND PERMIT AREA AND WITHIN A 2.25-MILE (3.6-KM) RADIUS OF THE PROPOSED NORTH TREND LICENSE BOUNDARY (IN ACRES)

COMPASS SECTOR	LAND USE											TOTAL
	C	F	M	P	R	W	H	C/S	RC	UR	I	
N	557.1	0.0	0.0	0.0	894.2	0.0	0.0	0.0	0.0	0.0	0.0	1451.3
NNE	427.8	0.0	0.0	0.0	1211.4	0.0	0.0	0.0	0.0	0.0	0.0	1639.2
NE	674.9	0.0	0.0	0.0	1221.7	0.0	0.0	0.0	0.0	0.0	0.0	1896.6
ENE	998.5	0.0	0.0	0.0	317.6	0.0	0.0	0.0	0.0	0.0	0.0	1316.0
E	331.6	0.0	0.0	0.0	739.7	0.0	0.0	0.0	0.0	8.7	0.0	1080.0
ESE	410.9	0.0	0.0	0.0	803.2	0.0	0.0	0.0	0.0	22.4	0.0	1236.5
SE	731.6	0.0	0.0	0.0	1245.9	0.0	0.0	22.6	0.0	2.7	0.0	2002.7
SSE	847.7	0.0	0.0	0.0	1626.5	0.0	0.0	0.0	0.0	10.4	0.0	2484.5
S	549.9	0.0	0.0	0.0	684.3	0.0	0.0	77.7	541.5	327.6	0.0	2181.1
SSW	326.9	0.0	0.0	0.0	375.7	0.0	0.0	0.0	1807.9	0.0	0.0	2510.5
SW	410.5	191.0	0.0	0.0	529.0	0.0	0.0	0.0	1082.8	0.0	0.0	2213.3
WSW	676.1	124.8	0.0	0.0	501.4	0.0	0.0	0.0	0.0	0.0	0.0	1302.2
W	546.7	0.0	0.0	0.0	620.4	0.0	0.0	0.0	0.0	0.0	0.0	1167.1
WNW	652.0	0.0	0.0	0.0	1328.9	0.0	0.0	0.0	0.0	0.0	0.0	1980.9
NW	1018.8	0.0	0.0	0.0	1943.2	0.0	0.0	0.0	0.0	0.0	0.0	2962.0
NNW	557.7	0.0	0.0	0.0	1197.5	0.0	0.0	0.7	0.0	0.0	0.0	1755.8
TOTAL	9718.6	315.8	0.0	0.0	15240.7	0.0	0.0	101.0	3432.1	371.8	0.0	29180.0

[1] 22 1/2° sectors centered on each of the 16 compass points

[2] See Table 3.1-1 for an explanation of land use types; C = cropland; F = forested land; M = mines, quarries or gravel pits; P = pastureland; R = rangeland; W = water; H = habitat; C/S = commercial and services; RC = recreational; UR = urban residential; I = industrial.

TABLE 3.1-4 RECREATIONAL FACILITIES WITHIN 50 MILES OF THE CURRENT AND PROPOSED NORTH TREND LICENSE AREAS

Name of Recreational Facility	Distance From Current License Area (miles)	Distance From North Trend Expansion Area (miles)
Red Cloud Campground	19.0	20.0
Pine Ridge National Recreation Area	13.0	15.0
Roberts Trailhead and Campground	11.0	14.0
Museum of the Fur Trade	24.0	27.0
Toadstool Park	18.0	11.0
Warbonnet Battlefield	24.0	22.0
Hudson-Meng Bison Kill Site	17.0	11.0
Crawford City Park	2.0	1.0
Whitney Lake	10.0	8.0
Legend Buttes Golf Course	2.0	1.0
Box Butte Reservoir	24.0	21.0
Ponderosa Wildlife Area	2.0	5.0
Peterson Wildlife Area	11.0	8.0
Walgren Lake State Recreation Area	38.0	45.0
Soldier Creek Wilderness	7.0	8.0
Chadron State Park	17.0	18.0
Agate Fossil Beds National Monument	27.0	25.0

Source: Nebraska Department of Roads, 2004.
DeLorme Maps, 1996.

Residential and industrial land uses in the county are concentrated within the city limits of Crawford and Chadron. Industrial land uses are located within the city limits of Crawford, and occur primarily around railroad facilities.

3.1.2.3 Agriculture

Several of the soil types found in the vicinity of the North Trend Expansion Area are classified as prime farmland (Dixon, 1982). However, in Dawes County, soils are classified by the U.S. Soil Conservation Service (SCS) as prime farmland only if irrigated. According to 2004 Nebraska State Agricultural Statistics, only two percent of Dawes County agricultural land is irrigated, and about 10 percent of harvested cropland acreage is irrigated. The remainder of the irrigated land is used for pasture, habitat, or rangeland (Nebraska Crop and Livestock Reporting Service, 1980; 1981).

Table 3.1-5 through Table 3.1-7 show agricultural productivity within Dawes County and the North Trend Expansion Area. Wheat and hay are the major crops grown on croplands within the area. Most of these crops are used for livestock feed while the remaining crops are commercially sold. The livestock inventory for Dawes County indicates that cattle account for more than 80 percent of all livestock. According to a report prepared for the Economic Development Department of the Nebraska Public Power Corporation (2005), the market value of livestock products accounted for 85.7 percent of the total market value of all agricultural products sold in 2002. Livestock and livestock products had a value of $28.81 per acre, indicating that livestock production on rangeland within the review area has a potential value of more than $440,000.

3.1.2.4 Habitat

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 include the Ponderosa State Wildlife Management Area Area, which is south of the North Trend Expansion Area and adjacent to the current license area as shown in Figure 3.1-1. Deer and turkey hunting are permitted within the Ponderosa State Wildlife Management Area. There is no land within the license area that is used primarily for wildlife habitat. Wildlife habitat is a secondary use of rangeland, forestland, and recreational land within the license area and the 2.25-mile review area.

TABLE 3.1-5 AGRICULTURAL YIELDS FOR CROPLANDS IN DAWES COUNTY, 2001

	Harvested		Yield		Production
	Acres[a]	km^2	Per acre	Per km^2	
Corn for Grain (bu)	3,100	12.65	97.5 bu	24,093 bu	302,300 bu
Sorghum for Grain (bu)	200	0.81	35.0 bu	8,649 bu	7,000 bu
Oats for Grain (bu)	400	1.62	46.0 bu	11,367 bu	18,400 bu
Winter Wheat for Grain (bu)	33,700	13.64	35.6 bu	8,797 bu	1,198,700 bu
All hay[b] (tons)	77,000	136.38	1.6 tons	395 tons	123,800 tons
Dry Edible Beans (lbs)	700	2.83	2,106 lbs	520,000 lbs	14,740 lbs
Sunflowers (lbs.)	1,200	4.86	988 lbs	244,000 lbs	1,185,000 lbs
Sugarbeets (tons)	600	2.43	20.2 tons	4,992 tons	12,100 tons

Notes:
bu bushels
a 1 acre = 0.0040469 km^2
b Includes wild and tame alfalfa.

TABLE 3.1-6 POTENTIAL AGRICULTURAL PRODUCTION FOR CROPLAND IN THE NORTH TREND EXPANSION AREA AND THE 2.25-MILE REVEIW AREA

	Percent of Total Planted[a]	Total Cropland (acres)[b]	Percent of Planted/ Harvested[a]	Harvested (acres)	Harvested (km^2)	County Yield (bu/acre)	County Yield (bu/km^2)
Wheat	33.3	9,718.6	89.03	8,652.5	35	35.6	1,830

Notes:
- a Same as for Dawes County.
- b 1 acre = .0040469 km^2.
- bu bushels

Source: Nebraska Agricultural Statistics Service, 2001.

TABLE 3.1-7 LIVESTOCK INVENTORY, DAWES COUNTY, 2002

	Number	Percent of Total	Animal Units [a]	
			Pounds (000s)	Percent
All cattle, except dairy	47,258	94.7	47,258	98.8
Dairy cattle	148	0.003	148	0.003
Hogs	305	0.006	67.1	0.001
Sheep	1,740	0.03	348	0.007
Chickens	431	0.01	2.2	0.00005
Total animals	49,882	100.0	47,823.3	100.0

Notes: [a] Animal unit conversions:

1 cow	=	1,000 lb.
1 hog	=	220 lb.
1 sheep	=	200 lb.
1 chicken	=	5 lb.
1 animal unit	=	1,000 lb.

Source: U.S. Census of Agriculture, 2002.

3.1.2.5 Residential

According to a site reconnaissance (conducted in June 2004 and recently updated) and a Nebraska Department of Natural Resources aerial photo of the license area, there is one occupied housing unit in the North Trend Expansion Area. The unit is in the south portion of the license area. The City of Crawford is located south of the license area within the 2.25-mile review area. The 2.25-mile review area includes Crawford, which contains 537 housing units, of which 473 are occupied, and an estimated 44 occupied rural housing units that are located outside of Crawford and the North Trend Expansion Area (US Census, 2000). There are 526 occupied housing units within the 2.25-mile review area.

Table 3.1-8 shows the distance to the nearest residence and to the nearest site boundary of residences within the 2.25-mile review area from the center of the North Trend Expansion Area for each 22 1/2° sector centered on each compass point.

There are no dwelling units within 1 km (0.62 miles) of the center point of the proposed North Trend Expansion Area. Four dwelling units are within 2 km (1.24 miles). Table 3.1-9 shows the distance to the nearest residence and to the nearest site boundary from the center of the site for each 22 1/2° sector centered on each compass point for the proposed North Trend Expansion Area.

TABLE 3.1-8 DISTANCE TO NEAREST RESIDENCE AND SITE BOUNDARY FROM CENTER OF CURRENT LICENSE AREA FOR EACH COMPASS SECTOR

Compass Sector[1]	Nearest Residence (ft.)	Nearest Site Boundary (ft.)
North	5,800	4,050
North-Northeast	11,850	3,050
Northeast	1,150	3,150
East-Northeast	15,000	2,900
East	None	4,250
East-Southeast	4,800	4,400
Southeast	5,700	8,100
South-Southeast	15,700	5,900
South	6,250	5,100
South-Southwest	17,250	2,250
Southwest	9,450	1,500
West-Southwest	5,500	1,250
West	15,100	1,200
West-Northwest	2,050	3,950
Northwest	6,400	6,300
North-Northwest	11,400	5,500

1 22 $^1/_2$° sectors centered on each of the 16 compass points.

TABLE 3.1-9 DISTANCE TO NEAREST RESIDENCE AND SITE BOUNDARY FROM CENTER OF NORTH TREND EXPANSION AREA FOR EACH COMPASS SECTOR

Compass Sector[1]	Nearest Residence (ft.)	Nearest Site Boundary (ft.)
North	None	11,000
North-Northeast	7,500	6,000
Northeast	8,400	4,200
East-Northeast	16,900	3,600
East	9,000	3,500
East-Southeast	3,400	3,500
Southeast	6,600	3,100
South-Southeast	5,000	4,800
South	4,700	4,800
South-Southwest	8,800	4,700
Southwest	11,700	3,000
West-Southwest	None	2,800
West	10,600	2,800
West-Northwest	None	3,200
Northwest	9,600	5,000
North-Northwest	5,300	6,300

1 22 $^{1}/_{2}$° sectors centered on each of the 16 compass points

3.1.2.6 Commercial and Services

There are retail and commercial establishments within Crawford and at Fort Robinson State Park. Commercial establishments are also secondary uses of some residential areas in Crawford. The four largest establishments include the Legend Buttes Health Clinic, the Ponderosa Villa Nursing Home, a livestock sale barn, and railroads. Facilities located

outside of Crawford, and within the 2.25-mile review area include the Crawford Cemetery, located at the east-central boundary of the license area.

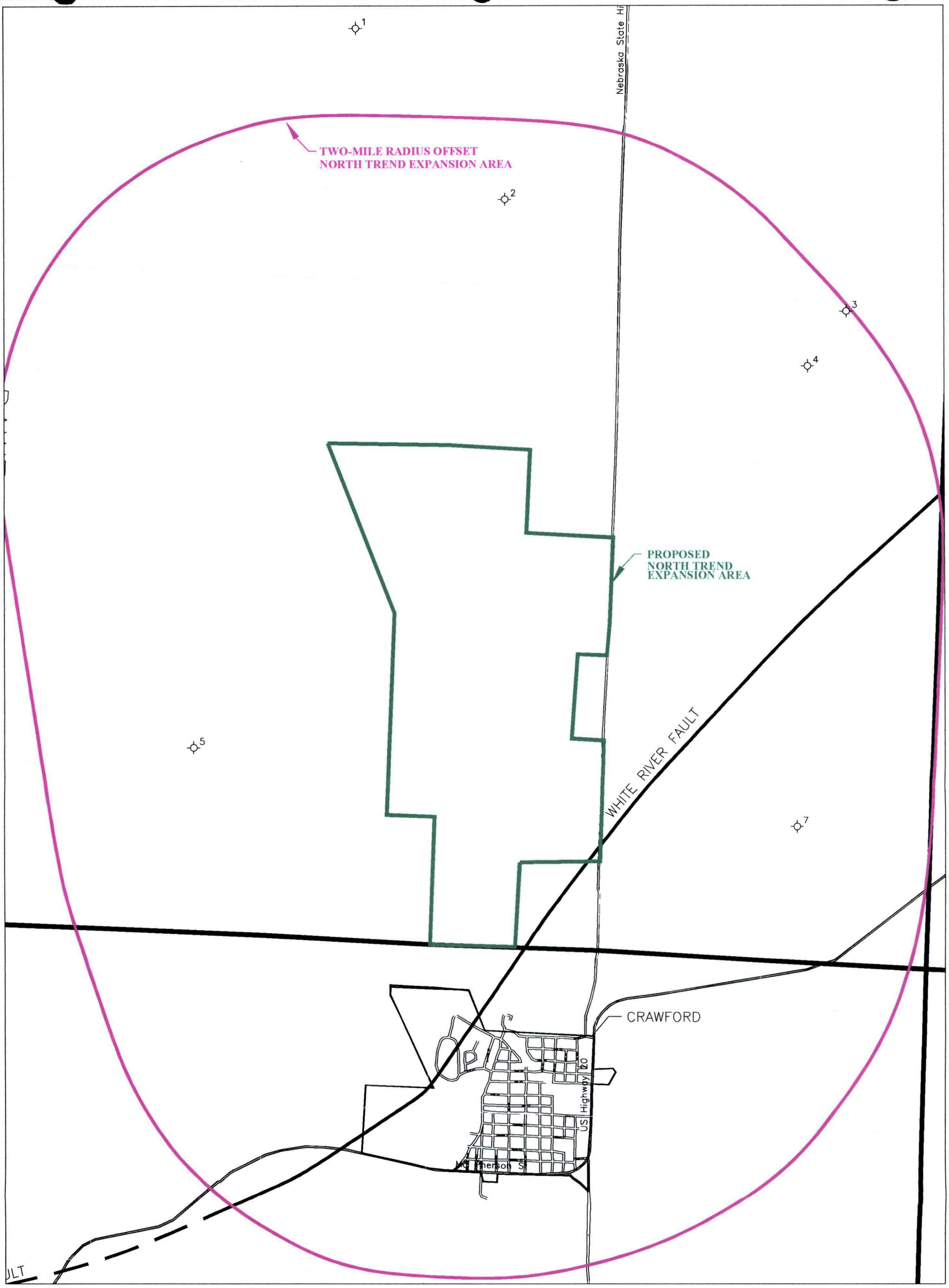
3.1.2.7 Industrial and Mining

There are no industrial or mining uses within the license area. There are gravel pits on Fort Robinson State Park. Most of the pits are inactive, although a few are mined periodically for local road construction purposes

Besides Crow Butte Resources, Conoco, Amoco Minerals, Santa Fe Mining, and Union Carbide have also drilled exploratory testing holes in the area. There are no other industrial facilities within the 2.25-mile review area.

There is one oil and gas test hole located within the North Trend Area. This well, referred to as the E.A. Soester No. 1, is located in Section 34, T32N, R52W, and was drilled to a total depth of 2,006 feet. Five oil and gas test holes are located within the 2.0-mile North Trend review area. Figure 3.1-2 shows the locations of the oil and gas test holes within the North Trend license area, and the 2.0-mile North Trend review area.

Based on review of public plugging records, all the referenced oil and gas test holes have been properly plugged in accordance with the Nebraska Oil and Gas Conservation Commission regulations (Ferret Exploration Company of Nebraska, 1993). A listing of oil and gas test holes pertinent to the North Trend Area is presented in Section 3.1.



LEGEND

5 LOCATION OF DRY OIL/GAS TEST HOLE

N
W E
E

0 1500 3000 6000
SCALE IN FEET 1" = 3000'

CROW BUTTE RESOURCES, INC.

FIGURE 3.1-2
NORTH TREND LOCATION OF GRAVEL PITS AND OIL/GAS TEST HOLES

PROJECT: 223-37	DATE: MARCH 2007
DWG: CBRNT3CBase.dwg	BY: KRS CHECKED: HPD

Petrotek
10288 West Chatfield Ave., Ste 201
Littleton, Colorado 80127-4239
303-290-9414
www.petrotek.com

3.1.2.8 Recreational

Part of the Fort Robinson State Park lies within the 2.25-mile review area of the North Trend Expansion Area (see Figure 3.1-1). Other recreation areas within the review area include the Crawford City Park and the Legend Buttes Golf Course.

3.1.2.9 Aesthetics

The North Trend Expansion Area is located on rolling plains with a backdrop of the spectacular buttes of the Fort Robinson State Park, located west of the project area. The North Trend Expansion Area landscape is rural and agricultural in character. The landscape colors are dominated by tan, gold, and green vegetation and tan soils. Riparian vegetation along the White River and Spring Creek exhibits considerable variety in form, texture, and color. Dark to light green colors and a variety of forms and textures of the riparian vegetation provide pleasing contrasts to the flat, horizontal lines of the surrounding agricultural land in the project area. As the North Trend Expansion Area has been used historically for cropland and grazing, it is unlikely that any undisturbed area exists within the proposed license boundary. Human influence is evidenced by producing croplands, scattered farmhouses, and fencing.

3.2 TRANSPORTATION

3.2.1 Highways

Nebraska Highway 2/71 and U.S. Highway 20 converge in Crawford. The 2003 average daily traffic counts are 360 vehicles on Nebraska Highway 2/71 at the east side of the North Trend Expansion Area, and between 1,330 and 1,720 vehicles on U.S. Highway 20 at Crawford south of the license area (Nebraska Department of Roads, 2003). County roads that cross through the North Trend Expansion Area are Moody and Mill Roads. These roads provide access to residences and agriculture within the license area. The county roads are accessed from Highway 2/71.

3.2.2 Railroads

The Burlington Northern Santa Fe (BNSF) Railroad runs in a northwesterly direction through the west side of the proposed license area. The BNSF rail line along the western boundary is used for combining local "pusher" engines with south bound trains to assist them in climbing the Pine Ridge south of Crawford. This rail line accommodates a significant amount of rail traffic, primarily from the coal mines in northeastern Wyoming. The D M & E Railroad runs in a northeasterly direction, and forms a portion of the southeast boundary of the license area. The junction of the two railroads is about 0.50 miles south of the license area.

3.3 GEOLOGY AND SOILS

This section describes the regional and local geology and seismology related to the Crow Butte Project and the North Trend Area. In this regard, discussion of the geology of the Crow Butte Project, and the current NRC-Licensed area (also referred to as the commercial study area [CSA]), in particular, has been presented in previous reports (Wyoming Fuel, 1983; Ferret Exploration of Nebraska, 1987). Detailed information contained in these reports (e.g., laboratory results and field data that describe formation characteristics [mineralogy, permeability, etc.] for the Pierre Shale, Brule Formation, Chadron Formation, and the Basal Chadron Sandstone in the CSA), also applies in a general sense to the North Trend Area. These data, in addition to new information from exploratory drilling/logging activities within the North Trend Area, are used to describe the geology and seismology in this section.

3.3.1 Regional Setting

The Crow Butte project is in Dawes County in northwestern Nebraska. Crawford is the principal town in the area and lies approximately four miles northwest of the current NRC-licensed area. The proposed North Trend license area lies approximately 5.5 miles northwest of the current NRC-licensed area.

Crawford is 25 miles west of Chadron, Nebraska and 70 miles north of Scottsbluff, Nebraska. Crawford is 21 miles south of the South Dakota state line and 33 miles east of the Wyoming state line. The topography consists of low rolling hills dominated by the Pine Ridge south and west of the project area.

3.3.1.1 Regional Stratigraphy

Sedimentary strata ranging from late Cretaceous through Tertiary are exposed throughout northwest Nebraska. Pleistocene alluvial-colluvial materials are abundant along the north slope of the Pine Ridge. Table 3.3-1 is a generalized stratigraphic chart for the region. Figure 3.3-1 shows a geological bedrock map of the northwest portion of the State of Nebraska (Burchett, 1986). Figures 3.3-2a, 3.3.2b, and 3.3-2c are a cross section location map and regional cross sections through the area, showing the configuration of major stratigraphic units in the region. Figures are included at the end of this section.

Table 3.3-1: General Stratigraphic Chart for Northwest Nebraska

System	Series	Formation or Group	Rock Types	Thickness
Miocene		Ogallala	SS, Slt	1560*
		Arikaree	SS, Slt	1070*
Oligocene/Eocene		White River	SS, Slt, Cly	1450*
Cretaceous	Upper	Pierre	Sh	1500
		Niobrara	Chalk, Ls, Sh	300
		Carlile	Sh	200-250
		Greenhorn	Ls	30
		Graneros	Sh	250-280
		D Sand	SS	5-30
		D Shale	Sh	60
		G Sand	SS	10-45
		Huntsman	Sh	60-80
	Lower	J Sand	SS	10-30
		Skull Creek	Sh	220
		Dakota	SS, Sh	180
Jurassic	Upper	Morrison	Sh, SS	300
		Sundance	SS, Sh, Ls	300
Permian	Guadalupe	Satanka	Ls, Sh, Anhy	450
	Leonard	Upper	Ls, Anhy	150
		Lower	Sh	150
	Wolfcamp	Chase	Anhy	80
		Council Grove	Anhy, Sh	300
		Admire	Dolo, Ls	70
Pennsylvanian	Virgil	Shawnee	Ls	80
	Missouri	Kansas City	Ls, Sh	80
	Des Moines	Marmaton/ Cherokee	Ls, Sh	130
	Atoka	Upper/Lower	Ls, Sh	200
Mississippian	Lower	Lower	Ls, Sh	30
Pre-Cambrian			Granite	

Notes: * Maximum thickness based on Swinehart, et al, 1985.

3.3.1.2 Pre-Pierre Shale Stratigraphy

Formations older than the Cretaceous Pierre Shale are listed on the General Stratigraphic Chart shown in Table 3.3-1. This chart has been developed from the published literature and nearby oil and gas test holes. The Upper Cretaceous Niobrara, Carlile, and Greenhorn-Graneros Formations outcrop in the Chadron Arch about 30 miles northeast of Crawford.

3.3.1.3 Pierre Shale

The Pierre Shale of Cretaceous age is the oldest formation of interest for the Crow Butte area since it is the lower confining unit. Typically, Crow Butte Resources (CBR) test holes have been terminated in the top of the Pierre Shale. Therefore, descriptions of the full Pierre section included herein are based on data obtained from other sources, and data from the CBR Class I disposal well located at the current NRC-licensed area.

The Pierre is a dark gray to black marine shale, with relatively uniform composition. The Pierre outcrops extensively in Dawes and Sioux Counties along the South Dakota boundary north of the proposed North Trend Permit Area (Witzel, 1974). The Pierre generally consists of black to dusty gray and brownish claystones that include thin layers of bentonite, shaley limes, concretionary zones, and an occasional thin sandstone. While the Pierre can be as much as 5,000 feet thick, it is approximately 1,500 to 2,000 feet thick in Dawes County, and has been regionally divided into six members based on lithology, sequence, and fossil content. Two members, the Sharon Springs Member and Gregory Member were recognized by Witzel (1974) in Pierre outcrops in Dawes County. Fossils present in the Pierre include numerous pelecypods and ammonoids, as well as Baculites, a straight ammonoid.

Although the Pierre Shale is up to 5,000 feet thick regionally, in Dawes County deep oil tests have indicated thicknesses of 1,200 to 1,500 feet. Figure 3.3-3 presents a regional isopach of the Pierre Shale. Exposure and subsequent erosion greatly reduced the vertical thicknesses of the Pierre prior to Oligocene/Eocene sedimentation. Consequently, the top of the present day Pierre contact marks a major unconformity and exhibits a paleotopography with considerable relief (DeGraw, 1969). As a result of the extended exposure to atmospheric weathering, an ancient lateritic paleo soil horizon or paleosol was formed on the surface of the Pierre Shale. It is known as the "Interior Paleosol Complex" of the Pierre Shale (Shultz and Stout, 1955) and is readily observed in certain outcrop exposures. Because the paleosol profile shows enrichment in iron and alumina, low calcium, but insignificant leaching of silica, Witzel speculated that the zone underwent less intensive weathering than that produced by typical laterites. Thus, the soil probably developed under subtropical rather than intensive tropical conditions. It should

also be noted that the Pierre-Oligocene contact is also characterized by erosion via overlying Oligocene (Chadron) sandstones, resulting, in deeply incised channels at some locations (Witzel, 1974).

3.3.1.4 White River Group

The White River Group is Oligocene/Eocene in age and consists of the Chadron and Brule Formations. Geologic maps (e.g., Figure 3.3-1) show this unit to be present as bedrock in the general CBR and North Trend area, noting that members of the White River Group outcrop as a band at the base of the Pine Ridge, which occurs about six miles southeast of Crawford, Nebraska.

3.3.1.5 Chadron Formation

The Chadron is the oldest Tertiary Formation in northwest Nebraska and lies with marked regional unconformity on top of the Pierre Shale. Swinehart et al (1985) indicate that the Basal Chadron Sandstone contains sandstone and conglomerate with some interbedded clay and is the depositional product of a large, vigorous braided stream system which occurred during early Oligocene/Eocene (approximately 36 to 40 million years before present). Witzel (1974) describes the Chadron as representing a variety of depositional facies including channel, flood plain, pond and upland environments, characterized regionally by lateral and vertical heterogeneity. Typically, the Chadron Formation has a sandstone and conglomerate at the base with overlying siltstone, mudstone, and claystone, which is green-hued (Singler and Picard, 1980). Regionally, the vertical thickness of the Chadron Formation varies greatly. On outcrop, the Chadron Formation varies in thickness from 135 to 205 feet (Singler and Picard, 1980). More recently, the maximum thickness of the Chadron Formation has been estimated at 300 feet (Swinehart et al, 1985). Based on CBR data, the Chadron Formation thickness in the CSA ranges from 300 to 600 feet. At North Trend, the Chadron Formation thickness is approximately 500 feet.

Witzel (1974) identified the Chadron Formation as consisting of three general stratigraphic divisions he called A (lower), B (middle) and C (upper) units. The lower portion of the Chadron is a very coarse, very poorly sorted conglomerate that occurs, where present, at the base of the Chadron. This conglomerate consists of well rounded, predominantly quartz and chalcedony cobbles ranging up to six inches across. The basal conglomerate occurs primarily in deeper entrenched valleys upon the Pierre and sometimes has cement with pyretic matrix. The Basal unit grades upward into 20 to 40 feet of porous, coarse to fine-grained, limonite-stained sandstone.

The B (middle) unit is predominantly green to pinkish in color and was deposited by two main types of depositional lithologies: channel and flood plain, with occasional localized ponds. Channel fills consist of greenish-brown sandstone composed of quartz and feldspar, cemented with calcium carbonate or silica. Finer-grained materials (siltstone, claystones) may occur adjacent to the channel sand deposits. Witzel states that the "*bulk of the Middle Chadron sediments are of floodplain type, grading laterally into the channel fills.*" Maximum thickness of the Middle Chadron varies from about 114 to126 feet.

The Middle and Upper Chadron are sometimes difficult to distinguish in the field (Wetzel, 1974), with the presence of [occasional] sandstones within the Middle unit being the predominant differentiator. The upper part of the Chadron represents a distinct and rapid facies change from the underlying sediments. The Chadron above the Upper/Middle Chadron sand is a light green-gray bentonitic claystone at the top, grading downward to green and frequently red claystone often containing gray-white bentonitic clay interbeds.

3.3.1.6 Brule Formation

The Brule Formation lies conformably on top of the Chadron Formation and consists of interbedded siltstone, mudstone, and claystone with occasional sandstone. The Brule Formation is reported to range in thickness from 130 to 530 feet (Singler and Picard, 1980). Witzel (1974) indicates that the Brule, in Dawes County, has a maximum thickness of 480 feet. The Brule had previously been subdivided into two separate members, the lower Orella (middle Oligocene) and the upper Whitney (upper Oligocene) (Schultz and Stout, 1938; Witzel, 1974). More recently, the maximum thickness of the Brule Formation has been described as 1,150 feet. This is due to the inclusion of the Brown Siltstone beds (Swinehart et al, 1985).

The Orella is composed of interbedded siltstone, mudstone, and claystone with occasional sandstones. The color of the Orella grades from green-blue and green-browns upward to buff and browns. The Orella was deposited in a fluvial setting with some eolian activity (Singler and Picard, 1980). Witzel states that the Orella member is about 200 feet thick in Dawes County, and can be subdivided further into 3 subunits. The Lower Orella is about 90 feet thick at a maximum, and is characterized by greenish to brownish buff silty clay with abundant fossil remains. Nodular sandy siltstone occurs at the base. The Middle Orella occurs unconformably atop the lower, and is about 146 feet thick at a maximum. This subunit is characterized by channel deposits in its lower portions, consisting of coarse, cross-bedded arkosic sands (Witzel, 1974). The middle Orella is capped by a major paleosol complex. The Upper Orella varies in thickness from 34 to 53 feet, and contains channel and floodplain facies.

The Whitney Member of the Brule is comprised of fairly massive buff to brown siltstones, primarily eolian in origin (Singler and Picard, 1980). Several volcanic ash horizons have been reported in outcrops (Swinehart et al, 1985). Some moderate to well defined channel sands are present in the upper part of the Whitney Member. These Brule channels are commonly water bearing in the otherwise generally impermeable Brule. Witzel states that the Whitney attains a maximum thickness of about 270 feet in Dawes County, and is more uniform in lithology than the underlying Orella Member. As with the Orella, the Whitney can also be subdivided into upper, middle, and lower subunits, distinguished by intervening volcanic ash layers. The Lower Whitney is about 90 feet thick and is described as a massive sandstone unit; it is capped by about 8 feet of Lower Ash. The Middle Whitney is lithologically similar to the lower and is about 76 feet thick. The Middle Whitney is capped by about a three-foot thick Upper Ash unit.

The Brown Siltstone beds have been recognized by Swinehart and others in northwest Nebraska (Swinehart et al, 1985). This informal member has been added to the upper part of the Brule Formation. This unit is described as volcanic sandy siltstones and very fine-grained sandstones. Fine to medium-grained sandstones occur locally at or near the base.

3.3.1.7 Arikaree Group

The Arikaree-Ogallala Groups are absent in the immediate North Trend project area. However, a general description for each group follows because they do occur on a regional scale.

The Miocene Arikaree Group includes three sandstone formations that form the Pine Ridge escarpment which trends from west to east across northwest Nebraska.

3.3.1.8 Gering Formation

The Miocene Gering Sandstone is the oldest formation of the Arikaree Group, and lies unconformably on the Brule Formation. The Gering is predominantly buff to brown, fine-grained sandstones and siltstones. These represent channel and flood plain deposits. Thickness of the Gering Formation ranges from 100 to 200 feet (Witzel, 1974).

3.3.1.9 Monroe Creek Formation

The Monroe Creek Formation overlies the Gering and is the middle unit of the Arikaree Group. The Monroe Creek Formation is lithologically similar to the Gering with buff to brown fine-grained sandstone. The unique characteristic of the Monroe Creek is the presence of large "pipy" concretions. These concretions consist of fine-grained sand similar to the rest of the formation with calcium carbonate cement and are extremely hard

and resistant to weathering. The reported thickness of the Monroe Creek Formation is 280 to 360 feet (Lugn, 1938, in Witzel, 1974).

3.3.1.10 Harrison Formation

The Harrison Formation is the youngest unit of the Arikaree Group. It is described as lithologically similar to the Gering and Monroe Creek Formations, with fine-grained unconsolidated sands, buff to light gray in color. The Harrison Formation is also noted for its abundance of fossil remains (Witzel, 1974).

3.3.1.11 Ogallala Group

The Miocene Ogallala Group overlies the Arikaree Group and is the outcropping unit south of the Pine Ridge. The Ogallala Group is composed primarily of sandstones that are coarser-grained, poorly sorted and contain only small amounts of volcanic material compared to the underlying Arikaree Group rocks (Souders, 1981). Some siltstone and mudstone is interbedded with the sandstones and gravels.

The Ogallala Group is the principal aquifer where it is present in northwest Nebraska. The Arikaree Group is the principal water-bearing geologic unit in Sioux, Dawes, and Box Butte Counties.

3.3.1.12 Regional Structure

Figure 3.3-1 presents structural features identified on the bedrock geology map and Figure 3.3-4 is a regional structural feature map. The most prominent structural expression in northwest Nebraska is the Chadron Arch. This anticlinal feature strikes roughly northwest-southeast along the northeastern boundary of Dawes County. The only surficial expression of the Chadron Arch is the outcropping of pre-Pierre Cretaceous rocks in the northeastern corner of Dawes County (Figure 3.3-1), as well as small portions of Sheridan County, Nebraska, and Shannon County, South Dakota.

The Black Hills lie north of Sioux and Dawes Counties in southwestern South Dakota. Together with the Chadron Arch, the Black Hills Uplift has produced many of the prominent structural features presently observed in the area today. As a result of the uplift, formations underlying the area dip gently to the south. The Tertiary deposits dip slightly less than the older Mesozoic and Paleozoic Formations (Witzel, 1974).

The Crow Butte Basal Chadron ore body lies in what has been named the Crawford Basin (DeGraw, 1969). DeGraw made detailed studies of the pre-Tertiary subsurface in western Nebraska using primarily deep oil test hole information. He was able to substantiate

known structural features and propose several structures not earlier recognized. The Crawford Basin was defined by DeGraw as being a triangular asymmetrical basin bounded by the Toadstool Park Fault on the northwest, the Chadron Arch and Bordeaux Fault to the east and the Cochran Arch and Pine Ridge Fault to the south (DeGraw, 1969). The town of Crawford is located near the axis of the Crawford Basin which is about 50 miles long in an east-west direction and about 25 to 30 miles wide at Crawford.

Figure 3.3-5 presents structural features identified previously by others and also new features proposed by DeGraw associated with the Crawford Basin. The geologic map of northwest Nebraska reproduced from the State Geologic Map, Figure 3.3-1, illustrates the recognized faulting in northwest Nebraska, but the Bordeaux Fault, Pine Ridge Fault, and Toadstool Park Fault proposed by DeGraw (1969) are not presented on the State Geologic Map. The Toadstool Park Fault has been noted on outcrop at one location in T33N, R53W, to have a displacement of about 60 feet (Singler and Picard, 1980).

Six northeast trending faults are identified or proposed in Sioux and Dawes Counties (Figure 3.3-5). All of these faults are down thrown to the north. One of these faults, the White River Fault, follows the White River north of Crawford and was postulated during the exploration drilling phase of the Crow Butte Project (Collings and Knode, 1984). The only other fault illustrated, the White Clay Fault, terminates the Arikaree Group rocks on the east from White Clay to about six miles east of Gordon (Nebraska Geological Survey, 1986).

The Cochran Arch was also proposed by DeGraw (1969) on the basis of subsurface data. The Cochran Arch trends east-west through Sioux and Dawes Counties, parallel to the Pine Ridge Fault proposed by DeGraw. Structural features subparallel to the Cochran Arch have been recognized based on CBR drill hole data. The existence of the Cochran Arch may explain the structural high south of Crawford.

The synclinal axis of the Crawford Basin trends roughly east-west and plunges to the west into what CBR informally calls the Inner Crawford Basin located west of the CSA (Collings and Knode, 1984). The Inner Crawford Basin is characterized by an increase in the thickness of the Chadron Sandstone.

3.3.2 North Trend Area Geology

3.3.2.1 Introduction

A local stratigraphic column, representative of both the North Trend and CSA, has been prepared and is shown as Table 3.3-2. The stratigraphic nomenclature of Swinehart, et al (1985) and Crow Butte Resources are shown on the column.

The general stratigraphy underlying the North Trend site, based on data from well CPW-2, is summarized in Table 3.3-2. Note that the nomenclature differs somewhat from that used by Witzel (1974) and has been modified consistent with the units used by CBR for the Crow Butte area, including North Trend. All maps and figures generated specific to the North Trend area are based upon data provided by CBR. The database used to construct figures and cross-sections extends approximately one section beyond the North Trend Expansion Area boundaries, but geologic picks are not consistently available for all locations.

Specific to the North Trend area, the stratigraphic sequence of interest, in descending order is as follows: alluvial sediments with occasional perched water, Brule Formation (including a sandy clay that is considered the shallowest overlying aquifer), Upper Chadron (upper confining layer), Upper/Middle Chadron sand (overlying sand, where present), Middle Chadron (upper confining layer), Basal Chadron Sandstone (production zone), and Pierre Shale (underlying confining layer). Because no sands occur for over 1,000 feet below the top of the Pierre Shale, site-specific analysis of these deeper intervals is not presented.

Table 3.3-2: Stratigraphic Chart for North Trend Expansion Area

Depth (feet; bgs)	Description
0 – 25	Topsoil and alluvial deposits; no wells
25 – 110	Brule Formation (interbedded silt and sandstone); BOW wells
110 - 290	Upper Chadron (silt and clay); no wells
Approx. 290-390	Upper/Mid Chadron Sand; MCOW wells
390 – 615	Middle Chadron (interbedded clay, claystone, and siltstone); no wells
615 – 659	Basal Chadron Sandstone (interbedded sandstone and clay); CPW and COW wells
659 +	Pierre Shale; no wells

The locations of 14 geologic cross-sections through the North Trend area are depicted on Figure 3.3-6. Of these 14 cross-sections that were constructed to assess site geology, nine are included as representative sections of the North Trend Area, constructed both parallel and perpendicular to local dip. Figures 3.3-7 through 3.3-15 (Cross-sections A-A', B-B', C-C', D1-D1', D2-D2' and E-E', I-I', K-K', and M-M', respectively) show the

geological cross-sections in detail. The cross-sections demonstrate that the Basal Chadron production zone is stratigraphically isolated from the overlying Upper/Middle Chadron sand and the water-bearing portion of the Brule Formation by a low permeability-confining unit (and the Upper/Middle Chadron). These sections also demonstrate the continuity of the Basal Chadron Sandstone and the excellent confinement provided by not only the overlying Chadron and Brule Formations, but the underlying Pierre Shale. The cross-sections, isopach and structure maps were generated with the PETRA software package using select drill hole data, geologic picks and logs provided by CBR. Figures 3.3-16 through 3.3-20 present 3-D views of the Brule, Upper/Middle Chadron sand, Basal Chadron Sandstone, and Pierre Shale and the relationship between those units. The geology of the Pierre, Chadron and Brule specific to the North Trend area is discussed below.

3.3.2.2 Pierre Shale - Lower Confinement

The Pierre Shale is a black marine shale and is the oldest formation typically encountered in CBR test holes associated with Class III operations. The Pierre Shale is the confining bed below the Chadron Sandstone which is the host for uranium mineralization (Figures 3.3-7 through 3.3-15.) The description provided under regional stratigraphy also describes the Pierre Shale within the North Trend area. The ancient soil horizon known as the Interior Paleosol has been scoured away by the overlying Chadron Sandstone throughout most of the North Trend Expansion Area. Figure 3.3-21 is a structure contour map constructed at the top of the Pierre for the North Trend Area.

The character of the entire Pierre Shale can be observed in nearby oil and gas well geophysical logs, from two wells, the Heckman No. 1 and Soester No. `. The Heckman No.1 hole is about six miles southeast (Section 24, T31N, R52W) of the North Trend area. The log from Heckman No. 1 is believed to be representative of the Pierre Shale within the Crow Butte Area, including North Trend. At the location of Heckman No. 1, the base of the Chadron Formation is at a depth of 525 feet. The Pierre Shale is 1,565 feet thick and rests on the Niobrara Formation at 2,090 feet. The spontaneous potential and resistivity curves for this hole qualitatively indicate a lack of permeable, water-bearing zones within the Pierre Shale. The Soester No. 1 well is located within the North Trend Permit Area, in Section 34, T32N R52W,. At this location, the Pierre is 1,265 feet thick and also shows no indication of permeable (water bearing) zones. At the Soester #1 well location, the top of the Pierre occurs at a depth of 645 feet, and the base is encountered 1,910 feet below ground surface.

X-ray diffraction analyses of two core samples from the CSA indicate that the Pierre Shale is primarily comprised of quartz and montmorillonite with minor kaolinite-chlorite and mica illite (Table 3.3-3). The black marine shale is an ideal confining bed with measured vertical hydraulic conductivity in the CSA of less than 10^{-10} cm/sec. The

electric log characteristics of the Pierre Shale and overlying units are shown on logs included on the cross sections, and illustrate the impermeable nature of the Pierre Shale.

3.3.2.3 Basal Chadron Sandstone - Mining Unit

The Basal Chadron production zone lies upon a marked regional unconformity on the top of the Pierre Shale in the North Trend area. Regionally, deposition of the Basal Chadron has been assigned to large, high-energy braided streams and this appears to also be characteristic of the North Trend area. In this regard, the Basal Chadron is lenticular with numerous facies changes occurring within short distances. A similar, but lower-energy depositional environment appears to account for the spatial variability of the intermittent Upper/Middle Chadron sand.

The Basal Chadron Sandstone is generally present at the bottom of the Chadron Formation and is a coarse-grained arkosic sandstone with frequent interbedded thin clay beds and clay galls. Occasionally, the Basal Chadron Sandstone grades upward to fine-grained sandstone containing varying amounts of interstitial clay material and persistent clay interbeds. A persistent clay horizon typically brick red in color generally marks the upper limit of the Basal Chadron Sandstone. The Basal Chadron Sandstone is the host member and mining unit of the Crow Butte ore deposit; no other commercial uranium mineralization has been identified in the overlying units.

The vertical thickness of the Basal Chadron Sandstone within the North Trend Area averages about 20 to 60 feet, although the unit is up to 170 feet thick west of the North Trend property boundary. An isopach map of the Basal Chadron Sandstone is presented in Figure 3.3-22. The top of Pierre Shale and Basal Chadron Sandstone structure is shown on Figures 3.3-21 and 3.3-23.

Thin section examination of Basal Chadron Sandstone samples collected in the CSA indicates a composition of 50% monocrystalline quartz, 30 to 40% undifferentiated feldspar, plagioclase feldspar and microcline feldspar (Table 3.3-3). The remainder includes polycrystalline quartz, chert, chalcedonic quartz, various heavy minerals and pyrite. X-ray diffraction analyses indicate that the Basal Chadron Sandstone is 75% quartz with the remainder K-feldspar and plagioclase.

Table 3.3-3: Estimated Weight Percent as Determined by X-Ray Diffraction

Phase	Upper Part Chadron Formation (2) Upper Confinement	Chadron Sandstone (4) (Mining Unit)	Pierre Shale (2) Lower Confinement
Quartz	22.5	75.5	26
K Feldspar	2	13	4
Plagioclase	1	9.5	1
Kaolinite-Chlorite	--	<1	9
Montmorillonite	44	<1	32
Mica-Illite	1	<1	15
Calcite	22	--	1.5
Fluorite	0.5	--	--
Amorphous	7	1	10.5
Unidentified	--	<1	1
TOTAL	**100**	**100**	**100**

CBR has collected mineralogical samples from the Chadron Formation in the North Trend area, and is currently assembling and evaluating this information.

Core samples and outcrops of the Basal Chadron Sandstone exhibit numerous clay galls up to a few inches in diameter, frequent thin silt and clay lenses of varying thickness and continuity, and occasionally a sequence of upward fining sand. These probably represent flood plain or low velocity deposits which normally occur during fluvial sedimentation. Within the North Trend Area, varying thicknesses of clay beds and lenses often separate the Basal Chadron Sandstone into fairly distinct subunits.

3.3.2.3.1 Geochemical Description of the Mineralized Zone

Hansley, et al (1989) conducted detailed geochemical analysis of the Crow Butte uranium ore to assess both ore genesis and composition. The Crow Butte deposits, including North Trend, are roll-type deposits with coffinite being the predominant uranium mineral species present. The origin of the uranium is in-situ rhyolitic ash material within the Basal Chadron. Coffinite is associated with pyrite, and high silica activity due to *dissolution of the rhyolitic ash which favored formation of coffinite over uraninite in* most parts of this sandstone. In addition, smectite is present in the samples examined, with the most common minerals in the sandstone being quartz, plagioclase, K-feldspar,

coffininte, pyrite, marcasite, calcite, illite/smectite and tyuyamunite. The heavy mineral portion of the samples contained several minerals including those above as well as garnet, magnetite, marcasite, and illmenite. Vanadium was detected in the samples primarily as an amorphous species presumed to have originated from the in-situ ash. Hansley, et al state that at least some uranium and vanadium remain bound to amorphous volcanic material and/or smectite rather than as discrete mineral phases.

Petrographic data obtained and examined by Hansley et al (1989) suggest that uranium mineralization occurred before lithification of the Basal Chadron. Hansley states: *"Dissolution of abundant rhyolitic volcanic ash produced U- and Si- rich ground waters that were channeled through permeable sandstone at the base of the Chadron by relatively impermeable overlying and underlying beds. The precipitation of early authigenic pyrite created a reducing environment favorable for precipitation and accumulation of U in the basal sandstone. The U has remained in a reduced state, as evidenced by the fact that the unoxidized minerals, coffinite and uraninite, comprise the bulk of the ore."*

The ore body ranges in grade from less than 0.05% to greater than 0.5%U_3O_8, with and average grade estimated at 0.26% equivalent U_3O_8 and 0.31% chemical U_3O_8. Table 3.3-3 presents the mineralogical composition of the Chadron Sandstone interval.

3.3.2.4 Middle Chadron and Upper/Middle Chadron Sand

The Middle Chadron confining layer occurs above the Basal Chadron Sandstone, and is described as a clay-rich interval that grades from brick red to grey in color with interbedded bentonitic clay. The Middle Chadron is about 250 to 300 feet thick in the North Trend Expansion Area. An isopach of the Middle Chadron confining unit is presented in Figure 3.3-24.

The Upper/Middle Chadron sand occurs above the Middle Chadron confining interval. It was created by a depositional environment similar to the Basal Chadron sandstone, but of lower-energy that would appear to account for the spatial variability of the Upper/Middle Chadron sand. The available data suggest that the Upper/Middle Chadron sand may be continuous across the site (see Figure 3.3-25), yet the regional depositional model suggests that the sand may occur intermittently. The continuity of this Upper/Middle Chadron sand, with regard to justification for detailed monitoring, is questionable. However, the sand does occur with sufficient frequency to justify its identification as a mappable stratigraphic marker. The Upper/Middle Chadron Sandstone is similar in appearance to the rest of the Chadron Sandstone, and is typically a very fine to fine grained, well sorted, poorly cemented sandstone.

The available data, maps and figures included herein indicate that the Middle Chadron is approximately 200 to 300 feet thick, while the Upper/Middle Chadron sand is approximately 10-70 feet thick in the North Trend Permit Area.

3.3.2.5 Upper Chadron and Brule Formations, Upper Confinement

The Upper Chadron confining unit represents a distinct and rapid facies change from the underlying portions of the Chadron, and is continuous across the North Trend Permit Area. An isopach map of the Upper Chadron is presented in Figure 3.3-26, and shows that this portion of the Chadron Formation can be from about 100 to 250 feet thick in the North Trend Permit Area. The upper part of the Chadron Formation is a light green-gray bentonitic clay grading downward to green and frequently red clay. X-ray diffraction analyses of the red clay indicate that it is primarily comprised of montmorillonite and calcite (Table 3.3-3). This portion of the Chadron often contains gray-white bentonitic clay interbeds. The light green-gray "sticky" clay of the Chadron serves as an excellent marker bed in drill cuttings and has been observed in virtually all drill holes within the Crow Butte Area, including North Trend. Based on data from the CSA, the vertical hydraulic conductivity of the upper confining intervals at Crow Butte is less than 1.0×10^{-10} cm/sec.

The Brule Formation lies conformably on top of the Chadron Formation. The Brule Formation is the outcropping formation throughout most of the Crow Butte Area. The Brule, including the uppermost portion discussed in Section 3.3.2.6 below, is about 50 to 100 feet thick in the North Trend Area. The lower part of the Brule Formation consists primarily of siltstones and claystones. Infrequent fine-to-medium-grained sandstone channels have been observed in the lower part of the Brule Formation. When observed, these sandstone channels have very limited lateral extent.

The Brule-Chadron contact is sometimes difficult to ascertain, as the contact between the two formations is gradational and cannot be consistently picked in drill cuttings or electric logs. Therefore, the Upper Chadron/Lower Brule may be considered a single confining interval.

3.3.2.6 Upper Part of the Brule Formation - Upper Monitoring Unit

The upper part of the Brule Formation is primarily composed of buff to brown siltstones which have a larger grain size than the lower part of the Brule Formation. Occasional sandstone units are encountered in the upper part of the Brule Formation. The small sand units have limited lateral continuity and, although water bearing, do not always produce usable amounts of water. These sandstones have been included in the upper part of the Brule Formation and are illustrated on the series of cross-sections as overlying the upper

confinement (Figures 3.3-7 through 3.3-12). The lowest of these water bearing sandstones would be monitored by shallow monitor wells during mining. This unit may correlate with the Brown Siltstone beds recognized by Swinehart et al, (1985).

3.3.2.7 North Trend Area Structure

Figures 3.3-21 and 3.3-23 present the structure on top of the Pierre and Basal Chadron, respectively, in the North Trend Area. Cross-sections presented in Figures 3.3-7 through 3.3-15 illustrate local structural trends across the North Trend Area (see Figure 3.3-6 for cross-section locations). The structure at the top of the Pierre dips to the south in the North Trend Permit Area through Sections 22 and 27, with dip changing and steepening to the northwest in southern portions of Section 34.

Previous drilling identified a structural feature referred to as the White River Fault located between the current permit area and the proposed North Trend permit area. The feature is oriented NE-SW generally along the drainage of the White River (Figure 3.3-5). The general location of the feature is shown on Figures 3.3-21 and 3.3-23. Deep data are limited, but suggest that the vertical movement along the feature appears to be approximately 200 feet, upthrown to the south-southeast. Drilling and logging data in the North Trend Area suggest that, while this fault may occur at depth, it may not continue upsection through the Pierre into and through the Chadron and Brule Formations in the North Trend Area. Therefore, based on the data available to date and presented herein, it is possible that the referenced structural feature is a fault at depth, movement along which is expressed upsection in the Pierre, Chadron and Brule as a fold (e.g., a monocline), as discussed below.

Cross sections presented in Figures 3.3-7 through 3.3-15 show a definite structural high in the southeastern portion of the North Trend Area, specifically in the southeast corner of Section 34, T32N, R52W. This is verified by structure contour maps constructed at the top of the Pierre and Basal Chadron Sandstone (Figures 3.3-21 and 3.3-23). Previous maps by CBR and others show the White River Fault to transect the Chadron and Upper units, suggesting that faulting transected both the Pierre surface and overlying Chadron post-depositionally. However, cross-section correlations are readily made without showing that the fault explicitly transects these upper units. While structure contour maps clearly shown the presence of a feature in the southeast portion of Section 34, the data does not mandate that contouring reflect a fault in this location. As a result, the presence of the White River Fault through the Chadron and Brule, as previously mapped, is not explicitly verified in new cross-sections, although there is definite evidence that a structural feature is present that impacted both the paleotopographic Pierre surface and thickness of overlying units.

Previous interpretations have indicated that the White River Fault transected through the Chadron and Brule Formations post-depositionally. If this had been the case, then isopach variations within the Chadron would not be readily apparent, or at least would not likely be associated with the fault. The cross-sections show that the Basal Chadron Sandstone is pervasive and correlatable throughout the area and does not appear to exhibit thickness changes across the White River Fault/fold, suggesting that movement along this feature did not impact deposition of the Basal Chadron Sandstone. However, in the area where the White River Fault is suspected to occur (Figures 3.3-5 and 3.3-25), the Middle/Upper Chadron (or Chadron/Lower Brule, depending upon interpretation) notably thins across the mapped fault suggesting that movement along the monocline/fold may have impacted deposition of the Middle/Upper Chadron (assuming that the Brule/Chadron picks are correct). This portion of the Chadron appears to thicken to the west and north of the fault area, and intermittent sandstones of the Middle Chadron are more readily identifiable in these thicker areas, based on available data. Structure contour maps of the Pierre surface show there to be lows in areas of the Chadron thickening, and highs where the Chadron thins. This is consistent with historical interpretations in the CBR permitting documents that suggest (1) an erosional paleotopographic surface of the Pierre Shale prior to deposition of the Chadron Formation, and (2) structural movement which occurred prior to or during deposition of the Middle/Upper Chadron which affected the depositional patterns of this unit in the area.

In summary, current data suggest that the White River Fault may be present at depth and movement along this feature impacted the deposition of the Middle/Upper Chadron. However, data do not clearly require that this fault transect the Middle/Upper Chadron or Brule, and mapped data suggest that movement along the structure occurred during deposition of the Chadron/Brule via uplift of a monocline or fold in this area. Crow Butte is committed to conduct additional exploratory drilling to better define the nature of the feature before commencing mining operations..

3.3.2.8 Conclusions- Site Geology and Confining Strata

The North Trend ore body represents a situation favorable for in-situ mining of uranium; the successful historic and continuing mining operations in the current Class III Permit area immediately southeast of North Trend within the same geologic setting further verifies this conclusion. Figures 3.3-7 through 3.3-15 and 3.3-22 present the location and lateral continuity of the Basal Chadron Sandstone mined interval, showing that this interval is laterally continuous throughout the North Trend Area, with thick portions occurring along a North-South trend in Sections 22, 27, and 34, as well as in Sections 28 and 33 west of the North Trend property boundary. The lower confining bed is the Pierre Shale and is over 1,000 feet in thickness. The Pierre Shale is a thick, homogenous black shale with very low permeability and is one of the most laterally extensive formations of northwest Nebraska.

The upper confinement is composed of the Middle Chadron Formation above the Basal Chadron Sandstone and that portion of the Upper Chadron and Brule Formation underlying the intermittent Brule sandstones. The Middle Chadron confining unit includes a clay-rich interval that grades from brick red to grey in color with interbedded bentonitic clay. The upper part of the Chadron Formation is an impermeable clay grading upward into several hundred feet of siltstones and claystones of the Brule Formation. These units separate the mining zone (Basal Chadron Sandstone) from the nearest overlying water bearing unit with several hundred feet of clay and siltstones. The Middle and Upper Chadron Formation clays also have a large lateral extent and have been observed in all holes within the North Trend Area. The thickness of the upper confinement ranges from approximately 250 to over 500 feet within the North Trend Area.

From Table 3.3-3, it is evident that the upper and lower confining beds (the Middle Chadron through Brule Formation and Pierre Shale) contain significant percentages of montmorillonite clay and other clays and/or calcite. These two analyses would indicate the presence of clay minerals with very fine grain sizes. Size distribution analyses of these beds verify that the material is quite fine grained. These two facts indicate that both the upper and lower confinement are significantly less permeable than the ore zone and essentially impermeable. Further, core and hydrologic data from the CSA indicate that the vertical hydraulic conductivity of the confining shales and clays overlying and underlying the Basal Chadron Sandstone are on the order of 10^{-10} cm/sec, or lower. The geologic information presented in this application clearly demonstrates the lateral continuity of the overlying and underlying confining zones on both regional and local scales, as well as the lateral occurrence and distribution of the Basal Chadron Sandstone mined interval.

3.3.3 Seismology

The Crow Butte Project Area, including the North Trend area, is in northwest Nebraska within the Stable Interior of the United States. The project area along with most of Nebraska and the surrounding region is in seismic risk Zone 1 on the Seismic Risk Map for the United States, and is therefore in an area of low Seismic Hazard (Figure 3.3-27) as presented by the USGS. Most of the central United States is within seismic risk Zone 1 and only minor damage is expected from earthquakes which occur within this area. The closest Zone 2 area is in the southeastern part of Nebraska within the eastern part of the central Nebraska Basin (Burchett, 1990) about 300 miles southeast from the proposed North Trend Expansion Area.

Although the project area is within an area of low seismic risk, occasional earthquakes have been reported. Over 1100 earthquakes have been catalogued within the Stable

Interior of the U.S. since 1699 by Docekal (1970). This study noted several earthquake epicenters within northwest Nebraska. All but two of these earthquakes were classified within the lowest category, Intensity I-IV, on the Modified Mercalli Intensity Scale of 1931.

Figure 3.3-28 is a seismicity map of Nebraska prepared by the USGS for the 1990-2001 time period. (http://earthquake.usgs.gov/regional/states/nebraska/seismicity.php). The location of the principal structural features of Nebraska including the Chadron and Cambridge Arches are shown in Figure 3.3-5. The earthquakes which have been recorded along these two structural features are tabulated in Table 3.3-4.

The strongest earthquake in northwest Nebraska (No. 21) occurred July 30, 1934 with an intensity of VI and was centered near Chadron. This earthquake resulted in damaged chimneys, plaster, and china. Earthquake No. 26 occurred on March 24, 1938 near Fort Robinson. This earthquake had an intensity of IV; no additional information is available. An Intensity IV earthquake should be felt indoors by many and cause dishes, windows, and doors to be disturbed. Earthquake No. 30 occurred on March 9, 1963 near Chadron. This earthquake was reported to last about a second and was not accompanied by any damage or noise and was not even noticed by many of the residents of Chadron. Earthquake No. 32 occurred on March 28, 1964 near Merriman. The vibrations from this earthquake lasted about a minute and caused much alarm but no major damage occurred. Books were knocked off shelves and closet and cupboard doors swung open. On May 7, 1978 an earthquake (No. 40) with Intensity V occurred in southwestern Cherry County, also near the Chadron Arch. No major damage was reported from this earthquake.

Although the risk of major earthquakes in Nebraska is slight (Burchett, 1990), some low to moderate tectonic activity has occurred (Rothe, 1981). This tectonic movement is also suggested by geomorphic and sedimentation patterns during the Pleistocene (Rothe, 1981), which reflect such movement. Recent seismicity on the Cambridge Arch appears to be related to secondary recovery in the Sleepy Hollow oil field (Rothe, et al, 1981). Deeper events, however, suggest current low level tectonic activity on the Chadron and Cambridge Arches. This activity is not expected to affect the mining operations in the North Trend Area.

The most recent earthquake recorded in Nebraska occurred February 1, 2006. The epicenter was about 20 miles east-northeast of Ainsworth, Nebraska, and was therefore over 200 miles east of Crawford. This earthquake had a recorded magnitude of 2.9, but was not felt at Crawford or the Crow Butte/North Trend area. According to the USGS (http://folkworm.ceri.memphis.edu/recenteqs/) no earthquakes have been felt in Nebraska since the February 1, 2006 event.

Table 3.3-4: Earthquakes in Nebraska

Date	Central Standard Time	Locality	Latitude Degrees North	Longitude Degrees West	Modified Mercalli (MM) Intensity	Source
March 17, 1884	14:00	North Platte	41.133	100.75	IV	A
Dec. 16, 1916	-----	Stapleton	41.55	100.467	II-III	A
Sept. 24, 1924	5:00	Gothenburg	40.95	100.133	IV	A
Aug. 8, 1933	-----	Scottsbluff	41.867	103.667	IV-V	A
30-Jul-34	1:20	Chadron	42.85	103	VI	A
24-Mar-38	7:11	Fort Robinson	42.683	103.417	IV	A
9-Mar-63	9:25	Chadron	42.85	103	II-III	A
28-Mar-64	4:21	Merriman	42.8	101.667	VII	A
7-May-78	10:06	SW Cherry County	42.26	101.95	V	B
6-May-83	0:15	NE Sheridan County	42.96	102.2	III	B
1-Jan-87	2:02	Crawford	42.79	103.48	III	B
8-Feb-89	23:16	Merriman	42.8	101.6	IV	B

Sources: A = Docekal, 1970
B = National Earthquake Information Service

3.3.4 Inventory of Economically Significant and Energy Related Deposits and Artificial Penetrations Inventory

According to the Nebraska Department of Economic Development website (www.neded.org) there has been no oil and gas production from Dawes County from 1994-2004. The only non-fuel mineral produced in Dawes County is sand and gravel. Based on data up to 2005, coal is not produced anywhere in Nebraska (http://tonto.eia.doe.gov/FTPROOT/coal/05842005.pdf).

Other than the monitoring wells installed by CBR and discussed in Section 3.4 (see Figure 3.4-15), there is only one deep penetration well that transects the Brule and Chadron in the North Trend Permit Area. This well, the Soester No. 1, is located in Section 34, Township 32 North, Range 52 West. Plugging information for this well show that the well reached total depth (TD) on September 3, 1977 with a total depth of 2006 feet. The well was subsequently abandoned, with the borehole filled with mud-laden fluid and cement emplaced from 124 ft to ground surface. This information shows that appropriate action was taken to properly abandon this well in accordance with regulatory requirements and common practice in place at the time of abandonment.

3.3.5 Soils

The Crow Butte North Trend Project Area is located in the semiarid west-central portion of Dawes County, Nebraska, just north of the city of Crawford. For the proposed project, an investigation was made of the local soils. Soils data for the North Trend Project Area was obtained from the United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), Soil Survey of Dawes County, Nebraska, published in February 1977.

The project area is bounded on the south by the White River and is located in the White River watershed. The terrain is generally flat with gentle rolling hills. Natural vegetation is dominated by drought tolerant short-grass prairie and large areas of mixed-grass prairie, but they have been largely replaced by agricultural crops within the project area.

Dawes County soils were formed by weathering of materials of the underlying geologic formations or of materials deposited by wind and water. The Brule Formation is widely exposed on lower slopes, is soft and weathered rapidly producing the Epping, Kadoka, Deota, Schamber and Mitchell soils. As this material weathered, it produced the Epping, Kodaka variant, Keota, and Mitchell soils. Overlying Tertiary-age bedrock at higher elevations is the Arikaree Group. This massive sandstone contains layers of compacted silt and clay. Soils formed from this fine grained material are Alliance, Busher, Canyon,

Oglala, Tassel and Rosebud. Sandstone mixed with loess formed soils such as Bayard, Bridget and Vetal formed in colluvial and alluvial materials.

Soil association is a landscape that has a distinctive proportional pattern of soils, consisting of one or more major soils and at least one minor soil. Three soil associations exist within the Project Area; Kadoka-Keith-Mitchell, Busher-Tassel-Vetal, and Tripp-Haverson-Glenberg.

The Kadoka-Keith-Mitchell soils are deep, nearly level to steep, well drained silty soils that formed in loess and in material weathered from siltstones, on uplands and foot slopes. Typically this association consists of undulating to rolling uplands that are dissected by many spring-fed creeks. Areas of this association are mostly west of the project area. Approximate percentages of soils in this association are Kadoka at 28 percent, Keith 23 percent and Mitchell at 18 percent. Minor soils and land types make up the remaining 31 percent. Minor soils in this series are Bridget, Duroc, Epping, Ulysses, Keota, and Schamber series, and areas of Loamy alluvial land and Badland.

The Busher-Tassel-Vetal soils are deep and shallow, very gently sloping to steep, well drained to somewhat excessively drained sandy soils that formed in colluvium and in material weathered from sandstone. These sandy soils are found on undulating to hilly uplands which are crossed by numerous creeks and intermittent drainageways.
Approximate percentages of soils in this association are Busher 35 percent, Tassel 32 percent and Vetal 15 percent. Minor soils and land types make up the remaining 18 percent. These include the Bayard, Jayem and Sarben soil types and sandy alluvial land.

The Tripp-Haverson-Glenberg soils are deep and shallow, very gently sloping to steep, well-drained to somewhat excessively-drained sandy soils that formed in colluvium and in material weathered from sandstone on uplands and foot slopes. These soils are found in undulating and hilly uplands that are crossed by numerous creeks and intermittent drainageways. Approximate percentages of soils in this association area Busher soils at 35 percent, Tassel soils at 32 percent, and Vetal soils at 15 percent. Minor soils and land types make up the remaining 18 percent. Minor soils in this association are soils in the Bayard, Jayem, and Sarben series and areas of sandy alluvial land and rock outcrop.

In certain areas, the soil material is so rocky, shallow, o severely eroded or variable that it has not been classified by soil series. These areas are called land types and are given descriptive names. An example of this is "sandy alluvial land" found within the Busher-Tassel-Vetal association.

Certain of the mapping units are composed of soil complexes or undifferentiated soil groups. A soil complex consists of areas of two or more soils so intricately mixed or so small in size that they cannot be shown separately on the soil map. Undifferentiated soil groups are made up of two or more soils that could be delineated individually but are

shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The name given uses the two dominant soil series represented in the group. Four of the mapping units within the restricted area belong to this category, where the names of dominant soils are joined by "and".

Soils Mapping Unit Descriptions

Table 3.3-5 summarizes those soils found within the North Trend Project Area. The first capital letter is the initial one of the soil name. The lower case letter that follows separates mapping units having names that begin with the same letter except that it does not separate sloping or eroded phases. The second capital letter indicates the class of the slope. Symbols without a slope letter are for soils that have a slope range of 0 to 2 percent or miscellaneous land types that have a wide range of slopes. A final number 2 in the symbol indicates that the soil is eroded. Those soils are also shown on Figure 3.3-29.

Table 3.3-5: Summary of Soil Resources within the Project Area

Map Unit	Map Unit Name	% of Project Area
Bg	Bridget silt loam, 0 to 1 percent slopes	1.22%
BgB	Bridget silt loam, 1 to 3 percent slopes	0.30%
BuD	Busher loamy very fine sand, 5 to 9 percent slopes	0.00%
BuD2	Busher loamy very fine sand, 5 to 9 percent slopes, eroded	0.11%
DuB	Duroc very fine sandy loam, 1 to 3 percent slopes	6.30%
GoB	Glenberg loamy very fine sand, occasionally flooded, 0 to 3 percent slopes	0.35%
HbB	Haverson silt loam, occasionally flooded, 0 to 3 percent slopes	0.27%
JmC	Jayem loamy very fine sand, 1 to 5 percent slopes	9.15%
JvD	Jayem and Vetal loamy very fine sands, 5 to 9 percent slopes	0.22%
KaD	Kadoka silt loam, deep variant, 3 to 9 percent slopes	5.27%
KaD2	Kadoka silt loam, deep variant, 3 to 9 percent slopes, eroded	1.04%
KeB	Keith silt loam, 1 to 3 percent slopes	29.43%
KeD	Keith silt loam, 3 to 9 percent slopes	1.68%
KfD	Keith and Ulysses silt loams, 3 to 9 percent slopes	9.79%
KoB	Keota silt loam, 1 to 3 percent slopes	0.44%
KpD	Keota-Epping silt loams, 3 to 9 percent slopes	3.05%
Lo	Loamy alluvial land	0.69%
OgF	Oglala loam, 9 to 30 percent slopes	0.50%
OhF	Oglala-Canyon loams, 9 to 20 percent slopes	0.26%
Sn	Sandy alluvial land	0.92%
SrC	Sarben fine sandy loam, 1 to 5 percent slopes	11.47%
SrD	Sarben fine sandy loam, 5 to 9 percent slopes	0.91%
SrF	Sarben fine sandy loam, 9 to 30 percent slopes	0.08%
SvF	Sarben and Vetal loamy very fine sands, 9 to 30 percent slopes	4.01%
VeC	Vetal and Bayard soils, 1 to 5 percent slopes	12.55%

Bg - Bridget silt loam, 0 to 1 percent slopes

The Bridget component makes up 100 percent of the map unit. Slopes are 0 to 1 percent. This component is on hillslopes on uplands. The parent material consists of loamy colluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 2c. Irrigated land capability classification is 1. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Soil blowing can be a hazard in cultivated areas. A large acreage of this soil is cultivated and is dryfarmed with wheat and alfalfa being the principal crops.

BgB - Bridget silt loam, 1 to 3 percent slopes

The Bridget component makes up 99 percent of the map unit. Slopes are 1 to 3 percent. This component is on hillslopes on uplands. The parent material consists of loamy colluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 2e. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water and wind erosion are hazards in areas where the soil surface is unprotected. Nearly all areas of this soil are dryfarmed to wheat, oats, or alfalfa. Native grass areas are used for grazing and hay.

BuD - Busher loamy very fine sand, 5 to 9 percent slopes

The Busher component makes up 100 percent of the map unit. Slopes are 5 to 9 percent. This component is on hillslopes on uplands. The parent material consists of residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell

potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17-20" P.z. ecological site. Nonirrigated land capability classification is 4e. Irrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Water and wind erosion are hazards in areas where the soil surface is unprotected. Most areas of this soil are native grass used for grazing and hay production. A few areas are dryfarmed to wheat, alfalfa, and oats.

<u>BuD2 - Busher loamy very fine sand, 5 to 9 percent slopes, eroded</u>

The Busher component makes up 99 percent of the map unit. Slopes are 5 to 9 percent. This component is on hillslopes on uplands. The parent material consists of residuum weathered from sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17-20" P.z. ecological site. Nonirrigated land capability classification is 4e. Irrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Water and wind erosion are serious hazards where the soil surface is unprotected. Nearly all areas of this soil are dryfarmed to wheat, alfalfa, and oats. A few areas are seeded to grass and used for grazing or hay production.

<u>DuB - Duroc very fine sandy loam, 1 to 3 percent slopes</u>

The Duroc component makes up 99 percent of the map unit. Slopes are 1 to 3 percent. This component is on swales on uplands. The parent material consists of alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 2e. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 5 percent.

Much of the soil is suited for irrigation and cultivated; however, the area is mostly dryfarmed to wheat, oats, or alfalfa. The rest of the acreage is in native and tame grasses used for grazing or hay production.

GoB - Glenberg loamy very fine sand, occasionally flooded, 0 to 3 percent slopes

The Glenberg component makes up 100 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains on valleys. The parent material consists of stratified calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY029NE Sandy Lowland ecological site. Nonirrigated land capability classification is 4w. Irrigated land capability classification is 3w. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Soil blowing is a hazard if the soil is cultivated and the surface is not protected. Small areas of this soil are cultivated with Alfalfa being the main dryfarmed crop. The rest of the area is in native or tame grasses used for grazing or hay production.

HbB - Haverson silt loam, occasionally flooded, 0 to 3 percent slopes

The Haverson component makes up 100 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains on valleys. The parent material consists of stratified calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY026NE Loamy Overflow ecological site. Nonirrigated land capability classification is 2w. Irrigated land capability classification is 2w. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Approximately half the acreage of this soil is in crops with the other half in range. Alfalfa is the main crop. Trees and shrubs cover some areas.

JmC - Jayem loamy very fine sand, 1 to 5 percent slopes

The Jayem component makes up 99 percent of the map unit. Slopes are 1 to 5 percent. This component is on hillslopes on uplands. The parent material consists of sandy and

silty eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 1 percent.

Soil blowing is a hazard if the soil surface is left unprotected. Most of the acreage of this soil is in native grass, which is used for grazing or hay. The rest of the acreage is cultivated with wheat or alfalfa being the main crops.

JvD - Jayem and Vetal loamy very fine sands, 5 to 9 percent slopes

The Vetal component makes up 50 percent of the map unit. Slopes are 5 to 9 percent. This component is on hillslopes on uplands. The parent material consists of loamy alluvium over eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 4e. Irrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Water and wind erosion are hazards in cultivated areas where the soil surface is left unprotected. Most areas are in native grasses used for grazing and hay production. A small acreage is cultivated to wheat, alfalfa, and oats.

KaD - Kadoka silt loam, deep variant, 3 to 9 percent slopes

The Thirtynine component makes up 99 percent of the map unit. Slopes are 3 to 9 percent. This component is on hillslopes on uplands. The parent material consists of alluvium derived from siltstone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R064XY036NE Loamy 17-20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability

classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent.

Water and wind erosion are hazards in cultivated areas where the soil surface is left unprotected. Most acreage of this soil is used for range with small areas used for hay production.

KaD2 - Kadoka silt loam, deep variant, 3 to 9 percent slopes, eroded

The Thirtynine component makes up 99 percent of the map unit. Slopes are 3 to 9 percent. This component is on hillslopes on uplands. The parent material consists of alluvium derived from siltstone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 3 percent. This component is in the R064XY036NE Loamy 17-20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent.

Water erosion is the main hazard. Nearly all the acreage of this soil is cultivated to wheat, alfalfa, or oats. A few areas are seeded to grass, which is used for grazing or hay production.

KeB - Keith silt loam, 1 to 3 percent slopes

The Keith component makes up 99 percent of the map unit. Slopes are 1 to 3 percent. This component is on plains on uplands. The parent material consists of loess. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 2e. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Soil erosion is the main hazard with modest water erosion potential in some areas. This soils is used for both crops and range. Winter wheat, alfalfa, and oats are the principal dryfarmed crops. Some areas are in grass and are used for grazing or hay production.

KeD - Keith silt loam, 3 to 9 percent slopes

The Keith component makes up 99 percent of the map unit. Slopes are 3 to 9 percent. This component is on hillslopes on uplands. The parent material consists of loess. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water erosion is the main hazard, with soil erosion a concern of management. A small acreage of this soil is used for crops, but most areas are in native grass and are used for grazing or hay production.

KfD - Keith and Ulysses silt loams, 3 to 9 percent slopes

The Keith component makes up 50 percent of the map unit. Slopes are 3 to 9 percent. This component is on hillslopes on uplands. The parent material consists of loess. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

The Ulysses component makes up 49 percent of the map unit. Slopes are 3 to 6 percent. This component is on hillslopes on uplands. The parent material consists of calcareous loess. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent.

Water erosion is a hazard, along with the controlling of soil blowing. Nearly all of the acreage of this soil is used for crops such as wheat, alfalfa, and oats. Only a few areas are irrigated and a small acreage is seeded to tame grasses used for grazing or hay production.

KoB - Keota silt loam, 1 to 3 percent slopes

The Keota component makes up 99 percent of the map unit. Slopes are 1 to 3 percent. This component is on interfluves on uplands. The parent material consists of calcareous loamy residuum weathered from siltstone. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY037NE Thin Upland ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 5 percent.

Soil blowing and water erosion are hazards. Much of the acreage of this soil is cultivated or has been seeded to grass. Wheat is the principal dryfarmed crop. Areas of grass are used for grazing or hay production.

KpD - Keota-Epping silt loams, 3 to 9 percent slopes

The Keota component makes up 70 percent of the map unit. Slopes are 3 to 6 percent. This component is on hillslopes on uplands. The parent material consists of calcareous loamy residuum weathered from siltstone. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY037NE Thin Upland ecological site. Nonirrigated land capability classification is 4e. Irrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 5 percent.

The Epping component makes up 29 percent of the map unit. Slopes are 3 to 9 percent. This component is on ridges on uplands. The parent material consists of loamy residuum weathered from siltstone. Depth to a root restrictive layer, bedrock, paralithic, is 10 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low.

Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY040NE Shallow ecological site. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water erosion and soil blowing are hazards. Most of the acreage of this mapping unit is used for dryfarmed crops such as wheat, oats or alfalfa. The rest of the acreage is in native tame grasses, which area used for grazing or hay production.

Lo - Loamy alluvial land

The Haverson component makes up 98 percent of the map unit. Slopes are 0 to 3 percent. This component is on flood plains on valleys. The parent material consists of stratified calcareous alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is frequently flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY026NE Loamy Overflow ecological site. Nonirrigated land capability classification is 6w. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Most areas of this land type are used for grazing but grass in a few areas is cut for hay. The hazard of flooding and deposition of sediment generally makes this land type unsuited to cultivation. The native vegetation is mostly grasses, and some areas support trees or shrubs. Most areas provide good food and cover for wildlife.

OgF - Oglala loam, 9 to 30 percent slopes

The Oglala component makes up 100 percent of the map unit. Slopes are 9 to 30 percent. This component is on hillslopes on uplands. The parent material consists of loamy residuum weathered from soft fine-grained sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Soil blowing and water erosion are hazards if the soil surface is not protected. Nearly all the acreage of this soil is in native grass. A few areas are seeded to tame grasses. This soil is unsuited to cultivation because of the steepness of the slopes.

OhF - Oglala-Canyon loams, 9 to 20 percent slopes

The Oglala component makes up 70 percent of the map unit. Slopes are 9 to 20 percent. This component is on hillslopes on uplands. The parent material consists of loamy residuum weathered from soft fine grained sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 40 to 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY036NE Loamy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

The Canyon component makes up 30 percent of the map unit. Slopes are 9 to 20 percent. This component is on ridges on uplands. The parent material consists of calcareous loamy residuum weathered from limestone and sandstone. Depth to a root restrictive layer, bedrock, paralithic, is 6 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY040NE Shallow ecological site. Nonirrigated land capability classification is 6s. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water erosion is a hazard if the cover of native grass is removed from these soils. Nearly all the acreage of this unit is in native grass and is used mostly for grazing. Nearly all of the areas that were cultivated have been seeded to grass. These soils are not suited to cultivation.

SrC - Sarben fine sandy loam, 1 to 5 percent slopes

The Sarben component makes up 100 percent of the map unit. Slopes are 1 to 5 percent. This component is on hillslopes on uplands. The parent material consists of sandy and loamy eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a

depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water erosion is a hazard in some areas but wind erosion is the main hazard. Nearly all the acreage of this soil is in cultivated crops such as wheat, alfalfa, and oats. Some areas are seeded to tame grass used for grazing or hay production.

<u>SrD - Sarben fine sandy loam, 5 to 9 percent slopes</u>

The Sarben component makes up 99 percent of the map unit. Slopes are 5 to 9 percent. This component is on hillslopes on uplands. The parent material consists of sandy and loamy eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 4e. Irrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water and wind erosion is a hazard in areas with disturbed surface. Nearly all the acreage of this soil is in cultivated crops; wheat, alfalfa, or oats. Some areas are seeded to tame grass used for grazing or hay production.

<u>SrF - Sarben fine sandy loam, 9 to 30 percent slopes</u>

The Sarben component makes up 100 percent of the map unit. Slopes are 9 to 30 percent. This component is on hillslopes on uplands. The parent material consists of sandy and loamy eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Water erosion and soil blowing are major hazards if the soil surface is left unprotected. This soil is generally too steep and too erodible for cultivation but where it occurs in

areas with soils that are suited to crops, it is cultivated along with those soils. Some areas are seeded to tame grass used for grazing or hay production.

SvF - Sarben and Vetal loamy very fine sands, 9 to 30 percent slopes

The Sarben component makes up 70 percent of the map unit. Slopes are 9 to 30 percent. This component is on hillslopes on uplands. The parent material consists of sandy and loamy eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 6e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

The Vetal component makes up 30 percent of the map unit. Slopes are 9 to 10 percent. This component is on hillslopes on uplands. The parent material consists of loamy alluvium over eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 4e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Water erosion and soil blowing are hazards if the soil surface is not protected. All the acreage of this mapping unit is in native grass used for grazing or hay production. This unit is too steep for the commonly grown crops.

VeC - Vetal and Bayard soils, 1 to 5 percent slopes

The Vetal component makes up 50 percent of the map unit. Slopes are 1 to 5 percent. This component is on stream terraces on valleys. The parent material consists of loamy alluvium over eolian deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is

3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

The Bayard component makes up 49 percent of the map unit. Slopes are 1 to 5 percent. This component is on stream terraces on valleys. The parent material consists of colluvial-alluvial sediments from calcareous sandstone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R064XY032NE Sandy 17 - 20" P.z. ecological site. Nonirrigated land capability classification is 3e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 6 percent.

Soil blowing is a hazard if the soil surface is not protected. About half the acreage of these soils is in crops and half is in range. Wheat, alfalfa and oats are the principal crops. Some areas are seeded to tame grasses used for hay production. Areas of native grass are used for grazing or the grass is cut for hay production.

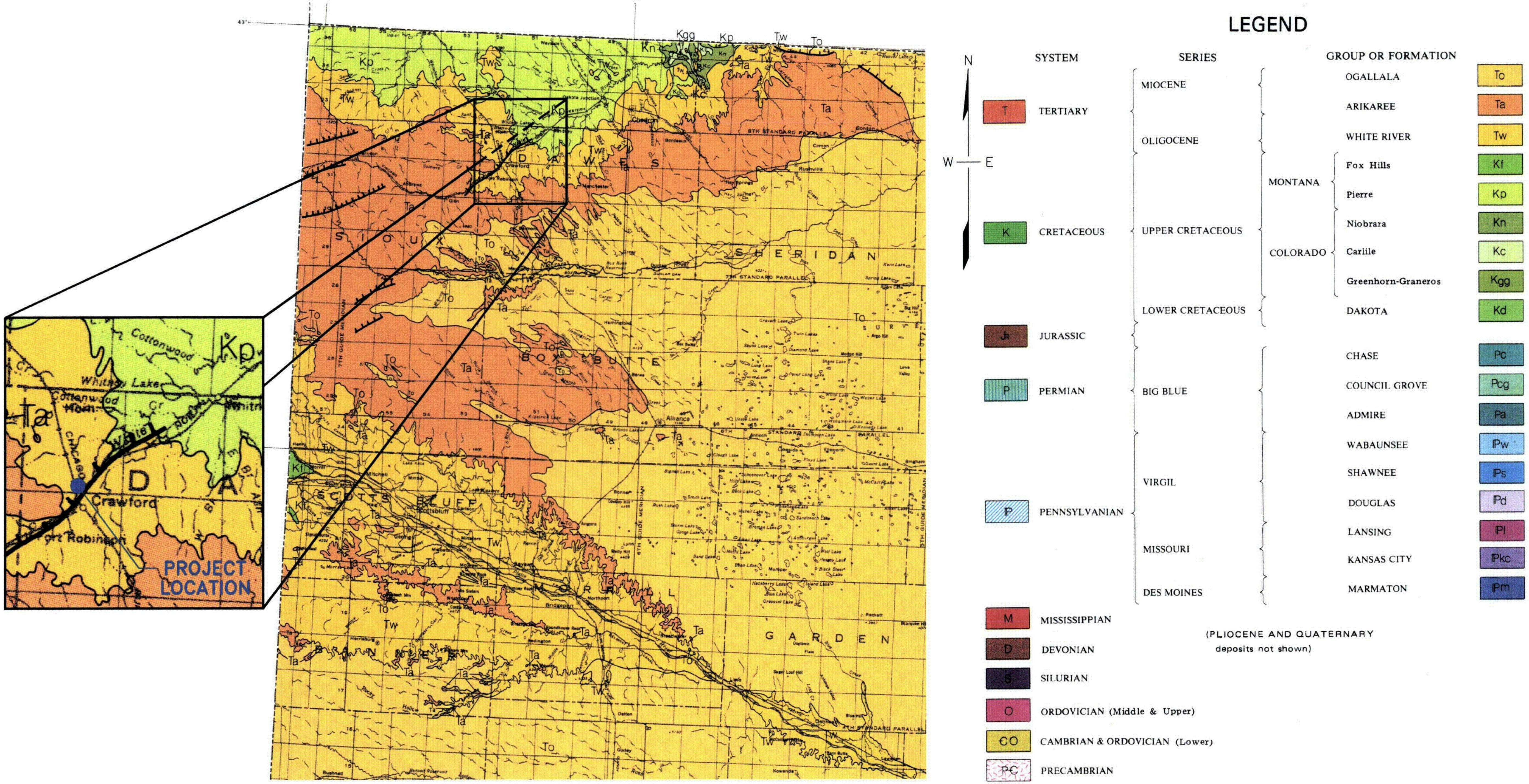


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FIGURE 3.3 - 1
BEDROCK GEOLOGY MAP, DAWES COUNTY

PROJECT: 223-37	DATE: MARCH 2007	
NTLAAFig2.6-1.dwg	BY: KRS	CHECKED: HPD

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Source: Nebraska Geological Survey

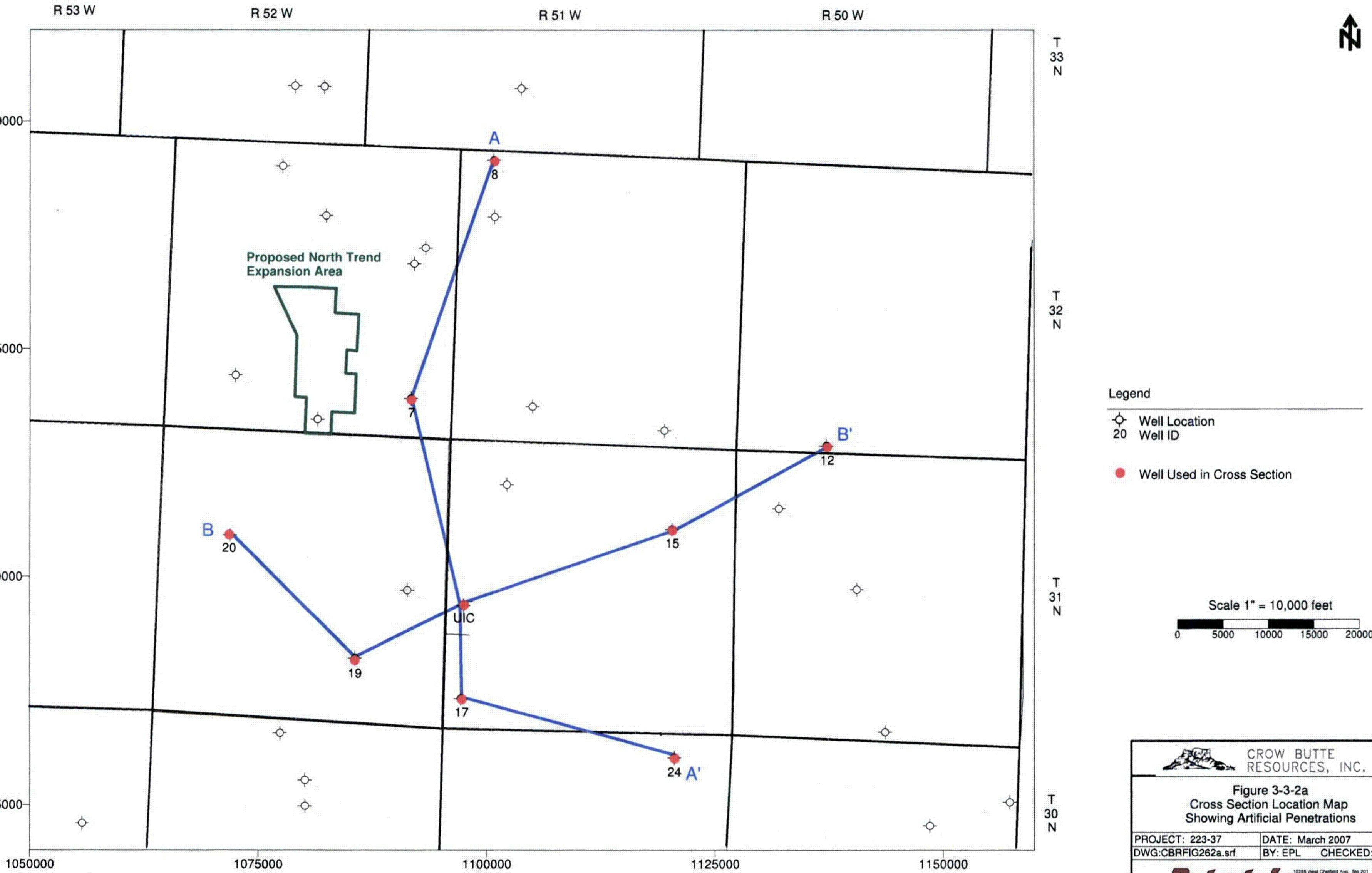

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Figure 3-3-2a
Cross Section Location Map
Showing Artificial Penetrations

PROJECT: 223-37	DATE: March 2007
DWG:CBRFIG262a.srf	BY: EPL CHECKED: HPD

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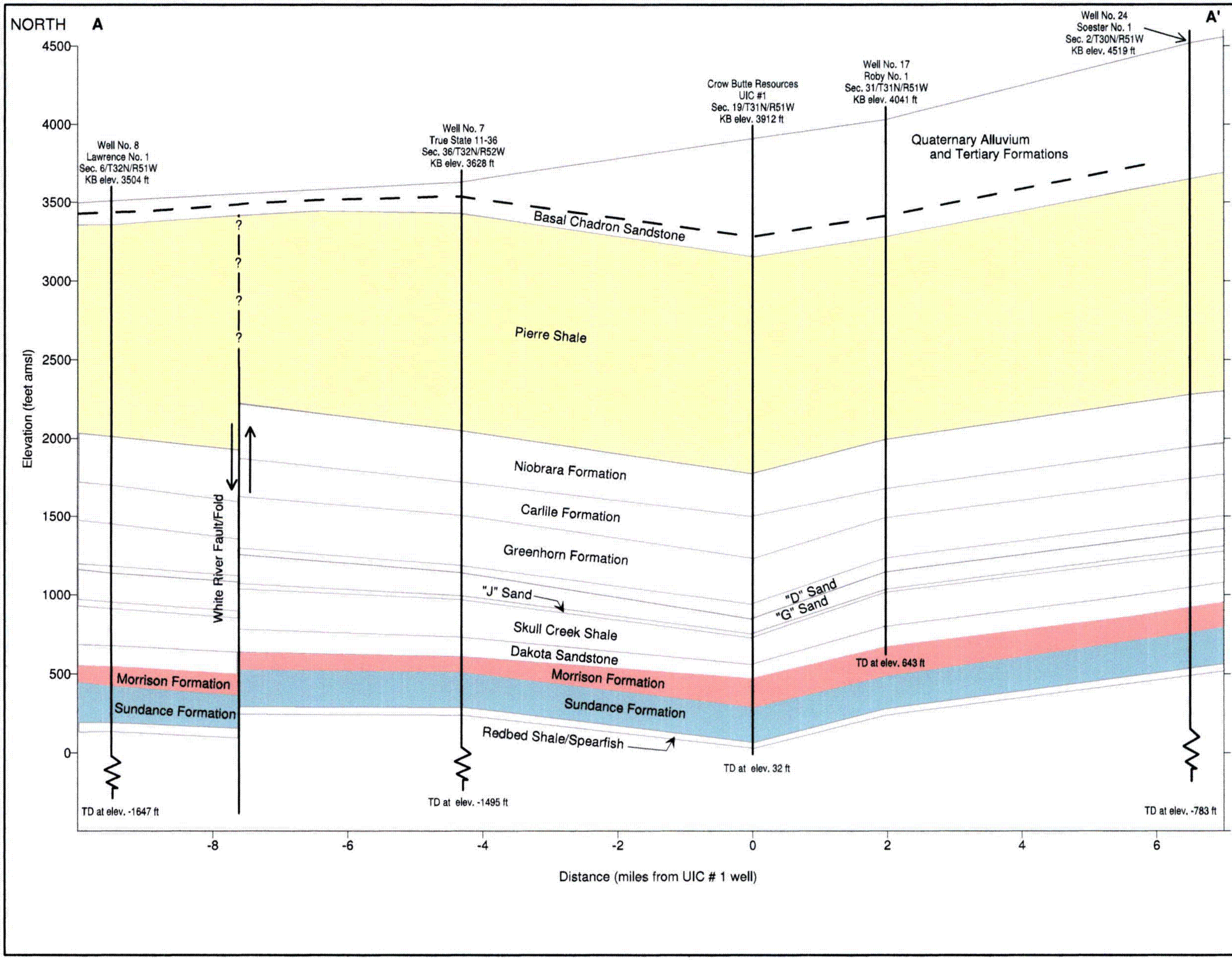

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Figure 3.3-2b
N.S Regional Cross Section

PROJECT: 223-37	DATE: MARCH 2007
DWG: CBRFIG262b	BY: EPL CHECKED: HPD

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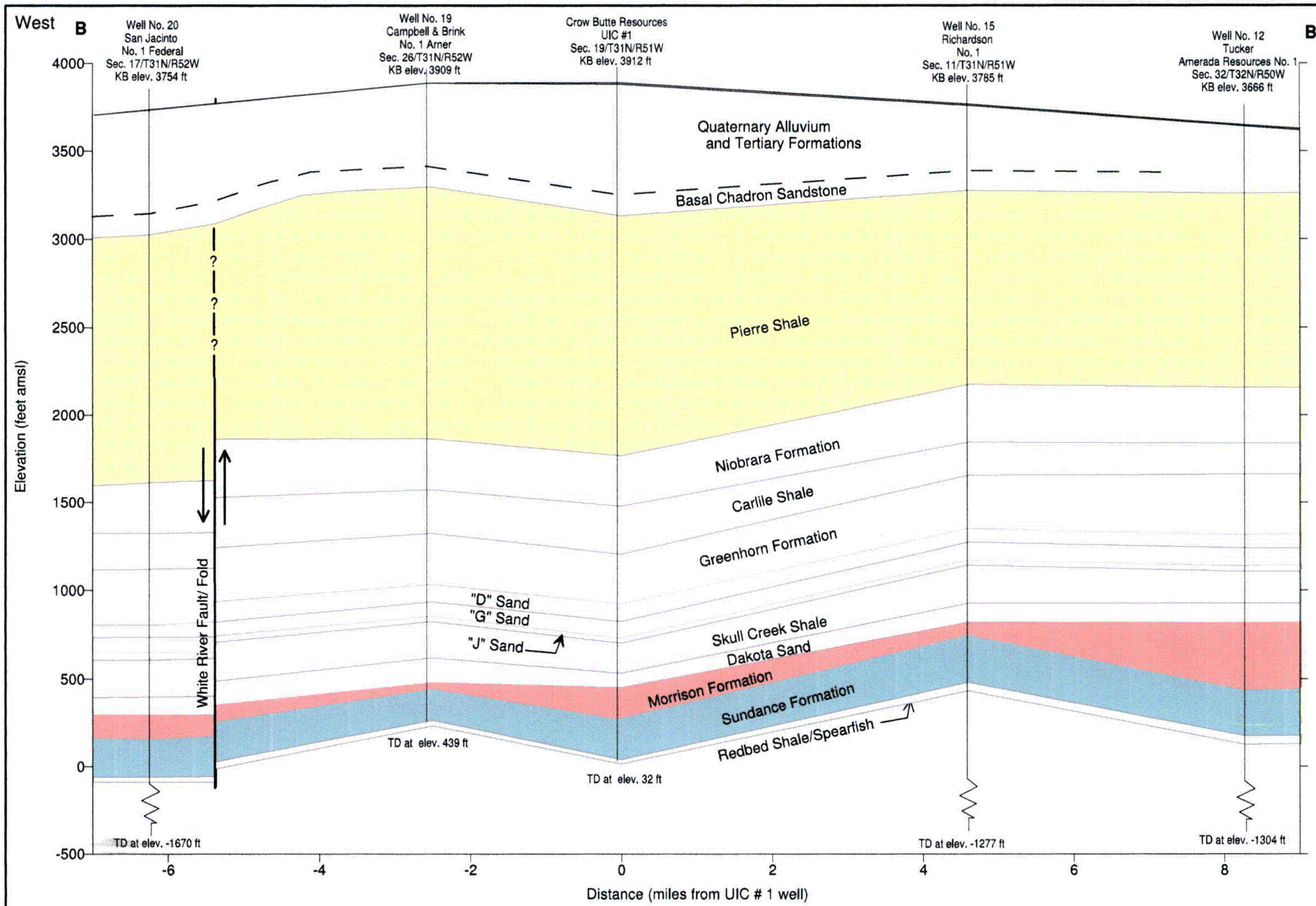

Orientation of Cross Section B-B' is indicated on Figure 2.6-2a

Vertical Scale 1" = 600 feet
Horizontal Scale 1" = 1.4 miles

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Figure 3.3-2c
E-W Regional Cross Section

PROJECT: 223-37	DATE: MARCH 2007
DWG: CBRFIG262c.SRF	BY: EPL

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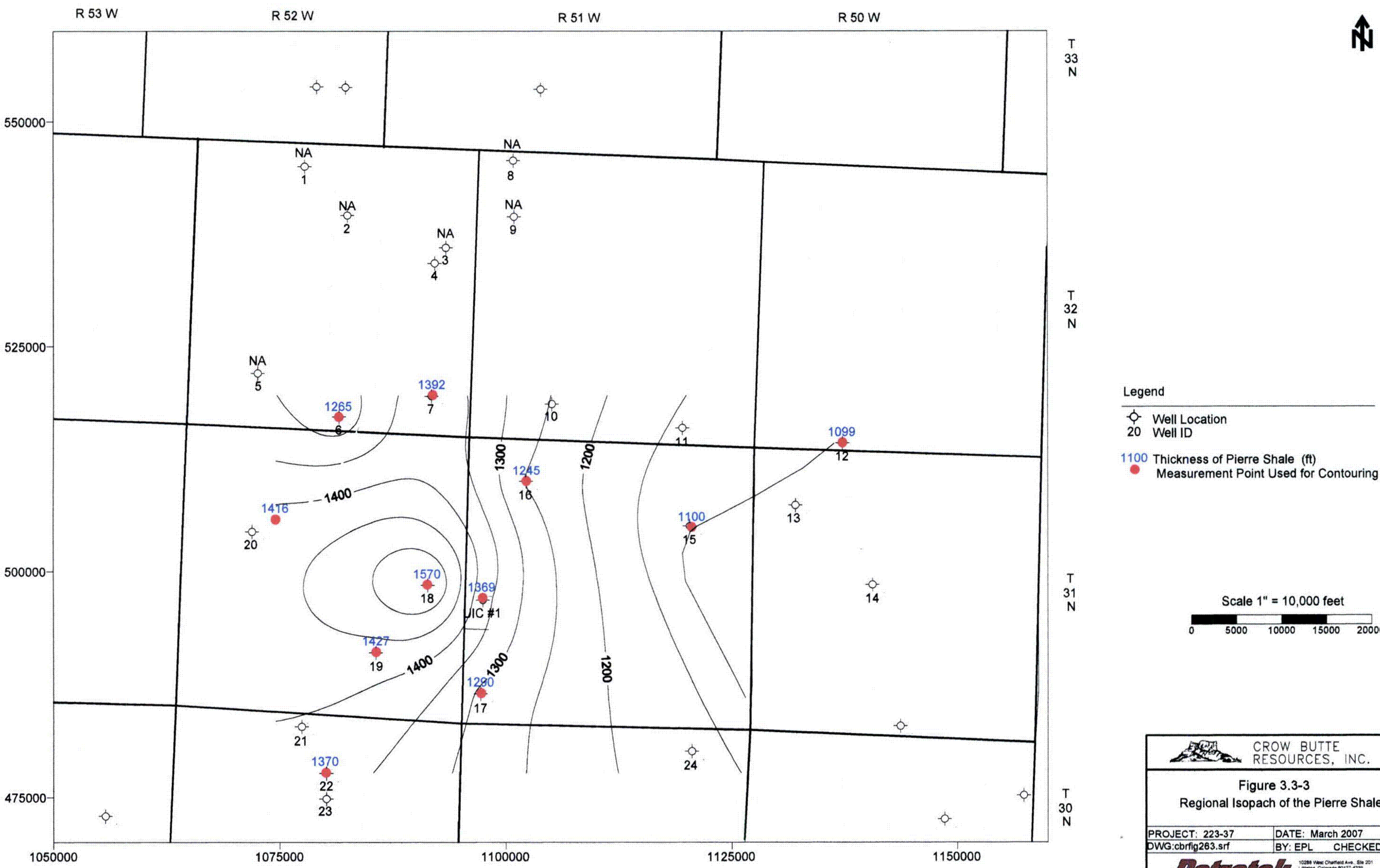

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Figure 3.3-3
Regional Isopach of the Pierre Shale

PROJECT: 223-37	DATE: March 2007
DWG:cbrfig263.srf	BY: EPL CHECKED: HPD

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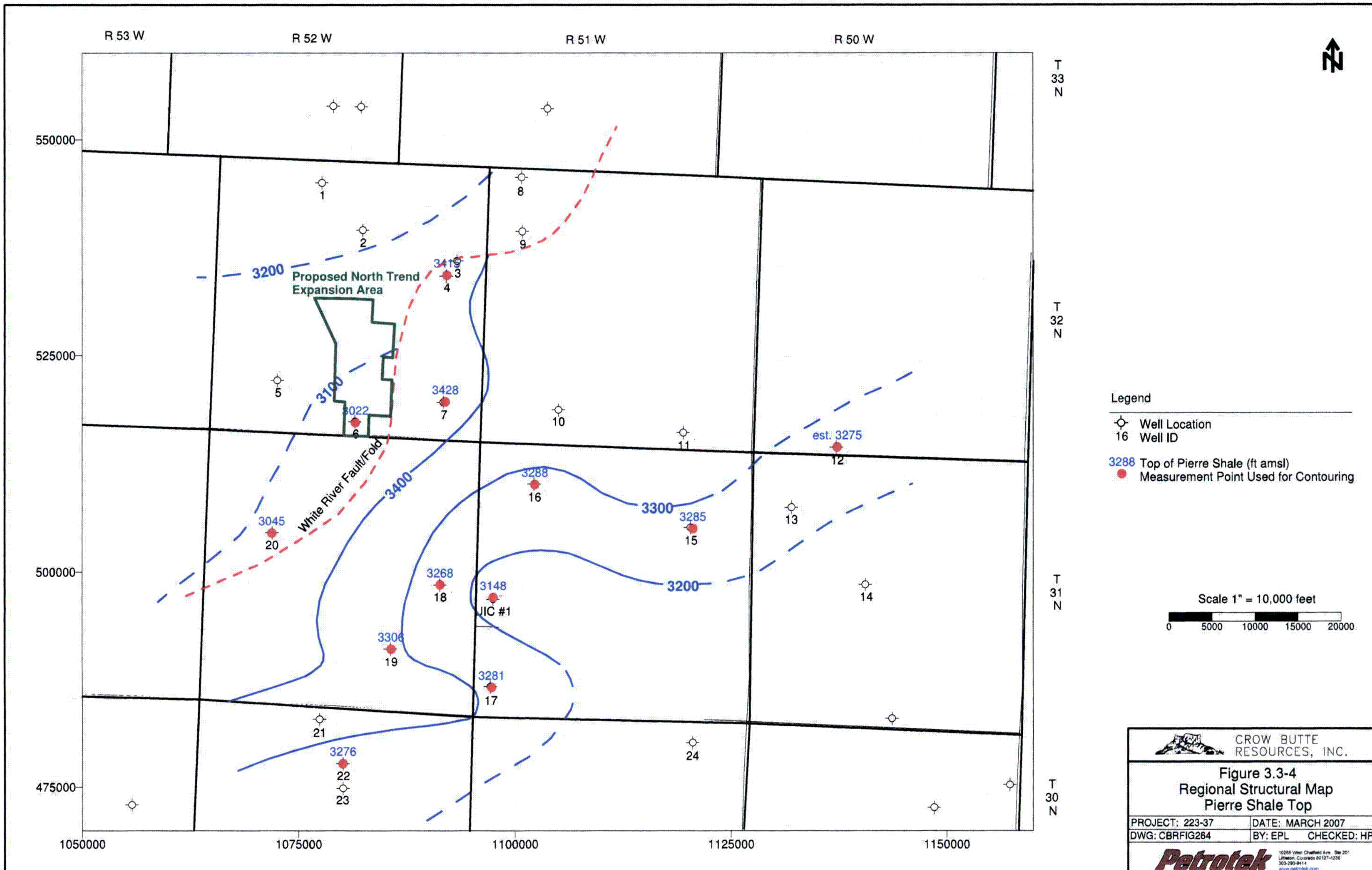
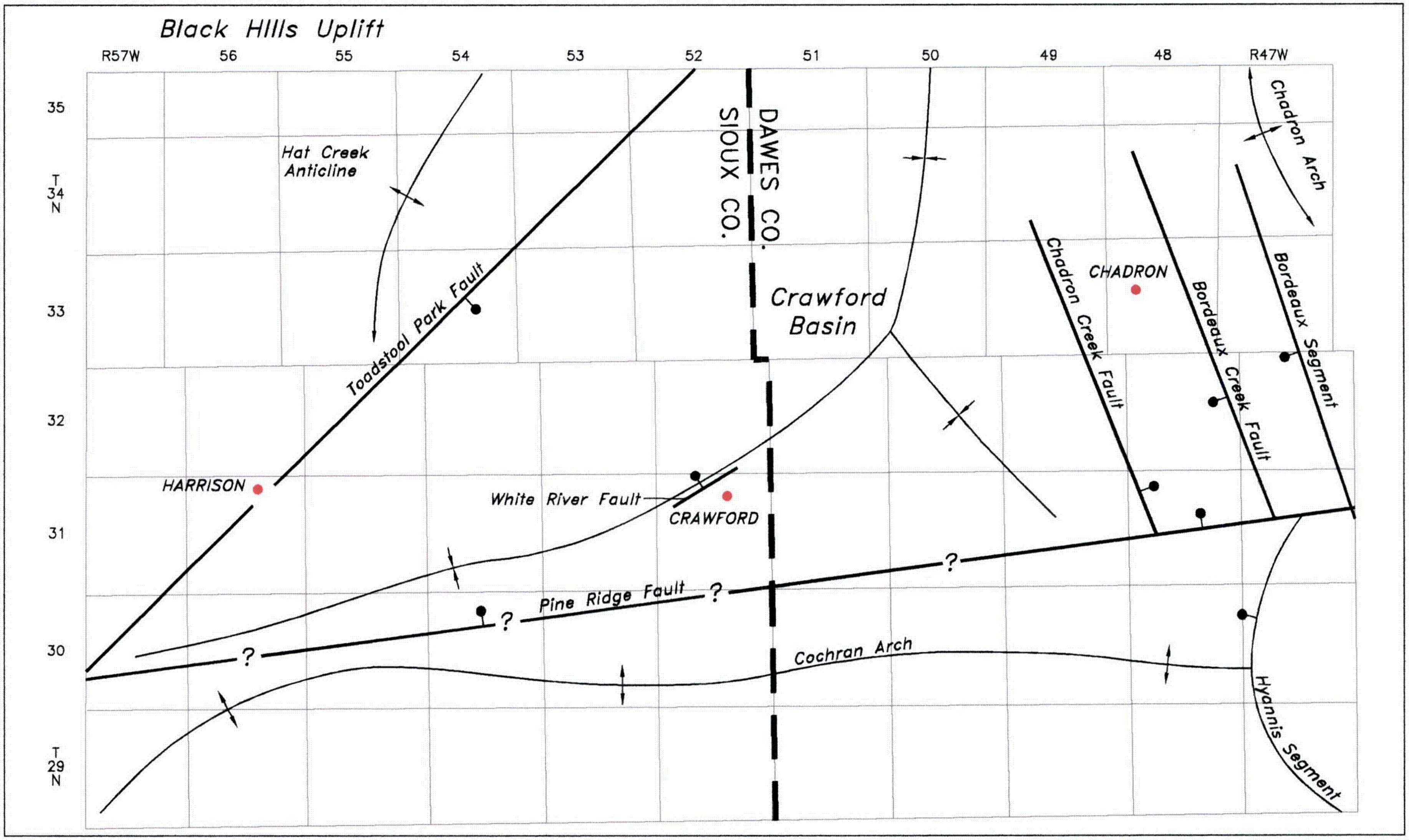


Figure 3.3-4
Regional Structural Map
Pierre Shale Top



LEGEND

Fault (Ball on downthrown side)

Anticline

Syncline

Modified from DeGraw, 1969; WFC–White River Fault only

0 5 10 20

SCALE IN MILES

N
W E

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FIGURE 3.3-5
STRUCTURAL FEATURES MAP
OF THE CRAWFORD BASIN

PROJECT: 223–37	DATE: MARCH 2007
NTLAAFig2.6–5.dwg	BY: KRS CHECKED: HPD

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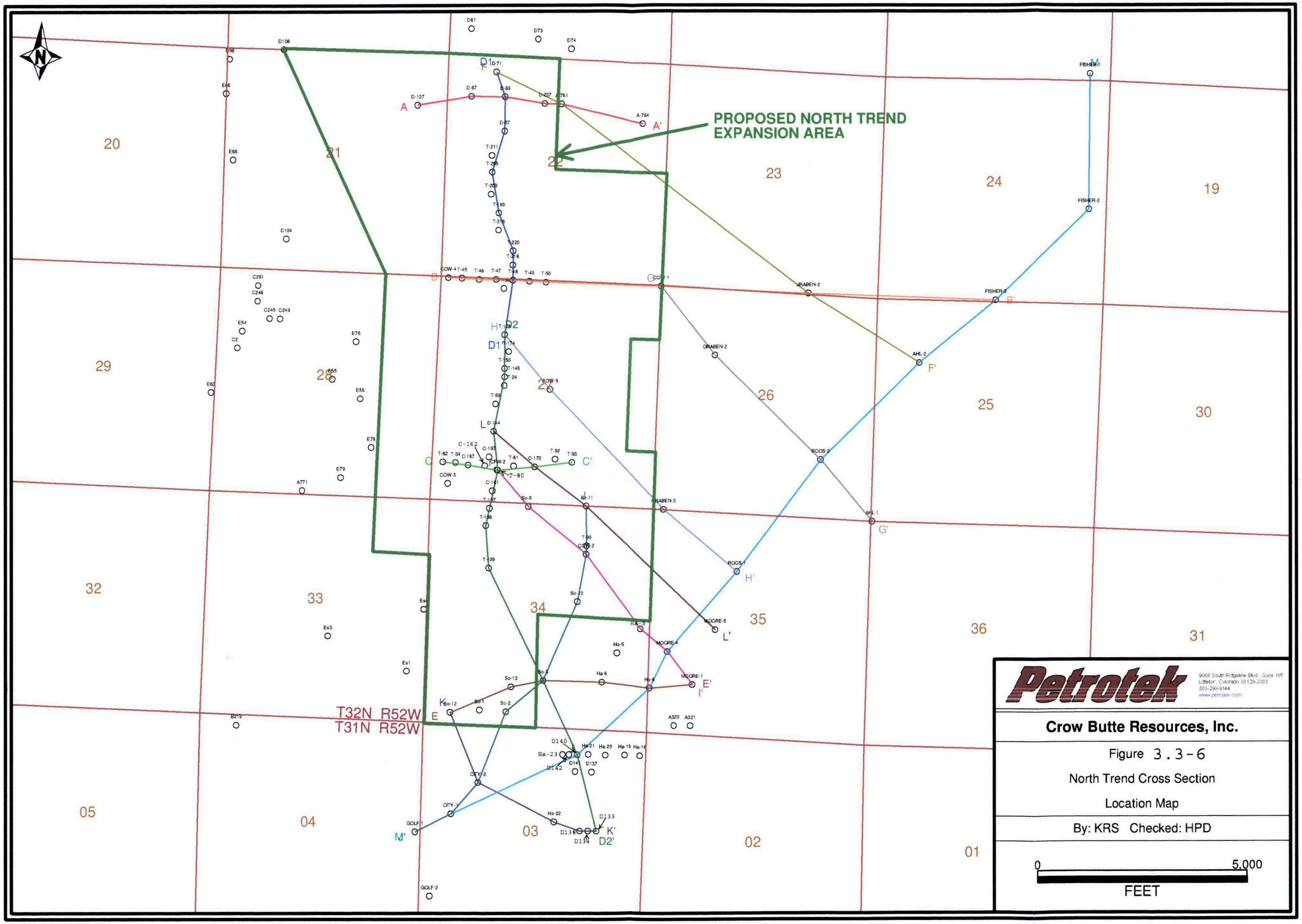

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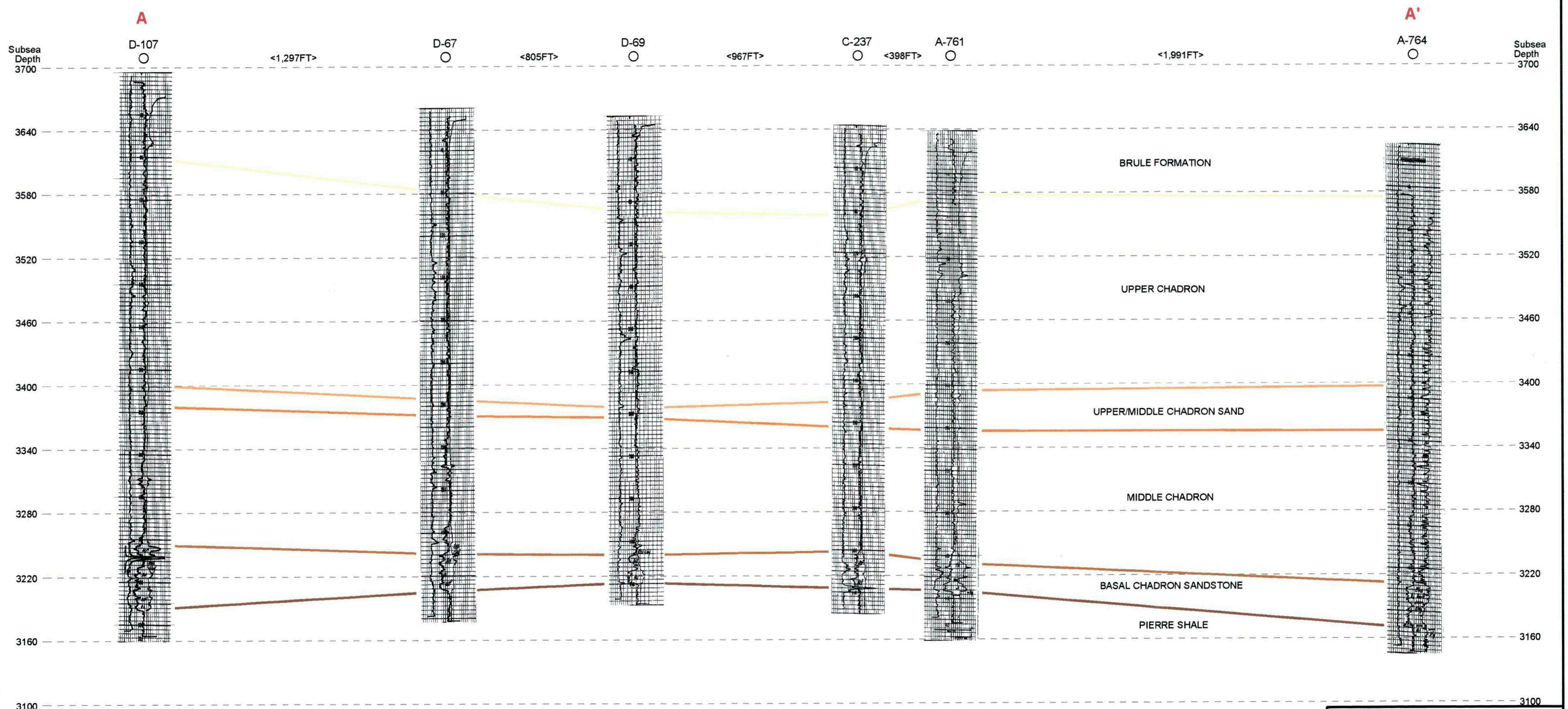
Figure 3.3-6

North Trend Cross Section

Location Map

By: KRS Checked: HPD

PETRA 4/2/2007 3:01:20 PM



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Cross Section: A - A'

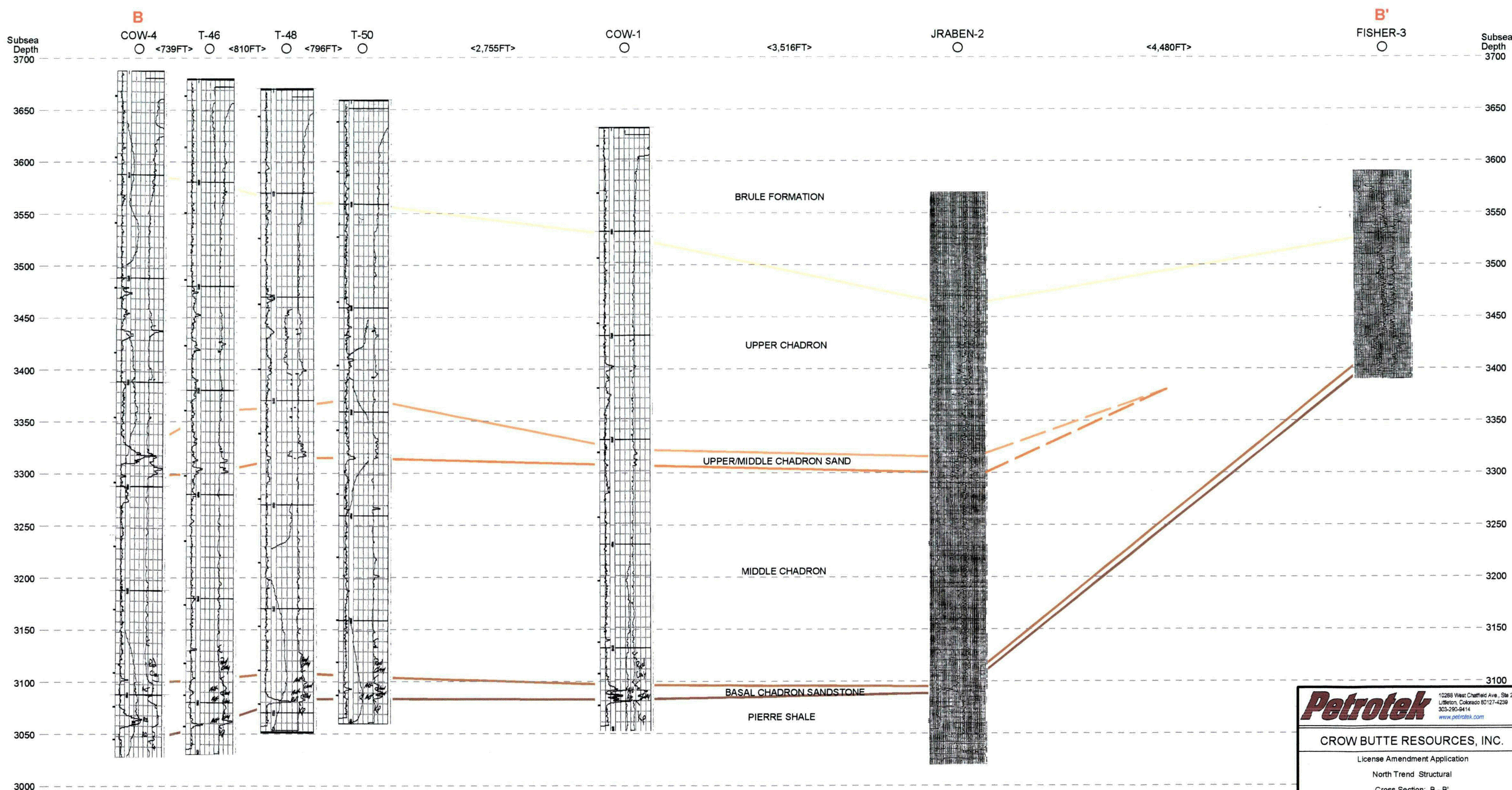
TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-7

By: KRS Checked: HPD/WB

March 12,2007 11:45 AM



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Cross Section: B - B'

TOPS AND MARKERS

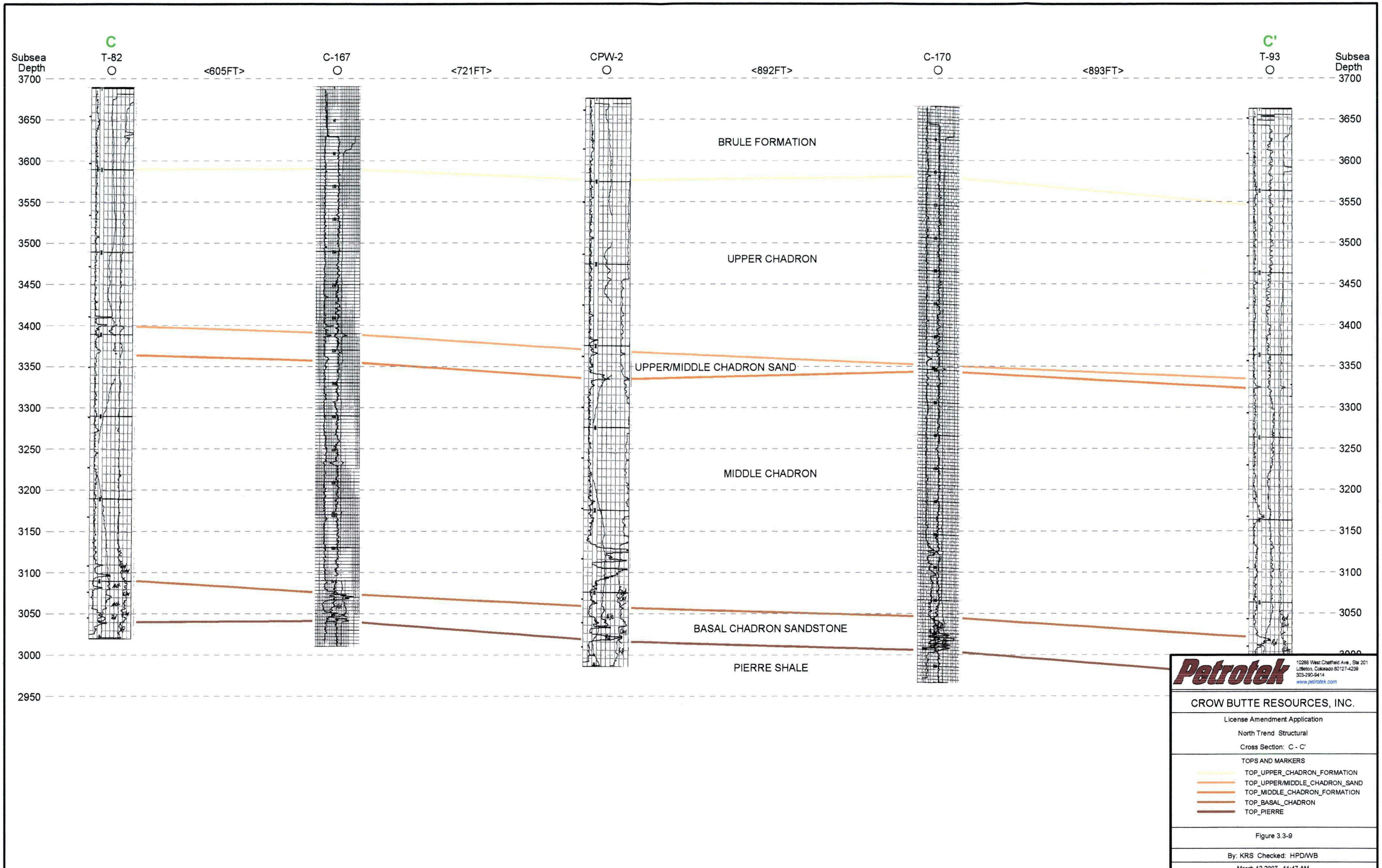
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-8

By: KRS Checked: HPD/WB

March 12,2007 11:46 AM

PETRA 3/12/2007 11:46:45 AM (Fig268.CSP)


C
C'
Subsea Depth
T-82
<605FT>
C-167
<721FT>
CPW-2
<892FT>
C-170
<893FT>
T-93
Subsea Depth
3700
3650
3600
3550
3500
3450
3400
3350
3300
3250
3200
3150
3100
3050
3000
2950
BRULE FORMATION
UPPER CHADRON
UPPER/MIDDLE CHADRON SAND
MIDDLE CHADRON
BASAL CHADRON SANDSTONE
PIERRE SHALE
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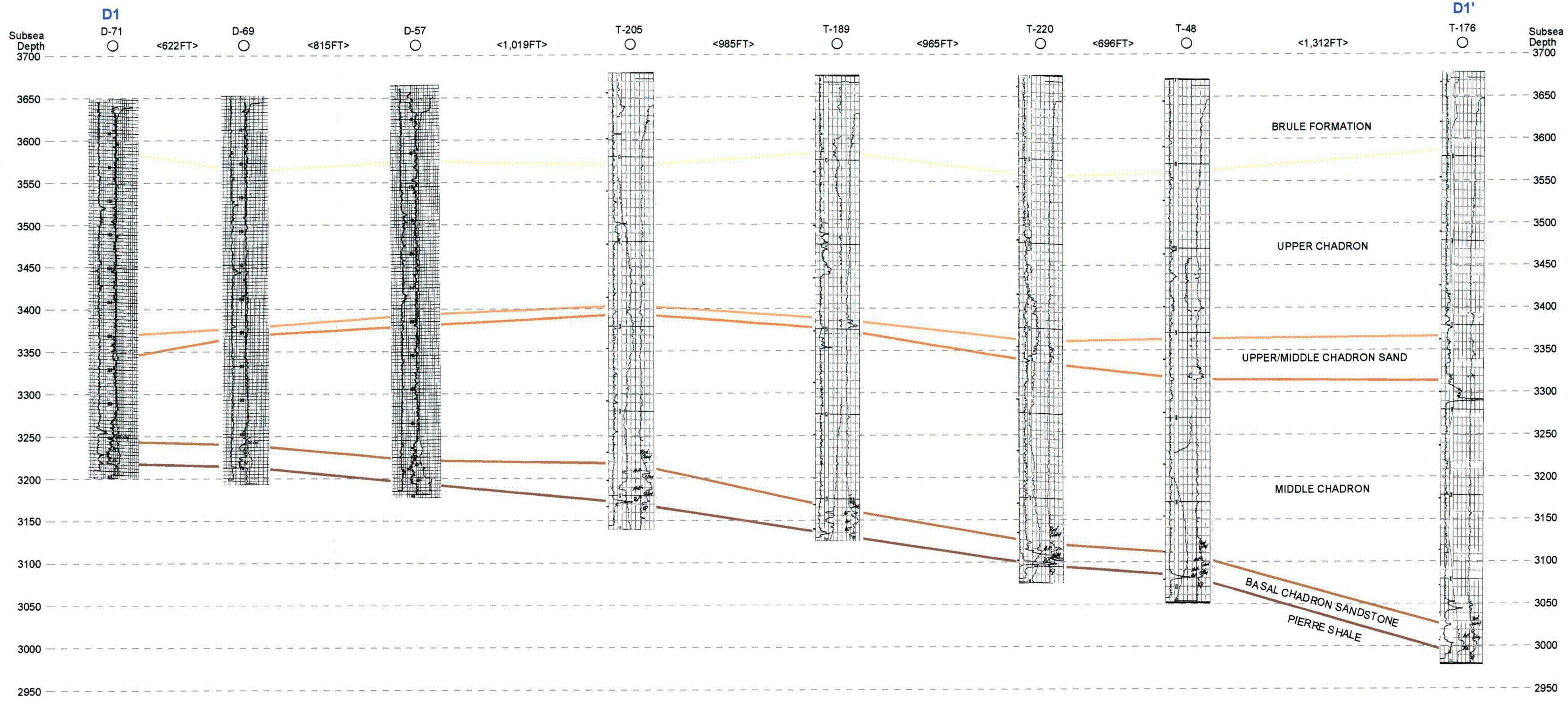
North Trend Structural
Cross Section: C - C'
TOPS AND MARKERS
TOP_UPPER_CHADRON_FORMATION
TOP_UPPER/MIDDLE_CHADRON_SAND
TOP_MIDDLE_CHADRON_FORMATION
TOP_BASAL_CHADRON
TOP_PIERRE
Figure 3.3-9
By: KRS Checked: HPD/WB
March 12,2007 11:47 AM



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North Trend Structural

Cross Section: D1 - D1'

TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-10

By: KRS Checked: HPD/WB

March 13,2007 4:38 PM

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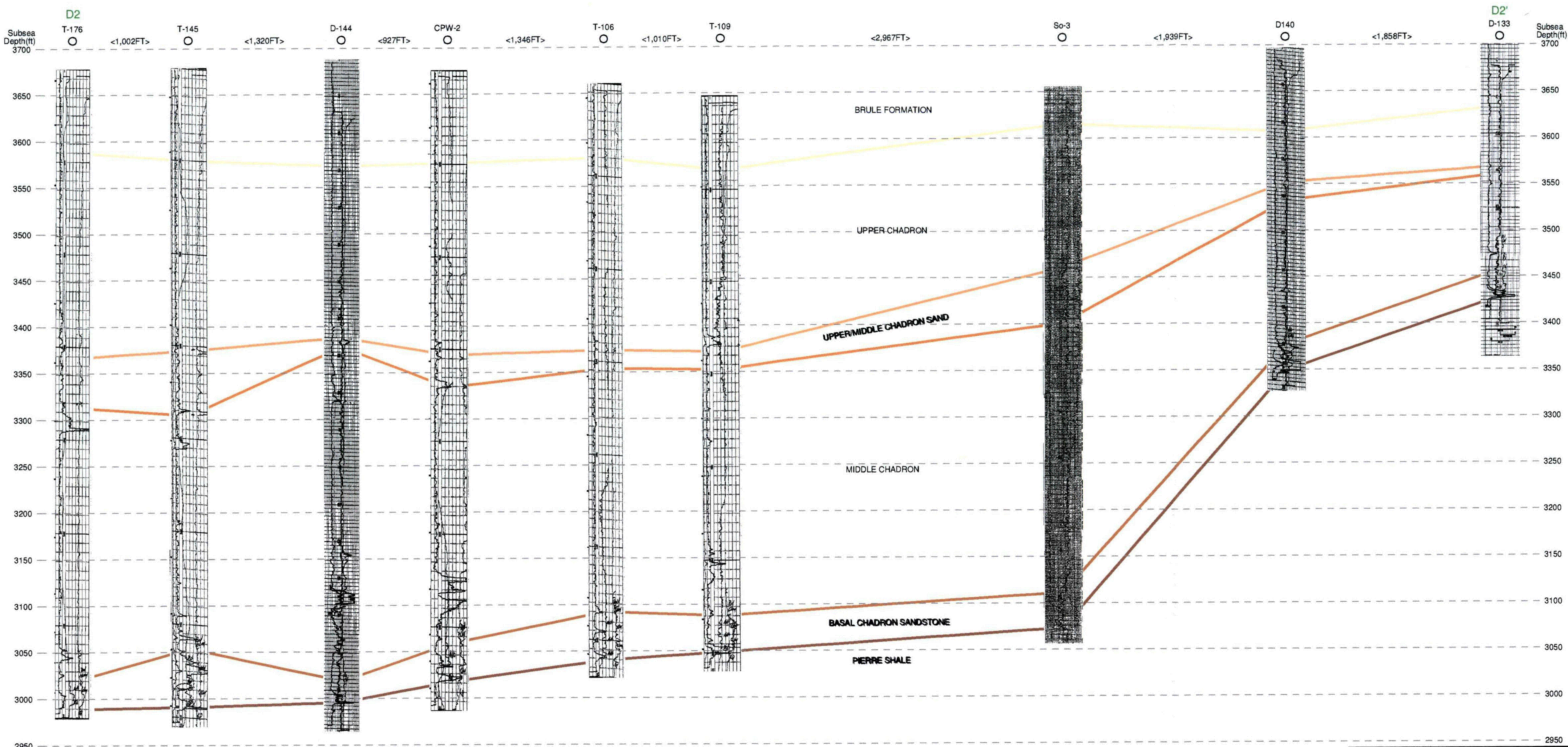

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North Trend Structural

Cross Section: D2 - D2'

TOPS AND MARKERS

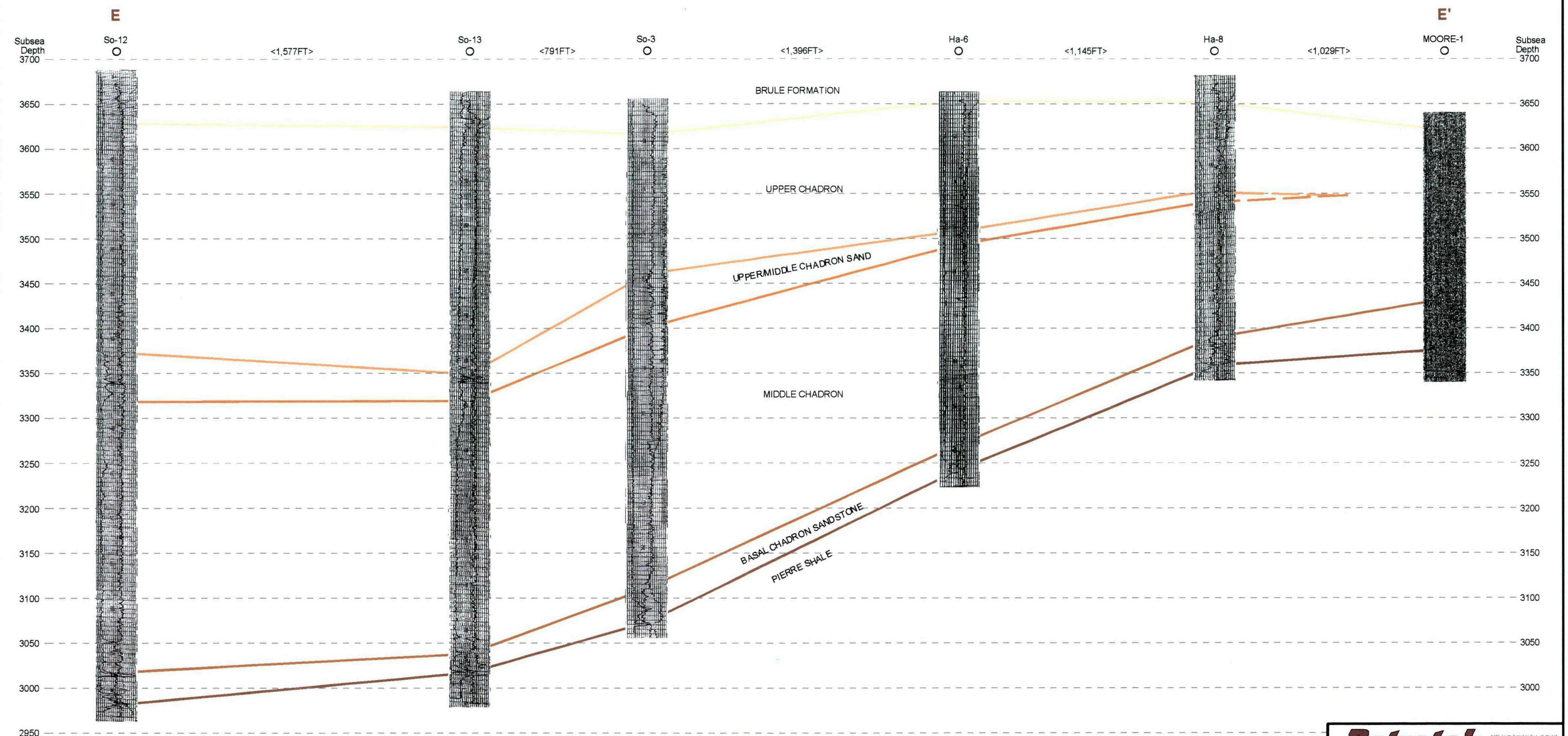
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-11

By: KRS Checked: HPD/WB

April 2,2007 3:47 PM

PETRA 4/2/2007 3:47:42 PM (Fig2611.CSP)



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North Trend Structural

Cross Section: E - E'

TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-12

By: KRS Checked: HPD/WB

March 13,2007 4:44 PM

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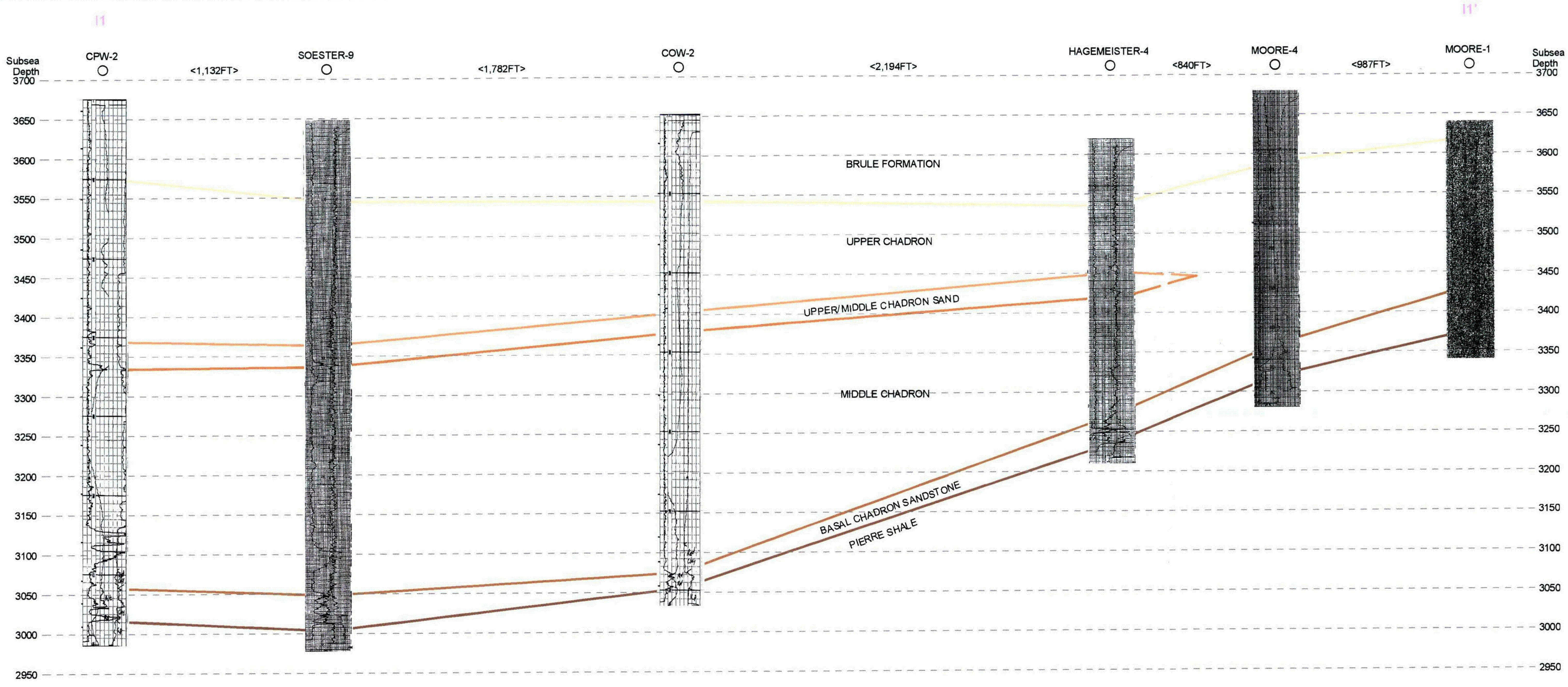

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Cross Section: I - I'

TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-13

By: KRS Checked: HPD/WB

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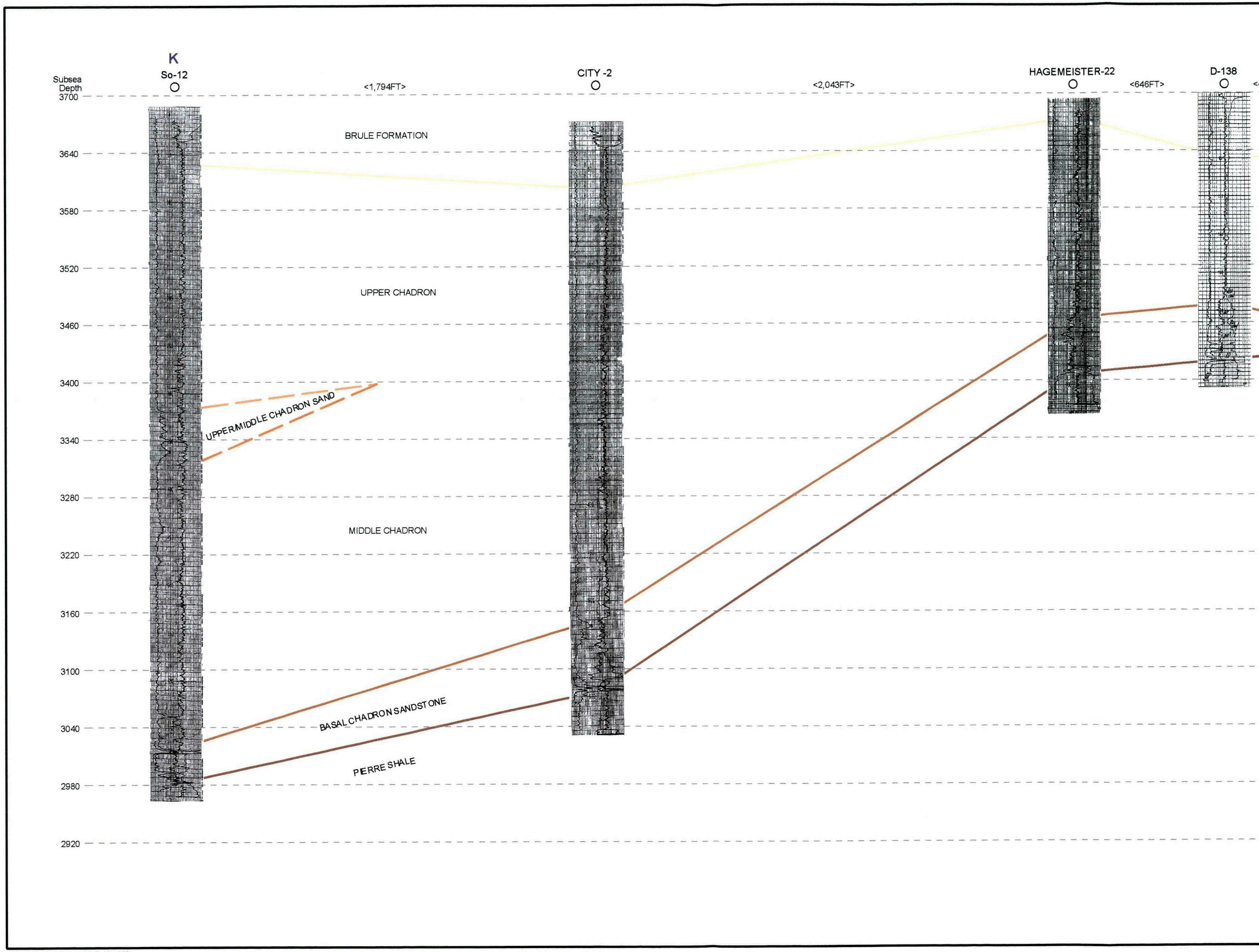

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North Trend Structural

Cross Section: K - K'

TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-14

By: KRS Checked: HPD/WB

March 12,2007 11:50 AM

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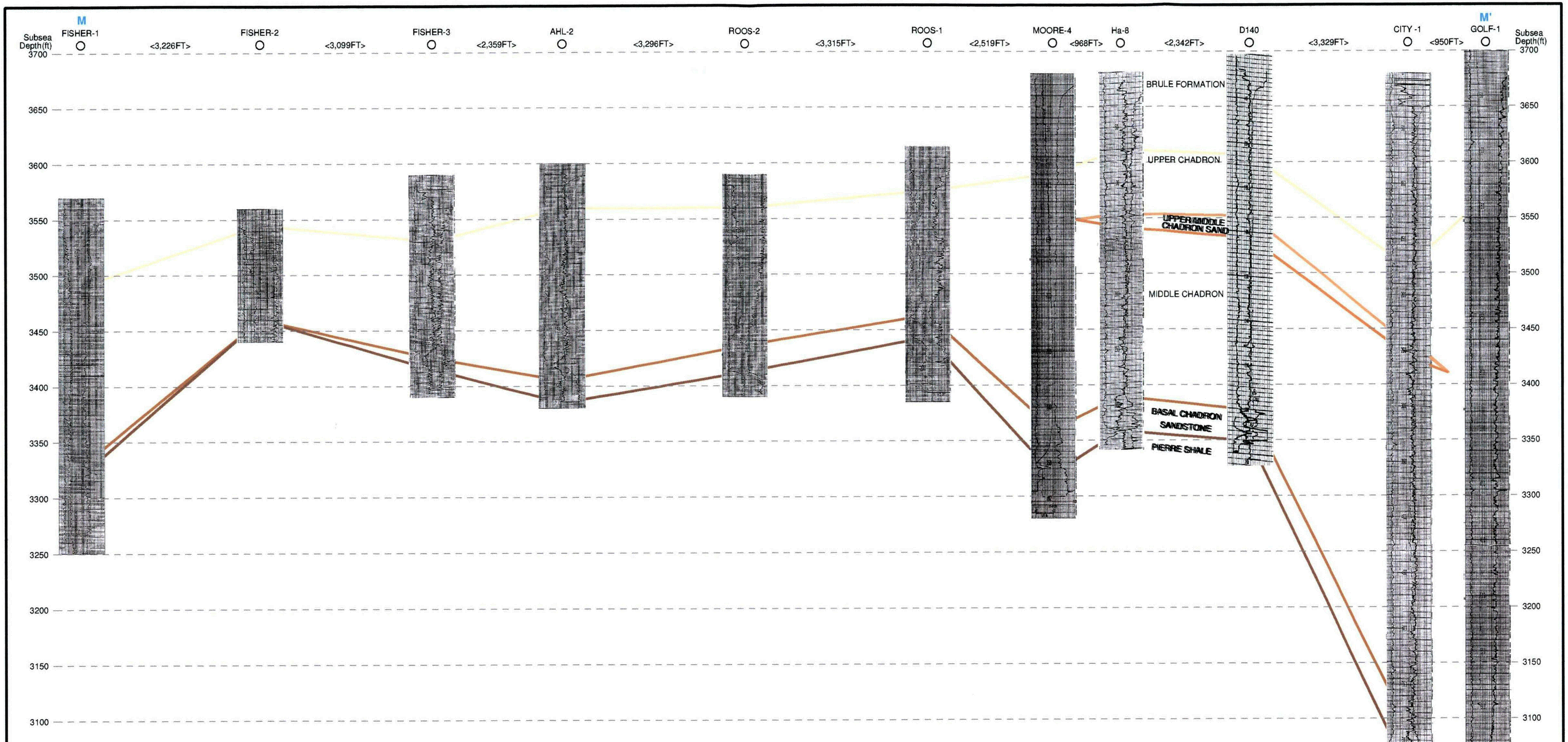

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North Trend Structural

Cross Section: M - M'

TOPS AND MARKERS

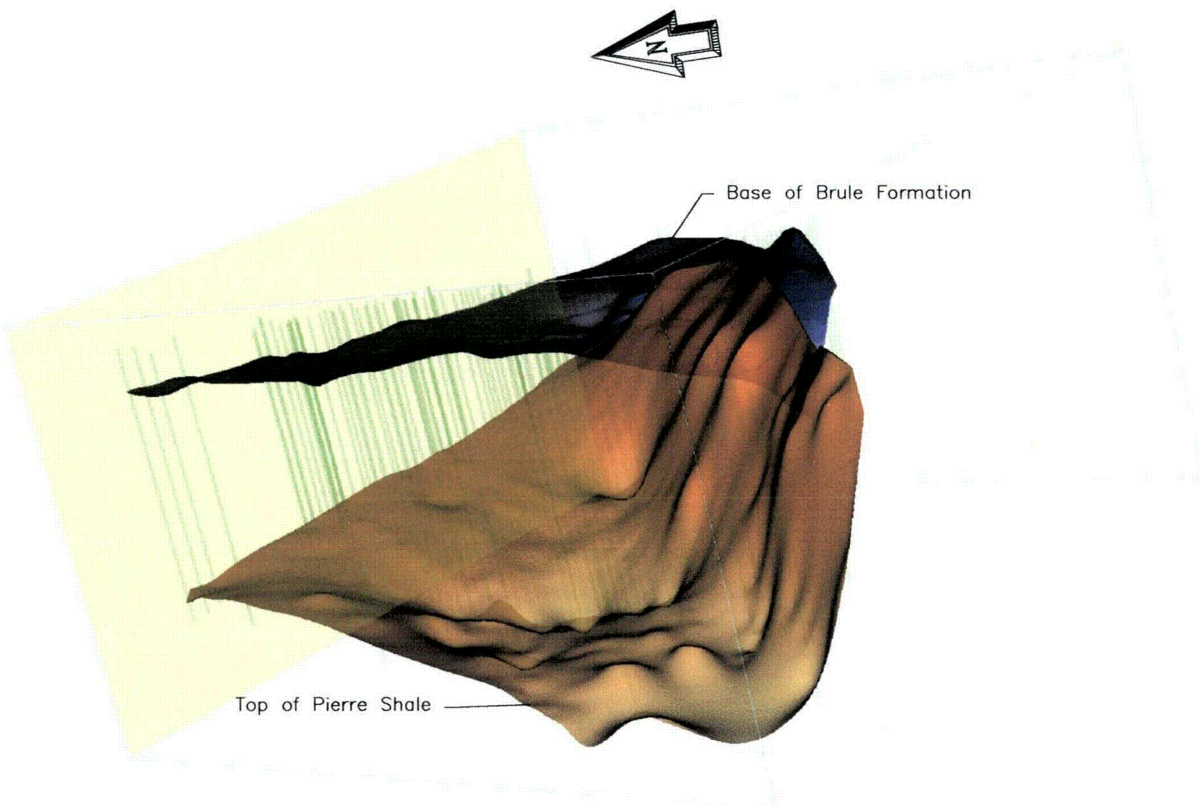
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 3.3-15

By: KRS Checked: HPD/WB

April 2,2007 3:41 PM

PETRA 4/2/2007 3:42:00 PM (Fig2615.CST)



VERTICAL EXAGGERATION = 15x

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FIGURE 3.3-16
BASE OF BRULE & TOP OF PIERRE
3-D VIEW LOOKING NORTHEAST

PROJECT: 223-37	DATE: MARCH 2007
DWG: Figure 2.6-16.dwg	BY: KRS CHECKED: HPD

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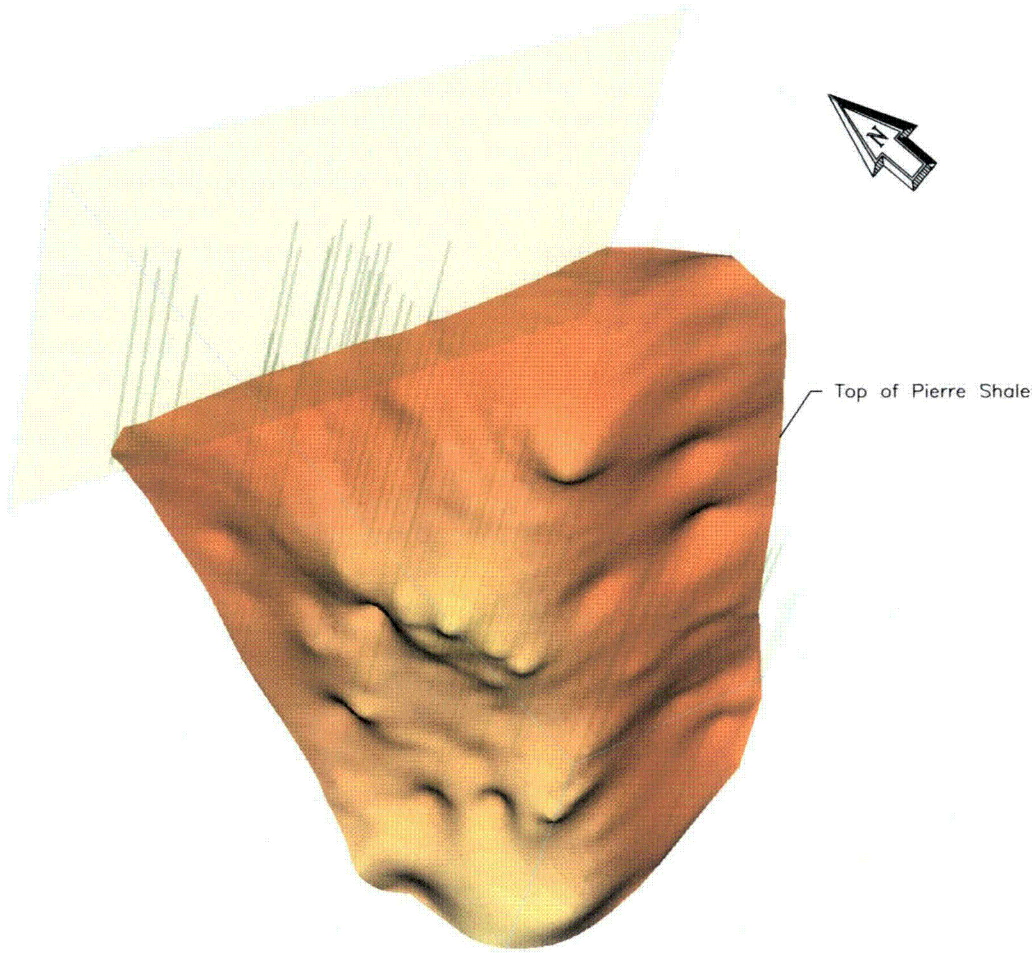

VERTICAL EXAGGERATION = 15x

CROW BUTTE RESOURCES, INC.

FIGURE 3.3-17

TOP OF PIERRE
3-D VIEW LOOKING NORTHEAST

PROJECT: 223-37	DATE: MARCH 2007
DWG: Figure 2.6-17.dwg	BY: KRS CHECKED: HPD

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